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超電導 Web21
Superconductivity

Superconductivity Web21

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The 12th International Superconductivity Industry Summit

The 12th International Superconductivity Industry Summit (ISIS) was held in Karlsruhe, Germany, from September 21 through 23, 2003. Some 30 experts from Japan, the United States, Europe, and other countries attended the summit.

This meeting was held about one month after a massive power failure crippled a large area of the North Eastern and Mid-western United States extending into Canada. This blackout strongly impressed the world afresh of the vulnerability of the modern electric power dependent lifestyle. The superconducting device has very small environmental impact and is small and highly efficient so that it can greatly contribute to enlarging the capacity of the power grid and enhancing its reliability. At the summit, these matters were strongly recognized during many discussions. As a result of the above-mentioned power failure, the need for the enhancement of the power grid reliability has been recognized more strongly than ever in the United States. It was reported in the meeting that the United State's budget for superconducting development will be increased in the next fiscal year.

In the meeting, opinions were exchanged in various areas such as the application of superconductivity to power including the power cable, motor, generator, SMES, FCL, transformer, etc.; the application to medical treatment including the MRI, magnetocardiograph, proton therapy using a cyclotron; superconducting electronics including the SFQ superconducting router, server; and applications to basic science such as the accelerator.

This meeting was distinguished by the participation of South Korea, in addition to Japan, the United States, and Europe. It was announced that South Korea had established CAST (Center for Applied Superconductivity Technology) under the direction of the Ministry of Science and Technology and had designated 2001 through 2003 as the core technology development stage, 2004 through 2006 as the pre-commercial stage, and 2007 through 2010 as the commercial stage. It was also reported that for the next 10 years, South Korea will be conducting research and development in superconductivity over a wide area from power applications to electronics at an annual investment scale of $10,000,000.

The next meeting is scheduled to be held in Jacksonville, Florida, USA, around October 2004.

(Reference 1) the 12th International Superconductivity Industry Summit Communiqué and (Reference 2) the composition of the meeting are attached.

(Reference 1) the 12th International Superconductivity Industry Summit Communiqué

International Summit on Superconductivity foresees major opportunities in solving electric power problems

Technologies also contribute to industrial advances in medical, environmental, transportation and information technology areas

For three days beginning September 21, 2003 high level representatives of the superconductivity industry worldwide mainly representing Europe, the United States, Japan and Korea convened at Forschungszentrum Karlsruhe, Germany at the 12th International Superconductivity Industry Summit to discuss developments in their field. The meeting was held little more than one month after the recent massive blackout in the eastern United States left millions without power and raised international concern on the vulnerability of power grids within the highly connected developed world, so completely dependent upon electricity. This has been further proven by the massive blackouts which happend in Denmark, Sweden and Italy during this September. A challenge before the delegates was to assess the steps necessary to hasten the day when superconductivity can contribute more fully to the more secure delivery of this modern necessity, just as it improves the quality of life in other areas today.

Delegates discussed how recent advances in superconductivity have enabled a wide range of compact, efficient and low-environmental-impact power technologies to boost power grid capacity and reliability that could, with modest support for development and demonstration projects, meet immediate societal needs within this decade. Examples discussed at the conference included controllable underground cables, motors, generators and synchronous condensers, transformers, SMES and fault current limiting devices. These technologies are expected to become critical as electrification and energy growth come into conflict with space limitations and other environmental concerns. In addition, established and emerging applications of superconductivity are already numerous, and impact a broad range of industries. From advanced information technology to medical science, from power application to environmental protection, from basic science to transportation, superconductivity enables an assortment of uniquely capable devices. Delegates heard reports on progress in the construction of the Large Hadron Collider at CERN for High Energy Physics, on the continued health of the MRI market, on the rapidly growing deployment of superconducting cellular phone filters, and on steady progress in qualifying magnetically levitated trains. Large motors for ship propulsion are another promising application in the transportation sector. Magnetocardiography and proton therapy with superconducting cyclotrons are further contributions of superconductivity to medical science. ISIS-12 presentations highlighted the many interdependencies between activities in different disciplines and on-going international co-operations. As in the life sciences and in information technology advances are critically dependent upon investments in enabling technology such as materials science and cryogenics.

The sheer diversity of opportunities may be reason enough for strong public and private support for this cross cutting technology. But power applications remain the primary focus of researchers and funding sources alike, and further sustainable public funding is urgently required to complete the development of cost effective devices able to impact grid reliability. Delegates were heartened to learn that policy makers in the US have been recognizing this, and that increased spending on power applications of superconductivity in the US was anticipated in the coming fiscal year.

NEXT MEETING

ISIS-13 will be hosted by CCAS and is tentatively scheduled for October 2004, in Jacksonville, Florida, USA. The member organizations of ISIS continue to encourage the pursuit of collaborative activities amongst themselves where possible to bring the joint goal of full commercialization of superconductivity ever closer.

(Note) CCAS stands for Coalition for the Commercial Application of Superconductors.
It is a nationwide commercial association for superconductor development in the United States.

(Reference 2) Composition of the meeting

Opening

Opening remarks P. Komarek, Forschungszentrum Karlsruhe GmbH

Keynote Speech R.Penco, Chairman of CONECTUS

Session 1: Current Technological Development-Large Scale Applications

"Big Step to 21st Century's Electric Transmission Network"
R. Hata, Sumitomo Electric Industries, Ltd.

"Status and Perspective of Large Scale Applications"
E. Masada, Tokyo University of Science

"New Perspective on Power Applications of HTS Wire"
J.Howe, American Superconductor Corp.

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"Superconducting Cyclotron-Driver for Proton Therapy"
H.U.Klein, ACCEL Instruments GmbH
"Status and Perspective for Industrial LTS Large Scale Applications in Europe"
G.Grunblatt, Alstom Magnets and Superconductors S.A.
"European Developments in HTS"
H.W.Neumüller, Siemens AG

Session 2: Current Technological Development-Electronics Applications
"Recent Progress of HTS and LTS Devices in Japan"
S.Hasuo, SRL/ISTEC
"Status and Perspectives in the US"
C.Rosner, Cardiomag Inc.

Special Presentation
"Twenty-first Century Frontier Project for Applications of Superconductivity Technology in Korea"
M.Park, CAST

Session 3: Awareness of Superconductivity: Public Relations & Governmental Contacts
"Awareness of Superconductivity in ISTEC"
O.Horigami, SRL/ISTEC
"Influencing Decision Makers: The CCAS Strategic Plan"
D.Andrews, Oxford Instruments Superconducting Technology
"Some Remarks on German & European Funding Policy"
P.Komarek, Forschungszentrum Karlsruhe GmbH

Session 4: Steps toward Stronger International Collaboration
"Industrial Networking for European Research Facilities"
M.Gehring, Babcock Noell Nuclear GmbH
"Experiences with International Cooperation in ISTEC"
O.Horigami, SRL/ISTEC
"Some Remarks on International Collaboration"
C.Rosner, Cardiomag Inc.

(Akihiko Tsutai, Director, International Affairs Dept., ISTEC)

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

Power

Trithor GmbH (November 5, 2003)

Trithor GmbH has received a top ranking in a federally sanctioned review on the advancement of HTS wire technology. The progress of Trithor and the other participants in the peer review process was ranked by a governmental committee based on the company's performance against previously stated goals, goals for the upcoming year, and the level of research integration with national laboratory (or industrial) partners. The committee noted that the HTS technology program at Trithor was "world-class" and a "focused, goal-oriented effort" with a "strong innovative streak fostered by management, leading to a strong team effort in achieving and exceeding stated goals." Trithor has concentrated their efforts on the development of a scalable manufacturing process for HTS wires and is presently considered to occupy the No. 1 manufacturing spot for HTS wires in Europe.

Source:
"Trithor receives Award for HTS Wire Production"
Trithor GmbH press release (November 5, 2003)
http://www.trithor.de/pdf/2003-11-05%20TrithorAchievesTopRankingFromNRW_en.pdf

American Superconductor Corporation (November 6, 2003)

American Superconductor Corporation (AMSC) has announced their second quarter financial results for the three-month period ending September 30, 2003. Net revenues for the second quarter reached US $9.6 million, up 115% from $4.5 million for the same period in the previous fiscal year and up 24% sequentially from the $7.8 million earned in the first quarter of 2003. The net loss for the second quarter was $7.3 million, compared with a net loss of $10.2 million for the same period in the previous fiscal year. Included in the second-quarter net loss is $1.4 million in non-recurring expenses connected with the company's previously planned debt financing. AMSC decided to pursue and completed a public equity offering in place of this debt financing in October 2003. The company issued 5.7 million shares of common stock in a public offering, generating net cash proceeds of $51.1 million. AMSC also received $4.8 million in new orders and contracts during the second quarter. The company's present backlog of orders and contracts totals $82.1 million, approximately $23 million of which should be recognized as revenue over the remainder of fiscal 2004. Interest in AMSC's dynamic reactive power grid stabilization products has increased significantly following the major blackouts that occurred in August and September.

Source:
"American Superconductor Reports Fiscal 2004 Second Quarter and Six-Month Results"
American Superconductor Corporation press release (November 6, 2003)
http://www.amsuper.com/html/newsEvents/news/106785329739.html

American Superconductor Corporation (November 12, 2003)

American Superconductor Corporation (AMSC) has delivered its first SuperVAR (TM) dynamic synchronous condenser to the Tennessee Valley Authority (TVA). The SuperVAR machine is a unique, breakthrough product for stabilizing grid voltages, thereby increasing service reliability and maximizing transmission capacity. Commented Greg Yurek, President and CEO of AMSC, "In the new reality that has emerged following the major blackouts that occurred in the U.S., Italy, and Denmark this summer and fall, the need for utilities to ensure a balance of reactive power on their grids has emerged as an urgent priority. Utilities are looking to the most effective dynamic reactive power grid stabilization technologies, which include industry-leading power electronics-based solutions such as our D-VAR(R) systems and new, high temperature superconductor-based solutions such as our SuperVAR dynamic synchronous condensers, to help them instantly protect their grids and their customers against sub-second voltage fluctuations." SuperVAR machines act as reactive power "shock absorbers", dynamically generating or absorbing reactive power (VARs), depending on the voltage level of the transmission system. The machines can instantly respond to voltage fluctuations, thereby protecting the power grid and electricity customers. The SuperVAR delivered to TVA is installed at an electrical substation serving a steel mill in Tennessee and will be connected to the grid early next year. TVA has already committed to the purchase of five additional SuperVAR synchronous condensers, subject to the successful evaluation and testing of the initial SuperVAR machine.

Source:
"American Superconductor Delivers New, Breakthrough Transmission Grid Stabilization Product To Tennessee Valley Authority"
American Superconductor Corporation press release (November 12, 2003)
http://www.amsuper.com/html/newsEvents/news/106785329744.html

Nexans (November 18, 2003)

Nexans has been awarded a contract to supply the HTS components for the US Department of Energy (DOE)'s US $12-million Matrix Fault Current Limiter (MFCL) project. The prime contractor for the MFCL project is SuperPower, Inc., a wholly owned subsidiary of Intermagnetics General Corporation. The new MFCL device will be based on proprietary technology developed by SuperPower. The MFCL will have a voltage rating of 138 kV and is expected to be the first transmission-level FCL in the world. Nexans SuperConductors GmbH will supply the HTS elements for the device, applying its proprietary and patented melt cast processing (MCP) technique. The contract marks the first time that a European supplier of HTS material will be used in a DOE project. The MFCL should be installed in a utility substation in 2006.

Source:
"Nexans' high-temperature superconductor elements are key to US Department of Energy's $12-million fault current limiter project"
Nexans press release (November 18, 2003)
http://www.nexans.com/medias/fichier_objet/031118/DOE_GB.pdf

National Institute of Standards and Technology (November 21, 2003)

Researchers at the National Institute of Standards and Technology (NIST) believe that next-generation HTS wire may be able to withstand more mechanical strain than initially thought, enabling their use in transmission grid applications. Sufficient strength and resiliency to withstand stretching and bending during power cable fabrication and installation are important practical requirements for HTS wire. The NIST researchers examined the electromechanical properties of second-generation HTS wire produced by American Superconductor Corporation and the Oak Ridge National Laboratory and found that the wire could stretch almost twice as much as previously believed without any cracking of the superconductor coating and almost no loss in the coating's ability to carry electricity. The researchers also found that strain-induced degradation was reversible to a certain degree, once the strain had been removed. The wire's strain tolerance was judged to be sufficiently high for even the most demanding electric utility applications, and the discovery of the reversible strain effect will enable new opportunities for research on

the mechanism responsible for electricity conduction in this class of superconductors. This research was described in the Nov. 17 issue of Applied Physics Letters.
Source:
"Prospects brighten for future superconductor power cables"
National Institute of Standards and Technology press release (November 21, 2003)
http://www.nist.gov/public_affairs/techbeat/tb2003_1121.htm#prospects

MRI and NMR

Varian, Inc. (November 11, 2003)

Varian, Inc. is expanding its range of NMR products to include a new 800 MHz Cold Probe intended for research in the fields of proteomics and structural biology. This product expands upon Varian's existing commercial line of Cold Probes intended for use in lower magnetic field spectrometers for bio-molecular and pharmaceutical research. Varian recently installed an 800 MHz Cold Probe at the National Magnetic Resonance Facility at Madison. The primary users of this product are expected to be academic research laboratories studying bio-molecules, like proteins, nucleic acids, and carbohydrates. High-field NMR instruments enable increased resolution and improved signal spread, allowing larger molecules to be investigated. The introduction of a Cold Probe further improves the sensitivity of NMR spectrometers, allowing the study of many biochemical systems that would otherwise be difficult or impractical.
Source:
"Varian, Inc. Shipping 800 MHz NMR Cold Probes for Proteomics Research"
Varian, Inc. press release (November 11, 2003)
http://www.corporate-ir.net/ireye/ir_site.zhtml?ticker=VARI&script=410&layout=-6&item_id=468651

Material

Superconductive Components, Inc. (November 12, 2003)

Superconductive Components, Inc. (SCCI) has announced their third-quarter financial results for the three-month period ending September 30, 2003. Total revenues for this quarter amounted to US $608,730, down from $863,179 for the same period in the previous fiscal year. Contract revenue increased to $118,020, compared to $68,376 for the same period in the previous fiscal year. This improvement was offset by a reduction in product revenue to $489,710, compared to $794,803 for the same period in the previous fiscal year. Although the ongoing weakness in the U.S. manufacturing sector continued to have an impact on the company's revenues, SCCI has taken steps to improve future product sales by strengthening their relationships with customers. Also in the third quarter, the company received a research contract valued at $518,000 from the U.S. Department of Energy (for a feasibility study on the production of cost-effective, kilometer-length BSCCO 2212 wires for high-field magnets of 12 Tesla and beyond at 4.2 K) as well as an award valued at approximately US $600,000 from the State of Ohio's Third Frontier Action Fund (for the scale-up of manufacturing processes needed to produce materials for lithium thin-film batteries). This income will be used to advance the company's position in the HTS and lithium thin film battery markets. SCCI is also proceeding with plans to move to new facilities in the first quarter of 2004; the

new facilities will enable the company to improve its manufacturing efficiency and response to product demand.
Source:
"Superconductive Components, Inc. Announces Third Quarter Results"
Superconductive Components, Inc. (November 12, 2003)
http://www.sciengineeredmaterials.com/ne/earnings/scci33.htm

Communication

ISCO International (October 24, 2003)

ISCO International has announced their financial results for the third quarter of 2003, ending September 30, 2003. Consolidated net revenues for the third quarter amounted to US $378,000, down from $430,000 for the same period in the previous fiscal year. The consolidated net loss was $1,573,000, compared to $2,806,000 for the same period in the previous fiscal year. The reduction in net loss was mainly due to the Company's ongoing outsourced manufacturing strategy and several other cost-control initiatives. Several delayed product orders should be placed in the second-half of the fiscal year, and a number of customers have already included ISCO International products in their 2004 budgets. The company has also obtained an additional $2 million credit line facility, $1 million of which was immediately drawn. Borrowings and interest on this supplement will be due one year from now.
Source:
"ISCO INTERNATIONAL REPORTS QUARTERLY RESULTS AND ADDITIONAL FINANCING"
ISCO International press release (October 24, 2003)
http://www.iscointl.com/

Basic

National Institute of Standards and Technology (November 20, 2003)

JILA, a joint institute of the National Institute of Standards and Technology (NIST) and the University of Colorado at Boulder, has created a super-cold collection of molecules behaving in perfect unison from a "sea" of fermions. Fermions are inherently difficult to coax into a uniform quantum state; JILA's creation of a "super-molecule" – or Bose-Einstein condensate (BEC) - should lead to an improved understanding of superconductivity. BECs are an unusual physical state where thousands of atoms behave as though they were a single entity, with identical energies and waveforms. This enables them to act as a "magnifying glass" for quantum physics. Several research groups have been working to produce a condensate from fermions. Since superconductivity occurs when electrons (a type of fermion) combine into pairs, the production of paired ultra-cold fermionic atoms could enable researchers to explore the physics underlying superconductivity as well as superfluidity in great detail. In the JILA experiment, a gas of potassium atoms was cooled with lasers and confined to an optical trap. The strength of a magnetic field applied across the trap was then slowly varied to increase the attraction between pairs of atoms, eventually converting most of the fermionic atoms into bosonic molecules. This research appeared in the November 26 online version of Nature. A separate research group at the University of Innsbruck in Austria also reported the creation of a Bose-Einstein super-molecule from lithium fermion atoms in the November 13

online version of Science.
Source:
"NIST/University of Colorado researchers create Bose-Einstein 'super molecule'"
National Institute of Standards and Technology press release (November 20, 2003)
http://www.nist.gov/public_affairs/releases/super_molecule.htm

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

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Feature Articles on Superconducting Digital Device
- Prospects for single-flux-quantum MPU technology -

Akira Fujimaki, Associate Professor
Graduate School of Engineering
Nagoya University

Semiconductors, particularly CMOS-LSI, have continued to increase their operating frequency and scale of integration according to the firm guiding principle of the scaling law. At present, however, a big problem attributable to the guiding principle itself has arisen. The major concern is the generation of heat from LSIs. It is extremely difficult to compose a CMOS-LSI of 20 GHz or more even by reducing the consumption of electric power and improving the cooling efficiency because of the heat generation. Wiring is also a stumbling block to increased speed. As a matter of fact, the delay time of a long wire like a bus increases rapidly as it is miniaturized, and it has already come close to the clock frequency.

The single-flux-quantum (SFQ) circuit is a unique circuit, including wiring, provided with high speed, low power consumption, and a high degree of integration. These features mean that the SFQ circuit has great advantages as a component device of an MPU that operates at several tens of GHz or more. From this point of view, the United States has blazed a trail in conducting research on the SFQ-MPU and has designed and trial manufactured the FLUX-1 (an 8-bit MPU).

Japan is also working toward the development of the SFQ-MPU in concert with universities including experts in architecture with support from NEDO. Considering that the SFQ cannot display its high performance without being matched to a room-temperature peripheral circuit with the appropriate bandwidth, the high-speed performance of the SFQ circuit was used to simplify the circuit in the present research. This concept is called CORE (COmplexity REduction).

With an MPU whose operating frequency exceeds 50 GHz, the adjustment of timing between data for arithmetic logic operations becomes difficult. In addition thereto, for parallel transmission, timing errors between bits within data must not be ignored. The bit-serial or bit-slice data processing method is an effective solution to these problems. In CORE 1 currently under research, a very compact MPU is composed using bit-serial data processing. Fig. 1 shows a photograph of CORE 1 in which the circuit operates at 16 GHz. In 2004, CORE 1 β will be developed, which will be made more efficient by mounting two or more ALUs. CORE 2 based on a new architecture and CORE 3-MPU with two or more ALUs mounted on one chip will be developed in 2005 and 2006, respectively. The computer composition method of CORE 3 is scalable. If the chip density becomes greater and packaging technologies such as MCM are developed, the performance of CORE 3 may exceed that of the semiconductor MPU.

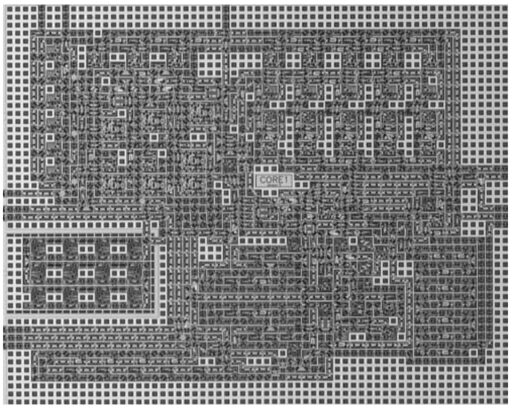

Fig. 1 Microphotograph of the CORE 1-MPU
The circuit is manufactured through NEC's standard process.

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Feature Articles on Superconducting Digital Device

- The development of superconducting SFQ memory for servers has been started -

Nobuyuki Yoshikawa, Associate Professor
Graduate School of Engineering
Yokohama National University

We are now developing an SFQ server in the NEDO "low-power consumption type superconducting network device development" project. One of the most important element circuit technologies in order to realize an SFQ server, is memory. This is because even if a very high-speed microprocessor is developed, unless the access speed between the processor and memory is sufficient, high-speed data processing is not possible. As a matter of fact, the clock speed of a semiconductor microprocessor has reached several GHz, but the memory access time of an SRAM is several ns. Compensating for this weakness is an important issue.

Various types of superconducting device memories using latch type circuits have been developed so far, but they are not suitable for our SFQ server. This is because signals need to be converted into level logic and the conventional memory is not efficient enough in speed or power consumption. On the other hand, although some suggestions about memories using SFQ circuits have been made so far, circuit architecture based on the two-dimensional array of memory cells has been considered difficult because SFQ circuits are low in driving force, which is a characteristic peculiar to SFQ circuits.

In order to solve the above problems and realize high-speed, large-capacity SFQ memories, we started developing random access memory using an SFQ shift register array and succeeded in demonstrating the high-speed operation of a prototype system. The conceptual diagram of our SFQ memory is shown in Fig. 1. The memory consists of an SFQ shift register array and address decoders. Data is stored in each shift register as bit-serial data word by word. Since the clock frequency can be raised to the limit of the SFQ circuit by this method and the memory structure is simple, the degree of integration is high. Also, there is good compatibility with an SFQ server in terms of data format. The decoder, which is composed of one-to-two switch trees, enables large-scale memory to provide high access speed.

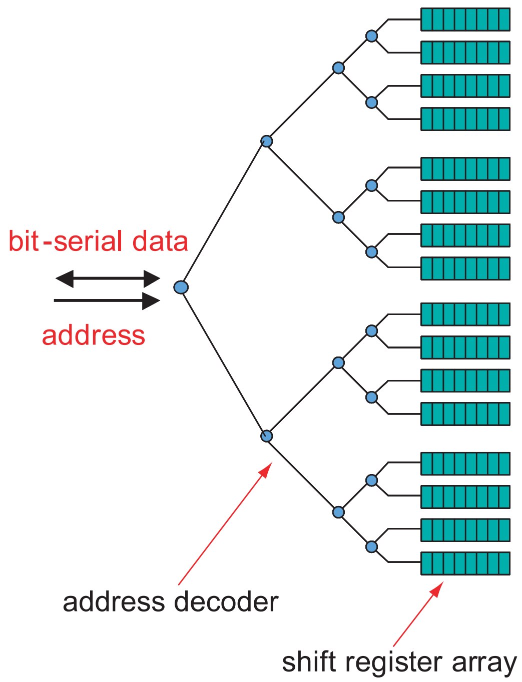

Fig. 1 Conceptual diagram of the SFQ memory
It consists of SFQ shift registers and address decoders.

The photo of the 4 x 8-bit SFQ memory chip which has been experimentally manufactured is shown in Fig. 2. The CONNECT cell library jointly developed by Nagoya University, SRL,

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Communications Research Laboratory, and Yokohama National University was used for designing the SFQ memory. NEC's Nb standard process was used to manufacture the integrated circuits. The total number of junctions on the circuits including the peripheral circuits for the high-speed test, was 2,300 and a chip measures 1 mm x 2 mm. We checked the write/read operation into and from an arbitrary address register at 20 GHz in the on-chip high-speed test. We are aiming to make this memory large and realize a 1-kb system within one year.

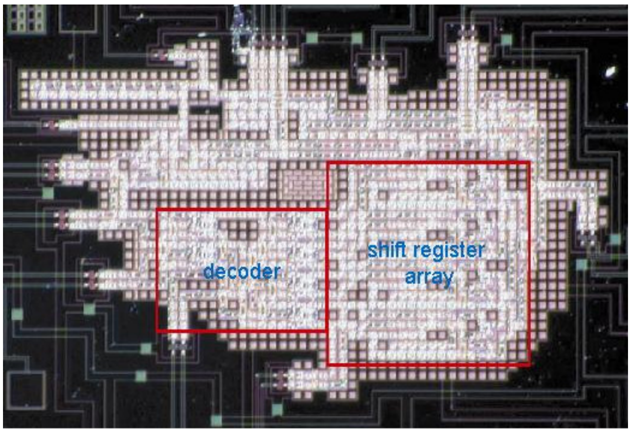

Fig. 2 Photo of a chip with a 4 x 8-bit SFQ memory
The main body of the SFQ memory is outlined by two black line border.
The remainder is the peripheral circuit to conduct the high-speed tests.

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Feature Articles on Superconducting Digital Device

- Progress Report on the Technical Development of a 2 x 2 Packet Switch for Routers -

The Low Temperature Superconducting Device Laboratory, Division of Electronic Devices, Superconductivity Research Laboratory of ISTEC has been developing a packet switch system using superconducting SFQ technology, as a Superconductors Network Device Project under contract to NEDO.

Internet traffic loads are increasing at a rate faster than Moore's Law. While link capacities can be easily increased by bundling optical fibers, it is difficult to sustain the packet-switching throughput of a node because of problems of the processing speed, power consumption, and packaging. SFQ circuit technology has characteristics of high-speed operation and low power consumption, so it is expected to solve the current router's problem.

As a first step, we designed, fabricated and tested a 2 x 2 packet switch circuit, which is a basic, elemental circuit of the packet switch. The 2 x 2 switch circuit can forward two input packets to the destinations. Because it is a random logic circuit, we constructed a top down cell base design environment on the basis of Cadence's CAD. The cell library, called CONNECT, has been developed in collaboration of Nagoya University, Yokohama National University, Communications Research Laboratory, and SRL. We also developed a new automatic circuit placement and routing tool. We designed the 2 x 2 switch circuit by using the tool. The fabricated circuit using the NEC standard process is shown in the figure below. As a result of the operational test using the CONNECT on-chip circuit test block, we verified successful operation up to 40 GHz. This is the world's fastest packet switch circuit.

We have been developing a wiring technology to change the wiring between circuits from the current Josephson transmission line (JTL) to a passive transmission line (PTL) such as a micro-strip line in order to enlarge logic density. This technology will reduce the power consumption, and decrease the operation delay. With these design technologies the switch scale can be expanded easily without performance degradation.

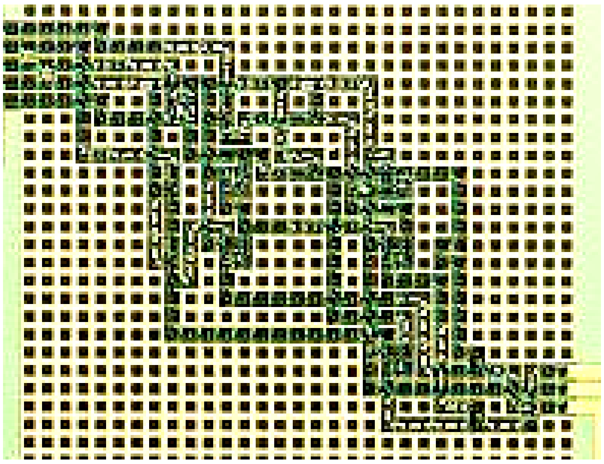

Fig. 2 x 2 crossbar switch

(Shinichi Yorozu, Low Temperature Superconducting Device Laboratory, Division of Electronic Devices, SRL/ISTEC)

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Feature Articles on Superconducting Digital Device

- Expectation for High-Speed Operation Demonstration of ADC by a 200-Junction Class Circuit -

Oxide-based SFQ devices require high-level thin film formation technology, but the circuit manufacturing technology is not mature yet. Therefore, the same degree of integration as that of Nb-based SFQ circuits is difficult to obtain. On the other hand, a high operating frequency can be realized because oxide-based devices can be operated at a high temperature of 30 K or more and a high output voltage junction is easily obtained. An analog-to-digital converter (ADC) modulator circuit manufactured by Hitachi, Ltd. using a lamp edge junction provided an operating frequency of 100 GHz at a temperature of 20 K. An ADC comparator circuit manufactured by SRL provided an operating frequency of 80 GHz at a temperature of 40 K. These results show the possibility of high-speed operation of oxide-based devices.

In the "low power consumption ultra high speed signal processing technology development" project started in fiscal 2003, we aim to manufacture more functional circuits using oxide-based SFQ circuits and demonstrate high-speed operation. Among others, ADC is a circuit where high-speed operation leads to high performance. The higher the sampling frequency is, the higher the ADC bit accuracy becomes. If an ADC modulator is manufactured with oxide-based SFQ circuits, analog input signals can be converted into digital SFQ rows at a sampling frequency of 100 GHz. Note that the modulator output is one bit. In this case, the ADC modulator must be provided with a digital filter circuit to increase the number of bits with the frequency lowered. Otherwise, increasing the number of bits must be left up to a semiconductor circuit with the frequency lowered. The adoption of the latter configuration can be practically realized with a relatively low degree of integration. We are pursuing our research, aiming to develop an ADC circuit in which a demultiplexer to reduce the frequency is connected at the rear stage of the modulator, with a high-frequency SFQ row output in parallel.

The realization of the ultra high-speed ADC is required in such fields as radio communications and instrumentation. Particularly, base stations for the fourth-generation broadband cellular phone, where a transmission rate of 100 Mbps is anticipated, require a large data processing capacity which far exceeds that of the current semiconductor technology. For this reason, high-speed performance of 14 bits or more at several hundred MHz is needed for the ADC. It is also necessary to make oxide-based devices that deliver high-speed performance to the full in order to realize the fourth-generation broadband transmission.

(Yoshinobu Tarutani and Keiichi Tanabe, Division of Electronic Devices, SRL/ISTEC)

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Feature Articles on Superconducting Digital Device
- Progress Report on Research of the Solid-State Quantum Bit -

Jaw-Shen Tsai, Research Fellow
NEC Fundamental Research Laboratory

Recently, the solid-state-device based quantum bit (qubit) has been realized mostly by the superconducting Josephson qubit and semiconductor quantum dot qubit. I have briefly described the latest experimental developments of the research in these fields below.

The Josephson qubit has degree of freedoms in charge and phase, and several types of Josephson qubits have already been realized at a level of one bit, taking advantage of the two kinds of degree of freedoms. To be more specific, they were: NEC's electric charge qubit in 1999; the University of Kansas' phase qubit in 2002; Saclay's qubit in 2002, where the degree of freedom for charge and that for phase coexisted; NIST's phase qubit in 2002, etc. The University of Kansas' and NIST's phase qubits created two or more different energy states with the same phase in a current-biased single Josephson junction where phase was the good quantum number. These experiments were conducted using two of these states to construct a qubit. Subsequently, in 2003, Delft University of Technology realized a different type of phase qubit (Science, 229, 1869, 2003). This was a three-junction SQUID based qubit device. Since it had an inductance loop, a global minimum energy condition existed in the phase condition. Two such minimum energy states were prepared by adjusting the external field and the eigenstates, consisting of bonding and anti-bonding states of the these two states, was used as the basis of a qubit. This type of qubit was characterized by the fact that it was accompanied by a macroscopic screening current induced in the superconducting loop, as well as by a macroscopic superconducting phase.

I have described experiments on one- qubit control so far. To construct a quantum computer, however, a two-qubit quantum logic gate that created entanglement was needed. Recently, there has been a breakthrough in a two- qubit experiment at our NEC's/ RIKEN team. We have succeeded in an experiment where quantum oscillations were simultaneously created at two electrostatically coupled charge qubits (Nature, 421, 823, 2003). As a result, there was a beating between the two quantum oscillations was observed. The analysis of the results proved that a quantum entanglement had been generated. Further more, based on the similar system, we have created a quantum logic gate that performs a controlled-NOT (CNOT) operation (Nature, 425, 941, 2003). In a system with electrostatically coupled two single-Josephson-junctions qubits, creation of entanglement was inferred from an energy domain experiment. (Science, 300, 1548, 2003). The fact that a quantum logic gate and the creation of entanglement became a reality in this manner has brought us one step closer to the realization of a solid-state universal quantum gate necessary to process quantum information.

On the other hand, there were progresses reported in the semi-conductor qubit. NTT succeeded in an experiment in the control of a semiconductor qubit in which two quantum dots were coupled (cond-mat/0308362). In this system, the basis of the qubit were states where either of the two dots had surplus electrons. The decoherence time was several ns, which was the same level as that of a typical superconducting charge qubit. University of Michigan succeeded in an experiment to drive an interstate transition which can be used for a quantum logic gate. This was done with a quantum dot system where bi-exciton states were involved (Science, 301, 809, 2003).

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Feature Articles on Superconducting Flywheel
- Prospects for the Development of the Superconducting Flywheel -

Flywheel electric power storage is a system in which electric energy is stored as rotational energy by rotating a flywheel and energy is removed with a generator as needed. It is promising as a load leveling system or a load fluctuation compensation system to use electric power effectively. The realization of low-loss, large systems is expected. Also, there are increasing needs for uninterruptible power systems (UPS) essential for semiconductor manufacturing plants, data centers, and other factories. At present, flywheel UPS units with a storage capacity of 1 to 5 kWh using mechanical and magnetic bearings have been commercialized. A large data center or a large plant requires a power supply of at least several minutes, which means that it needs a UPS unit with a storage capacity of several tens of kWh or more. In addition, reduced rotational loss during standby is strongly desired. It has been impossible up to now to make the unit large and at the same time reduce the rotational loss by using conventional bearings. The bulk superconductor bearing , which can solve these two problems at the same time, has made its debut. After passing the development stage of small systems, with national support, Japan, the United States, and Germany are developing 10 to 30-kWh-class flywheel power storage technology using superconducting bearings.

The "R & D of Superconducting Bearing Technology for Flywheel Energy Storage," a NEDO project in our country, has been commissioned to ISTEC. ISTEC sub-commissioned parts of the project to five companies and is carrying out this project in concert with these companies to develop the basic technology, aiming to achieve low loss and large size. To be more specific, ISTEC is developing the constituent technologies of radial-type 100-kWh-class superconducting bearings advantageous for making the system large, manufacturing 10-kWh-class power storage equipment to verify the system, and evaluating the operational tests. Three and a half years have passed since Phase II was started in the year 2000. For the constituent technologies of bearings, we have almost achieved our initial goals concerning the loading force (the force to support a rotor), and rotational loss. We also have the prospect of solving the problem of the fall of the rotational axis with time, which is peculiar to superconductivity.

For 10-kWh-class operational test equipment, at the beginning, rotating a heavy flywheel stably at a high speed was a big challenge for us. We succeeded in rotating a 400kgr flywheel rotor up to 12,000 rpm using a rotation test equipment employing magnetic bearings. We have the prospect of rotating a flywheel at a higher speed. Ishikawajima-Harima Heavy Industries Co., Ltd. is now manufacturing a test operation equipment under commission from ISTEC. After the plant test, we are planning to conduct repeated long-term operational tests over the next fiscal year. at Matsuyama FW Research Center of Shikoku Research Institute Inc. We will carry out superconducting bearing tests, rotational loss characteristic tests, evaluation of loss in each section and efficiency, vibration stability tests of rotation axis, etc. We aim to clarify the problems the system has, with a view to commercializing it. A successful 10-kWh-class operational test will be proof of the world's first superconducting flywheel energy storage on an actual machine level and also a big step toward the commercialization.

(Naoki Koshizuka, Deputy Director, Morioka Laboratory for Applied Superconductivity Technology, SRL/ISTEC)

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Feature Articles on Superconducting Flywheel
- Technical Development and Prospects for Ultra High-Speed Flywheels -

Osamu Saito
Technical Research Laboratory
Machine Element Department
Ishikawajima-Harima Heavy Industries Co., Ltd.

The flywheel electric power storage equipment stores electric energy as rotational energy by rotating a flywheel. Since the stored energy is proportionate to the weight of the flywheel and the square of the RPMs, it is effective to rotate the flywheel at a high speed in order to increase the amount of energy stored.

Fig. 1 shows the 10-kWh-class operational test equipment developed in the NEDO project. A CFRP (Carbon Fiber Reinforced Plastic), which can resist the forces at high RPMs, is used for the main body of the flywheel (Dia. 1m). Also, magnetic bearings are used to reduce the vibrations of the axis of rotation. It is taken for granted that the main body of such a flywheel resists high-speed rotation. It is a challenge for us to establish the manufacturing technologies to prevent the main body of a flywheel from being deformed unevenly by strong centrifugal forces. Uneven deformation would throw the flywheel out of balance and disable high-speed rotation. In addition, technology to reduce rotational losses caused by magnetic bearings, which would lead to decreased storage efficiency, and technologies to stabilize the vibration at high-speed rotation with the help of magnetic bearings are major challenges.

In order to solve these challenges, we developed the manufacturing and machining technology of the main body of a large flywheel. For magnetic bearings, we also succeeded in rotating a flywheel at up to 12,000 rpm on rotation control test equipment, by applying the zero-power control developed by Professor Nonami of Chiba University. We now have the prospect of rotating it at high speeds.

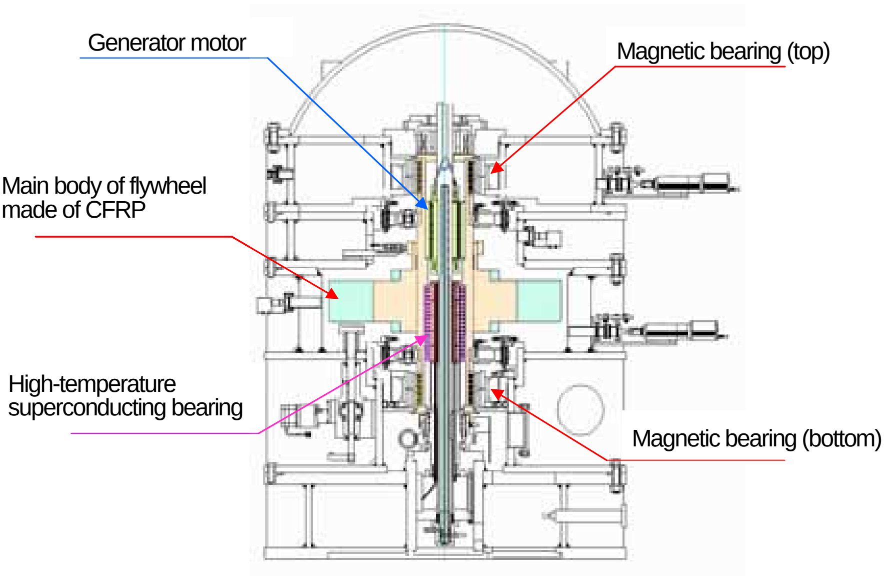

Fig.1 10-kWh-class operational test equipment

We will be carrying out a shop test for the 10-kWh-class operational test equipment and also conduct a field test at the Shikoku Research Institute Inc. to clarify the problems the system has, with a view to commercializing the system.

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Feature Articles on Superconducting Flywheel

- Progress Report on the Technical Development of the Superconducting Bearing -

Fumihiko Ishikawa, Manager
Load Leveling and Power Applied Technology Research Division
Shikoku Research Institute Incorporated

The development of the superconducting bearing for flywheel electric power storage equipment in which we can make the most of its characteristics, that is, non-contact, low loss, is being conducted as a national project and in other projects.

The superconducting bearing obtains a levitation force through the magnetic flux pinning force of a high-temperature superconductor, with the high-temperature superconductor and permanent magnets facing each other. There are two ways of making them face each other: the axial type (thrust type) in which the superconductor and permanent magnets face each other horizontally and the radial type in which both of them face each other cylindrically (See Figs. 1 and 2). In either case, the levitation force is roughly proportionate to the facing area of the superconductor and permanent magnets. Therefore, the facing area needs to be increased by making the superconducting bearing larger in order to support heavier matter. In this case, there is no choice but to make the bearing diameter larger for the axial type. For the radial type, it is possible to make the diameter and axis longer. The limit to which the diameter can be made large depends on the anti-centrifugal force of permanent magnets installed on the rotation side. Axial types, which are relatively easy to manufacture and clear and simple in principle, are often used on the laboratory level, but in the national project radial types (Fig. 2) are under development because eventually the system needs to be made large.

The levitation capacity of a radial type superconducting bearing has reached a maximum of 10 N/cm^2 per facing area of the superconductor and permanent magnets. Look at the radial type shown in Fig. 2. In a 10-kWh-class flywheel bearing currently under development, the outer diameter of the cylindrical superconductor is 12 cm and its height is 30 cm. It has the capacity to support a maximum load of 1 ton. In reality, since allowances need to be made for the levitation force, the flywheel bearing is designed to support a 400kg rotor.

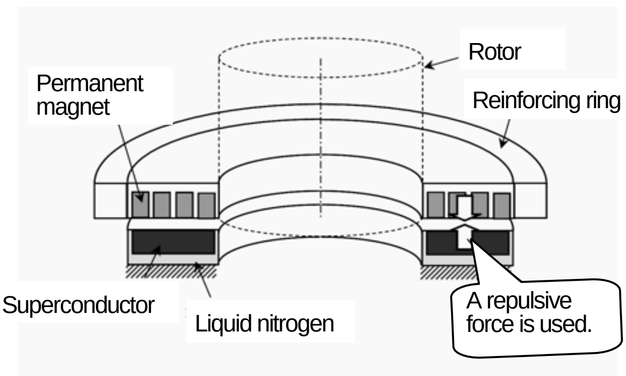

Fig. 1 Axial-type superconducting bearing

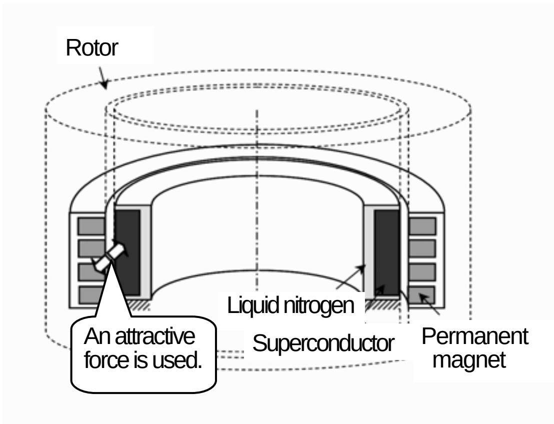

Fig. 2 Radial-type superconducting bearing (outer rotor type)

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In the project, the development of superconducting bearings for a 100-kWh-class flywheel was started as the next step. In the outline design, the outer diameter of the cylindrical superconductor is about 20 cm, which is a size larger than that of superconducting bearings for a 10-kWh-class flywheel. A partial module with the axial length being 10 cm in the exact size is now being trial manufactured. When this is completed, the superconducting bearing technology to support a several-ton-class flywheel should be established.

Incidentally, although a superconducting bearing is a non-contact component, a hysteresis loss in a superconductor due to uneven flux in the rotation direction of a permanent magnet or mechanical vibrations will be produced in the actual superconducting bearing, resulting in rotational loss. The rotational loss which is converted into the coefficient of friction of a mechanical bearing is of the order of 10^{-5} to 10^{-6}. It has been confirmed that the coefficient of friction of a superconducting bearing is incomparably smaller than that of a mechanical bearing.

As has been discussed, the development of superconducting bearings is proceeding to a step where they support a 1-ton-class rotor. It may safely be said that the development is making steady progress toward commercialization.

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Feature Articles on Superconducting Flywheel

- Present Status of Bulk Superconductors for Superconducting Magnetic Bearings -

Koji Matsunaga
Safety Research Group
Nuclear Research & Training Center
Nuclear Power Division
Shikoku Electric Power Co., Inc.

In the NEDO project "Research and Development of Superconducting Bearing Technologies for Flywheel Energy Storage System," outer rotor type radial superconducting magnetic bearings, composed of a rotor of a permanent magnetic circuit and a stator of a superconducting bulk assembly, is studying. This report describes the progress of the development of Y-based superconducting bulks, which are used for the bearing stator.

1. Y-based bulk superconductors for 10 kWh class flywheel bearings

The Y-based bulk superconductors used in the superconducting magnetic bearings for 10 kWh class operational test equipment, were produced by circumferentially dividing a cylinder having an outer diameter of 123.2 mm, an inner diameter of 93.2 mm, and a height of 60 mm into 8 equal parts, thus resulting in bulks shaped like Japanese roof tiles. On the basis of the results of measurements conducted until fiscal 2002, of the trapped magnetic field distribution and the repulsive force of 52 roof-tile-shaped Y-based bulk superconductors, we selected 40 bulks having good performance and manufactured a stator for the bearing. That is, we adhered and fixed to the inside of a cylindrical cryostat of the stator, with a cylinder composed of 8 such roof tiles piled in five tiers. We set temperature sensors in the stator too. Fig. 1 shows the completed unit and the liquid nitrogen immersion test.
Subsequently, the bearing stator was sent to Ishikawajima-Harima Heavy Industries Co., Ltd., which was in charge of assembling the 10 kWh class operational test equipment. The assembly, adjustment, and other operations are now under way.

After the assembly is completed

Liquid nitrogen immersion test

Fig. 1 Manufacture and test of a bearing stator for 10 kWh class operational test equipment

2. Y-based bulk superconductors for 100 kWh class flywheel bearings

We are evaluating the performance of Y-based bulk superconductors having the size and shape (See

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Fig. 2) as those needed for superconducting magnetic bearings for 100 kWh class flywheels. Fig. 3 shows an example of the trapped magnetic field distribution at the temperature of liquid nitrogen (the distance between the magnetic field sensor and the bulk superconductor is 1 mm). A favorable characteristic has been obtained.

A bearing module will be manufactured and tested, and the performance of the bearing will be evaluated.

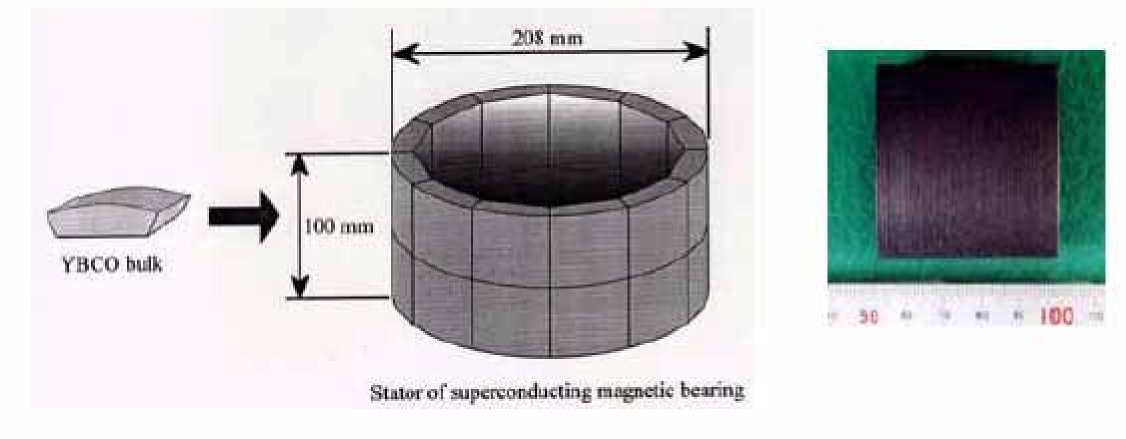

Fig. 2 Y-based bulk superconductor for a 100 kWh class bearing

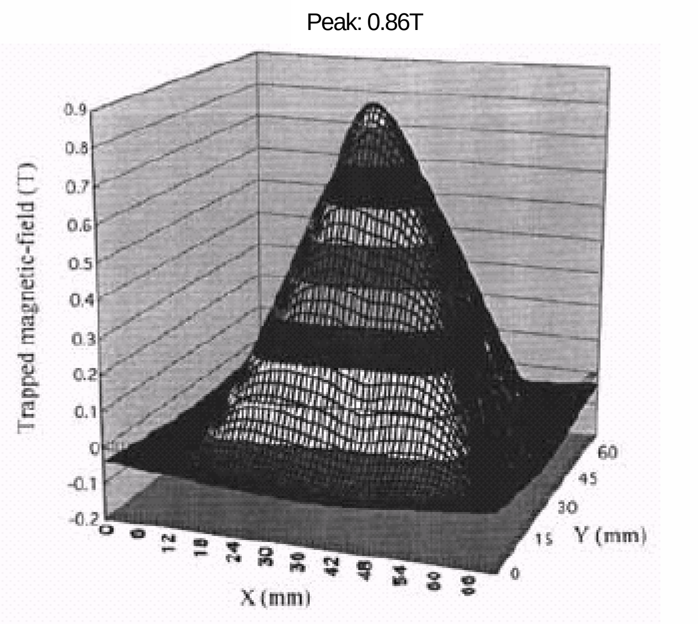

Fig. 3 Trapped magnetic field distribution of a Y-based bulk superconductor for a 100 kWh class bearing

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Feature Articles on Superconducting Flywheel
- Prospects for the Flywheel Market -

Satoshi Morozumi
Energy Policy Research Department
Mitsubishi Research Institute, Inc.

Flywheels currently on the market can be roughly divided into two groups: large flywheels based on hydraulic turbine generator technology and small flywheels using high-speed rotation technology by the help of conventional magnetic bearings. Large flywheels are being used to supply pulse power for JT-60 of the Japan Atomic Energy Research Institute, to stabilize the DC voltage of overhead wire for the Keihin Electric Express Railway Co., Ltd., and to absorb system disturbances caused by a fluctuating load in Okinawa. Small flywheels, which have been springing into wide use recently, are mainly used to prevent voltage sags and power outage.

Western manufacturers in particular are presently broadening their market reach in small flywheels. For example, several American companies including Active Power and Beacon and some European companies such as Pillar and Urenco have entered the market. Some Japanese start-up companies have also gone into business. Currently, the domestic market is dominated by foreign companies having agencies in Japan.

The market of flywheels for enhancing the quality of power has rapidly grown in 2000 and 2001. Pillar and Active Power are expanding their sales in the world market so much that their sales are equal to the market size of the UPS of 100 MVA or more for the same period in Japan. The sales of flywheels in 2002, however, when the IT slump was serious, were below the 2001 level as would be expected. If IT-related business proceeds to the next phase, the sales of flywheels are most likely to show growth again. Flywheels, which have no lead accumulators, are easy to maintain and do not cost much in later years. Since the flywheel's inertia can start an emergency generator during a power failure, the flywheel will be useful where recovery from a power outage is unpredictable. This function is an advantage.

A calculation of the flywheel market done in the past showed that the market size in the backup market related to data centers will be 25 billion yen in 2010 if Japan's IT industry grows steadily and the flywheel replaces the battery-type UPS in the UPS market. The calculation was done on the assumption that the unit price of a flywheel was 100,000 yen/kW. Existing buildings are often remodeled into data centers. For this reason, it would be important that an existing building has been designed so that a flywheel can be installed.

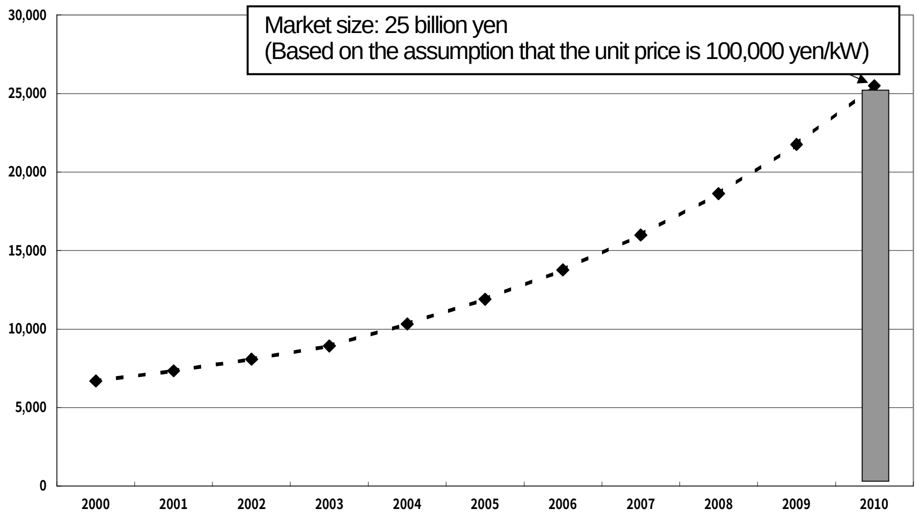

Fig. Growth curve of the flywheel market up to 2010

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Feature Articles on Standardization

- Prof. Kozo Osamura Awarded the prize of the Minister of Economy, Trade, and Industry -

Professor Kozo Osamura of Kyoto University, was awarded the prize of the Minister of Economy, Trade and Industry on October 14, 2003 for his meritorious services to industrial standardization projects in the superconductivity field. The conferment ceremony was performed by Mr. Hiroshi Nakagawa, the Director-General of the Industrial Science and Technology Policy and Environment Bureau of the Ministry of Economy, Trade and Industry, who acted as a proxy for Mr. Shoichi Nakagawa, the Minister of Economy, Trade and Industry, at the start of a “National Conference on Standardization and Quality Control” at the JA Hall of the JA Building in Ohtemachi. In this conferment ceremony, 30 persons who have provided distinguished services to industrial standardization projects and four organizations and one company which have done meritorious services to industrial standardization projects also received awards. Additionally, the Japanese Standards Association’s Standardization Literature Prize and was awarded to four persons and the Standardization Contribution Prize to one organization.

Professor Osamura has rendered great services in the superconductivity field for 17 years since 1986. He chaired the superconductivity standardization committee in our country and also the domestic technical committee for IEC (International Electrotechnical Commission)/TC90 (superconductivity) International Superconductivity Standardization. He also served as the IEC/TC90 WG5 combiner, IEC/TC90 WG2 co-combiner, and chairman of the JIS draft preparation committee to create industrywide standards for superconductivity, maintain the standards, and incorporate them into superconductivity-related products. The conferment of this prize is a credit to all the persons concerned in the standardization of superconductivity. We would like Professor Osamura to continue to render all possible assistance.

Professor Osamura has offered his congratulations as follows:

It is an unexpected honor to have received such a great prize. Come to think about it, the superconductivity standardization work in Japan started as a task of the new material standardization research committee for power substitutes for petroleum /superconductivity material subcommittee, commissioned by the Agency of Industrial Science and Technology, at the New Material Center affiliated with the Osaka Science and Technology Center in 1986. Subsequently, the TC90

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(superconductivity), a technical committee for the International Electrotechnical Commission (IEC), was established in 1990 and our country hosted the committee. A domestic technical committee came into being with Mr. Yasuji Sekine appointed chairman. So far, one standard for technical terms and 12 standards for tests have been approved as international standards on the basis of the original draft submitted by the relevant agencies of our country. On the basis of the international standards, five JIS standards came into existence. I owe such a great success to all the committee members engaged together in the standardization for superconductivity for a long time and the utmost efforts of the secretariat.
I think this award should be shared by all the people concerned. Superconducting materials are a key to the development of state-of-the-art technologies in various fields such as energy, information processing, space, medical treatment, etc. They are the most important clue to the development of industry through the 21st century. I have renewed my determination to contribute to future industrial development as much as possible through my standardization work. Please accept this modest speech as an expression of my gratitude.

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(Yasuzo Tanaka, Editor)

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Feature Articles on Standardization

- Superconductivity in Standardization Strategy -

Akio Iwanaga, Director
Standardization Office for Industrial Infrastructure
Standards Development and Planning Division
Industrial Science and Technology Policy and Environment Bureau
Ministry of Economy, Trade and Industry

The TBT (Technical Barriers to Trade) agreement that came into effect in 1995 and the Agreement on Government Procurement stipulate that member countries are obliged to use laws, standards, and government procurement standards based on international standards. The acquisition of certification of international standards such as ISO and IEC has an influence big enough to control the world market.

For this reason, the competition for ISO and IEC certificates has become keener among countries. There is a polarization particularly between the European bloc and the non-European bloc including the United States and Japan in some technical fields such as the pressure vessel and welding. In some cases, upper committees such as TMB have arbitrated differences between the two blocs. Under these circumstances, a concept of “Global Relevance” has drawn attention in ISO and IEC recently. This concept aims to develop globally acceptable international standards; it is deeply regrettable that existing standards have been developed under the initiative of Europe. Development of performance standards and essential differences in climates and other conditions should be incorporated in international standards. The basic rule has already been decided, and details are now under study. It is important for our country to continue making efforts to cope with international standards, using this new system, by means of strategies of getting our own technology to be adopted as international standards or at least preventing our own technology from being excluded from international standards.

Next, I will move on to domestic trends. Firstly, strengthening industrial competitiveness has been ranked as an important policy goal. It is well known that the government announced the “Industry Discovery Strategy” last December and the “Intellectual Property Strategy” this June. Of special note is their touting of international standardization as their policy tool. The government has proposed the view with respect to the “intellectual property strategy” that even if excellent research and development results are produced and patents are taken out, unless the relevant technology is incorporated into international standards, the technology will not be put to practical use in the world market. The government has also emphasized that we should undertake an integrated promotion of research and development, acquisition of intellectual property rights, and standardization.

In response to these internal and external conditions, the Ministry of Economy, Trade and Industry is preparing a tool to step up its commitment to standardization in R&D projects conducted by research and development institutions, in addition to a conventional support tool for international standardization by means of alliance with Asia. Also, in the JIS system, aiming at the acquisition of international standards, the government is going to improve international standards proposition routes using forum standards and to establish a system to turn draft standards into JIS standards promptly and efficiently this November. Furthermore, the government has decided to formulate an action plan, by next February, in which medium and long-range international standardization strategies by technical fields will be put together.

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Let us turn our eyes to the international standardization in the superconductivity technology field. In IEC, TC90 is working energetically. Our country has hosted a TC and chaired six WGs, and 13 IEC standards proposed by Japan have already been set up. Taking the above-mentioned internal and external standardization conditions into consideration, Japan needs to take action such as actively submitting proposals for international standardization of products as well as test methods so that our superconductivity technology can acquire international market share.

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Feature Articles on Standardization

- Present Status and Prospects for Standardization in Superconductivity -

1. Environment surrounding standardization in superconductivity

The IEC (International Electrotechnical Commission)/TC90 (superconductivity), which was hosted by our country, has been playing a key role in promoting activities for standardization in superconductivity in our country for 17 consecutive years. Thirteen standards for IEC and another five for JIS have already been issued. Japan is contributing to the superconductivity-related industry as well as the development of superconductivity-related technology. During this period, as superconductivity markets such as MRI and NMR slowly develop, the environment surrounding standardization in superconductivity will be changing from research and development to technical development and to cultivation of the market. Against the backdrop of this environment, it is essential to review the strategies of the activities for standardization in superconductivity and select standardization targets, turning our eyes to related markets, too.

2. Three main pillars of strategies for standardization in superconductivity

For superconductivity standardization strategies in our country, activities for basic standards such as existing superconductivity-related term standards and test method standards were reviewed. The following three main pillars based on Japan's standardization strategies were confirmed in 2001.

(1) Securing compatibility in the common market in the superconductivity application field
(2) Promoting international standardization activities conducted mainly by IEC/TC90
(3) Promoting standardization activities and research and development projects in a unified way

3. Results of standardization activities obtained so far

The following 13 IEC standards and five JIS standards have been issued through the superconductivity standardization activities for 17 years.

(1) 13 IEC standards
 (a) One standard for superconductivity-related terms: IEC 60050-815
 (b) 12 standards for test methods: IEC 61788-1, IEC 61788-2, IEC 61788-3, IEC 61788-4, IEC 61788-5, IEC 61788-6, IEC 61788-7, IEC 61788-8, IEC 61788-10, IEC 61788-11, IEC 61788-12, and IEC 61788-13
(2) One IEC standard under deliberation: IEC 61788-9: Trapped magnetic flux density test method of superconducting bulks
(3) Five JIS standards
 (a) One standard for superconductivity-related terms: JIS H 7005
 (b) Four standards for test methods: JIS H 7301, JIS H 7302, JIS H 7303 and JIS H 7304

Incidentally, these JIS standards were decided after the Japanese Industrial Standards Committee's deliberations on draft national standards were prepared, in conformance with the IEC international standards, by the JIS draft preparation committee.

4. Future five standardization activities

Future superconductivity standardization activities can be narrowed down to the following five points.

(1) Abolishment, revision, and supplement of existing standards, or what they call maintenance activities

A maintenance team (WG) for the nine standards of IEC 61788-1, -2, -3, -4, -5, -6, -7, -10, and -12 was organized in spring 2003 and the maintenance activities have already begun. Comments have been offered on the seven standards of IEC 61788-1, -2, -3, -4, -6, -7, and -10 from Japan, the United States, China, Italy, and Poland.

(2) Promotion of standardization suitable to the superconductivity market

The present superconductivity market is steadily developing in some limited fields such as MRI and NMR and has already reached 350 billion yen. Low-temperature superconducting materials have been mainly applied to these fields. We have high expectations for market expansion in the near future, which will accompany the application of high-temperature superconducting materials.

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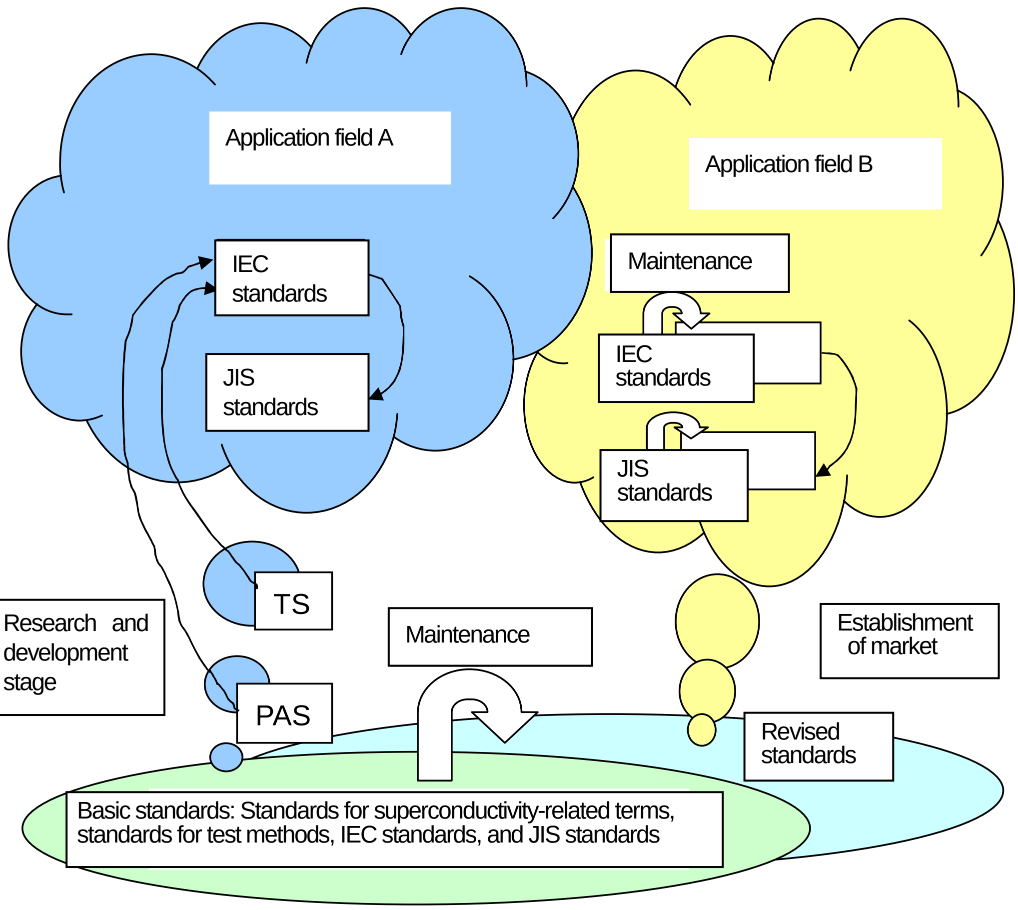
(3) Promotion of IEC/TC90 activities that play an important role in international standardization
IEC/TC90, hosted by Japan and chaired by the United States, is composed of 13 member countries with the right to vote (P members), that is, Australia, China, France, Germany, Italy, Japan, South Korea, Poland, Romania, Russia, Turkey, the United States, and the United Kingdom. Continual activities are required under this system.
(4) Creation of normative documents such as publicly available specifications and technical specifications from the results of research and development projects
It is recommended that normative documents such as Publicly Available Specifications (PAS) and Technical Specifications (TS) be created from the results of research and development projects so that they can be universal common property.
(5) Reinforcement of the superconductivity standardization promotion system with IEC/TC90 Superconductivity Committee playing a key role
The IEC/TC Superconductivity Committee, which is chaired by Shigeki Saito (Managing Director, ISTEC), is operated with the cooperation of 12 related organizations. A Technical Subcommittee (chaired by Kozo Osamura, a Professor at Kyoto University) and a JIS Draft Preparation Subcommittee (also chaired by Kozo Osamura) have been set up under this committee. It is desired that this system be reinforced and this international standardization organization operate smoothly.



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Feature Articles on Standardization

- Present Status on Integrated Promotion of R&D Projects and Standardization -

The integrated promotion of R&D projects and standardization is one of the three pillars of the superconductivity standardization strategy of our country. Standardization activities based on this strategy already started in fiscal 2002 and have been promoted in R&D projects such as the "Superconductivity Magnetic Energy Storage Technology Development," "Superconducting Generator Basic Technology Development," "AC Superconducting Power Equipment Basic Technology Research and Development," and "Superconductivity Application Basic Technology Development." It is expected in these integrated promotion activities that draft international normative documents such as Publicly Available Specifications (PAS) and Technical Specifications (TS) will be created from the results of these R&D projects and the results of the R&D projects will be incorporated into international standards. For details on PAS and TS, refer to the following "Standardization Activities" in this issue.

The integrated promotion of R&D projects and standardization is based on the database construction project for standardization associated with each project promoted by ISTEC, which were started in fiscal 2002, and the "Standardization Investigation Associated with Standardization of Superconducting Power Equipment Basic Technologies" commissioned by the Ministry of Economy, Trade and Industry, which was started in fiscal 2003. In response to the results of the ISTEC database construction project, the superconductivity technical investigation committee, chaired by Prof. Kozo Osamura of Kyoto University, which is operated in close coordination with ISTEC and IEC/TC90, will prepare PAS and TS drafts in the latter project, commissioned by the Ministry of Economy, Trade and Industry.

First, I will describe the progress of the standardization activities in the "Superconductivity Power Storage System Technology Development" project.

The purpose of the activities is to prepare a draft PAS on superconductors for superconducting magnetic energy storage (SMES) equipment, in response to the database construction project associated with the standardization of SMES technology.

For low-temperature superconductors for superconducting magnetic energy storage (SMES) equipment, the database construction work on SMES (100 MW/15 kWh class) Nb-Ti superconductors for system stabilization and SMES (100 MW/500 kWh class) Nb-Ti superconductors for load fluctuation compensation and frequency regulation has been under way since fiscal 2002. The preparation of a draft PAS based on this database was started in fiscal 2003 in the SMES subcommittee, chaired by Prof. Takakazu Shintomi at KEK, established under the superconductivity technology investigation committee.

Next, I will describe the progress of the standardization activities in the "Superconducting Generator Basic Technology Development" project.

The purpose of the activities is to prepare a draft TS on low-temperature superconductors for superconducting generators, in response to the database construction project associated with the standardization of superconducting generators.

For low-temperature superconductors for superconducting generators, the database construction work on 70 MW-class, 200 MW-class, and 600 MW-class Nb-Ti superconductors has been under way since fiscal 2002.

The preparation of the draft TS based on this database was started in fiscal 2003 in the generator subcommittee, chaired by Mr. S. Akita of the Electrical Physics Department, Komae Research Laboratory, Central Research Institute of Electric Power Industry, established under the superconductivity technology investigation committee.

Furthermore, the related database construction project and standardization are under way in line with the progress of the "AC Superconducting Power Equipment Basic Technology Research and Development," and "Superconductivity Application Basic Technology Development" projects. I believe firmly that the results of these standardization activities will not only help to prepare normative documents by a consensus of experts but give a strong incentive to international superconductivity-related technology development and contribute to the development of the superconductivity-related market in the end. I think the guidance and cooperation of the people concerned are essential for successful standardization.

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Standardization Activities

- Expectations on the enactment of the normative documents, PAS and TS -

The enactment of the international normative documents, Publicly Available Specification (PAS) and TS (Technical Specification), is now under way as standardization activities to cope with the rapid progress in state-of-the-art technologies and urgent market needs. Great expectations are placed on their enactment. Among the international superconductivity standardization activities, IEC (International Electrotechnical Commission)/TC90 (superconductivity) is preparing to make drafts to enact the PAS and TS.

A PAS is a normative document which indicates a consensus of experts and is defined as being approved by the majority of international P members. Therefore, the PAS is an intermediate, publicly available specification concerning technology under development. Its consensus level is lower than that of a normal international standard (IS). It does not have the same qualification as that of a formal IS. A draft PAS can be approved and issued in a year or so. There are three types of PAS: one that is prepared by IEC/TC, one that is prepared by an external consortium, and one with a high marketability prepared by IEC/TC. A PAS must be reviewed at least every three years. The shift to a higher level specification, that is, to TS or IS, or the abolishment must be decided six years later. Incidentally, it has been pointed out that there are many kinds of PAS and the distinction between them is not clear. Deliberations are still continuing, aiming at PAS of higher quality.

A TS is a normative document formulated through a formal consensus procedure and is defined as one that requires approval of two-thirds of the international P members for its publication. Thus, a TS passes through the same deliberation process as that of a new project item proposal. It refers to a specification for which the approval necessary for the publication of an IS has not been obtained in the end, one for which the target technology is still under development, and one for which a consensus may be obtained as an IS in the future for some reason or other. A draft TS can be issued with approval in about one and a half years. A TS must be reviewed at least every three years. The shift to a higher level specification, that is, to IS, or the abolishment must be decided six years later.

Incidentally, the IS is a normative document formulated through a formal consensus procedure and is defined as one that is supported by more than two-thirds of the international P members and opposed by less than one fourth. The normal IS procedure from proposition to publication requires at least three years. Also, the contents of an IS must be reviewed at least every five years and must be regularly reviewed by international P members.

As mentioned above, all of the PAS, TS, and IS are international normative documents and are clearly distinguished from general technical reports, TR (which is defined as a reference document by ISO/IEC).

Originally, the IS was the basic element of national standardization and was used as a standard to prepare a draft for an international bidding or international contract. In order to publish and maintain an IS, however, it is necessary to follow the formal, long-time consensus procedure, and an IS cannot respond to rapid progress in technological development or address market needs to the full. In other words, recent standardization activities aim to supplement IS' slowness by developing a PAS to cope with rapid technological progress and a TS to address urgent market needs. The enactment of a PAS or TS also serves as a "mediator" that smoothly feeds back the results in a research and development project of state-of-the-art-technology such as superconductivity to the superconductivity-related industry and leads the results to the development of the superconductivity-related market.

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- JNC votes for DC for maintenance -

The polls for a document (DC) necessary to discuss comments on the maintenance of IEC (International Electrotechnical Commission)/TC90 (superconductivity) standards, which had been circulated since May 16, 2003, were closed on September 26. The Japan National Committee, JNC, added a new comment on this DC and cast a favorable vote for the DC. At the same time, JNC judged whether current experts in each working group (WG) were qualified or not and recommended combiners for WG4 and WG7.

Main comments added by the JNC are as follows:
(1) IEC 61788-1, WG2 (Ic test method of Nb-Ti composite conductors): Checking the inward and outward Lorentz force, adding the term "three-component superconducting wire," and drawing attention to a rise in temperature during sample adjustment work.
(2) IEC 61788-2, WG7 (Ic test method of Nb_3Sn composite conductors): Writing the one-mandrel method on new Annex D.
(3) IEC 61788-3, WG3 (Ic test method of silver sheathed Bi-based conductors): No additional comments.
(4) IEC 61788-4, WG4 (Residual resistance ratio test method of Nb-Ti composite conductors): No additional comments.
(5) IEC 61788-6, WG5 (Room-temperature tensile test method of Nb-Ti composite conductors): Scope expansion on Cu/Cu-Ni/Nb-Ti, Nb_3Sn, and silver sheath Bi-based conductors
(6) IEC 61788-7, WG8 (Surface resistance test method): Description of temperature ranges except 30 K to 80 K, update of Fig. 5, Fig. A･3 and Fig. A･4, and addition of mode charts (TE_{011} and TE_{013}) for new closed-type resonators
(7) IEC 61788-10, WG11 (Critical temperature test method): Scope expansion on Cu/Nb_3Al, MgB_2, and Y-based coated conductors, and correction of descriptions of the adiabatic method and quasi-adiabatic method

These maintenance cycles will be conducted in the following order. For maintenance of each WG, all the work up to step (6) must be completed by the review date.
(1) Collation of comments/suggestions by the TC organizer
(2) Close examination of collected comments/suggestions and preparation of a draft revision by each WG
(3) Submission of a maintenance cycle report (MCR) with a draft revision to the TC organizer by each WG
(4) Preparation, acceptance, and deliberations of a committee draft (CD)
(5) Committee draft vote (CDV)
(6) Deliberation on final draft international standards (FDIS)
(7) Issue of international standards

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- Comments on revision of superconductivity-related international standards collected -

The cut-off date for acceptance of comments from each country on the document (90/142A/DC) necessary to study views on maintenance of IEC (International Electrotechnical Commission)/TC90 (superconductivity) 7 standards, which had been being circulated since May 16, 2003, and for renewal of

experts in each working group (WG) was September 26, 2003. The international organizer summarized the comments as shown below:
Also, the international organizer instructed us to discuss these comments in the domestic WG and build a consensus and prepare a draft revision into which the results of the discussion in the international WG are incorporated after the consensus is approved by the domestic technical committee. After that, this draft revision and a maintenance cycle report that covers the renewed organization of WG will be prepared and referred for international discussion.

[1] Main comments

The following additional comments on DC came from Japan, China, Italy, and Poland. There were no comments from the United States, Germany, or France.

(1) IEC 61788-1, WG2 (Ic test method of Nb-Ti composite conductors)

Japan: Checking the inward and outward Lorentz forces, adding the term "three-component superconducting wire," and drawing attention to a rise in temperature during sample adjustment work, etc.

China: Scope expansion on Cu/Cu-Ni/Nb-Ti, Cu-Ni/Nb-Ti, indication of U-1, Ic neighborhood limit of exponential function, etc.

Poland: Adding Ic standards and others

(2) IEC 61788-2, WG7 (Ic test method of Nb_3Sn composite conductors):

Japan: Writing the one-mandrel method on new Annex D and others.

China: Clarifying the expression for sample cooling in scope, Ic neighborhood limit of exponential function, etc.

(3) IEC 61788-3, WG3 (Ic test method of silver sheathed Bi-based conductors)

China: Clarifying the description of the weak link, clarifying the expression for sample cooling in scope, suggesting a change in Ic standards, reinstating Ag and/or Ag alloy, Ic neighborhood limit of exponential function, etc.

(4) IEC 61788-4, WG4 (Residual resistance ratio test method of Nb-Ti composite conductors)

China: Reviewing the expression for "resistance" and "voltage" in Section 4, reviewing the expression for "resistivity" and "RRR" in Section A.1, deleting subsection 4 (COV…) of Section A.1, adding a bending strain effect correction method of RRR to new A.5 Section, etc.

(5) IEC 61788-6, WG6 (Room-temperature tensile test method of Nb-Ti composite conductors)

Japan: Scope expansion on Cu/Cu-Ni/Nb-Ti, Nb_3Sn, and silver sheathed Bi-based conductors

(6) IEC 61788-7, WG8 (Surface resistance test method)

Japan: Description of temperature ranges except 30 K to 80 K, update of Fig. 5, Fig. A・３ and Fig. A・4, addition of mode charts (TE_{011} and TE_{013}) for new closed-type resonators, etc.

China: Suggestion of a detailed description example of the coupling structure, recommendation of the dimensions of a sapphire column at higher frequencies, e.g. 18 GHz, reviewing the definition of a radiation loss, reviewing the expression for target precision in Section 8.1,

(7) IEC 61788-10, WG11 (Critical temperature test method)

Japan: Scope expansion on Cu/Nb_3Al, MgB_2, and Y-based coated conductors, and correction of descriptions of the adiabatic method and quasi-adiabatic method

China: Test method with consideration given to a difference between characteristics of LTS and HTS, uniformity of expressions for the bending strain equation, adding some types of resistance thermometers, etc.

[2] Renewal of experts

(1) Japan: Replacement of one person in WG2, deletion of one person in WG8, recommendation of a WG4 combiner and a WG7 combiner,

(2) China: Renewal (WG1, WG2, WG3, WG4, WG5, WG6, WG7, WG8, WG9, WG10, and WG11)

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(3) Italy: Renewal of WG3, WG7, and WG8
(4) Poland: Replacement of one person (in charge of WG1, WG9, WG10, and WG11)

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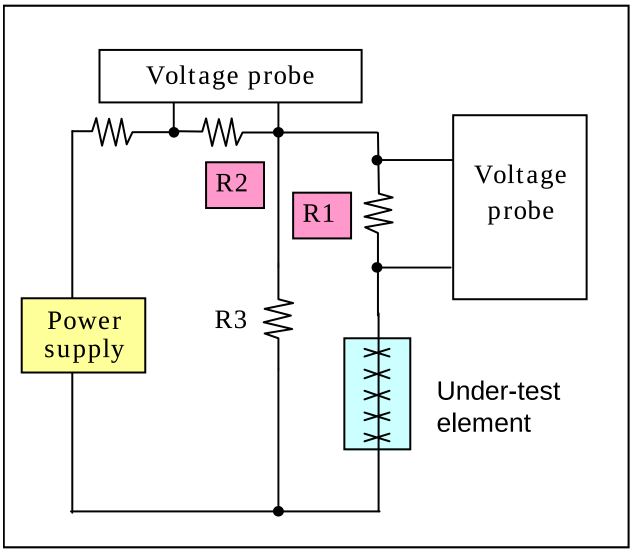
Patent Information

Published unexamined patents for the second quarter of fiscal 2003

The following are ISTEC's patents published in July through September, 2003. For more information, access the homepage of the Patent Office of Japan and visit the Industrial Property Digital Library.

1) Publication No. 2003-194867
"Electrical Measuring Device":
Superconducting circuits element constructed in series of Josephson junctions is too sensitive to noise to correctly measure the original voltage-current characteristics of the element. In this invention, two resistors(R1, R2) are connected in series with the under-test element, and the third resistor(R3) is connected in parallel with the series circuit of the under-test element and the first resistor(R1). This invention has enabled the effect of noise on the under-test element to be sufficiently excluded and the original characteristics of the under-test element to be calculated, by measuring the voltage across the first and second resistors.



2) Publication No. 2003-204265
"Analog-digital Converter Using Superconductor":
In high-temperature superconductor circuits with comparatively large inductance value, an output of the QOS(Quasi One-junction SQUID) type comparator will fall into an uncertain state in which alternately outputs "0" and "1" values, resulting in poor accuracy. The above-mentioned uncertain state can be avoided and high accuracy can be obtained by installing new circuits in which the input current will be divided into plural paths having a QOS type comparator and an output circuit. This circuit configuration will be used in a flash type superconductor A-D converter. The comparator will generate a value "0" or "1" depending on the divided input current value when the clock signal is reached. The output circuit will normally pass through the input value from previous comparator in synchronizing with the clock. But the output circuit will output the value "1" during a period in which the comparator repeats "0" and "1" alternately in every clock.

3) Publication No. 2003-257259
"Superconducting Film and its Manufacturing Method":
This invention is related to the TFA-MOD method, one of the superconducting film manufacturing methods. This method consists of four processes and is characterized by the fact that calcination is performed so that the average grain size of the copper oxide contained in the coating film after the calcination is 25 nm or less. The first one is a process where yttrium or lanthanoid, barium, and copper fluoroacetate are dissolved in solvent to prepare a coating solution. The second one is a process where the above coating solution is applied to a substrate to form a coating film. The third one is a process where the above coating film is calcinated in an oxygen atmosphere. And the last one is a process where the coating film is finally baked in

a vapor atmosphere at a higher temperature than that of the calcination. This invention has enabled a superconducting layer with a higher critical current value to be manufactured.

4) Publication No. 2003-264319

"High-temperature Superconducting Josephson Junctions and Superconducting Electronic Device provided with them":

This invention is related to the formation of the interface modified barrier of high-temperature superconducting Josephson junctions. Attention is drawn to the fact that the barrier region is composed of constituent elements of both top and bottom superconducting electrode layers. For the one electrode layer, a superconductor containing metal elements such as La and Sm with a relatively large ion radius is used. For the other electrode layer, a superconductor containing metal elements such as Y and Yb with a relatively small ion radius is used. This composition will improve lattice matching between the barrier and both electrode layers, resulting in a drastic decrease in spreading of the Josephson junction characteristics. Consequently, there was an actual example where the standard deviation (σ) of the critical current value of 100 Josephson junctions was 7% or less.

5) Publication No. 2003-264458

"Superconducting Single Flux Quantum Multi-input Exclusive OR Circuit":

The purpose of this invention is to provide a superconducting single flux quantum multi-input exclusive OR circuits that can operate at high speeds without increasing the number of logical stages. 2-input exclusive OR circuits execute exclusive OR operation for 2-input signals and output the result. In conventional superconducting single flux circuits, multi-input exclusive OR circuits with inputs of more than 3 are cascaded with plural 2-input exclusive OR logic stages. In this invention, 3-input exclusive OR circuits are realized by addition of one more input to the conventional 2-input exclusive OR circuits. The additional input, however, must be phase-shifted respect to the phase of other two inputs by the desired phase. In a similar manner, it can perform logical exclusive OR operations for four or more inputs.

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

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