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Superconductivity

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Contents:

Top of Superconductivity Web21

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The World's First Superconducting Levitation at the Temperature of Liquid Oxygen

Achieved higher performance by using nanotechnology for texture control

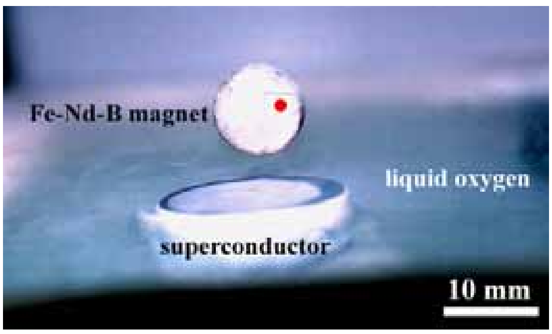
The International Superconductivity Technology Center (ISTEC), Superconductivity Research Laboratory (SRL), Morioka Laboratory for Applied Superconductivity Technology, and Iwate Industrial Research Institute succeeded in the world's first superconducting levitation experiment at the temperature of liquid oxygen (183℃ below zero, absolute temperature: 90K). The findings were presented at the 4th Workshop on Processing and Applications of Superconducting (RE)BCO Large Grain Materials, which was held at Jena, Germany from June 30 through July 2, 2003.

Superconducting levitation experiments of a high-temperature superconductor at the temperature of liquid nitrogen (196℃ below zero, absolute temperature: 77K) are generally conducted in science museums and science festivals. Some junior and senior high schools are also taking up these experiments in class, and the development of a maglev train using superconducting levitation is under way in China.

With respect to industrial applications, liquid oxygen is widely applied in different fields and is used as a liquid fuel for launching rockets as well as an oxygen gas supply source in medical treatment. Under these circumstances, there was an attempt to create a high temperature superconductor through liquid oxygen cooling.

The critical temperature, however, of a Y-Ba-Cu-O type superconductor applicable at temperatures higher than that of liquid nitrogen is approximately 182℃ below zero (absolute temperature: 91K). Therefore, up until now, the application of a superconductor at the temperature of liquid oxygen has been considered impossible because superconductors cannot fully demonstrate their properties at this temperature.

The above research group attempted to disperse a fine Gd211 phase to improve the critical current density at the temperature of liquid oxygen in the (Nd, Eu, Gd)-Ba-Cu-O system whose critical temperature is 178℃ below zero (95K), which is higher than that of Y-Ba-Cu-O by 4℃.
The group manufactured a superconductor by microfabricating a Gd211 phase to be added down to about 70 nm (nanometers) by using ball milling. A small amount of Zr (zirconium), the raw material for the ceramic ball used for ball milling, was mixed with the sample during microfabrication. The nano particles composed of ultra-fine Zr-Gd-Ba-Cu-O of approximately 20 to 50 nm dispersed in the sample. The critical current density at the temperature of liquid oxygen rose from a conventional state of almost zero to a value as high as 40,000 A/cm^2 at a temperature of liquid oxygen of 90K. Superconducting levitation was made possible by liquid oxygen cooling.



The photograph shows a newly developed (Nd, Eu, Gd)-Ba-Cu-O superconductor, cooled with liquid oxygen, on which a permanent magnet is levitated. The permanent magnet has a Japanese flag attached to it.
Liquid nitrogen is transparent and colorless, but the liquid oxygen is a beautiful light bluish color.

This work was supported by the New Energy and Industrial Technology Development Organization

(NEDO) as Collaborative Research and Development of Fundamental Technologies for Superconductivity Applications.

Naoki Koshizuka
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Top of Superconductivity Web21

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Succeeded in Recovering a Space Experiment Sample

The Bulk Superconductor Laboratory of the Division of Material Science & Physics of the Superconductivity Research Laboratory is conducting a containerless melt growth experiment on large bulk superconductors under microgravity, using a satellite. Recently, the laboratory successfully recovered an experiment sample. In Japan, this was the first time a satellite recovered an experiment sample.
This containerless melt growth experiment uses a next-generation Unmanned Space Experiment Recovery System (USERS) satellite developed by the Institute for the Unmanned Space Experiment Free Flyer (USEF). The USERS satellite was launched with the H-IIA Rocket No. 3 in September 10, 2002.

In the present experiment, there was melt growth of a large plate-shaped Gd123 material with a diameter of 127 mm and a thickness of 20 mm. A joint consisted of a Nd123 seed crystal and a MgO grip was fixed in the middle of the top of the sample. Crystal grew in a one-point support state by holding this joint under microgravity. Samples were arranged in each of three experiment furnaces and three experiments were conducted. Two or more heaters surrounded the samples, and the outsides of the heaters were covered with high-performance heat insulators, so that the electric furnace is an ambient furnace with a chamber structure. Figure 1 shows the schematic diagram of an electric furnace. Each furnace is provided with a mechanism to protect the experiment samples from impact at the time of launch as well as a mechanism to enable a non-contact experiment with the samples by holding the seed crystal under microgravity. In addition, the furnaces are designed so that they have a two-way temperature gradient (in the directions of diameter and thickness). This is in order to minimize the temperature of the seed crystal fixed at the center top of the sample, which is accomplished by actively exhausting the heat from the proximity to the seed crystal and by changing the generation of heat caused by two or more heaters around the samples according to the gradient.

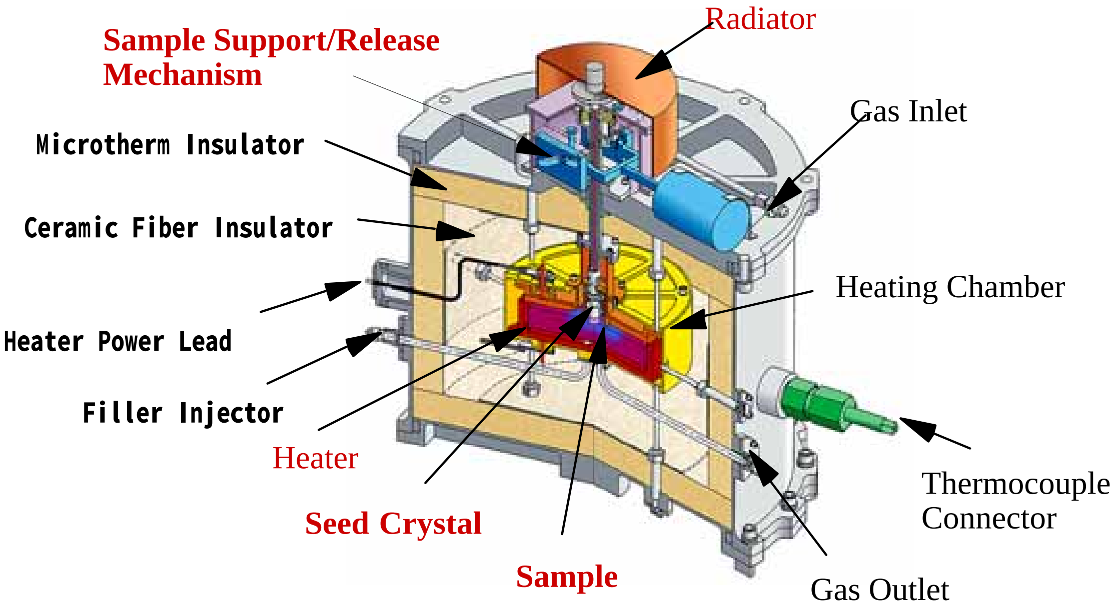

Fig. 1 Cross-sectional schematic diagram of space experiment furnace

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The first experiment began on October 2, 2002. Since there were a few problems, the experiment was modified halfway through. In the second and subsequent experiments, there were also modifications. After the modifications, the experiments went as planned. From analyzing data transmitted from the satellite such as the distribution of temperatures, pressure changes, oxygen concentration changes, oxygen absorption, and the supply condition obtained at this time, the decomposition and crystal growth of the samples almost proceeded as predicted.

The superconducting material manufacturing experiment was completed in the middle of March 2003. Subsequently, a minimum success experiment was carried out with experiment equipment in a service module (SEM). After that, the USERS satellite's reentry module (REM) was disconnected from the SEM at 4:06 a.m. on May 30 (Japan Standard Time). Then the deorbit motor was ignited at 5:45 a.m. and the SEM entered the re-entry trajectory. Afterwards, the recovery vehicle (REV) –a capsule unit at the nose of the REM– reentered the earth's atmosphere. An aircraft visually identified the REV, which had splashed down over international waters to the east of the Ogasawara Islands, at around 6:34 am. A recovery vessel arrived at the splashdown and successfully recovered the REV at around 9:50 a.m. Figure 2 shows how the REV was recovered.

Fig. 2 REV recovery
(The REV is under the water below the red floating bag.)

After being brought to land and transported to the Kawagoe Plant of IHI Aerospace (IA), the REV was disassembled and the mission panel was removed. At present, the electric furnaces are now being removed from the mission panel (See Fig. 3) at IA's Tomioka Plant. The disassembly of the electric furnaces and the removal of the samples will begin at the Superconductivity Research Laboratory on July 7. Evaluation of properties, structures, and other facets of the recovered bulk samples will be made. At the same time a contrast experiment will be conducted on land to clarify any differences between experiments on land and under microgravity. It is expected that the findings will serve to help manufacture high-performance bulk material on land.

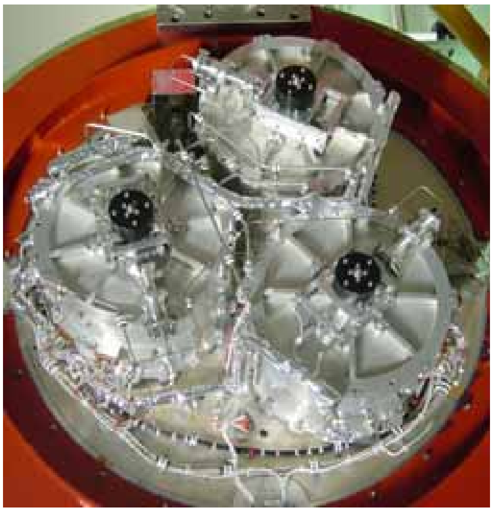

Fig. 3 Three electric furnaces (before liftoff) installed on the mission panel
The surface of the recovered electric furnaces was corroded by seawater.

(Naomichi Sakai, Bulk Superconductor Laboratory, Division of Material Science & Physics, SRL/ISTEC)

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Top of Superconductivity Web21

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Forum on Superconductivity Technology Trends 2003

ISTEC held a forum on superconductivity technology trends, titled "Accelerated Superconductivity Technology," on Tuesday, June 3, 2003 at the Toshi Center Hotel, Tokyo. Some 240 representatives of the Japanese government, corporations, academic circles, mass media, and participants from the public participated in the forum, where research results, challenging issues, and trends in superconductivity technologies for commercialization were presented and there was keen discussion.

Director Kazuhiko Honbu of the Research and Development Division at the Industrial Science and Technology Policy and Environment Bureau in the Ministry of Economy, Trade and Industry and Director General Kazuo Natori of Advanced Power Generation and Storage Technical Development Department in the New Energy and Industrial Technology Development Organization (NEDO) delivered congratulatory addresses at the opening of the forum. Their speeches focused on the results of research and development projects and expressed hopes for practical application as early as possible. Director General Shoji Tanaka of the Superconductivity Research Laboratory (SRL) expressed in his keynote speech that 16 years have passed since finding a high-temperature superconductor, and that a new reality has emerged recently, which is completely different from existing low-temperature superconductors. He added that application technologies are expanding into new areas that cover technologies from quantum computers up to nuclear fusion, breaking through the limits of existing technologies, and he showed visions of the future for the years from 2010 to 2020.

Director Setsuko Tajima of the Division of Material Science & Physics of SRL reported that the development of superconductivity technology has reached the stage where accumulated findings in basic research can be utilized to improve superconductor characteristics. Director Keiichi Tanabe of the Division of Electronic Devices of SRL reported an overview of superconducting device research and introduced recent results and issues about low-temperature SFQ operating 2×2 switches at 50GHz and about operating the QOS converter of a high-temperature SFQ circuit at 97GHz (35K) and others.

Keiji Tsukada of Hitachi, Ltd. reported on development results including a magnetocardiograph where a low-temperature superconductor SQUID is applied and the clinical cases; a practical application to a magnetocardiograph where a high temperature superconductor SQUID is applied for real-time measurement; a hybrid superconductive magnetic shield as a peripheral technology; and an impedance magnetocardiograph.

Senior Staff Masato Murakami of SRL expressed his hopes for manufacturing large size bulk superconductors in space and introduced magnetic levitation, magnet application, and conductor application as specific examples that have reached a practical application level for industry. These applications were based on the successful development of a process technology that enabled dramatic improvement in trapped magnetic fields and improvement in mechanical strength due to resin impregnation.

Takashi Matsuda of DIAX Co., Ltd. reported on a magnetron-sputtering system where bulk superconductors are applied, its characteristics for forming films, and guidelines for improving the characteristics.

Director Yuh Shiohara of the SRL-Division of Superconducting Tapes & Wires reported on the progress generating high critical current density, which is a target of R&D of Fundamental Superconducting application Technologies project, on the progress in process technology development for the long tape/wire

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manufacturing process, and possible efforts for their practical applications in the future.

Associate Professor Hiroyuki Ohsaki at the University of Tokyo forecast the technological development of superconducting wires and their costs, a roadmap for the development of applied equipment until the year 2020, and a way to practical application.

Managing Director Yoshinori Tatsuta of ISTEC reported on the accomplishments of designing and manufacturing a model coil based on an SMES cost reduction technology, results of the experiments, and possibilities for high temperature superconductivity SMES. These will emphasize the importance of energy (power) storage technology, boosting the needs for SMES.

Deputy Director Naoki Koshizuka of the Morioka Laboratory for Applied Superconductivity Technology of SRL reported on an improvement in the loading capacity of a superconducting flywheel; development of elemental technologies including rotation loss reduction and axis fall reduction; experiments on superconducting bearing operations; and the development and future task of applied technologies including the main unit and shaft damping for the flywheel.

Lastly, Professor Eisuke Masada of Tokyo University of Science addressed in his keynote speech that the research and development projects of superconductivity have been entering a new phase and that the attitudes of the government and society are changing about subsidizing these technological development projects. Professor Masada emphasized the need for formulating a development strategy from a long-term viewpoint and for reviewing development needs to make superconductivity the basic technology in society. Specifically, Professor Masada emphasized developing society-based superconductivity applications with high marketability, integrating knowledge and findings in a broad range, and stimulating people's interest in superconductivity.

The R&D of Fundamental Superconducting application Technologies project has been entering a new phase. Hopes for remarkable achievements in research and their early application are growing. This forum made the participants realize the significance and importance of the ongoing integrated research and development projects among academic, industrial, and governmental circles.

Director General Shoji Tanaka of SRL gave the keynote speech.

Participants in the forum

(Masaharu Saeki, Director, Research & Planning Department, ISTEC)

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Top of Superconductivity Web21

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Technological Issues of Superconducting Power Equipment

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Superconducting power equipment abounds with diverse characteristics that existing power equipment, made of copper and iron, cannot achieve. Since superconducting power equipment has low power loss and can be made small and light-weight, it is technologically superior to existing power equipment. The capacity of the Japanese power system has also come to maturity in terms of scale. Thus, the need for applying superconducting power equipment has decreased for large power generation, which was once the central subject of research, and for the planned transmission of electricity. Along with the ongoing liberalization of power system, especially in the retail market, however, technological problems are anticipated to emerge due to the lowering tolerance of power systems, which are taking place in some other countries where the electricity market has been liberalized. Superconducting power equipment will be very useful for solving these problems.

Superconducting power cable can cut carbon dioxide emissions. In addition, laying superconducting power cables in conduits can cut power transmission costs. These advantages are one major factor that has driven the research and development of superconductivity power equipment. Laying conduits will lead to a short construction period. Since the superconducting power cables weigh less than existing power cables, cables can be laid on existing infrastructure. This short construction period enables constructing cable lines only when demand for electricity becomes eminent. This investment deferment effect is extremely attractive for power companies. Laying cables on existing infrastructure also enables using new routes that were impossible to use as transmission routes in the past. Thus, electric power will come to have broader options for transmission. Superconducting power cables will be characterized as playing an important role in liberalized power system equipment.

Application of a superconducting fault current limiter to a point connecting a generator with a power system will enable installing a power station in the power system, unlike in the past when connecting new power sources was impossible because of short-circuit current capacity. Power generation via distributed power sources diversifies options. Thus, the superconducting fault current limiter is likely to play the key role in a power system of distributed power sources, which is expected to grow in the future.

At present, the development of an SMES is underway for system stabilization, compensation for fluctuating loads, and frequency control of the power system control. In addition, the development of an SMES is underway against instantaneous voltage drops. These functions are essential to solve technological problems due to lowering tolerance of power systems. Thus, the needs for SMES systems for power systems will increase more and more.

As mentioned above, technological needs for superconducting power equipment have increased during the ongoing liberalization of the electric power market because much superconducting power equipment can solve existing problems. Thus, the development of superconducting power equipment should focus more on the characteristics that meet these urgent needs.

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Top of Superconductivity Web21

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Current Technological Development of Superconducting Transmission Cable

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This section describes the current "Development of technology for cooling a 500 meter-long conductor with liquid nitrogen" among "Research and Development on fundamental technology for superconducting power transmission cable" in the "Research and Development of fundamental technologies for superconducting AC power" (Super-ACE) project, which was commissioned to us by NEDO in 2000.

The purpose of this 5-year research project is to develop technology for cooling a 500-meter-long conductor with liquid nitrogen. In the first three years, a trial model of a heat-insulating pipe will be manufactured and studied. First a trial model of a 30-meter-long conductor and then of a 300-meter-long heat-insulating pipe will be manufactured on the plant production line. On the basis of the data collected from the production line, the world's longest 500-meter 77kV-1kA-class single-core cable (superconducting wire: Bi2223 tape) will be manufactured and tested.

The development items and results obtained so far are shown below:

1) Heat-insulating pipe model

-We manufactured a 10-meter-long heat-insulating pipe and recognized the amount of heat leak (temperature of liquid nitrogen) of 0.3 W/m in the straight line unit.

2) 30-meter long model conductor (Fig. 1)

-Acquisition of data necessary for cable design

-Thermal contraction and stress that accompany cooling

-Pressure loss in liquid nitrogen circulation

3) 300-meter long heat-insulating pipe

-Checking the workmanship using plant facilities

-Checking the pumping time, ultimate vacuum, and leak test

-Checking cooling time and heat leak

4) Study on the electric insulation thickness of a conductor

-We indicated our fundamental thinking to determine the insulation thickness of a superconducting cable.

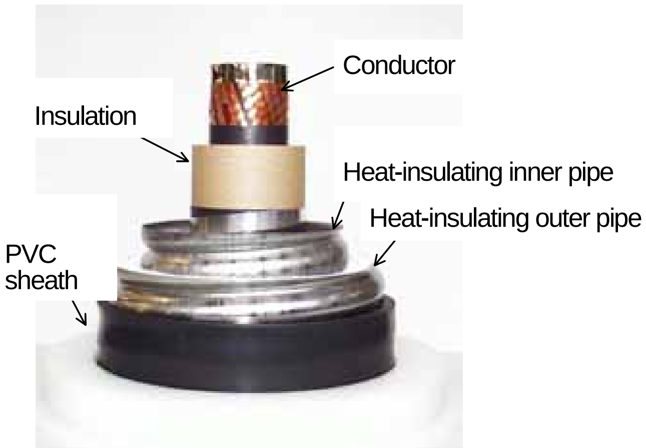

Fig. 1 30-meter long model conductor

500-meter long cable test

The superconducting cable test will be carried out by the Yokosuka Research Center of the Central Research Institute of the Electric Power Industry from March through December 2004. The cable layout is shown in Fig. 2.

The purpose of this test is to establish cryogenic cooling technology (vacuum insulating, thermal contraction, and cryogen flow) and to clarify the viability of a 5-kilometer-class superconducting cable. We have sent the work to the Institute of Electric Engineers in order to standardize the test method for determining test items and contents.

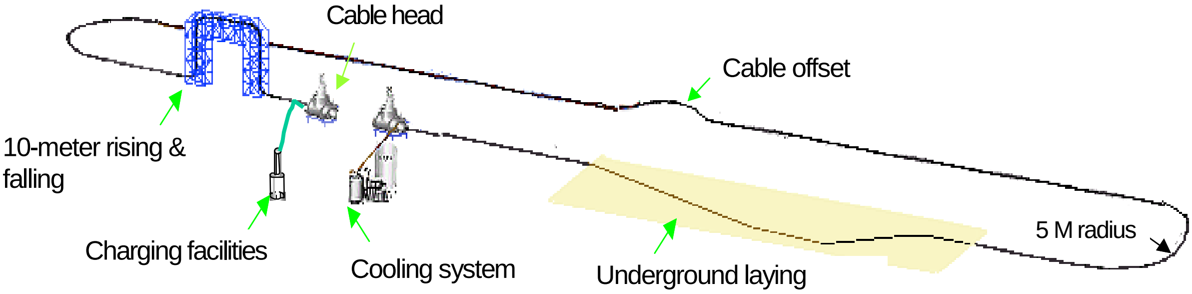

Fig. 2 500-meter test layout

In this "Research and Development on fundamental technology for superconducting power transmission cable," in addition to the development of technology for cooling the present 500-meter-long conductor, we are developing the following materials.
-Large-capacity conductor with a current-carrying capacity of 3 kA with an AC loss of 1 W/m
-Bi2223 wire with a high-resistance barrier layer provided around a superconducting filament
-Slush nitrogen as a coolant with solid nitrogen dispersed into liquid nitrogen

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Top of Superconductivity Web21

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Current Technological Development of Superconducting Transformer

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This section describes the current "Research and development of the AC superconducting magnet" in the "Research and Development of fundamental technologies for superconducting AC power equipments" (Super-ACE) project, which NEDO commissioned to us in 2000, as a part of the innovative global warming control technology program promoted by the Ministry of Economy, Trade and Industry.

In this research, assuming a three-phase 66 kV -77 kV/6.9 kV -10 MVA-class transformer as an application device, we have addressed the following fundamental technology issues.

(1) Higher voltage transformer of the 66 kV -77 kV-class

(2) Larger current transformer of the 800 A class and AC loss reduction

With respect to cooling technology, we also implemented the basic design for the cooling system. We have researched and developed each element of technology for the past three years, verified the technology with each element model, and established each technology. Our results are shown below:

For the higher voltage transformer, we conducted insulation tests with a bushing and a model coil to determine the electric insulation properties in a sub-cool liquid nitrogen (66K) environment. In order to verify if a resin-impregnated capacitor bushing, which is used for a normal transformer, can be used in a sub-cool liquid nitrogen environment, we conducted AC withstand voltage tests (applied voltage: 140 kV and 160 kV) based on 66 kV and 77 kV-class standards of the Standards of the Japan Electric Committee (JEC) of Institute of Electrical Engineers. We also conducted lightning impulse tests (applied voltage: 350 kV and 400 kV) and verified that there was not any dielectric breakdown. For the coil, after conducting a voltage oscillation analysis, an electric field analysis and other analyses, we carried out dielectric breakdown tests, using a model coil (7 types in total, 5 to 10 samples each) with a winding structure simulated. With these tests, we determined the insulation properties necessary for 66 kV-77 kV-class equipment design.

For the larger current transformer, we worked on the low-heat penetration of a 1 kA-class current lead and optimizing the conductor composition of a 6.9 kV/500 A-class coil. It is necessary to arrange the existing Bi2223 tape wires so they are multi-parallel and to perform transposition composition in order to increase the current-carrying capacity of a coil. In order to determine the AC loss in arranging tape wires so they are multi-parallel, we designed and manufactured a measuring instrument. Then we measured the AC loss with the coolant temperatures (66 K and 77K) and the number of transpositions as parameters. We verified that additional loss is not caused by the multi-parallel arrangement of tape wires. Subsequently, we manufactured a 500 A-class model coil (a conductor with 20 coils in parallel) and evaluated current-carrying, current distribution, and other characteristics (Photo 1). In addition, we conducted even short-time

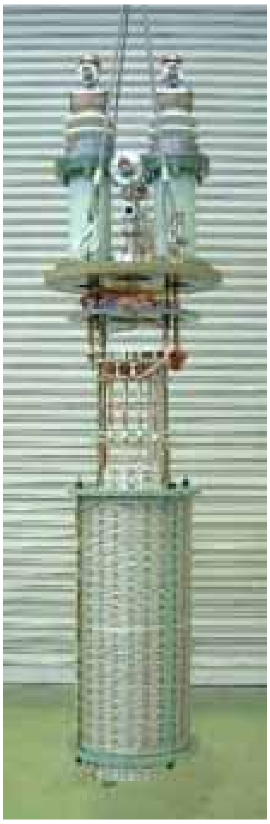

Photo 1
Large-current model coil

overload simulation tests to establish 500 A-class coil structure technology. We reduced the penetration heat by about 12% by providing an electric current lead using a conventional conduction cooling system with a vacuum insulation layer.

For cooling technology, we conceptually designed a three-phase 66 kV/6.9 kV-10MVA superconducting transformer before studying the cooling system. On the basis of a magnetic field analysis and the above-mentioned AC loss, we calculated the loss at operating temperatures of 66 K and 77 K, and estimated the required cooling capacity, considering the anticipated penetration heat. We found that the AC loss at a temperature of 66 K is approximately 2 kW and that a cooling capacity of about 3 kW is sufficient, considering the penetration heat. Given these results, we studied the cooling system, selected a sub-cool liquid nitrogen cooling system (66 K), and completed the basic design.

In this fiscal year, we are planning to compile the findings verified by using an element model, design and manufacture a single-phase 66 kV/6.9 kV-2 MVA-class superconducting transformer as a partial model of three-phase 66 kV/6.9 kV-10 MVA, and verify the technological viability of the superconducting transformer through performance evaluation tests.

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Top of Superconductivity Web21

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Current Technological Development of Superconducting Fault Current Limiter

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Applying a fault current limiter to an electric power system enhances the reliability of the electric power supply and power quality. In addition, a superconducting fault current limiter can prevent increases in short-circuit currents of distribution lines caused by installing or adding dispersed power sources, which have spread widely in recent years. Installing this superconducting fault current limiter in substations will eliminate the necessity of replacing existing circuit breakers and distribution lines. The cost efficiency is attracting attention.

As a national project related to high-temperature superconducting fault current limiter technology, a five-year plan for the "Research and Development of Fundamental Technologies for Superconducting AC Power" (Super-ACE project) has been under way since fiscal 2000. The New Energy and Industrial Technology Development Organization (NEDO) commissioned the Super-ACE project to the Engineering Research Association for Superconductive Generation Equipment and Materials (Super-GM) as part of the Ministry of Economy, Trade and Industry's (METI) project. We will report on the progress of the fundamental technology research and development of the high-temperature superconducting fault current limiter promoted in this project.

The research and development of the SN transition resistive type superconducting thin film fault current limiter aims to establish large-current/high-voltage technology by increasing the current-carrying capacity and arranging wires in multi-parallel/series through widening the area of the thin film of the current limiting element.

The National Institute of Advanced Industrial Science and Technology is attempting to widen the area by applying the metal organic deposition (MOD) method. The institute succeeded in generating full superconducting film by forming a thin YBCO film onto a 10 cm x 30 cm sapphire substrate (intermediate layer CeO_2) and achieved a maximum Jc value of 1.9 MA/cm^2 using the inductive measurement method.

For the technological development of thin film manufacturing, in the Super-ACE project, the Super-GM adopted the pulsed laser deposition (PLD) method and achieved a maximum Jc value of 3.3 MA/cm^2 (the transport measurement method), although the film area was quite small. Also, concerning the technology to increase the current-carrying capacity, the Super-GM proposed a polygonal element arrangement, which suppresses the drift among elements and in elements, and manufactured 6 parallel elements with a 1-cm-wide superconducting film arranged in polygon. The verification of continuous current-carrying showed that an electric current of 380 Arms can be continuously carried. For 100 V in 5mm-wide hexagon parallel arrangement, it was verified that 4.7 kA can be reduced to 1/23 or less. Regarding technology to increase the voltage, the applicable voltage can be increased by arranging a thin metal film, manufactured on a substrate of aluminum nitride, on a YBCO thin film as a parallel resistor. The Super-GM manufactured a current limiting module with 40 elements with the increased applicable voltage connected in a series and successfully passed the current limiting test of 6.6 kV-class, the voltage in the distribution system. The current limiting module withstood a peak voltage of 11.9 kV and could cut down a short-circuit current of 3.5 kA to 1/6 or less.

In addition, the Super-GM is conducting research and development on the reactor for a rectifier-type fault current limiter using coils of Bi superconducting tape wire, aiming to apply it to high-voltage systems.

The Super-GM is now designing and manufacturing a 66 kV/700 A-class pulse model coil. In the end, a 66 kV/125 A model coil will be arranged in 6 rows in parallel. The Super-GM has manufactured a cryo vessel and three unit coils, and has succeeded so far in passing a current of 375 A in a parallel connection.

As for overseas-technological development, in Europe, ABB Ltd. developed and tested an 8 kV/800 A-class Bi system resistance type current limiter, and Rolls-Royce succeeded in a current limiting test with an 11-kV system. Also, Siemens manufactured a 7.2 kV/100 A-class Y system thin film resistance type current limiter on an experimental basis.

In the United States, GA developed a 12.5 kV-class/1.2 kA reactor type fault current limiter, although it is a metal system one.

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Top of Superconductivity Web21

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The Status Quo of Development of Superconducting Power Control SMES

Shigeo Nagaya, Leader
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Superconductivity technology can process high current efficiently and compactly. This technology is expected to be the next generation technology that will sustain power in the future because the technology can be widely applied to power generation, power transmission and transformation, and power storage.

In the past, technological development of power systems emphasized new technologies that enabled efficient reinforcement of facilities to meet increasing demand for electricity in the future. The development and application of superconductivity technology, however, will greatly impact society. Superconductivity technology is such an epoch-making technology that it is likely to replace existing power technologies.

In addition, recent changes in the social environment, including liberalization of the retail power market, around the power industry have urged technological development projects for power systems to flexibly and swiftly meet changes in diverse needs from a broader viewpoint. A typical example is the development of a superconducting magnetic energy storage (SMES) system that is now underway.

This SMES development started as a power storage technology for load leveling to meet increasing power demands. This aimed to disperse small pumped storage power stations in a nearby power consumption area to meet increasing peak demands. This concept was based on SMES's high power storage efficiency. Considering the characteristics of a SMES, unlike other storage technologies such as storage batteries, a SMES can discharge electricity by the second. Repeated charging and discharging of electricity does not deteriorate the electricity. These characteristics are optimal for system stabilization and fluctuation load compensation for controlling power systems.

Semiconductor plants, liquid crystal display(LCD) plants, and other high-tech plants, which have supported recent information technology(IT) systems, have been demanding high quality electricity, especially urgent measures against instantaneous voltage drops. When considering the reliability of the present power supply in Japan, compensation within one second will provide almost complete reliability.

To compensate for instantaneous voltage drops is to make instantaneous output, that is, a kW system. The value of the system is determined by the cost per kW and the cost of loss that occurs from instantaneous voltage drops. Since the energy storage part of a SMES consists of coils, the system can be built with the storage capacity required for compensation operations alone. Storage batteries cannot charge and discharge all their energy in seconds. Therefore, the storage unit is designed to be large, leading to more costly equipment. Much of the superconducting power equipment poses problems in terms of cost when it is compared with other replacement technologies. Therefore, a SMES for instantaneous voltage drop compensation is very advantageous in terms of both costs and functions.

At present, the Chubu Electric Power Co. Inc. is preparing for actual field experiments with a SMES to compensate for instantaneous voltage drops with an output of 5MW. This will be carried out from July in a state-of-the-art LCD plant in a service area of the Chubu Electric Power Co. Inc.

In the past, the development of a SMES began toward load levelling because the SMES is characterized as having high storage efficiency. The development of SMES, today, is going to be carried out for use as system control equipment and as equipment to compensate for instantaneous voltage drops. A flexible and strategic development project that meets these needs will open the door to the practical application of superconducting power equipment that people have long awaited.

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Top of Superconductivity Web21

Fall, 2003 Date of Issue: October 15, 2003

Superconductivity Web21

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Trends in Electric Power Technology for Buildings

In cooperation with the environment and energy department at NTT, as well as experts on power electronics and power distribution technology, the Trend Research Committee of the International Superconductivity Technology Center (ISTEC) examined DC superconducting power supply systems, commissioned by NEDO for fiscal 2002, under the theme of "low temperature systems for supplying power for large buildings." The first research results indicated possibilities for applying DC superconducting cables and other superconducting power equipment.

Two years before starting this project, NTT Facilities Inc., as the secretariat, had set up a committee titled "Making a DC Power Supply System in the IT generation" headed by Professor Masada at Tokyo University of Science. ISTEC's past research predicted a growing number of projects to construct data centers after observing an increasing trend in the communication traffic volume. In addition, an article titled "Improvement in Environmental Efficiency–NTT Faces the Wall–" with the subtitle "Energy-Saving Sluggish," was published in the Nikkei Sangyo Shimbun issued on September 11, 2002, also indicating the significance of the research and examination mentioned above.

The environmental efficiency referred to by the newspaper is the value obtained by dividing sales by the amount of carbon dioxide emissions. Cutting carbon dioxide emissions while increasing sales leads to improving environmental efficiency. NTT foresees that in the future, the current environmental efficiency can barely be maintained as it is. Three factors that reduce environmental efficiency, which are the main factors that block improving environmental efficiency, are as follows:
(1) Lowered efficiency of facility operation is brought about when multiple facilities have to be set up in a transition stage. For example, broadband communications and mobile phones are changing product models swiftly, which also compel carriers to concurrently set up additional communicator facilities.
(2) A growing number of "always-on" subscribers due to growing fixed charge services whether the communication tool is used or not.
(3) Replacing NTT equipment alone with energy-saving equipment is not enough because routers and other communication devices of ADSL service providers are kept at NTT stations. They also consume a lot of power.

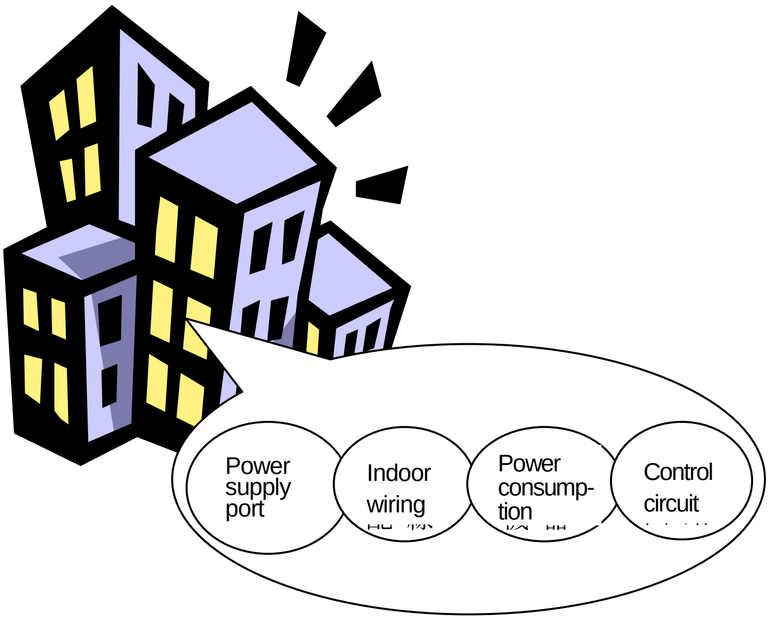
In fact, NTT has been replacing servers, routers, and other such equipment with devices conforming to DC power specifications. The existing systems go through three AC-DC conversions while electricity comes from commercial power supply to the CPUs of servers. These conversions cause major energy losses. In the first place, the CPU of a server runs on DC. Thus, preparing and combining DC devices will require only one AC-DC conversion, greatly contributing energy saving. Since DC power supply adopts as low as approximately the 48V class, this necessarily leads to adopting a high current carrying system, which is an application area for superconductivity.

As results of further examination under these environments, the DC power supply system still has technological problems that must be solved, compared with the AC power supply system. We did obtain results indicating the following characteristics of the DC power supply system:
(1) The reliability of the system is higher by an order of magnitude than the AC power supply system.
(2) The power supply efficiency is 20% higher than the AC power supply system.
(3) The design requires little space.
(4) The system is scalable (power supply capacity can be added without power cuts).
(5) The system is compatible with clean energy (fuel cells, etc.).

Moreover, applying superconducting cables will lead to an improvement in energy savings by some 3%, in addition to saving space. This rate of 3% is available when current superconductivity technology is applied. In the future, when a method is developed for controlling heat intrusion into the superconducting part from the normal conducting part, the energy savings will increase.

The application of superconducting cables mentioned above assumes that the cables are used at a liquid nitrogen temperature. Once a liquid nitrogen environment system is furnished in a building, superconducting fault current limiters, superconducting transformers, and superconducting power storage systems can be implemented easily. As a whole, they will become more compact and light-weight. In addition, power electronics used for power converters will see a reduction in current carrying loss in low temperature environments. The entire efficiency will dramatically increase. Research and study of superconducting DC power supply has just begun, including research on the characteristics of power electronics in low temperature.

Although the IT bubble has collapsed in the United States, it seems definite that telecommunication traffic will continue to expand. We foresee that the DC power supply system will be implemented in the future, followed by implementing the superconducting power supply system. In order to realize this roadmap, we will continue further examination.



(Osamu Horigami, Director, SRL/ISTEC)

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Top of Superconductivity Web21

Fall, 2003 Date of Issue: October 15, 2003
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Development of an MEG System for the Deep Brain Areas

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Kanazawa Institute of Technology

Introduction

We have developed a 320-channel whole-head MEG system, as an early diagnosis measurement instrument for dementia including Alzheimer's disease. The MEG system has a potential to detect magnetic field signals from the cerebral cortex and deep brain areas such as the hippocampus. This research project was carried out as part of the Ishikawa Prefecture Collaboration of Regional Entities for the Advancement of Technological Corporation "Development of Advanced Technology for the Measurement and Evaluation of Brain Functions" supported by the Japan Science and Technology Corporation. The Applied Electronics Laboratory of Kanazawa Institute of Technology and two industry-university joint partners, Yokogawa Electric Corporation and Eagle Technology, Inc., conducted the research.

SQUID Sensor for Deep Brain Measurement

In relation between brain functions and dementia, memory defects are characterized as the most obvious signs of dementia. Therefore, studying aspects of the hippocampus that is related to memory functions seems to be the major guidance for dementia diagnosis. Conventional MEG systems, however, have usually adopted gradiometers with which it is very difficult to detect magnetic field signals in deep brain areas, such as the hippocampus. For deep brain measurement, our MEG system has adopted magnetometers that are more sensitive to the magnetic field caused by deep source. In addition, the sensors are arranged to detect three orthogonal components of magnetic fields. We call it vector magnetometer. (Refer to Figure 1.) It enables advanced signal processing and data analysis.

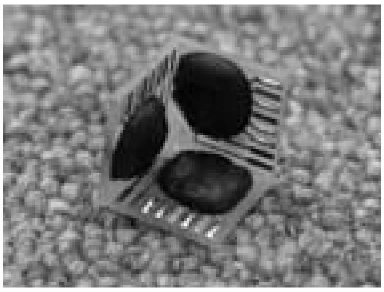

Fig. 1 Vector Magnetometer

The System Configuration

Our MEG system can operate 320 channels, which consists of 160 channels for magnetometers and 160 channels for 50-mm base-lined co-axial gradiometers. The Dewar allows an examinee to lay on their back for measurement. The magnetically shielded room is enclosed with a three-layered magnetic shield and a single-layer electromagnetic shield. It also has a 78.9dB@ 1Hz magnetic shield performance. (Refer to Figure 2.) The data acquisition system has 640 inputs, and allows continuous recording and average recording via multiple triggering.

Fig. 2 Dewar and Magnetically Shielded Room

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Example of MEG measurement

Figure 3 illustrates auditory evoked brain magnetic field waveforms by our MEG system. The upper waveform is a result made by the gradiometer while the lower waveform is made by the magnetometer. At the peak of N100m around 100msec after stimuli onset, the waveform made by the magnetometer is substantially larger. At this moment, the magnetic field source is located in a relatively shallow area. When such a source is deeper, the difference between the upper and lower waveforms will be greater, demonstrating the high amplitude of the magnetometer. Figure 4 depicts a magnetic field distribution where data made by the vector magnetometer is applied. It is the combination of the contour map made of normal components, and the arrow map made of tangential components, which makes it easier to see the orientations of magnetic force lines.

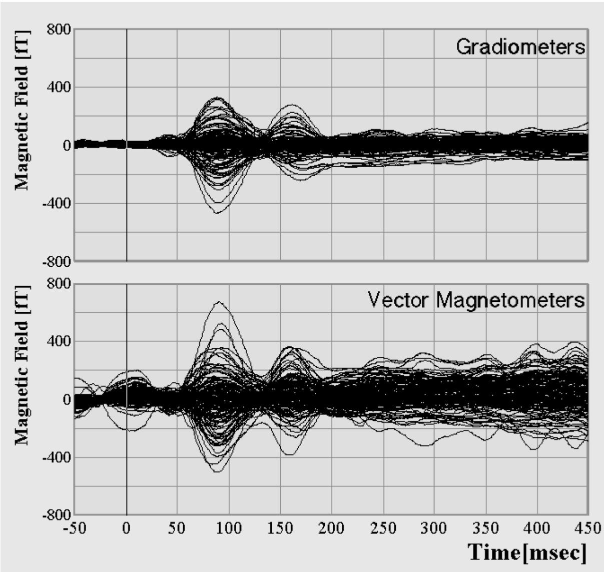

Fig. 3 Examples of Auditory Evoked Brain Magnetic Field Measurement

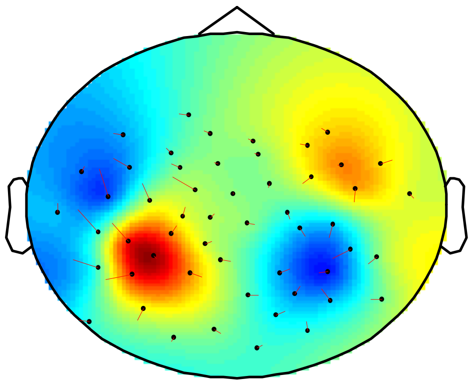

Fig. 4 Magnetic Field Distribution Made by a Vector Magnetometer

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Top of Superconductivity Web21

Fall, 2003 Date of Issue: October 15, 2003

Superconductivity Web21

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Current Magnetocardiograph (MCG) Development Significance of Approval as a Clinical Medical Instrument

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Magnetocardiographs measure temporal changes and the spatial distribution of magnet fields caused by the electrophysiological activities of the heart. Many high-sensitivity SQUID magnet-sensing units carry out the measurements. A magnetoencephalograph is also similar to this unit. The difference basically lies in the object to measure–the brain or the heart–and the form of their sensor arrays. Some 40 magnetoencephalograph units have already been installed in Japan. They are used for diagnosis for epilepsy and determining the removable area of the brain before operating. Although there is a long history of magnetocardiography, it was not used for clinical examinations. This is because the magnetocardiograph was not approved as a medical instrument. The use of the magnetoencephalograph was approved in the United States for the first time, while the use of the magnetocardiograph was approved in Japan ahead of the United States at the end of 2002 (Figure 1).

Fig. 1 LTS 64 Channel Magnetocardiograph (made by Hitachi High-Technologies Corporation)

Electrocardiographs have been used widely in hospitals to diagnose the heart for abnormal electrocardiac performance. In general, standard 12 lead electrocardiographs are used, which measure 12 combinations of electric potential differences. They had a small number of lead points though. To overcome this limit, a body-surface electrocardiograph that can locate some 100 measurement points of electrodes on the surface of torso was developed in order to obtain detailed spatial data. This electrocardiograph, however, had a problem. It was difficult to attach electrodes on the body surface, and contacts were often defective. This instrument is not used as routine examination today since it tended to produce defective signals. Such detailed spatial data of the heart is available with non-contact magnetocardiographs. Tsukuba University and the National Cardiovascular Center, which have engaged in clinical magnetocardiography research, have published many research articles on visualizing abnormalities of excitation propagation in arrhythmias, angina pectoris, cardiac infarctions and other ischemic heart diseases, and arrhythmias of fetuses.

Present magnetocardiographs use liquid helium as their refrigerant. The instrument used is called an LTS system. We are also developing an HTS magnetocardiograph, which is a next-generation magnetocardiograph, that uses liquid nitrogen as the medium or a superconducting SQUID cooled down by a refrigerator. The major challenges of the superconducting SQUID seem to lie in sensitivity and mass-producibility. Under a technology commercialization project financially assisted by the Ministry of Economy, Trade and Industry and NEDO, we have successfully developed a 16-channel compact magnetocardiograph (see Figure 2). To save space, we have developed an open cylindrical magnetic

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shield with a revolving door and a system configuration that enables measuring while the examinee is sitting. Although the new system is still noisier than the LTS-SQUID system by nearly an order of a magnitude because of the magnetic shield and signal processing, it has achieved sensitivity below 100 fT/Hz. This range of sensitivity enables detecting waveforms of the heart of adults without averaging.

Both the HTS magnetocardiograph and the LTS magnetocardiograph will continue to be properly used according to their characteristics. The former will be primarily used for preventive diagnosis of the heart. The latter will be used for determining patient treatment and thorough examinations such as embryonic examinations measured by the weakest signal pulses. We think that superconductivity will thus become more familiar as magnetocardiographs prevail.

Fig. 2 HTS 16 Channel Magnetocardiograph

(Published in a Japanese version in the July 2003 issue of *Superconductivity Web 21*)

Top of Superconductivity Web21

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Subject on SQUID Non-destructive Test – Its Application to C/C Composite

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In addition to lightweight and high specific tensile strength and high specific stiffness, C/C (carbon fiber reinforced carbon composites), one of the advanced composite materials, can withstand temperatures as high as 3,000℃. It is beginning to be used for space shuttles, aircraft, brake disks for cars, and other devices because of these properties. Microscopic cracks that occur on C/C and fiber breaks, however, may be distributed in a complicated way. These compound defects are very difficult to detect with conventional nondestructive tests such as X-ray flaw detection and ultrasonic testing.

The National Institute of Advanced Industrial Science and Technology focused on electric current detouring defective parts when the current is passed through an object. The institute developed the original SQUID nondestructive test technology. This new technology enables estimating the defective area from the current detour area by inducing the current in an object from the outside and visualizing the detoured current. At the same time, the state of defects can be estimated from the amount of the detoured current.

A detoured current can be approximately converted from the space differential of a magnetic field. Therefore, a current distribution map can be prepared directly from the space differential of a magnetic field measured with a SQUID gradiometer.

We made samples by working with the Space Science Laboratory and applied this technique to three states. One was where only cracks were generated while a tensile load was applied to a 3-mm-thick C/C board, the second was where fiber breaks were added to the above-mentioned state, and third was a state just before the final fracture. The obtained detoured current map is shown in Fig. 1. The defect distribution area can be estimated from the area where the current direction changes. There is a high correlation between the amount of electric current that detours the defect distribution area found in Fig. 1 and the

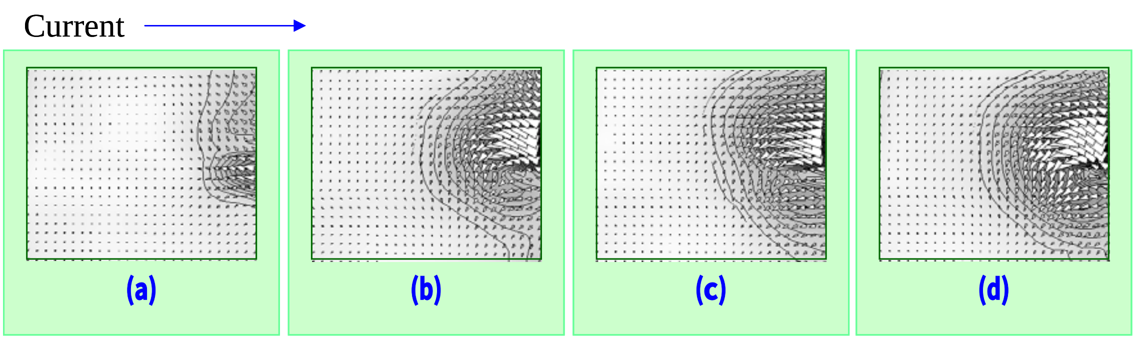

Fig. 1 Detoured current distribution area extending as the C/C degradation develops
(a) No load, (b) Crack stage, (c) Fiber break stage, (d) Stage just before the final fracture

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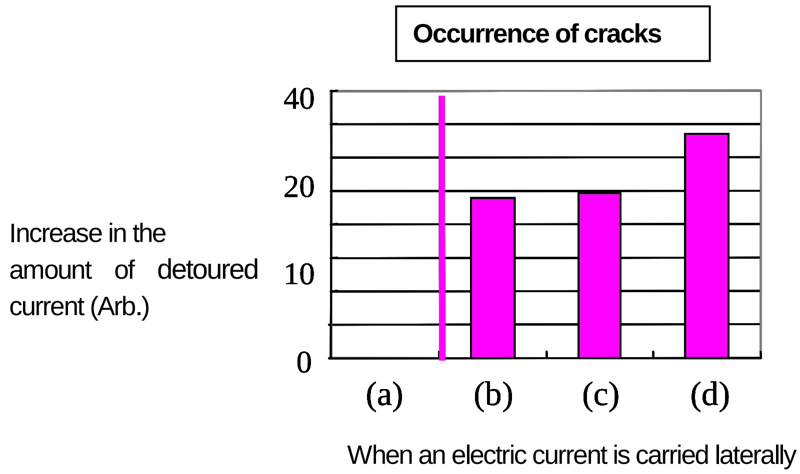
defect (Fig. 2). These findings in the experiment show the significant potential of this test for degradation diagnosis and the remaining life assessment of carbon composite materials for quality and safety control.



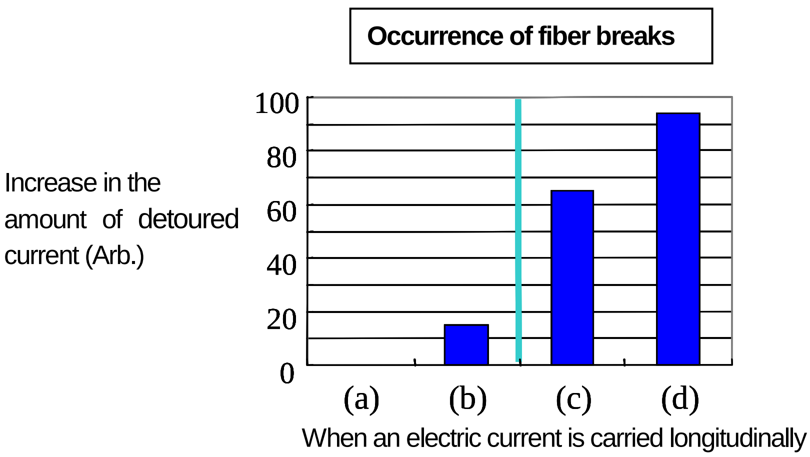


Fig. 2 Relation between the amount of detoured current and the state of defect, indicating a change from unloaded condition

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Top of Superconductivity Web21

Fall, 2003 Date of Issue: October 15, 2003

Superconductivity Web21

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Development of Transmission Line Inspection Equipment by SQUID

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The Kansai Electric Power Company developed how to inspect the internal degradation of power cables and suspension bridge cables without damaging them by using the SQUID inspection equipment.

Aged power facilities will increase from now on because a large amount of power equipment including transmission lines was installed during the era of high-speed economic growth. Now that the growth in power demand has slowed down, it is required to determine the most appropriate time to replace aged facilities according to the reliability of each individual facility and its use.
The statutory useful life of an electric cable is 40 years, but if a cable does not deteriorate, it may be used longer. Understanding the deterioration of a cable can greatly prolong the replacement intervals.

Our company visually checks the deterioration of the wires. It is quite difficult to discover internal deterioration with conventional flaw detection technology using ultrasound and eddy currents. The technique developed recently is a combination of newly developed image processing and preprocessing of subjects, on the basis of an existing SQUID sensor and a sensor drive unit. This technique has enabled us to check internal corrosions and flaws on the monitor without cutting or damaging wires. It can also be applied to suspension bridge cables, as well as to cables whose "core" consists of stranded steel strands.

The SQUID sensor is an instrument developed to measure micro-magnetic fields for physical measurement and medical care. In order to measure magnetism, it is necessary to convert it into an electric current and measure the current. Using a superconducting element will dramatically enhance the conversion efficiency into an electric current so that magnetism can be detected with sensitivity as high as one millionth of a geomagnetism (50 µT).
It has been known for a long time that flaws and corrosions in material can be found by using a magnetometric sensor to detect variations in magnetism caused by the deterioration of a substance. Since general magnetometric sensors such as a flux gate element do not have sufficient sensitivity or resolution, they cannot detect such subtle deterioration. While SQUID has high resolution, its sensitivity is so high that SQUID is susceptible to electric noise in the air. The detection technology using SQUID has not been put to practical use, owing to this disadvantage.

We have solved the following two problems by improving the existing SQUID inspection device and combining it with other processes, so that we successfully developed a new inspection method applying the SQUID inspection device.
1) Excessive detection sensitivity and electric noise obstructs inspection.
A sensor that is desensitized to some degree is used to discriminate between signals from wire deterioration and from electric noise, so that only signals indicating deterioration are captured. This has enabled outdoor inspection.
2) It is difficult to determine the deterioration level from measured signals.

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The deterioration level can be determined visually on the monitor by adopting measured signals to image processing with additional data processing for wires.

Our company is planning to develop a practical inspection device, applying this inspection technique, in a few years, aiming at downsizing and weight reduction to such an extent that the device can actually be used at high locations such as at the tops of steel towers.

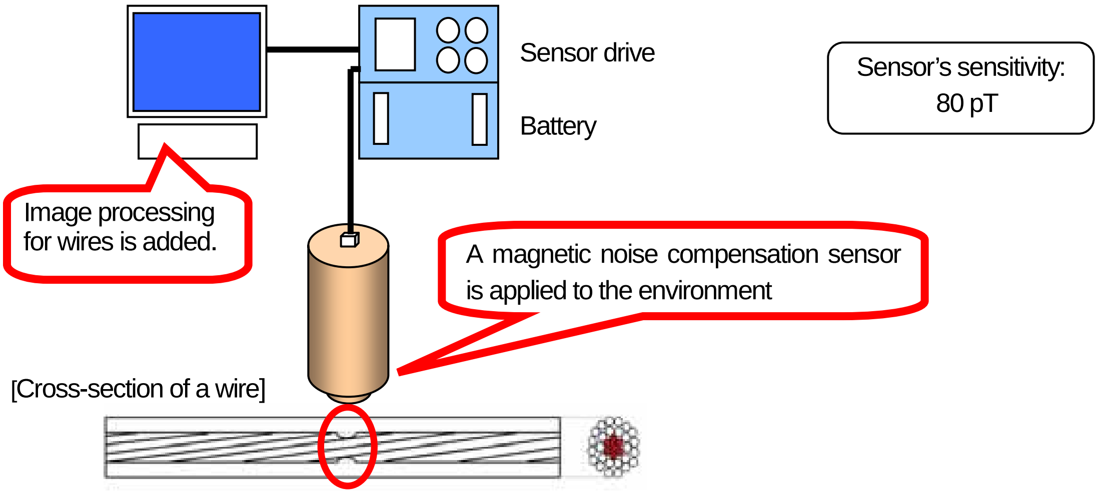

Fig. 1 System configuration of SQUID inspection device

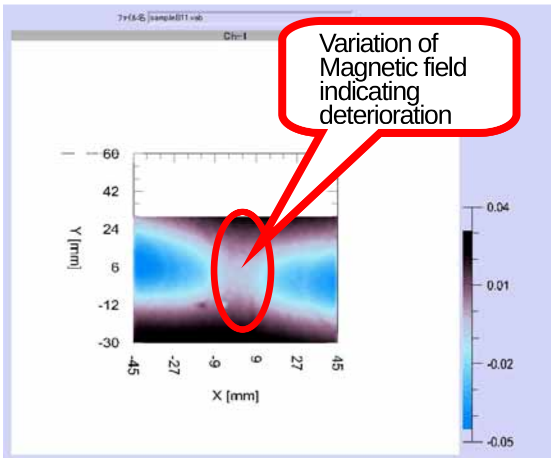

Fig. 2 Example of wire inspected with SQUID inspection device
Conversion of deterioration into variations in the magnetic field is displayed on the monitor.

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Top of Superconductivity Web21

Fall, 2003 Date of Issue: October 15, 2003

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Superconductivity Related Product Guide

- Products related to superconducting quantum interference device (SQUID) -

○ Shimadzu Corp.
SQUID Magnetometer, Biomagnetic Measuring Equipment (vector type 129 channel SBI-100: magnetoencephalograph MEG)
Tel: 075-823-1271, Fax: 075-811-8185, e-mail: medical@shimadzu.co.jp

○ Sumitomo Electric Hightechs & Co., Ltd.
High-temperature superconducting magnetometric sensor SQUID Introductory Kit, High-temperature superconducting magnetometry sensor SQUID Experimental Kit, High-temperature superconducting SQUID high-sensitivity magnetometric sensor SEIQUID II, SQUID Microscope using high-temperature superconducting SQUID, Biomagnetic Measuring Equipment, Antigen-antibody Reaction Inspection Equipment, Detector for Magnetic Foreign Objects Mixed in Food, Semiconductor Inspection Equipment, Geological Survey Equipment and other scientific equipment
Contact: Mr. Ohashi (Sales Department); Tel: 03-3423-5921, Fax: 03-3423-5924
Contact: Mr. Nagaishi (Technical Department); Tel: 072-771-3022, Fax: 072-771-3023

○ Scientific Equipment Department, Seiko Instruments, Inc.
Nb low-temperature scanning type SQUID microscope and other scientific equipment
Tel: 043-211-1338, Fax: 043-211-8067, e-mail: yukiya.watanabe@sii.co.jp
Contact: Yukiya Watanabe, Nanotech Sales Department

○ Marketing Department for Medical Care, Life Science Department, Hitachi High-Technologies Corporation
MC-6400 Hitachi Magnetocardiograph system
Tel: 03-3504-5818, Fax: 03-3504-7756, e-mail: naito-shigeaki@nst.hitachi-hitec.com
Contact: Shigeaki Naito, Magnetocardiograph System Manager

○MEG Center, Aerospace Products Business Headquarters, Yokogawa Electric Corp.
Magnetoencephalography (MEG), Small-size Weak Magnetic Field Measuring Equipment
Tel: 0422-52-5662, Fax: 0422-52-5946, e-mail: meg@csv.yokogawa.co.jp
Contact: Toshihide Miyabe

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Top of Superconductivity Web21

Fall, 2003 Date of Issue: October 15, 2003

Superconductivity Web21

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Decided to Entrust ISTEC with the Y-system Wire Project

The New Energy and Industrial Technology Development Organization (NEDO) invited entrusted organizations from the public to participate in a 5-year project on "Research and Development on Basic Technologies Required for Superconductivity Applications" from fiscal 2003 to 2007. ISTEC and the co-proposal companies of Fujikura, Ltd. and Sumitomo Electric Industries, Ltd. were chosen as entrusted organizations for the project as of May 29, 2003.

1. Significance of being entrusted with the project

For Y-system wire, although several tens of meters of high-performance wire have been developed as a result of research and development of organizations such as ISTEC, some problems still need to be solved. No company has yet established its own technology to finish a laminated structure necessary for all Y-system wire. It is necessary to conduct research efficiently including the smooth movement of samples for lamination between research implementation companies, making wire, and sample management, according to the wire manufacturing process. On the basis of the actual performance in the previous project, co-proposal companies, re-entrusted companies, and cooperative study universities need to form a cooperative study body, with the ISTEC management and research capabilities being the core of this study body. The fastest way to achieve this goal leading to commercialization is to effectively and efficiently promote the above research and development under the strong leadership of the project leader through close coordination with the implementing organizations. This project will efficiently contribute to industrial revitalization in relevant fields.

2. Background and necessity of the project

The results of research on wire and materials in NEDO's this project until the last fiscal year revealed that the two-dimensionality of an RE123 superconducting material, the orientation of superconducting crystal grain ascribable to d-wave superconducting characteristics, the grain boundary characteristics and other characteristics greatly affect the properties of the wire. Since these characteristics constituted a great barrier to manufacturing high-performance wire, it took more time to develop long wire than to develop bismuth-system wire. Technology to greatly enhance the electromagnetic properties of wire was beginning to be clarified in Phase I Research and the Development on Basic Technologies Required for Superconductivity Applications (fiscal 1998 to 2002). In reality, wire from several centimeters to several tens of centimeters long with a superconducting critical current density exceeding 1,000,000 A/cm^2 has been successfully developed in several manufacturing processes. Japan now leads the world in terms of length and properties in the keen development competition among Japan, Europe, and the United States. There are still many outstanding technical issues concerning the commercialization of RE123 superconducting wire, such as enhancing the film-forming speed, improving the productivity, making individual wires longer, rendering the properties uniform, making the film thicker for a higher critical current, reducing costs in the wire manufacturing process. It is urgent to solve the above issues in order to see the light at the end of the tunnel for commercialization.

3. Technical issues to be solved in this project

We have achieved a measure of success so far in our country's Research and Development on Basic Technologies Required for Superconductivity Applications. On the basis of this success, we will select the best possible process for each element of technology that is the most likely to be realized for the goal of commercializing Y-system wire, among the many wire manufacturing processes studied up to now, and continue our research and development on the long wire manufacturing process. The long wire

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manufacturing process is divided into two groups according to the efficiency of technological development: high-performance long-wire process development and low-cost long-wire process development. In parallel with the research on these manufacturing processes, we will evaluate long-wire development of technology for workability as a key technology to facilitate incorporating wire into equipment and systems. We will also enhance the properties of the material level, develop high-temperature superconducting material upgrading (sophistication) technology that enhances the crystal grain boundary and the junction interface properties between wires, and feed back findings to wire manufacturing processes for improvement to facilitate achieving our goal. In any case, bearing the use of equipment for commercialization in mind, it is essential to make the individual wires longer, make the film thicker for a higher critical current, enhance the film-forming speed related to productivity, and reduce costs in order to develop wire manufacturing processes that can withstand commercialization. Through precise structure control, optimizing manufacturing conditions, and upsizing equipment as well as process stabilization including the development of large-scale equipment, we aim to solve the above issues and achieve our goal. (See Table 1.)

Table 1 Research and development goals in this project

Wire specifications	Interim goal (by the end of 2005)		Final goal (by the end of 2007)	
	High-performance wire	Low-cost wire	High-performance wire	Low-cost wire
Wire length (m)	200m		500m	
Critical current	Ic= 200 A/cm wide (@77 K, 0 T)		Ic= 300 A/cm wide (@77 K, 0 T)	
	Ic= 20 A/cm wide (@77 K, 3 T)	---------	Ic= 30 A/cm wide (@77 K, 3 T)	---------
Manufacturing speed	---------		5 m/h	
Cost	Shows a wire manufacturing process with which the final goal can be achieved.		12 yen/Am (@77 K, 0 T)	8 yen/Am (@77 K, 0 T)

4. Results expected of this project

In the researches in this project, a RE123 superconducting material (RE: Y, Sm, Nd, Ho, etc.) demonstrated excellent superconductor properties. When it is used for wire, it is also excellent in high-magnetic field properties at temperatures of liquid nitrogen (64 - 77 K) and it is high in critical current density in its own magnetic field. It can be used for low-AC loss compact cable conductors for electric power, which is the main application of superconducting wire. In addition, the findings obtained so far reveal that it is an excellent material for applications to high magnetic fields for magnets including SMES (superconducting magnetic energy storage). Moreover, different from the bismuth-system wire, the RE123 wire does not use noble metals such as silver in large quantities and it is high in critical current per cross section of a wire. Consequently, future substantial cost reduction is expected.

Through accumulating technical expertise and concentration of development capabilities in Japan, we intend to develop technology to manufacture, at high speed and low-cost, long, high-performance wire with excellent superconducting properties, by promoting this project. In doing so, we can maintain our industrial, technological competitive edge, create a new high-temperature superconducting wire manufacturing industry (this superconducting wire has innovative functions that cannot be realized by conventional

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technology), and dramatically improve the performance of conventional devices. The promotion of this project will greatly contribute to economic recovery in Japan. In addition, it is expected that energy loss reducing effects will contribute to environmental protection including energy savings and reducing CO_2 emissions.

(Yuh Shiohara, Director of Division of Superconducting Tapes & Wires ; Teruo Izumi, Division of Superconducting Tapes & Wires, SRL/ISTEC)

(Published in a Japanese version in the August 2003 issue of *Superconductivity Web 21*)

Top of Superconductivity Web21

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The Status Quo of a Japan-US Joint Project on AC Loss

Superconductivity is expected to bring about large energy-saving effects. Reducing AC loss will greatly improve energy-saving efficiency when high temperature superconducting transmission cables and other superconducting equipment and systems are applied. This will also contribute to reducing carbon dioxide emissions. To this end, it is essential to formulate the method and standard for assessing AC loss of superconducting equipment and guidelines for reducing AC loss. This three-year joint project "the Research and Development Concerning the Assessment on AC Loss and Reduction of Loss" started in 2002. In collaboration with the United Sates, given their experience in assessing the AC loss of superconducting wires, Japan intends to establish the technology to assess the AC loss of yttrium-based high temperature superconducting wires and to develop a loss analyzing simulation capable of formulating a guideline for loss reduction, because Japan desires to apply yttrium-based superconductivity technology as soon as possible.

At present, a Y-based superconducting wire has been made for assessment. Based on this wire material, the Japanese counterparts are trying to assess basic characteristics of elements that are necessary for assessing diverse kinds of AC losses. In addition, the Japanese side has implemented and built up a system for developing AC loss assessment technologies. The system has begun to work for assessment. We have also started preparations for developing simulation technologies that are expected to gain momentum in the future. Progress on individual topics in the joint project is described below:

Concerning producing wires for assessment, we produced wires on a hastelloy metallic substrate using the IBAD method (orientation intermediate buffer layer) and the PLD method (superconducting layer). Specifically, we produced a number of wires whose thickness of the superconducting layer and the stable layer were different before providing them for groups that assess basic superconductivity characteristics and develop AC loss assessment technologies.

Concerning assessing basic superconductivity characteristics, we used a low temperature laser scanning microscope to assess the characteristics of local superconductivity. We also examined the mechanism of DC carrying characteristics and effects on critical current-limiting factors on an IBAD substrate. In addition, we used a magnetic optical microscope to observe magnetic flux behavior intruding into the wire. As a result, we identified uneven behavior that is different from that in metal wires.

Concerning the development of AC loss assessment technologies, we have built up a complete AC loss measurement system, and a middle loss assessment system for strong AC magnetic fields. In addition, we used a prototype system to measure the AC loss of a Y-based wire in the IBAD/PLD methods. We found that magnetized loss was controlled by the magnetic field component vertical to the tape surface. After measuring the total AC loss of a wire of a small critical current that transmits alternating current under the vertical, transverse magnetic AC field, we found that the contribution of the external magnetic field was dominant. Moreover, we measured AC loss by preparing one sheet of tape layer and six sheets of tape layers (inter-layer insulated) to study the impact of demagnetizing field effects. We found a tendency for the loss to approach Slab's theoretical value as the number of layer sheets increases.

Concerning the development of a simulator, we focused on shortening the calculation time in our preparation. Then, we compared and examined to see how combinations of a variety of iteration methods and matrix solution methods, which deal with non-linear superconducting characteristics, would affect their

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calculation time.

To exchange information on the results of the joint research project, we are holding technical meetings for American and Japanese researchers. We are also holding meetings for researchers who are conducting experiments and research to promote efficiently developing wire assessment technologies.

(Yuh Shiohara, Director, Division of Superconducting Tapes & Wires; Teruo Izumi, Division of Superconducting Tapes & Wires, SRL/ISTEC)

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What's New in the World of Superconductivity (August)

Power

American Superconductor Corporation (August 6, 2003)

American Superconductor Corporation (AMSC) has reported its financial results for the first quarter of fiscal 2004, ending June 30, 2003. Net revenues increase by 171% to US $ 7.8 million, compared to $2.9 million for the first quarter of 2003. Meanwhile, the net loss decreased from $10.8 million for the first quarter in 2003 to $8.4 million for the presently reported quarter. AMSC is continuing to reduce its annual cash burn rate by reducing operating and capital expenditures; the company expects to attain a cash burn rate of $13-15 million for fiscal 2004. AMSC received $17.2 million in new orders and contracts during the first quarter of 2004, bringing their total backlog to $87.4 million. Approximately $32 million of this backlog is expected to be recognized as revenue over the remainder of fiscal 2004. Finally, the SuperMachines business unit, which designs, develops, and manufactures HTS motors, generators, and synchronous condensers achieved its first profitable quarter, with a net income of $11,900 from $5.5 million in revenue. The unit is expected to continue to be profitable throughout the remainder of the fiscal year, generating about $1.5 million in cash.

Source:
"American Superconductor Reports Fiscal 2004 First Quarter Results"
American Superconductor Corporation press release (August 6, 2003)
http://www.amsuper.com/html/newsEvents/news/106010118401.html

Intermagnetics General Corporation (August 6, 2003)

BOC Group, a multibillion-dollar global leader in the supply of industrial gases, refrigerants, and related equipment, will join the HTS cable project that is presently underway in Albany, New York. BOC Group will be responsible for developing the large-scale cryogenic refrigeration system needed to cool the HTS cables. The group will design, install, monitor, and operate the refrigeration system for the duration of the four-year project. Neil Greenfield, Senior Vice President of BOC, commented "(BOC) is prepared to develop a cryogenic refrigeration system that meets the stringent demands of this project and that also has the necessary cost effectiveness and reliability necessary for the commercial viability of HTS technology. We are committed to providing long-term customer support, which we believe will be a key element in ensuring the success of HTS technology in the utility industry."

Source:
"Intermagnetics Announces BOC to Join Albany HTS Cable Partnership"
Intermagnetics General Corporation press release (August 6, 2003)
http://www.igc.com/news_events/news_story.asp?id=93

Intermagnetics General Corporation (August 14, 2003)

Intermagnetics General Corporation (IMGC) has announced that the U.S. Department of Energy (DOE) will provide half of the projected US $12 million price tag to develop a new HTS fault current limiter for the protection of utility grids from damaging current surges. The device, known as a Matrix Fault Current Limiter (MFCL) will be based on proprietary technology developed by SuperPower, Inc., a subsidiary of IMGC. Nexans has also joined the development team as a strategic partner and will supply the "melt cast" superconductors that will be used in the device in addition to sharing the private sector costs of the program. Nexans "melt cast" superconductors have a

substantially higher current carrying capacity than other more commonly used wires and tapes. The project will be performed as part of the DOE's Superconductivity Partnership Initiative (SPI) program. The Electric Power Research Institute (EPRI) has also committed $600,000 to the project. Argonne, Los Alamos, and Oak Ridge National Laboratories will also participate in the project, providing expertise in the areas of high voltage engineering, cryogenics, and analytics. Glenn H. Epstein, chairperson and chief executive officer of IMGC, predicted "We expect to develop several prototypes, culminating with the installation of a 138 kV HTS matrix fault current limiter in a utility transmission substation in about three years."
Source:
"Intermagnetics Announces DOE Funding of $6 Million for Project to Develop HTS Device Designed to Protect Utility Grids"
Intermagnetics General Corporation press release (August 14, 2003)
http://www.igc.com/news_events/news_story.asp?id=94

Electric Power Research Institute (August 25, 2003)

The recent power outage that occurred in the Northeastern United States and Eastern Canada has brought additional attention to the aging electrical infrastructure in the US and the need for modernization. A recent report published by the Electric Power Research Institute (EPRI) examines the present challenges facing the electricity sector in the US and presents a "Framework for Action" to guide future economic, regulatory, and technical direction. Input from a broad cross section of stakeholders, including utilities, federal and state regulators, industry and business, consumer groups, labor unions, and environmentalists, was used to compile the report. The report states that technology will become an important enabler in achieving the report's five goals: stabilize electricity markets, provide for the public good, protect the environment, educate and empower the consumer, and unleash technical innovation, transforming the aging electricity system into a smart, interactive, electronically controlled system. To access the two-volume report or a report summary, visit
http://www.epri.com/corporate/esff/viewpdfs.asp.
Source:
"EPRI Board Releases Report Detailing Vision for the Future for U.S. Electric Power"
Electric Power Research Institute press release (August 25, 2003)
http://www.epri.com/corporate/discover_epri/news/2003releases/082503_esff.html

American Superconductor Corporation (August 25 and 29, 2003)

American Superconductor Corporation (AMSC) has filed a registration statement with the Securities and Exchange Commission for a proposed public offering of 4,000,000 shares of its common stock. The lead underwriter for this offering is Needham & Company, Inc. The offering includes an option for the underwriters to purchase up to an additional 600,000 shares to cover over-allotments, if necessary. The offering replaces the previously announced secured debt financing plan to raise US $50 million in the form of a term loan, convertible subordinated notes and a working capital credit facility, which AMSC will no longer pursue.
Sources:
"American Superconductor Announces Plan for Common Stock Offering"
American Superconductor Corporation press release (August 25, 2003)
http://www.amsuper.com/html/newsEvents/news/106181295601.html
"American Superconductor Announces Filing of Public Offering Registration Statement"
American Superconductor Corporation press release (August 29, 2003)
http://www.amsuper.com/html/newsEvents/news/106783294602.html

Material

Superconductive Components, Inc. (August 15, 200)

Superconductive Components, Inc., has reported their financial results for the second quarter ending June 30, 2003. Total revenue for the second quarter decreased by 12.4% from that of a comparable period in the previous fiscal year to US $627,765. The gross profit margin, however, improved to 32.7% for the second quarter, compared to 31.2% for the same period in the previous fiscal year; this increase was mainly due to revenue from government contracts. Dan Rooney, Chairman and Chief Executive Officer of Superconductive Components, stated "During the second quarter we simplified our balance sheet, began to implement plans to improve sales, and remained focused on our long-term strategic growth opportunities. Our top priority is to increase revenue and return to profitability."

Source:
"Superconductive Components, Inc. Reports Second Quarter Results"
Superconductive Components, Inc. (August 15, 2003)
http://www.sciengineeredmaterials.com/ne/earnings/scci23.htm

NMR and Magnet

Oxford Instruments Superconductivity (August 18, 2003)

Oxford Instruments Superconductivity has reported the successful installation of two 900 MHz NMR magnets, the key component in Varian's Inova ™ NMR spectrometers, at state-of-the-art NMR facilities in Japan. The magnets have a field strength of over 21 Tesla, which is 11% stronger than that of previous generation systems. This increased magnetic field strength enables better spectral resolution, improved sensitivity, and a 20% increase in the signal-to-noise ratio. The NMR spectrometers will be used in advanced drug studies and environmental protection applications.

Source:
"900MHz NMR magnet technology big in Japan"
Oxford Instruments Superconductivity press release (August 18, 2003)
http://www.oxford-instruments.com/SCNNWP699.htm

Oxford Instruments Superconductivity (August 19 and 20, 2003)

Oxford Instruments Superconductivity has been selected as the primary supplier of magnetic technology to Thermo Electron Corporation, enabling a new generation of instruments, such as the world's first commercially available, high-performance Hybrid Ion Trap – Fourier Transform Mass Spectrometer (FTMS), to be designed for medical and scientific research. FTMS is ideal for use in routine pharmaceutical and biochemical research. The FTMS market is expected to grow exponentially over the next five years. The initial supplier agreement is valued at €3 million over the next 18 months, with €1 million already committed.

Sources:
"Oxford Instruments wins major order enabling a new generation of Mass Spectrometry based bio-tools"
Oxford Instruments Superconductivity press release (August 19, 2003)
http://www.oxford-instruments.com/OIGNWP700.htm
"Superconducting magnets - essential technology at the heart of new mass spectrometry technique"
Oxford Instruments Superconductivity press release (August 20, 2003)

http://www.oxford-instruments.com/SCNNWP701.htm

Sensor

National Institute of Standards and Technology (August 12, 2003)

The National Institute of Standards and Technology and Boston University have developed a detector that counts single pulses of light while simultaneously reducing false counts to virtually zero. The new device operates at a near-infrared wavelength, such as that used for fiber optic communications. The detector consists of a tungsten film coupled to a fiber optic communication line. The tungsten film is chilled to 120 mK, its superconductivity transition temperature; when the fiber optic line delivers a photon to the tungsten film, the temperature rises and the apparatus detects the resulting increase in electrical resistance. The detector is a key technology for the development of secure quantum communications and cryptography. Eventually, code-makers hope to use a rapid series of photons in one or two different states to transmit information in an unbreakable code. Project funding was provided by the Defense Advanced Research Projects Agency (DARPA) and the NIST Advanced Technology Program (ATP). For a detailed discussion, please refer to the July 28 issue of Applied Physics Letters.

Source:
"Single photon detector conquers the dark side"
National Institute of Standards and Technology press release (August 12, 2003)
http://www.eurekalert.org/pub_releases/2003-08/nios-spd081203.php

Communication

Superconductor Technologies Inc. (August 7, 2003)

Superconductor Technologies Inc. has announced its financial results for the second quarter and six-month period ending June 28, 2003. Total net revenues for the second quarter increased by 49% to US $11.3 million, from $7.6 million for a comparable period in the previous year. Net commercial product revenues for the second quarter increased by 75% to $8.9 million, compared to the $5.3 million earned in the first quarter of the same year. Government and other contract revenue increased to $2.3 million, compared to $785,000 for a comparable period in the previous year. The total net loss for the quarter second quarter was $3.1 million, including $666,000 in litigation expenses. M. Peter Thomas, STI's president and chief executive officer, said "The second quarter was one of solid achievement for STI, in particular for the sales and manufacturing teams." The company ended the quarter with a product backlog of $7.1 million. STI raised $10.1 million in an equity private placement transaction during the second quarter.

Source:
"Superconductor Technologies Inc. Announces Second Quarter Results"
Superconductor Technologies Inc. press release (August 7, 2003)
http://ir.thomsonfn.com/InvestorRelations/PubNewsStory.aspx?partner=5951&storyId=92444

ISCO International, Inc. (August 11, 2003)

ISCO International, Inc. has launched a next-generation Adaptive Notch Filter (ANF ™) Flex product that line scans wireless communication bands, deploying dynamically tunable filters to prevent interference from

disturbing network performance. Customers can easily program the product to scan and protect an entire bandwidth or a customer-defined bandwidth subset. Several of ISCO International's customers have been evaluating a prototype of the device, and interest in the product appears to be strong, with several purchase orders already received. The product, which can scan up to seven CDMA carriers, can be fully customized to meet the customer's existing and future needs. "This is a major step in the product evolution path planned to extend the range of applications to wide-band systems," commented Dr. Abdelmonem, CEO of ISCO International.
Source:
"ISCO International Announces Arrival of Next Generation ANF Product"
ISCO International, Inc. press release (August 11, 2003)
http://www.iscointl.com/

Superconductor Technologies Inc. (August 14, 2003)

Superconductor Technologies Inc. (STI) announced the launch of it new SuperLink ™ Rx 1900 integrated cryogenic receiver front-end (CRFE), which is designed for the PCS wireless market. The product is the first of STI's fully integrated systems designed for outdoor use and includes a SuperLink Rx front-end as well as up to six dual HTS-Ready ™ duplexers in a weatherized unit. The product features passive thermal management, utilizing a Stirling cooler at the core of its cryogenic technology. The product has already been shipped and deployed, and one commercial order has been received. In a recent urban 1xRTT cluster trial, data speeds increased dramatically by more than 50% because of the improvement in system sensitivity.
Source:
"Superconductor Technologies Inc. Expands SuperLink(TM) Rx Family
With Introduction OF SuperLink(TM) Rx 1900 Designed for PCS Networks"
Superconductor Technologies Inc. press release (August 14, 2003)
http://ir.thomsonfn.com/InvestorRelations/PubNewsStory.aspx?partner=5951&storyId=92773

ISCO International, Inc. (August 21, 2003)

ISCO International announced a US $700,000 draw on its $4 million credit line. The company secured the credit line in October 2002 from affiliates of its two largest shareholders; the arrangement matures on March 31, 2004. The fulfillment of the $700,000 request leaves the $ 4 million facility completely utilized by ISCO International.
Source:
"ISCO International Announces Credit Line Financing"
ISCO International, Inc. press release (August 21, 2003)
http://www.iscointl.com/

ISCO International, Inc. (August 22, 2003)

On August 21, 2003, the Court issued rulings on the "judgment as a matter of law (JMOL)" motion filed by ISCO International, Inc., and the motion for "judgment of inequitable conduct and unenforceability" and attorney fees filed by Superconductor Technologies, Inc. (STI), regarding the jury verdict in the patent infringement case that ISCO International brought against STI last year. The court overturned the jury determination of unfair competition on the part of ISCO and denied all requests for damages, including the US $3.87 million jury award to STI. Nevertheless, the Court did not overturn the jury determinations of patent invalidity and unenforceability based on inequitable conduct and denied ISCO's request for a new trial. ISCO continues to believe that this is an enforceable patent and is considering what step to take next; this may include filing an appeal.
Source:
"ISCO International Announces Court Rulings in Patent Litigation Post-Trial Motion Process"

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5-34-3, Shimbashi, Minato-ku, Tokyo 105-0004, Japan Tel: 03-3431-4002, Fax: 03-3431-4044

ISCO International, Inc. press release (August 22, 2003)
http://www.iscointl.com/

Superconductor Technologies Inc, (August 25, 2003)

Superconductor Technologies Inc. (STI) announced that the Court has reached its final ruling in the patent lawsuit brought against STI by ISCO International. The Court affirmed the unanimous jury verdict stating that the "215 patent" was invalid and unenforceable because of inequitable conduct. However, the Court overturned the jury's verdict of unfair competition and bad faith on the part of ISCO International as well as the compensatory damage award and the reimbursement of legal fees associated with the case.
Source:
"Superconductor Technologies Inc. Receives Judge's Final Ruling on '215 Patent Infringement Lawsuit"
Superconductor Technologies Inc, press release (August 25, 2003)
http://ir.thomsonfn.com/InvestorRelations/PubNewsStory.aspx?partner=5951&storyId=93276

Basic

Los Alamos National Laboratory (August 21, 2003)

Researchers at the National High Magnetic Field Laboratory (NHMFL; a division of the Los Alamos National Laboratory) have obtained evidence that appears to support the leading theory regarding the underlying mechanism of superconductivity. Using high-temperature superconductors made from bismuth, strontium, lanthanum, copper, and oxygen, the researchers described how sharp changes in the Hall Effect may provide evidence of a phase transition that is commonly believed to be the source of superconductivity. Although the exact nature of the phase transition remains uncertain, its discovery and continued study should improve our understanding of superconductivity. The unique instrumentation and high magnetic field capability of the Pulsed Field Facility at NHMFL makes it one of the few places in the world where this type of research can be performed. The high magnetic fields enable the nature of the particles that contribute to a material's superconductivity to be observed without obstruction from the superconductivity phenomenon itself. For a detailed discussion, please refer to the August 21 issue of Nature.
Source:
"Scientists explore complex nature of superconductivity"
Los Alamos National Laboratory press release (August 21, 2003)
http://www.lanl.gov/worldview/news/releases/archive/03-112.shtml

(Akihiko Tsutai, Director, International Affairs Department, ISTEC)

Top of Superconductivity Web21

Patent Information

Introduced below are ISTEC's patents published from January through June 2003. For more information, access the homepage of the Patent Office of Japan and visit the Industrial Property Digital Library.

Published Unexamined Patents for the Fourth Quarter of Fiscal 2002

1. Publication No. 2003-020225: "METHOD FOR MANUFACTURING OXIDE SUPERCONDUCTOR AND OXIDE SUPERCONDUCTOR"

This invention relates to superconductive film fabrication of YBCO-system using the LPE method, which reduces the critical temperature deterioration for lower thin film portion in the conventional LPE method (for example, Tc is 90K or higher for a thick film but approximately 77K for a thin film). Tc at 90K or higher can be obtained even for a film thickness of 1 to 3μm by the LPE method using a solution containing calcium in addition to constituent elements of a rare-earth oxide superconductor.

2. Publication No. 2003-031861: "POWER SUPPLY LINE CIRCUIT"

This invention relates to a power circuit for SFQ logic circuits with operating frequency over 100 GHz, in which a power supply line to the circuit element of each logic circuit is constituted by a resistance and a superconducting wire so that the superconducting wire at the joint to the circuit element serves as a discontinuous point of a characteristic impedance. Thereby, it is possible to improve an operating frequency by suppressing leakage current, to reduce power consumption, and to decrease the area occupied by a power supply line.

3. Publication No. 2003-034527: "THICK FILM OF TAPE-LIKE OXIDE SUPERCONDUCTOR AND METHOD FOR MANUFACTURING IT"

This invention relates to fabricating a high-quality high-temperature superconductor film using the metal organic deposition method (MOD method) with organic acid salts containing fluorine (such as TFA salt) as a starting material. A superconductor film having a thickness of 0.5 μm or more and a critical current density of 0.7 MA/cm^2 or more at 77K is obtained by optimizing steps of coating the material on a substrate and calcinating and heat-treating the coated substrate, these steps are executed several times to produce precursor of thick film oxide superconductor, and optimizing a heat-treating step for crystallizing in a water-vapor atmosphere.

4. Publication No. 2003-055765: "METHOD FOR DEPOSITING SUPERCONDUCTIVE THIN FILM USING MOCVD PROCESS"

The MOCVD method (Metal Organic Chemical Vapor Deposition method) using dipivaloymethanate (DPM) as a source gas is superior for forming a high-quality high-temperature superconducting thin film. It is, however, difficult to uniformly maintain the thermal decomposition reactions of all MO source gases of superconductor components over a large area. In the present invention, the thermal decomposition reaction can be moderated by mixing β-diketone with the Cu source gas, which thermally decomposed at the lowest temperature. Thus, the above disadvantage is significantly reduced.

5. Publication No. 2003-055766: "METHOD FOR DEPOSITING SUPERCONDUCTING THIN FILM USING MOCVD PROCESS"

The MOCVD method (Metal Organic Chemical Vapor Deposition method) using dipivaloymethanate

(DPM) as a source gas is superior for forming a high-quality high-temperature superconducting thin film. It is, however, difficult to uniformly maintain the thermal decomposition reactions of all MO source gases of superconductor components over a large area. In this invention, a thermal decomposition reaction can be controlled by using a combination of $Cu(DPM)_2$ and ethylenediamine as the Cu source gas, which thermally decomposed at the lowest temperature, instead of conventional $Cu(DPM)_2$. The thermal decomposition reactions is reduced and thus, the above disadvantage is significantly reduced.

6. Publication No. 2003-059352: "HIGH-TEMPERATURE SUPERCONDUCTOR FILM HAVING FLAT SURFACE"

This invention relates to reducing undesirable segregations and particles produced on a high-temperature superconductor film of 123-system formed by the sputtering method or laser vapor deposition method. One group (such as Y-Ba-Cu) with large differences among ion radiuses of constituent metallic elements is different from other group (such as Nd-Ba-Cu) with small differences among ion radiuses of constituent metallic elements in the generation mechanism of these segregations and particles, and a remarkable advantage is obtained by selecting a proper composition ratio between these two groups.

7. Publication No. 2003-069094: "LAMP EDGE TYPE JOSEPHSON JUNCTION ELEMENT AND ITS MANUFACTURING METHOD"

This invention relates to the formation of high-temperature superconducting Josephson junctions and clarifies a method for improving the junction characteristics and reducing the critical current fluctuation. The film-fabrication temperature difference between an upper superconductive electrode and a lower superconductive electrode is increased and a smooth film can be formed by changing the four-element constitution of RE-Ba-Cu-O to a constitution of five elements or more obtained by adding other substitutional element to RE and Ba. This achieves the advantages of suppressing the deterioration of the characteristic of the lower electrode, increasing of the IcRn product and decreasing of the Ic fluctuation.

8. Publication No. 2003-089516: "MgB_2 SUPERCONDUCTOR AND METHOD FOR PRODUCING THE SAME"

This invention relates to producing an MgB_2 superconductor using the PIT (Power in Tube) method, by which an MgB_2 superconductor having a critical temperature of 39K can be formed by filling a mixed powder of Mg powder and B powder at a weight ratio of 1:2 into a copper pipe and heat-treating the mixed powder at 700 ˚C for 12 hours.

(Published in a Japanese version in the July 2003 issue of *Superconductivity Web 21*)

Published Unexamined Patents for the First Quarter of Fiscal 2003

1. Publication No. 2003-095650: "MgB_2-BASED SUPERCONDUCTOR HAVING HIGH CRITICAL CURRENT DENSITY AND METHOD FOR MANUFACTURING THE SAME"

This invention relates to producing an MgB_2 superconductor having dispersed Ti and a Ti compound in an MgB_2 polycrystalline after pressure-molding a mixed powder obtained by mixing raw powders of Mg, B, and Ti at an atomic ratio of Mg:B:Ti=(0.7-1.2):2:(0.07-0.3) and baking the mold at 600˚C or higher. This method can produce an MgB_2 superconductor having a critical temperature of 39K and a critical current density of $1.3x10^6 A/cm^2$ (at 20K).

2. Publication No. 2003-095652: "123 SUPERCONDUCTOR OF CALCIUM-SUBSTITUTED RARE-EARTH SERIES"

This invention relates to a rare earth 123-system superconductor, which is easily produced and shows a high irreversal magnetic field. For a rare earth 123-system superconductor mainly made of a substance whose chemical formula is expressed as $REBa_2Cu_3O_{7-d}$ (RE denotes a rare-earth element), replacing a part of RE with Ca can maintain a irreversal magnetic field to be 10T or more when applying a magnetic field in the c-axis direction at a temperature of 77K.

3. Publication No. 2003-101089: "PERSISTENT CURRENT SWITCH MATERIAL AND MANUFACTURING METHOD THEREFOR"

This invention provides a compact and lightweight persistent current switch having a large electric resistance value under the normal conducting state. Adding a Zn or Mg element to an RE123 superconductor (RE denotes Y or rare-earth element, including Nd123 or Sm 123) can control a critical temperature in a range of 30K to 96K, and also forming a thick LPE film on a meander- or spiral-shaped seed film provides long current carrying pass.

4. Publication No. 2003-121076: "ATMOSPHERE CONTROL TYPE HEAT TREATING FURNACE"

This invention relates to a heat-treating furnace requiring atmosphere control suitable for heat treatment of long-length materials such as ceramics, organic compounds, and metallic compounds. The furnace tube is formed into a double structure, and four partition plates are set between an outer tube and an inner tube in order to form two sets of gas feed passage and gas exhaust passage. Several gas-outgoing holes are formed on each gas feed passage, and several gas-incoming holes are formed on each gas exhaust passage. Different types of gases are supplied through these at different flow rates in order to generate a pressure difference between the gas-outgoing holes and gas-incoming holes as well as to make the different types of gases flow uniformly in the vertical direction to the axis of the furnace tube. Thereby, it is possible to properly control the ambience in the furnace in accordance with a predetermined condition and obtain a long material having uniform characteristics.

5. Publication No. 2003-137693: "COMPOSITE SUBSTRATE"

This invention relates to a substrate having an intermediate layer that can decrease lattice mismatching between the substrate and an oxide superconducting thin film, and high-quality epitaxial thin film can be easily grown. A thin film of a compound expressed as $REBa_2TaO_6$ (RE:Nd, Sm, Eu, Gd, Dy, etc.) is formed on a substrate made of MgO, Al_2O_3, or $SrTiO_3$ as an intermediate layer. Then, a rare-earth-based oxide superconducting thin film made of $NdBa_2Cu_3O_{7-d}$ or the like is expitaxially grown on the composite substrate. By using the intermediate layer, it is possible to use MgO and Al_2O_3, which are substrate materials superior in cost and suppliability, as practical-use substrate materials for superconducting devices.

(Published in a Japanese version in the August 2003 issue of *Superconductivity Web 21*)

(Katsuo Nakazato, Director, R & D Promotion Division, SRL/ISTEC)

Top of Superconductivity Web21

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Standardization Activities

- Distribute Documents for Comments (DC) and Start IEC Standards Maintenance -

The IEC/TC90 (Superconductivity) distributed Documents for Comments (DC) to the P-member nations of the IEC/TC90 on May 9, 2003. This meant the actual start for the maintenance of the current IEC standards. The working groups (WG) that will review the IEC (International Electrotechnical Commission) standards and the maintenance time limits will be stated below. Of the targeted IEC standards, comments on IEC61788-5 and IEC61788-12 have not yet been proposed. The DC announces recruitments for the WG4 and WG7 conveners and requests new registration of experts into different WGs.

IEC	Title	Time Limit	WG
IEC 61788-1,Ed.1.0	Superconductivity - Part 1: Critical current measurement - DC critical current of Cu/Nb-Ti composite superconductors	2006	2
IEC 61788-2,Ed.1.0	Superconductivity - Part 2: Critical current measurement - DC critical current of Nb_3Sn composite superconductors	2006	7
IEC 61788-3,Ed.1.0	Superconductivity - Part 3: Critical current measurement - DC critical current of Ag-sheathed Bi-2212 and Bi-2223 oxide superconductors	2006	3
IEC 61788-4,Ed.1.0	Superconductivity - Part 4: Residual resistance ratio measurement - Residual resistance ratio of Nb-Ti composite superconductors	2006	4
IEC 61788-7,Ed.1.0	Superconductivity - Part 7: Electronic characteristic measurements - Surface resistance of superconductors at microwave frequencies	2006	8
IEC 61788-5,Ed.1.0	Superconductivity - Part 5: Matrix to superconductor volume ratio measurement - Copper to superconductor volume ratio of Cu/Nb-Ti composite superconductors	2005	6
IEC 61788-6,Ed.1.0	Superconductivity - Part 6: Mechanical properties measurement - Room temperature tensile test of Cu/Nb-Ti composite superconductors	2007	5
IEC61788-10.Ed.1.0	Superconductivity - Part 10: Critical temperature measurement - Critical temperature of Nb-Ti, Nb_3Sn, and Bi-system oxide composite superconductors by a resistance method	2007	11
IEC 61788-11,Ed.1.0	Superconductivity - Part 11: Residual resistance ratio measurement - Residual resistance ratio of Nb_3Sn composite superconductors	2007	4
IEC 61788-12.Ed.1.0	Superconductivity - Part 12: Matrix to superconductor volume ratio measurement - Copper to non-copper volume ratio of Nb_3Sn composite superconductors	2007	6

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- Issuing two IEC Standards -

The International Electrotechnical Commission, IEC, issued superconductivity related testing method standards in April and May in 2003, which relate to an AC loss testing method of a niobium/titanium-composite superconductor. The standards are effective until December 31, 2008.

IEC 61788-8:2003 Superconductivity Part 8; AC loss measurements-Total AC loss measurement of Cu/Nb-Ti composite superconducting wires exposed to a transverse alternating magnetic field by a pickup coil method

This case relates to a total-AC-loss testing-method standard according to a pickup coil method of a niobium/titanium-composite superconductor having a filament diameter of 1 to 50 µm, coupling time constant of 40 ms, and wire diameter of 0.2 to 1 mm.

IEC 61788-13:2003 Superconductivity-Part 13: AC loss measurements-Magnetometer methods for hysteresis loss in Cu/Nb-Ti multifilamentary composites

This case relates to a niobium/titanium-composite superconductor AC-loss (hysteresis loss) testing-method standard according to the magnetometer method (VSM: vibrating-sample magnetometry).

To obtain these IEC standards, use the Web purchase from the IEC home page <http://www.iec.ch/> or the service purchase from the home page of the Japanese Standards Association <http://www.jsa.or.jp/>.

- IEC/TC90 Superconductivity Committee Steering Committee in fiscal 2003 -

The IEC/TC90 Superconductivity Committee (Chairperson: Shigeki Saito/Senior Managing Director of ISTEC) held the 16th IEC/TC90 Superconductivity Committee Steering Committee at the conference room in the Shinbashi Annex of the Mori Building on June 10, 2003.

In this meeting, the drafts for the business report for fiscal 2002, the balance settlement statement for fiscal 2002, the business plan for fiscal 2003, and the budget balance for fiscal 2003 were all approved. The major business for fiscal 2003 is "standardization research on standardizing superconducting-power-equipment technology foundation" currently applied to the public subscription business in fiscal 2003 by the Ministry of Economy, Trade and Industry.

The standardization research finally proposes the preparation for a draft of publicly available specifications (PAS) and technical specifications (TS) of the superconducting power equipment technology like the superconducting magnetic energy storage system (SMES) and superconducting generator, reflecting the research and development from existing R&D projects in collaboration with them as part of the industrial technology enhancement strategy in Japan.

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- METI Has Adopted the Project of "Standardizing Basic Technologies for Superconducting Power Equipment" -

As of June 19, 2003, the Ministry of Economy, Trade and Industry(METI) of Japan decided to adopt the project of "Standardizing Basic Technologies for Superconducting Power Equipment," which had been applied for by the International Superconductivity Technology Center (ISTEC).

This commission project is one of the 35 subjects that the METI has decided to work on for standardization. For example, these subjects include ultra-slim battery cells for mobile equipment, ITS (intelligent transport systems), bioinformatics, photocatalysts, and advanced composite materials. By strategically promoting international standardization, Japan expects to acquire new international markets for these new technologies and new products. Nations which desire to make international standards proposals are obliged to submit them to the ISO/IEC within three years from fiscal 2003 after collecting and analyzing the relevant information on a research and development subject.

The aforementioned project, for which ISTEC has won a commission contract, aims primarily to formulate international standardization proposals for the research and development projects that have been adopted or are underway. These include the "Research and Development of Basic Technologies for Superconducting Power Equipment," "Development of Superconducting Magnetic Energy Storage System Technology," "Research and Development of fundamental technologies for superconducting AC power," "Research and Development on Basic Technologies Required for Superconductivity Applications." Japan needs to put together the research results and data from these projects to analyze them because Japan plans to make international standardization proposals for technological specifications (TS) for superconductors for superconducting power equipment, an open specification for superconductors for superconducting magnetic energy storage system (SMES), and PAS by the end of fiscal 2006. Japan is a managing member of the IEC/TC90 (Superconductivity). This project lives up to Japan's superconductivity standardization strategy. The results of this project will reinforce Japan's international competitiveness, which the METI is promoting. Japan’s strategy consists of ensuring market conformity, emphasizing international standardization, and integrating promotion of research and development projects. The aforementioned project meets the third part of Japan’s strategy. This project will contribute to promoting international standardization and developing superconductivity markets.

Professor Kozo Osamura at Kyoto University has been appointed as Chairperson of the Superconductivity Technology Study Committee for this project. The project has almost created a steering system. Specifically, the Superconductivity Technology Study Committee will have a Power Generation Subcommittee, SMES Subcommittee, and Transmission and Transformation Subcommittee to promote this project.

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(Yasuzo Tanaka, Standardization Department, ISTEC)

Top of Superconductivity Web21

