

Ferrofluids

NIPPON FERROFLUIDICS CORPORATION

C ONTINUOUS CHALLENGES TO THE FUTURE



A handwritten signature in black ink, appearing to read 'Akira Yamamura'.

Akira Yamamura
President
Nippon Ferrofluidics Corporation

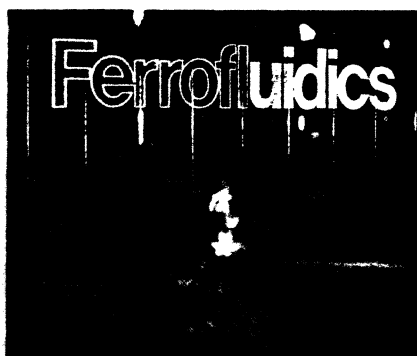
Initially, Nippon Ferrofluidics Corporation was established as a subsidiary of Ferrofluidics Corporation (U.S.A.), in September 1980. Later in 1987 Nippon Ferrofluidics Corporation was reorganized as an independent corporate body financed by Kubota Co., and other companies, and is expanding its activity steadily.

Ferrofluids, which I encountered in my 14 years of experience with business in America, now attract high technology industries as a unique magnetic fluid material, particularly in the field of semiconductor and computer technology. This is mainly due to our continuing efforts and strategic plan over the past decade: commitment to meet requirements of high technology industries, expansion of innovative ultra-modern facilities, solid marketing, and recruitment of dedicated, and highly motivated staff.

Our major priority is to open new approaches to development of new products by intergrated research on new materials and advanced vacuum technology.

We are also proud of our worldwide scope of operation. Our key aspect of strategy is its global perspective, largely through our partner, Ferrofluidics Corporation(U.S.A.). We set priorities to identify partners overseas for development and marketing of our products and technology. It gives us an appreciation that there are important differences that we have to accounted for: diversification of value systems. Thus, our worldwide experience in communication and collaboration gives us flexibility to the company's overall strategy.

We, Nippon Ferrofluidics Corporation, are committed to meet the increasing demands with our innovative yet flexible approaches as a future-oriented company through 21st century not only domestically but also internationally.



■ **Spike phenomenon**

When the magnet is placed under the ferrofluids in a plate, ferrofluids show spiky process due to magnetic effects on surfactant. This phenomenon is called "Spike phenomenon", and visualized using computer graphics as shown in the picture.

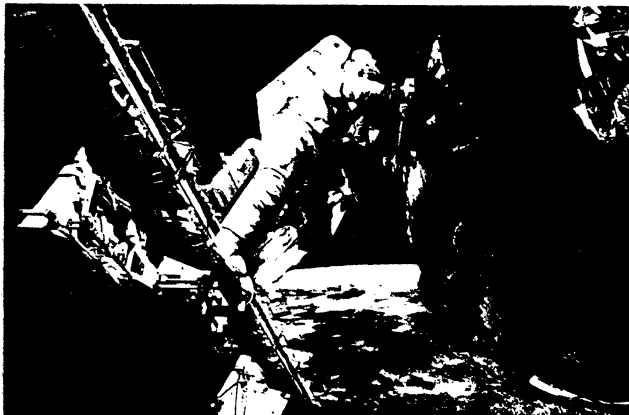


STEP FORWARD TO THE WORLD, TO THE FUTURE!

A NEW CLASS OF MATERIALS INTRODUCED BY NASA

In 1969 Ferrofluidics Corporation (U.S.A.) was incorporated by two distinguished scientists, Dr. Ronald Moskowitz and Dr. Ronald E. Rosensweig. They played a pioneering and key role in the development of ferrofluid technology and its applications, which was one of the major NASA outer space projects.

Ferrofluidics Corporation received a license from NASA for ferrofluid technology, and established as the recognized, nonexclusive world leader for the production of ferrofluids and application products. Ferrofluids are the new product introduced by NASA technology.



FERROFLUIDICS IS SUPPORTED BY ITS NOVEL TECHNOLOGY

Ferrofluidics group accumulates ferrofluid-related patents and know-how during continuing efforts in improvements of ferrofluid technology. The group, as a worldwide leader, is committed to meet the increasingly demanding requirements of high technology industries, with ferrofluids.

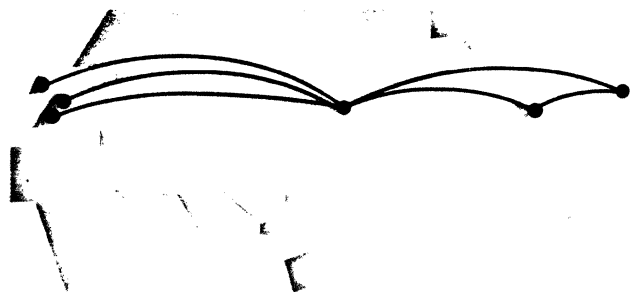
Nippon Ferrofluidics Corporation is proud of its leadership position in research and development of technology applications in the Ferrofluidics group. Nippon Ferrofluidics Corporation has a worldwide scope of operation through collaborative research and development of ferrofluids, and its application products, in particular, with Ferrofluidics Corporation (U.S.A.). Active participations in intergroup seminars on advanced technology and marketing strategy routinely held in the U.S.A..

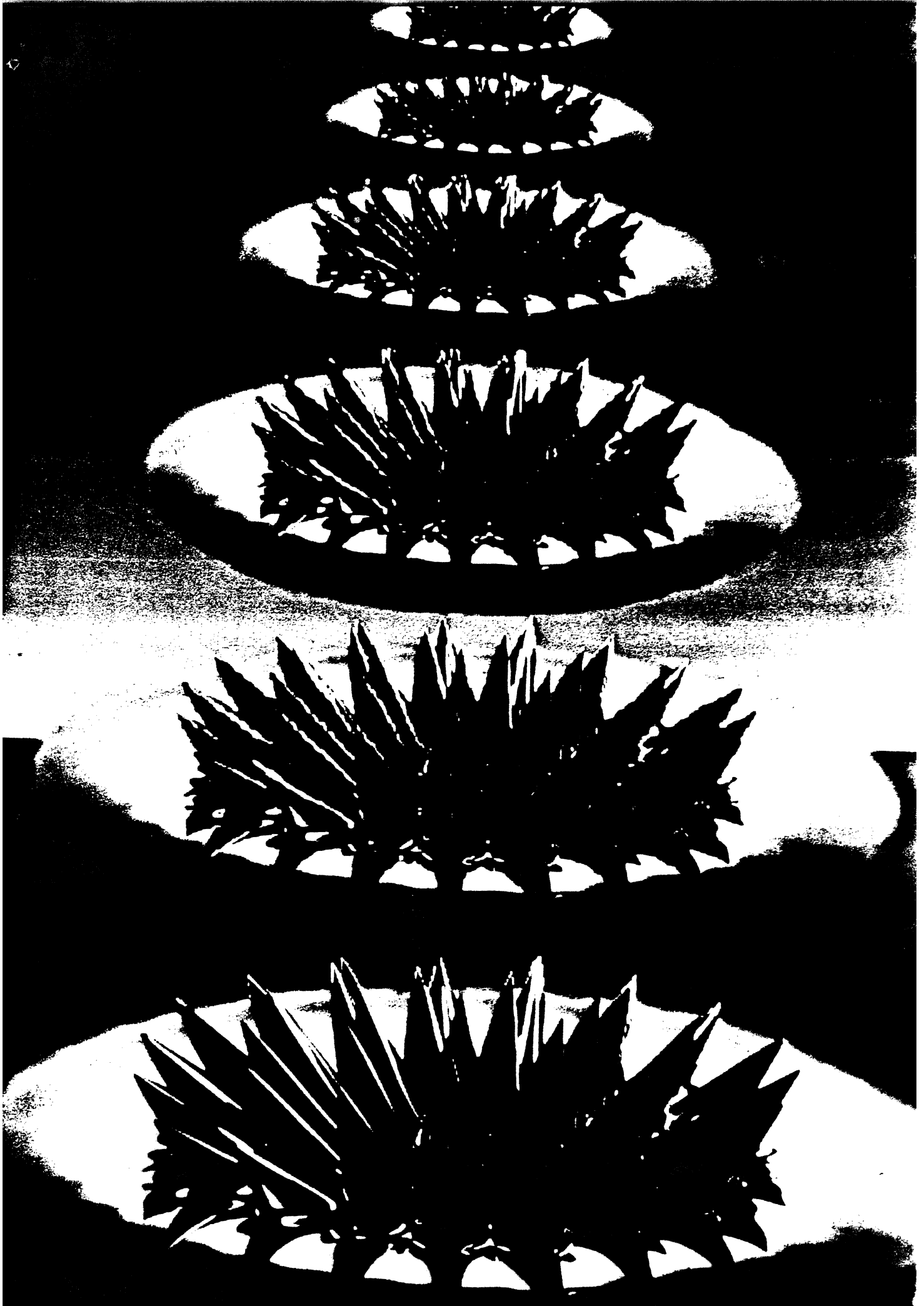
In the process, we, Nippon Ferrofluidics Corporation, have gained exciting new knowledge and expanded our capability to create innovative ferrofluidic products.

NIPPON FERROFLUIDICS CORPORATION PLAYS A MAJOR ROLE IN THE FERROFLUIDIC GLOBAL NETWORK

Ferrofluidics Corporation (U.S.A.) has affiliated companies in West Germany, England and France, and its group-oriented activity is dispersed and penetrated into all over the world. As a key member of Ferrofluidics group, Nippon Ferrofluidics Corporation shares the commitment to keep ferrofluidic technology, product performance, and marketing strategy with 100% quality.

Our future goals are to provide a significant benefit to our life by utilizing promising ferrofluidic technology worldwide.

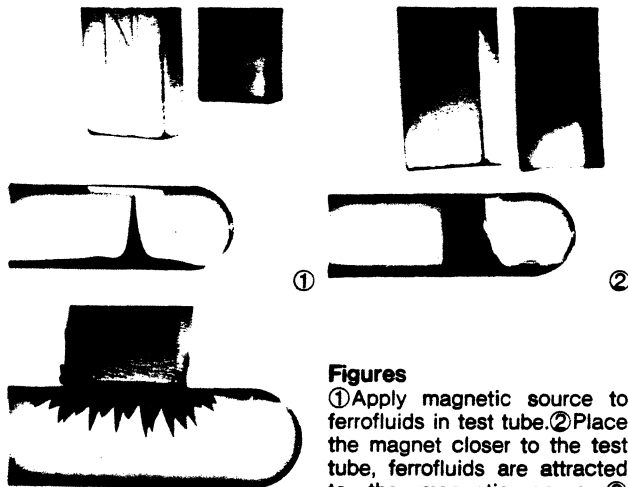




FERROFLUID-A MOST ADVANCED TECHNOLOGY WITH FULL OF PROMISE

FERROFLUID IS A MAGNET-RESPONDING FLUID

Black-colored fluid shown in this picture is a magnetic fluid, ferrofluid. When a magnetic field is applied to ferrofluid, the ferrofluid acquires a magnetic moment, and then be precisely positioned and controlled. The ferrofluid was developed and synthesized under NASA research program of outer space projects in 1960. Ferrofluids were conceived as a novel answer to problems of zero gravity in outer space applications: how to use liquid fuel in a space shuttle under zero gravity: is it possible to develop magnetic controllable liquid fuel by mixing iron particles into fuel... The answer was an introduction of this unique new class of materials, ferrofluid to the world of high technology.



① ②

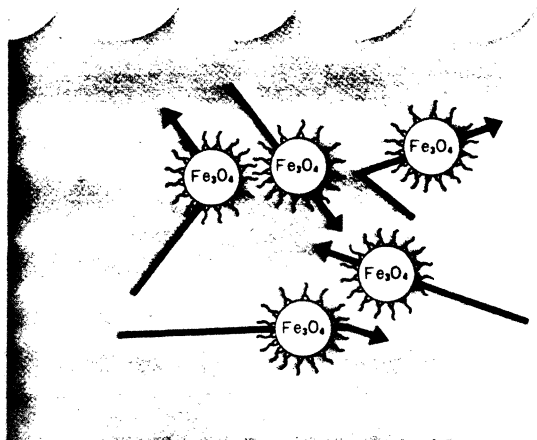
Figures

① Apply magnetic source to ferrofluids in test tube. ② Place the magnet closer to the test tube, ferrofluids are attracted to the magnetic source. ③ Place the magnet still closer, then ferrofluids fully react with the magnetic source as shown in this picture. ③

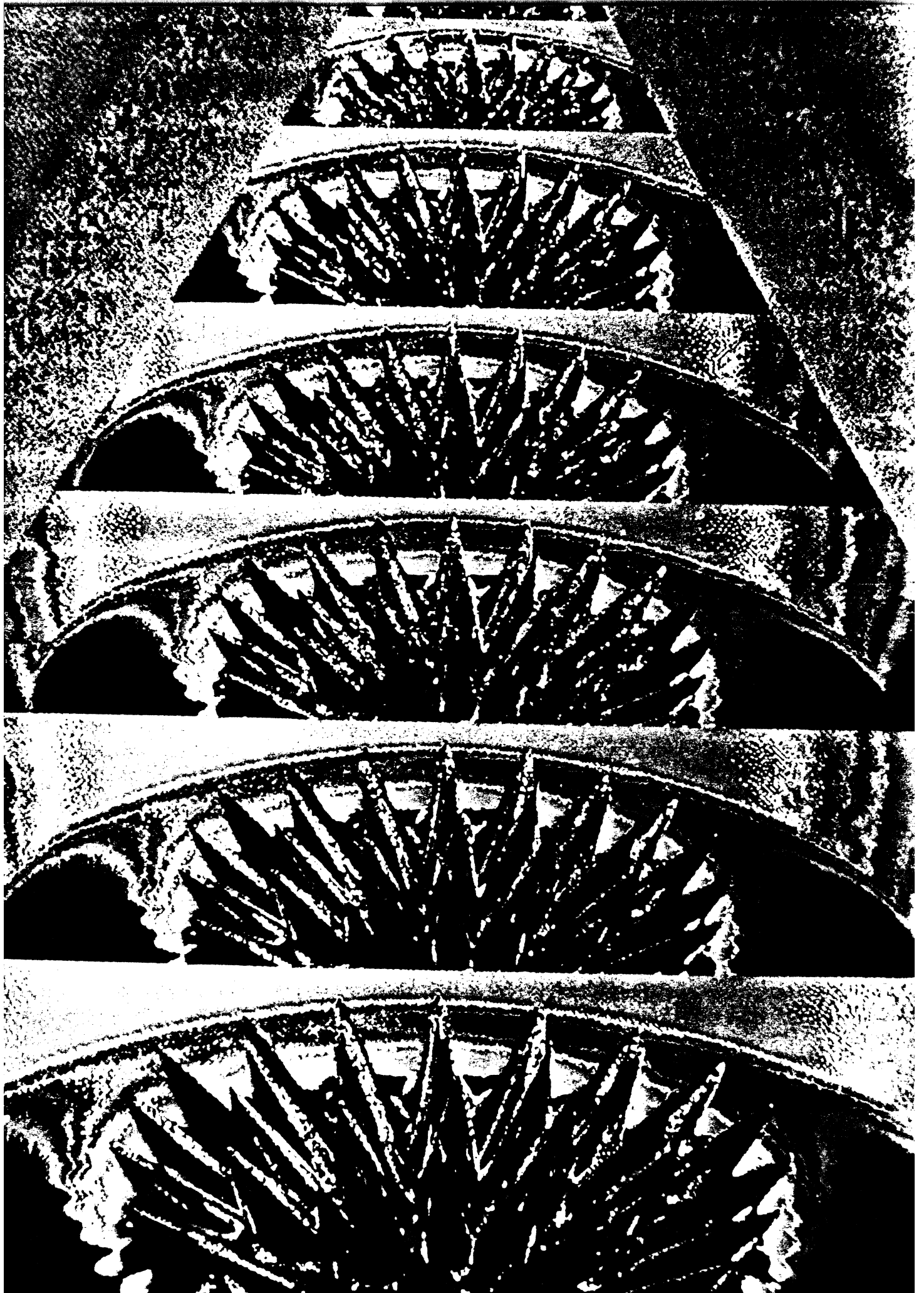
A PROFILE OF FERROFLUID

Ferrofluids are composed of three fundamental components; magnetic particles, surfactant, and base oil. Ferrofluids are stable colloidal suspension of sub-domain magnetic particles, approximately 100 Å in size of Fe_3O_4 (magnetite), coated with a stabilizing dispersing agent, and dispersed into base oil. Thus, ferrofluid is an ultra-stable colloidal magnetic fluid, without agglomeration, precipitation and separation by defying the force of gravity.

This new material, ferrofluid, plays an important role in the currently on-going research in high technology, and opens new possibilities for imaginative applications in the future.



Schematic of ferrofluid ■ BASE OIL ~ SURFACTANT

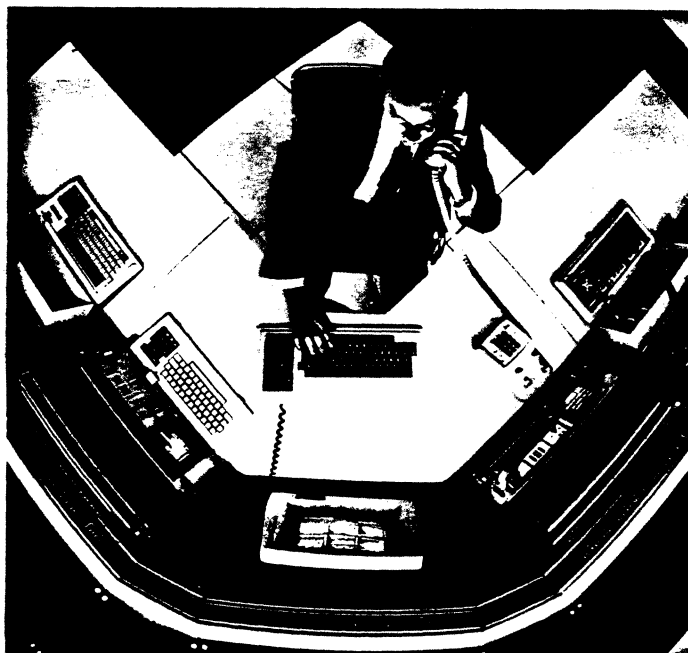
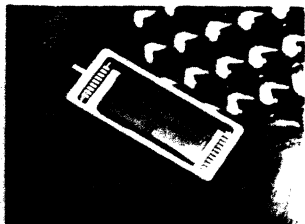


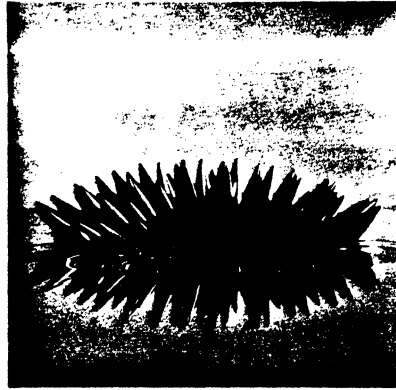
FERROFLUIDS STIMULATE PROGRESS IN YOUR LIFE

If you are now at work, just look around in your office! You might not notice where ferrofluids are being used... Inside a personal computer on your desk ferrofluidic seal is used to prevent contaminations in the hard disk drive memory systems. A calculator in your pocket ferrofluids are also employed in industrial process of IC memory production. Even in a color printer next to you, ferrofluids help stepping motor for maintaining high quality of performance. For quality control of video tapes familiar to you, ferrofluids are also applied to magnetic domain detection. Ferrofluids are used in your audio loud-speakers for producing high fidelity per-

formance. You will find ferrofluids in your cosmetics such as eye brash liner and mascara.

In high technology industries where a most advanced reliable quality is always required, ferrofluids are extensively applied to various parts of high technology; densimetric separation, heat transfer engine, actuators, valves, grinders, sensors, medical apparatus and equipments, display products, to mention just a few. A unique new material, Ferrofluid, accelerates progress in high technology. The magnetic fluid, ferrofluid, literally attracts possibilities of technological progress with its magnetic power.



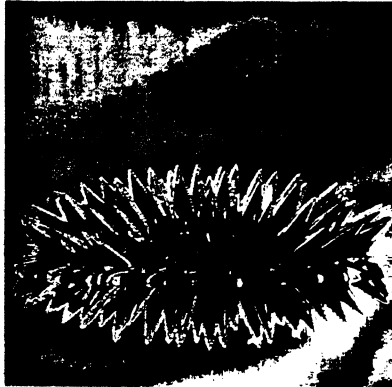


U R

IMAGINATIVE APPROACHES TO FERROFLUIDS

We, Nippon Ferrofluidics Corporation, emphasize research and development based on our unique and flexible imagination. We provide an imaginative corporate climate in order to open exciting, unexpected possibilities for unique applications of ferrofluids. Sometimes our attempts might not be logical, or might be rather divergent, or adventurous.

The unique combination of our special approaches and ferrofluids, a highly advanced new class of materials, creates a totally new product of multipotential application. As the pioneer and technological leader of the ferrofluidic industry we carry out our mission of the research and development with our unique and flexible mind.



PRODUCTS

FERROFLUIDS FOR MAGNETIC DOMAIN DETECTION

Ferrofluidic products of EMG series are used as water-based ferrofluids for magnetic domain detection, which is applicable to quality control of magnetic tapes and disks. This material is water-soluble, therefore, it can be used by diluting into water, and it is cost-effective. This product enables accurate magnetic domain detection by applying ferrofluids, with a magnetic field gradient, regardless of magnetic field potentials.

FERROFLUIDS FOR HIGH FIDELITY AUDIO LOUD-SPEAKERS

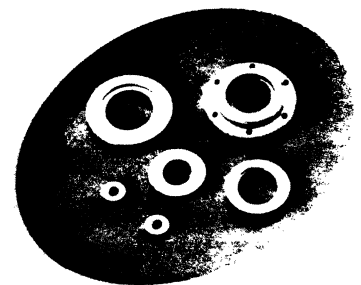
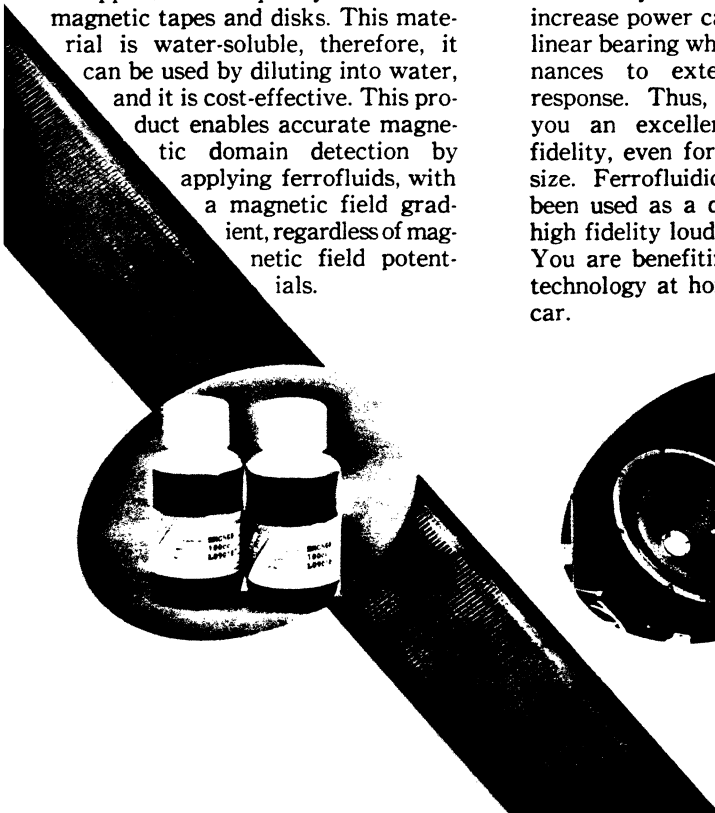
Remarkable improvements in high fidelity audio speakers are attainable with ferrofluids. Ferrofluids convert heat away from the voice coil to increase power capacity, and act as a linear bearing while damping out resonances to extend the frequency response. Thus, ferrofluids provide you an excellent quality of high fidelity, even for a speaker in small size. Ferrofluidic APG series have been used as a design component in high fidelity loud-speaker production. You are benefiting from ferrofluidic technology at home and also in your car.

EXCLUSION SEALS

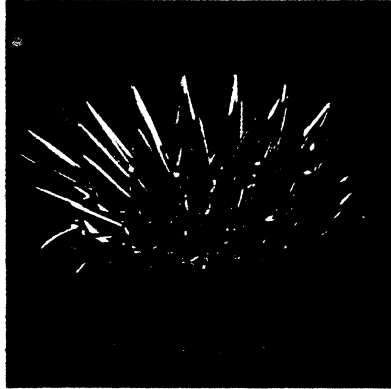
Any computer is vulnerable to cigarette smoke.

The exclusion seal is employed in preventing heads or disks damages from microscopic particles, smoke and mists.

This exclusion seal improves drive reliability which is critical to computer flying head clearances required for trouble-free performance. The exclusion seal produces an absolute seal against an ultra-micro contamination of $0.1 \mu\text{m}$ (1/10000mm), and currently ferrofluidic exclusion seal is used in a variety of hard disk drives and enjoys universal acceptance by disk drive manufacturers of personal computers to super computers.



OUR PRODUCTS



AGGRESSIVE APPROACHES TO INOVATIVE PRODUCTS

We set challenging goals to integrate our highly specialized ferrofluidic technology and human well-off in the future. As a worldwide leader in the high technology industry, our ultimate mission is harmony integration of our accumulated technological know-how and the quality of life.

We, Nippon Ferrofluidics Corporation, are committed to seeking the promising future for human beings through our continuing involvements in ferrofluidic research and development.

VACUUM FEEDTHROUGHS

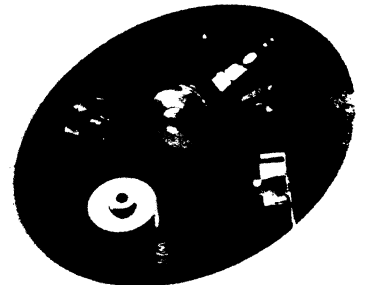
Various vacuum systems are essential for semiconductor processes, where absolute sealing preventing the ingress of airborne particles and leakage is always required.

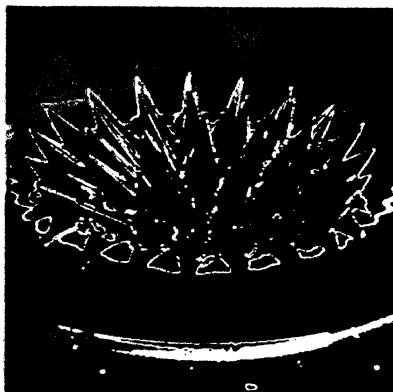


Ferrofluidic rotary vacuum feedthrough is a unique nonwearing and zero leakage seal using ferrofluids as the sealing medium, providing hermetic and long-lasting trouble-free performance, which is mandatory for the next generation semiconductor industry.

INERTIA DAMPERS

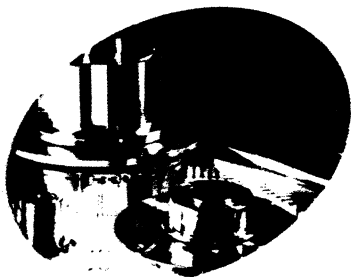
A phenomenon peculiar to ferrofluids is "levitation", (which connotes floating by magical power.) If, for example, a golf ball is placed into a bowl containing ferrofluids, and then place the magnet under the bowl, a golf ball would leap out of the bowl, leaving the bowl empty. Ferrofluidic inertia dampers, although in a small size, are used for reducing settling time and for absorbing the stepper motor vibrations remarkably.





FERROFLUID FILM BEARINGS

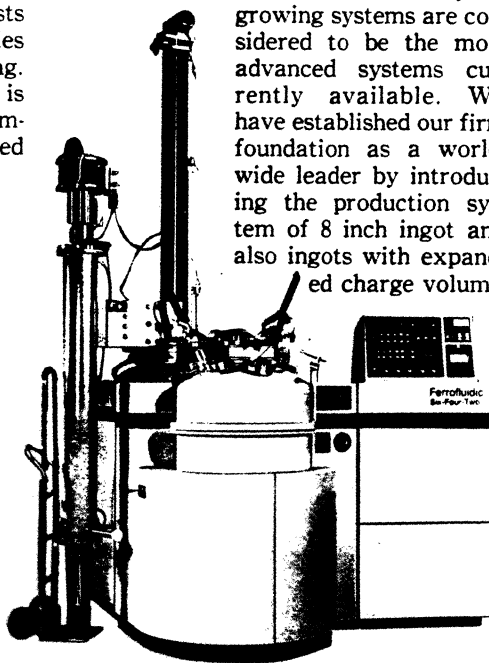
Hard disk drives require accurate rotations of spindle. Conventional mechanical ball bearings used for hard disk spindles hardly induce non-repeatable run-outs of less than 0.1 μm , with all current technologies. Ferrofluidic film bearing provides significant rotational accuracies so that non-repeatable run-outs are nearly immeasurable. In addition, Ferrofluidic film bearing remarkably reduces mechanical noise and mists while providing greater accuracies and significant system damping. Thus, Ferrofluidic film bearing is ideal for the next generation computer hard disk drives, with improved capacity and performance.



SILICON CRYSTAL GROWING SYSTEMS

Silicon crystal growing systems were developed to produce ingots that are essential for production of semiconductor elements. Ferrofluidic CZ type silicon crystal growing systems incorporate U.S. and Japan patented ingot isolation systems and our own vacuum feedthrough sealing technology, resulting in rapid progress in its vacuum quality. Our fully automated and computer-controlled silicon crystal

growing systems are considered to be the most advanced systems currently available. We have established our firm foundation as a worldwide leader by introducing the production system of 8 inch ingot and also ingots with expanded charge volume.



EXPANDING OUR ROLE WITH NEW MATERIALS

We, Nippon Ferrofluidics Corporation, emphasize research and development of new materials and novel products of our unique magnetic fluid, ferrofluids, in collaboration with computer, semiconductor and biotechnology industries.



NIPPON FERROFLUIDICS CORPORATION PROVIDES THE ENVIRONMENTS IN HARMONY WITH TECHNOLOGY AND AN ELITE TEAM OF PROFESSIONALS

Nippon Ferrofluidics Corporation provides an environment to create the opportunity and incentive for the development of human and technical potentials of our staff. We encourage high individual growth and teamwork in harmony with our specialized technology.



Sales call



Presentation of new product

Headquarters (Head Office)

The headquarters of Nippon Ferrofluidics Corporation locates in Akasaka Twin Tower Building in Akasaka. Akasaka is one of the major centers of Tokyo, surrounded with central government functions including Diet, government offices, embassies, major business enterprises, and hotels. A newly built Ark Hills Building occupied with internationally renowned business such as banks, broadcasting, security firms, theaters and concert halls with ultra-modern facilities, is functioning 24 hours. Akasaka is well known as a leading business district as well as a center of worldwide cultural performance.



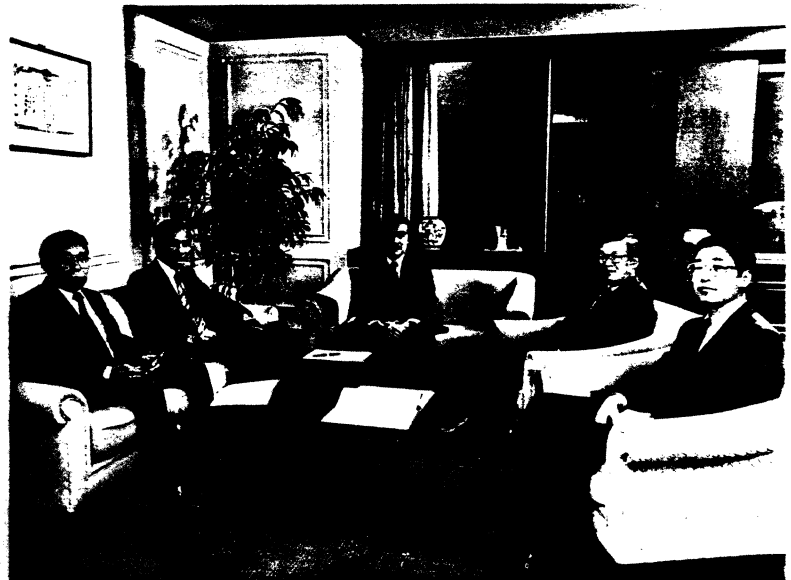
Akasaka Twin Tower Building



Computer system



Sales meeting



Board of directors



Makuhari Messe (new convention center)



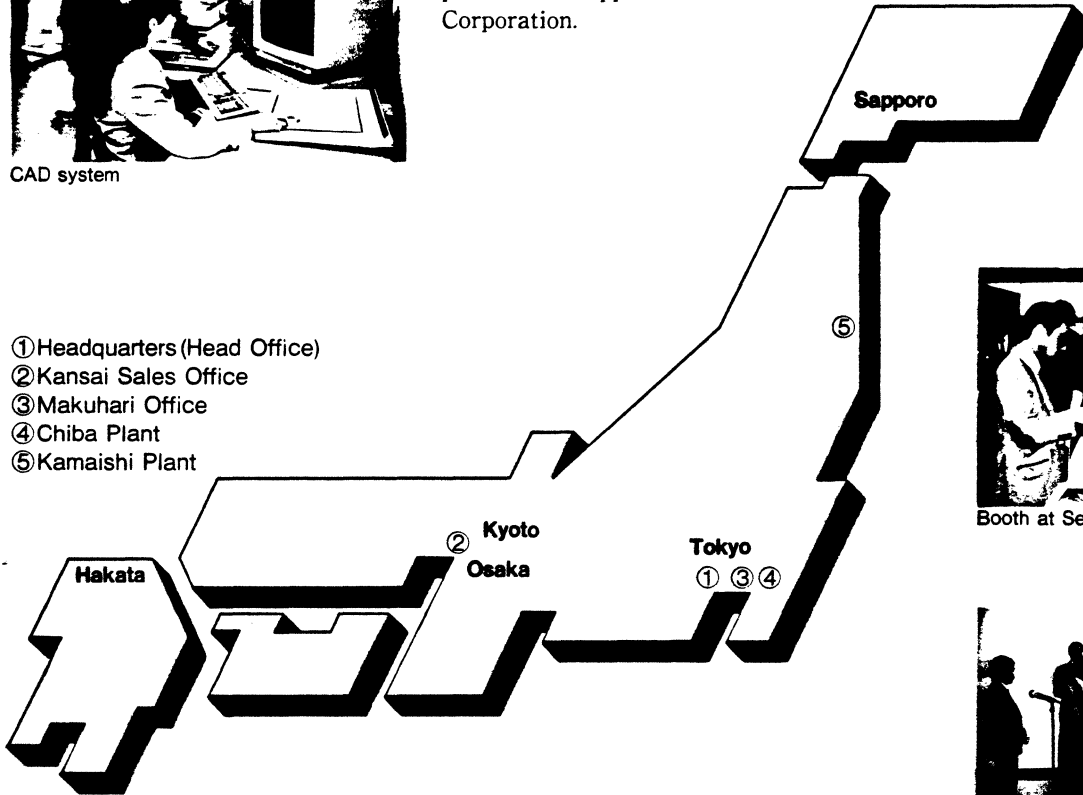
CAD system

Makuhari Office

Makuhari Office, characterized as an elite team of professionals in research and development, has established its unique position within the company.

In Makuhari Office, our technical staffs span a wide range of highly specialized disciplines within magnetism, computer control system, engineering, and electronics, by setting a challenging goal: production of reliable products of Nippon Ferrofluidics Corporation.

- ① Headquarters (Head Office)
- ② Kansai Sales Office
- ③ Makuhari Office
- ④ Chiba Plant
- ⑤ Kamaishi Plant



Booth at Semicon show



Welcome ceremony



Shin Osaka Station



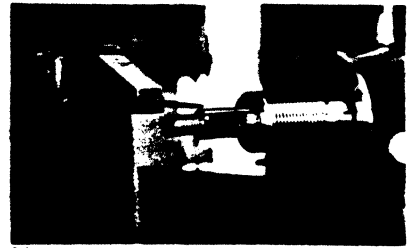
Shin Osaka Grand Building

Kansai Sales Office

Kansai Sales Office locates in the 12th floor of Shin Osaka Grand Building, with a magnificent, panoramic view of Osaka City. It is only a 10 minutes walking distance from Shin-Osaka, a Shinkansen (bullet train) station. This Office is committed to meet all requirements of high technology industries in the whole area of Western Japan. Kansai Office is actively engaged in expanding marketing areas covering the whole western part of Japan.



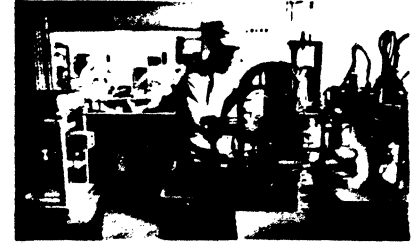
Year-end party



Measurement of run-out



Regular meeting



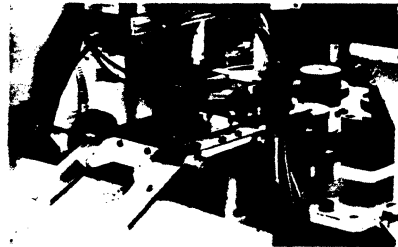
Clean room

Chiba Plant

Our Chiba plant with 150 staffs is in Yokaichiba Industrial City. An ultra-modern facility equipped with Class 100 clean rooms initiated its operation in 1982.

Production of ferrofluidic exclusion seals for computer use is automatically operated; therefore, productivity is increasing.

This Plant has an easy access to the New Tokyo International Airport only a 30 minutes drive and here all staffs welcome guests from all over the world. This district including tennis courts, baseball grounds, parks and beach near the factory comforts our hard-working staffs.



Automatic line for EX seals



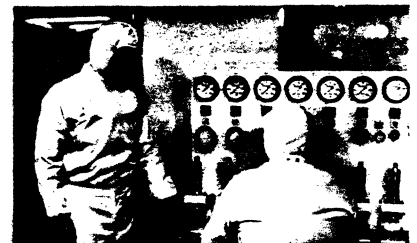
Feedthrough assembly



View of Chiba plant



Reliability test



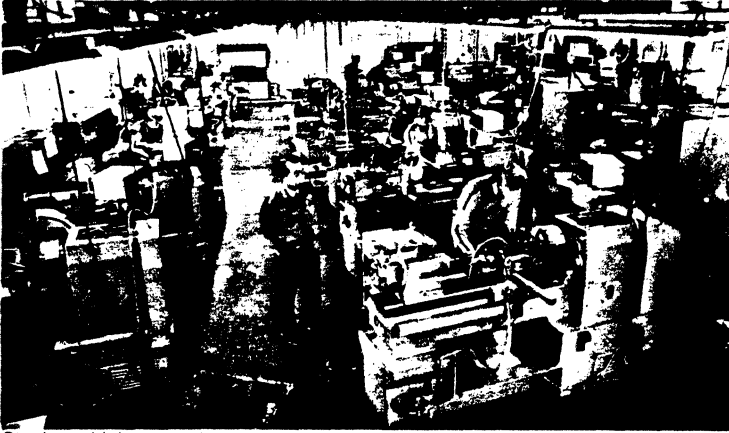
Inspection of leakage



Silicon crystal growing systems



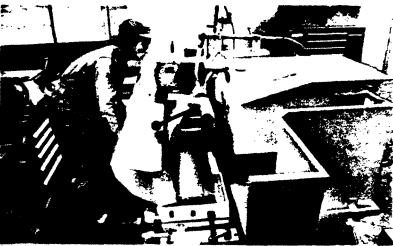
Engineering discussion



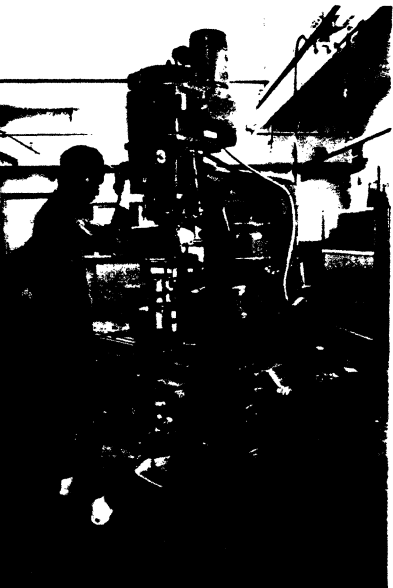
Steel machining experts



Machining center



Cylindrical grinder



Milling machine



View of Kamaishi plant

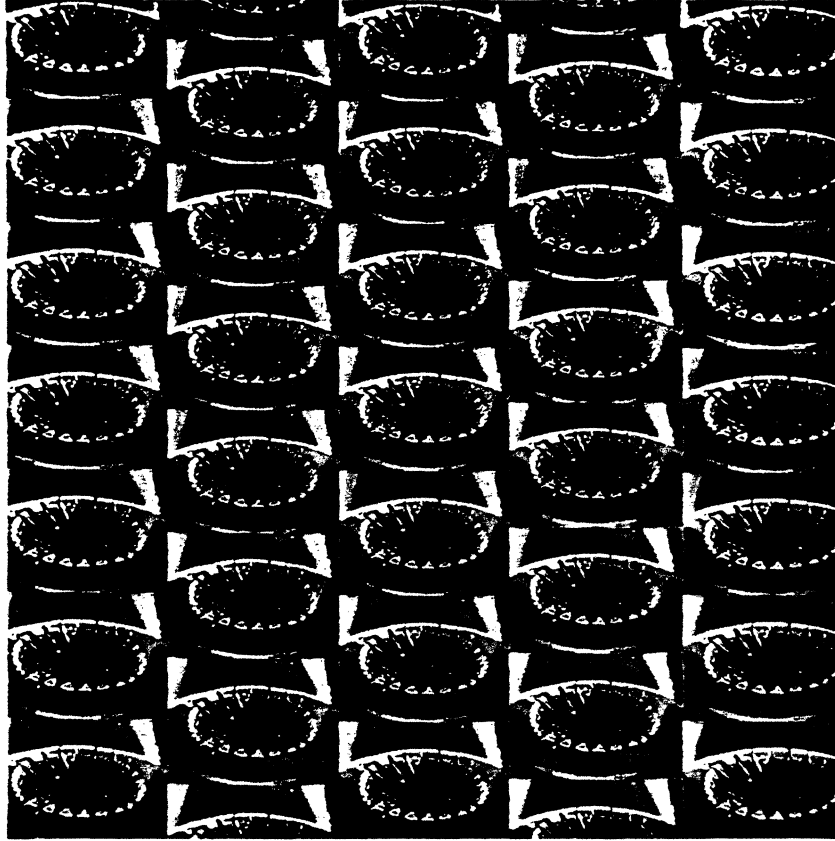
Kamaishi Plant

In March 1989 a new plant in Kamaishi was started its operation in order to supply the demands of our products. This Kamaishi Plant located in the city of Kamaishi is now operating with location agreement obtained from the city.

Kamaishi Plant of 5600m² space, located in the middle of nature-trees and a river, has been equipped with the complete production flow systems. One of our major products, vacuum feedthroughs are manufactured here utilizing full completion systems of vacuum feedthrough parts to assembly productions in clean rooms.



Lathe



■ NIPPON FERROFLUIDICS CORPORATION.

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