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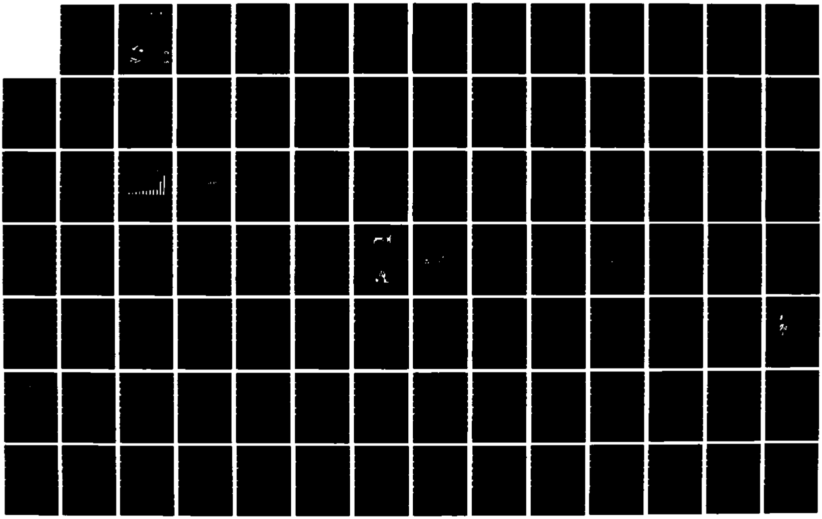

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JANUARY TO MARCH 1985 VOL. 10, NO. 1

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DEPARTMENT OF THE NAVY OFFICE OF NAVAL RESEARCH FAR EAST
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This is a quarterly publication presenting articles covering recent developments in Far Eastern (particularly Japanese) scientific research. It is hoped that these reports (which do not constitute part of the scientific literature) will prove to be of value to scientists by providing items of interest well in advance of the usual scientific publications. The articles are written primarily by members of the staff of ONR Far East and the Air Force Office of Scientific Research with certain reports also being contributed by visiting state-side scientists. Occasionally, a regional scientist will be invited to submit an article covering his own work, considered to be of special interest.

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Cell biology
Genetic engineering
Biotechnology
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Welding education
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Welding engineering
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Japan

SCIENTIFIC BULLETIN READERSHIP SURVEY, 1985

The purpose of this report is to provide the science and technology community information and insights on foreign, especially Far Eastern (more specifically Japanese), scientific research activities of interest to the Department of Defense. In order to insure that this report maintains its usefulness to you, it is requested that you take a moment to fill out and return this questionnaire.

1. Have the research topics described here been of use to you?

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CONTRIBUTORS

Nicholas A. Bond, Jr., currently the Director of ONR Far East, is an engineering psychologist on leave from California State University at Sacramento. Dr. Bond's main interests are in man-machine interface, decision aiding, and the maintenance of complex systems by humans. He is a fellow of the American Psychological Association.

Kimiko O. Bowman is a mathematical statistician and was born in Tokyo, Japan, but received her Ph.D. degree in statistics from the Virginia Polytechnic Institute. Dr. Bowman is on the staff of the Engineering, Physics and Mathematics Division of the Oak Ridge National Laboratory in Oak Ridge, Tennessee. Dr. Bowman's research interest lies in statistical research using high speed computing and estimating parameters.

Thomas W. Eagar, a liaison scientist with ONRFE, is on leave from his position as associate professor of materials engineering at the Massachusetts Institute of Technology. Dr. Eagar's professional interests are broadly in manufacturing processes for metals and ceramics with more specific interest in welding and joining technology.

Francis R. Hama was formerly associated with Princeton University. He is now a visiting scientist at Institute A für Mechanik and at Institut für Aero- und Gasdynamik, Stuttgart University. His continuing research interests are in boundary layer instability and transition.

Clancy Hatleberg is a Commander in the U.S. Navy, and a program officer at the Naval Ocean Systems Center in San Diego. He holds a Ph.D. degree in mechanical engineering from the University of New Mexico.

P. F. Iampietro, a physiologist, is on the scientific staff of the Air Force Office of Scientific Research, Far East. Previously he directed the Air Force basic research program in the life sciences. His scientific interests include environmental physiology and a more recent interest in membrane phenomena. Dr. Iampietro is a member of the American Physiological Society.

Magne Kristiansen was born in Elverum, Norway, and received his Ph.D. degree in electrical engineering from the University of Texas in 1967. Dr. Kristiansen is currently P.W. Horn Professor of Electrical Engineering at the Texas Institute University, Lubbock, Texas. His current research interests lie in plasma dynamics, pulsed power technology, and physical electronics.

Sung M. Lee is professor of physics and also Director of the Keweenaw Research Center of the Michigan Technological University in Houghton, Michigan. Dr. Lee received his Ph.D degree from Ohio State University in 1965. Dr. Lee was a NATO Senior Fellow in 1974 and his research interests include infrared optics, acoustics, and applied physics.

Yoon Soo Park is currently a senior scientist with the Air Force Office of Scientific Research, Far East. Prior to his assignment in Japan in September 1983, Dr. Park was a task manager and research physicist at the Avionics Laboratory, Air Force Wright Aeronautical Laboratories. His research interests lie in the areas of solid state physics, electronic materials and devices. Dr. Park is a fellow of the American Physical Society and a senior member of IEEE.

M. Frank Rose is currently a senior research physicist in the Electronic Systems Department of the Naval Surface Weapons Center, Dahlgren, Virginia. Dr. Rose received his Ph.D. degree in solid state physics from Pennsylvania State University in 1966. Dr. Rose's current research interests are in pulse power technology, advanced energy conversion, and high power fast switch technology.

Tsugio Satoh, Science Advisor of ONR Far East, was an applied biologist at the U.S. Navy Public Works Center, Yokosuka, Japan, for nine years and has had field experience in entomology and pest management technology. His current interests include information processing, communications, and wildlife management.

CONTENTS

Cover: This picture of copper-lead separation depicts a technology used in 18th century Japan. The copper-lead mixture is melted not quite to the liquid stage; the copper is pushed upward and the silver containing the lead then flows downward. The tools used for handling the metals are iron. This technique is called "Shibori buki," or since it was imported from abroad, "Nanban buki" (European-style technology). The pen and ink drawing was taken from a Sumitomo handbook called, *Illustrated Record of Copper Metallurgy*, compiled in the 19th century by the Sumitomo family now doing business as the Sumitomo Metal Industries, Ltd. They have graciously allowed the print to be reproduced on the cover of the *Scientific Bulletin*.

ENGLISH-JAPANESE TRANSLATOR FOR ECONOMIC NEWS

While there is much publicity concerning the fifth generation machine translation effort, there are special translation schemes which may be ready for application quite soon; these have not been widely publicized. As one example, Hitachi and the Quotation Information Center in Japan are now collaborating on an English-to-Japanese translation system for economic news. The inputs will be stock and commodity prices from European and Western markets, bank and discount rates, currency conversion, shipping space information at world ports, and so forth. A dictionary of at least 50,000 English words is being established with emphasis on complete coverage of commercial and economic terms. If the system is successful, an Asian subscriber could call up general tabular information, and could also "construct" his own search schemes and tabular formats to fit his needs. The system is expected to be on sale in 1986. No information is available on the software though it is known that a Japanese team visited Britain to see what could be learned from the PRESTEL project there. (In the early 1980s, PRESTEL offered tabular information, but was not a commercial success; a frequent complaint was the lack of flexibility offered to the subscriber.)

This economic news translator is another example of the way that Japanese technological efforts can proceed by delimiting a difficult domain. General English-to-Japanese translation presents very difficult problems which neither the fifth generation, nor any other project, will solve any time soon. Economic news, however, is rather simple linguistically with most sentences being in declarative mode, and with most queries also aimed at specific items, numbers, and listings. Thus delimited, the translation problem appears to be far more tractable. The Japanese approach in automatic character recognition seems to follow much the same strategy. In that domain, the intent is not to produce a machine that can read any old sloppy handprinted kanji character, but rather to design a system that could read well-formed handwritten material. Under that constraint, correct reading percentages in the high 90s have been achieved. [See "Automatic Recognition of Handprinted Chinese-Japanese Kanji: The Last Frontier of Character Recognition?" ONR *Scientific Bulletin, 9,* (3) 1 (1984).]

Nicholas A. Bond, Jr.
ONRFE/AFOSRFE

EYE FATIGUE FILTERS FOR CRT DISPLAYS

Two Japanese manufacturers are now offering special filters for CRT display terminals. YIS Corporation (Shizuoka-ken, 430) uses a slightly roughened (0.1 μm) surface; they claim that the filter has an average reflection of 0.07%, and that ultraviolet transmittance is reduced to nearly zero.

Nippon Sheet Glass (Osaka, 541) puts a layer of gray polyvinyl butyral in a glass sandwich (one glass surface is matte to 0.2 μm). Reflections and ultraviolet emissions are reportedly very satisfactory. Though neither company has reported full ergonomic evaluations of these filters, the materials seem promising for continuous use terminals, especially those with bright secondary light sources. As described in an earlier *Bulletin*,[1]

[1] "Human Factors in Advanced Displays," Nicholas A. Bond, Jr. *ONR Far East Scientific Bulletin, 9,* (1), 48, (1984).

psychophysical methods for assessing "visual fatigue" are well developed in Japanese laboratories.

Nicholas A. Bond, Jr.
ONRFE/AFOSRFE

BASIC RESEARCH IN FIVE COUNTRIES

Many international comparisons are offered regarding the scale of scientific effort in the developed countries. A recent official one from Japan is shown in the figure below. From this bar graph, one could infer that the Japanese scientific enterprise, as measured in basic research money costs, is second only to America's; and perhaps more surprising, Japanese science is now spending more than Britain and France combined. Though all such charts are subject to many caveats and cost indexing difficulties, those who watch science support trends will note some interesting sponsorship facts in the figure. For example, the private research proportion in the developed countries is fairly negligible, except for America. But universities and colleges spend most of the research money, in all the countries.

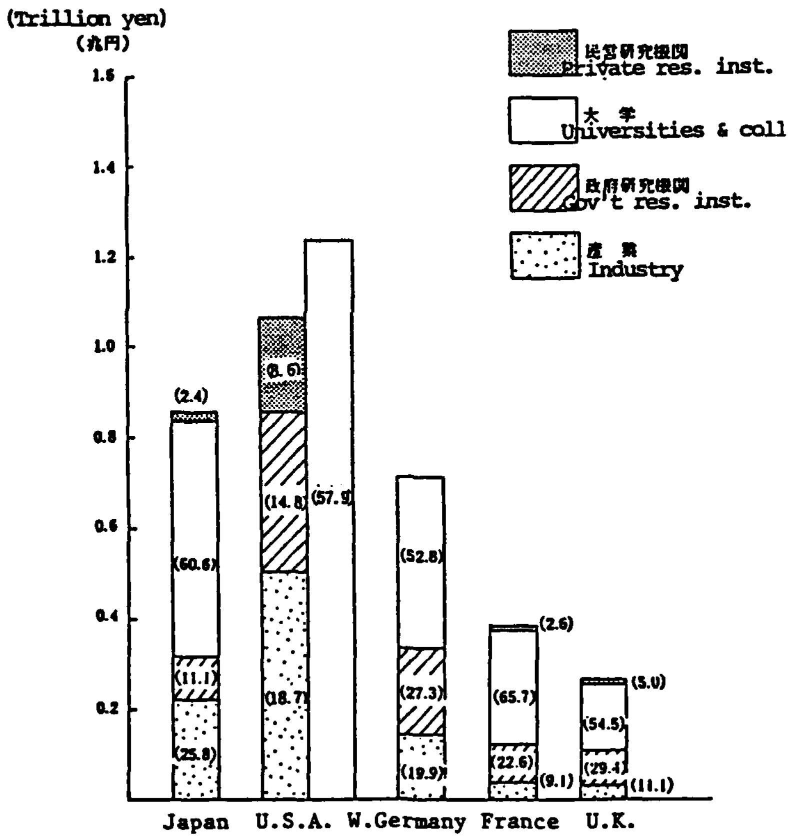

Figure 1. International Comparison of Basic Research Expenditure, by Kind of Organization*

*Taken from the U.S. Embassy, Tokyo Office of the U.S. National Science Foundation, *Report Memorandum #62,* "Japan's White Paper on Science and Technology for Japanese Fiscal Year *1983,*" translated by M. Miyahara of NSF/ Tokyo.

What the figure does not show is the very small proportion of defense-related R&D in Japan, which is far less than 10% of the total, on any measure (cost, personnel, etc.). Also not shown here, but carefully tracked by the Japanese, are certain growth ratios in science, such as total physical science expenditures for 1981, divided by those for 1967. These ratios are now about four in Japan, compared to two or three in the Western countries.

Nicholas A. Bond, Jr.
ONRFE/AFOSRFE

SPECIAL RESEARCH PROJECT (TOKUTEI KENKYU) IN ELECTRONICS

The Ministry of Education, Science and Culture (MESC) has announced the initiation of a Special Research Project entitled "Alloy Semiconductor Electronics" beginning April 1985. It is a three-year project with a total budget of 600 million yen ($2.4 million). The project is going to involve 45 university researchers at 15 major universities throughout Japan. The Special Research Project called "Tokutei Kenkyu" is a type of research grant for research in areas of strong scientific and social needs to be conducted over a specific period (for three years).

The following is the announcement translated from the Japanese text:

- Alloy Semiconductor Electronics

. Objective

At present many electronic devices such as diodes, transistors, and integrated circuits are being fabricated from the elemental semiconductor Si and compound semiconductors such as GaAs within the framework of their intrinsic physical properties. These electronic devices have formed today's technology base bringing about the second industrial revolution.

In the future, however, in electronics, the use of alloy semiconductors, whose physical properties can be artificially tailored, will become indispensable. Many electronic devices are dependent on alloy semiconductors as seen in such devices as high mobility transistors (HEMT), superlattice devices, modulation-doped multilayer thin film devices, high-efficiency energy conversion devices, high speed and high sensitivity infrared detector cathodes, new functional and high performance devices required in supercomputers, electrooptical devices, energy-saving and robotics electronics. However, there remain many fundamental and unknown problems in alloy semiconductors. The specific objectives of the program are:

- to systematically define and clarify basic problems in crystal growth mechanisms, crystal structure, evaluation methods, material design, thin film and heterojunctions, and device fabrication of alloy semiconductors,

- to improve performance and reliability of current devices such as detectors for optical fiber communications, visible lasers, ultrahigh speed and frequency transistors, and to contribute to utilization of these devices,

- to establish clearly the basis of the design scheme of materials and properties by investigating tailoring of physical properties of bulk alloy

Professor Matsuda has published more than ten reports on cracking of austenitic stainless steels and is now studying cracking of aluminum alloys. He has shown that zirconium additions to aluminum alloys have the most beneficial effect on reducing hot cracking. He has developed a microscope which can produce high speed movies of hot cracks as they form. The new work on ion nitriding is developing fundamental hardness profiles on pure metals from Groups IVa, Va, and VIa of the periodic table as well as developing surface hardness data on commercial alloys. Plans for the future include evaluation of the best oxide additions to tungsten welding electrodes, i.e., either Y_2O_3, La_2O_3, ThO_2 or ZrO_2; arc modeling of plasma composition as it relates to arc temperature and synthesis of ceramic powders by reaction of gases in an inductively coupled plasma generator.

. Division of Welded Structures
Professor K. Hirokawa, Associate Professor S. Fukuda

Professor Hirokawa's work includes stress analysis at welded joints and structural discontinuities, significance of defects, and fatigue and brittle fracture of structures.

. Division of Fusion Welding
Professor K. Inoue, Associate Professor A. Omori

Work in this division includes video image analysis of objects, control of arc welding robots, data base management for welding, sensing of the welding process, plasma spraying of ceramic coatings, and laser surfacing. A vacuum plasma spraying apparatus has recently been installed. Samples of ceramic coated stainless steel are subjected to aqueous corrosion tests. It has been found that pin holes in the ceramic lead to severe pitting. It is hoped that laser surface remelting will eliminate these pinholes.

. Division of Pressure Welding
Associate Professor A. Matsunawa

Professor Matsunawa's main interests include rapid solidification of austenitic stainless steels, laser beam-plume interactions, reactive surface hardening with lasers (e.g., formation of TiN on titanium metal) convection in the molten weld pool, and the physics of gas jets in oxyacetylene cutting of steels. He has made extensive use of laser Schlieren techniques to study gas flow in oxyacetylene cutting and the formation of laser plumes. In cutting he has shown that a shock front developes at the leading edge of the cut which is related to loss of the cutting action. His laser plume studies show that fine metal particles are ejected subsonically from the surface; that the plume can be either laminar or turbulent and that the plume is a relatively low temperature, weakly ionized plasma.

- Summary

The main difference between the Welding Research Institute and the Department of Welding Engineering is that the primary objective of the former is research and the primary purpose of the latter is education. The Welding Research Institute has excellent facilities and produces such a large amount of high quality research that they publish their own English language journal of nearly 800 pages per year. It is clear that in the past decade, Osaka University has become one of the premier welding research centers of the world. It is not necessarily the largest, but the overall quality of the research is certainly among the very best.

TRENDS FOR THE FUTURE

aluminum-silver alloy with 0.2% lithium gives complete wetting; however, it is necessary to work at the liquidus of the alloy to prevent excessive alloying of the braze metal with the base metal. They have also found that addition of 0.1% silicon suppresses the formation of titanium-aluminum intermetallics.

. Division of Chemical Reaction
Professor N. Iwamoto

Professor Iwamoto has studied the fundamental structure of welding slags and fluoride and oxide glasses for many years using x-ray diffraction, x-ray photoelectron spectroscopy, and electron spin resonance. Presently, most of his research is not directed toward welding, but toward problems of chemical analysis and reaction in the nuclear fusion program.

. Division of Material Physics
Professor T. Enjo, Associate Professor Y. Kukuchi

Professor Enjo's interests cover many areas including underwater welding, internal friction of titanium alloys from 77 K to 300 K, hydrogen embrittlement of steels, stress corrosion cracking, and diffusion bonding. The metal-to-metal diffusion bonding studies include the following:

METAL/METAL	INSERT	TEMPERATURE
Al/Al	none	many
Ti/Ti	none	many
Al/Cu	none	many
Al/Ti	6 μm Ag	600°C
Ti/Fe	5 μm Ni	800°C

Professor Enjo's extensive studies of ceramic-to-metal bonding will be detailed in a subsequent article on this subject.

. Division of Elasticity and Plasticity
Professor Y. Ueda

The Division of Elasticity and Plasticity has performed some excellent analyses of the three-dimensional residual stresses in thick plate as well as analysis of the effects of such residual stresses on structures. They have also performed analysis of fundamental strength limitations of ships and offshore structures.

. Division of Welding Instruments
Professor F. Matsuda, Associate Professor M. Ushio

One of the most active research groups is Professor Matsuda's. He has worked on hydrogen cracking, metal transfer, hot cracking, and now, ion nitriding. The study of hydrogen cracking includes a model to determine whether failure will occur in the weld metal or the heat affected zone of HY130 steel, based on metal hardness, applied stress, and time. The work on metal transfer includes studies of pulsing to reduce spatter in carbon dioxide shielded welding and the effect of flux additions on droplet transfer in flux-cored arc welding. In both cases, conditions have been developed for optimum metal transfer characteristics.

association as their support from the Ministry of Education is supposed to keep them separate of commercial enterprises. Discussion of such items causes considerable confusion and one is never quite sure whether the question has been misunderstood or whether one has touched upon a topic of peculiar sensitivity. In any case, the faculty are quite proud of their separateness from commercial needs; yet one often feels that these men have a keen awareness of the practicality of their work. This feeling is much stronger at the Welding Research Institute than in the Department of Welding Engineering where any connection with specific problems of the industrial world is more remote.

- Facilities

The equipment of the Welding Research Institute is much more impressive than that of the Welding Engineering Department. Indeed, the institute is similar to a national laboratory in the United States in this respect. Equipment includes the latest microprobes, spectrometers, testing apparatus, and general welding equipment. The listing given in Table IV is certainly not the type of equipment to be found in a welding laboratory anywhere else in the world (except perhaps the Paton Institute in Kiev). Of particular note are the three high power electron beam units (one of 300 kW, which in practice has not been successful, plus two of 100 kW capacity), the 15 kW AVCO Corporation laser and the 100 kW microwave plasma beam. With such facilities, the Welding Research Institute is equipped to perform many types of work in addition to welding; and as will be seen later, nonwelding research is becoming more common.

- Research Programs

. Division of Welding Energy Sources and Heat Transfer
Professor Y. Arata, Associate Professor S. Miyake

Professor Arata is internationally known as the leading researcher in high energy density electron beams. A film produced in his laboratory won the top prize of the International Institute of Welding several years ago. Recently, he has completed second and third films illustrating the processes of laser and electron beam welding and cutting. The second film shows the formation of two distinct plasmas, one blue and one pink, being emitted from the beam hole when welding steel. By studying the behavior of these plasmas, Professor Arata has been able to improve laser beam welding of steels.

Professor Arata's other interests include a 60 GHz microwave plasma beam heater which is being studied in connection with the magnetic fusion research program, ceramic to metal bonding, and automation of the welding process. They have also used the microwave plasma beam to study surface hardening of metals as it can give a power density of 100,000 W/cm^2.

. Division of Heat and Mass Transfer
Professor I. Okamoto, Associate Professor M. Naka

Although research in this koza includes some studies of thermal cutting and soldering, most of the research involves brazing. For example, they have studied vacuum brazing of 3004 aluminum alloy using an aluminum-silicon-magnesium cladding on the base metal as the filler metal. At pressures below 10^{-1} Torr, vaporization of magnesium from the cladding prevents metal flow. For an unknown reason, a preheat treatment at 270°C improves wetting and the addition of 0.1% bismuth improves the ability to fill gaps by 20%.

They are also studying brazing of titanium with aluminum base filler metals. An

In order to provide better understanding and control of the welding process, Professor Nishigiuchi is developing mathematical models to describe the changes which occur when welding parameters are changed. The work includes a model of surface depression of the molten pool by the arc force. This is coupled to a simplified heat flow model which allows one to predict weld pool shape and distortion for out-of-position welding processes. The model predicts that arc force is dominant in distorting the weld pool surface; this contrasts with a recent theory in the United States of the opposite opinion.

In addition to modeling of the arc weld pool, a model of nugget formation in resistance spot welding is being developed. It is hoped that this model will help ensure reliability of spot welds without subsequent tests.

- Summary

The primary purpose of the Department of Welding Engineering is educational; however, there is considerable research in progress. Much of this research appears coupled to the undergraduate or master's thesis experience. The strength of this approach is that many different ideas may be tested, but the disadvantage is that extended projects progress more slowly due to changes in the student personnel as they graduate. The facilities for research are generally very good. There is a strong emphasis on use of small, personal computers for many tasks. The ties to industrial problems seem to be minimal; indeed, most of the faculty profess no direct connection with any commercial problems, thus permitting them to pursue whatever research interests them and provides good educational value. While such an environment provides a fertile birthplace for new ideas, it does not encourage development or application of these ideas to practice. The Welding Research Institute was established for these latter purposes.

WELDING RESEARCH INSTITUTE

At the end of World War II, the United States sent a study group to Japan to survey shipbuilding technology. The American delegation found the Japanese to be equivalent to the United States in every area except welding, where they estimated that it would take Japan twenty years to catch up. This report shocked the Japanese into establishing strong research centers for welding technology. From these centers, there arose some very influential men who, in 1964, urged the government to establish a National Welding Institute. In 1966, the government passed a resolution to establish such a center. In 1969, a research center was established at Osaka University, and in 1972, it became the Welding Research Institute. Today it is one of 12 National Research Institutes of the Ministry of Education established for use as a national facility. Its planned size includes 10 koza and five special centers. As shown in Table III, nine of the koza and two of the centers have been started to date. Figures 1 and 2 show that the growth was steady from 1972 to 1980 but has leveled off since 1981.

The institute serves to focus a number of disciplines on problems of welding technology, and to apply knowledge gained in other fields to welding. It currently has a professional research staff of 31, but it draws more than twice as many additional researchers from other universities and national laboratories. One of the unique features of the institute is that they have a technical assistant assigned to seven of the nine koza. There are no such technical assistants in the Department of Welding Engineering. These staff help maintain and instruct outside users on the more sophisticated equipment that the institute has. In addition, there are approximately 15 persons from industry who have returned for temporary retraining in newer techniques. This latter category illustrates the close ties of the institute to industry; however, the faculty prefer not to emphasize such an approach or a local energy approach.

. Welding Equipment
Professor S. Nakata, Associate Professor M. Nishikawa

The major studies in this chair include computer-aided manufacturing systems, monitoring of the welding process, and fundamental physical processes occurring in welding. In one project, a special robot programming language is being developed so that a theoretical part shape can be input to the system and the welding sequence can be determined by the computer. In other studies, they are using high speed cinematography to study metal flow in gas tungsten arc welds and they have done considerable work on voltage monitoring of resistance spot welds. Some work on computer image analysis is also underway.

. Welding Design
Professor Y. Mukai

Much of the work of this chair involves studies of fatigue and stress corrosion cracking. The materials of interest are austenitic stainless steels and ultrahigh strength steel in 3% sodium chloride and distilled water. Specific studies include multistep loading, effective size of clustered defects, and elevated temperature fatigue.

. Materials Science for Welding
Professor Y. Kikuta, Associate Professor T. Araki

Professor Kikuta's main research interests include hydrogen cracking and acoustic emission monitoring of hot and cold cracks. In their study of hydrogen, they have attempted to model the local concentration of hydrogen based on the thermal history of the weld and the elastic-plastic behavior of the joint. They are also attempting to relate local steel microstructure to hydrogen crack susceptibility.

Professor Kikuta has studied frequency spectral analysis to 400 kHz to aid in acoustic emission analysis of cracking. During hot cracking they detect three distinct spectra. One comes from the arc itself as evidenced by the fact that it disappears when the arc is terminated. Another is due to frictional movement of the steel in its fixture due to thermal stresses and the last can be correlated with hot cracking. Similar transducers have been tested on commercial spherical tanks to detect cold cracking. The remote signals are relayed to the computer using FM radio telemetry. Location of cracks was detected within 6.5% error by time difference and within 29% error by attenuation methods. It is hoped that this method may be practical for continuous monitoring of cracking behavior of commercial structures.

. Nondestructive Testing of Welds
Professor T. Senda

The principal techniques studied by Professor Senda are radiography and ultrasonics. In radiography, they have studied methods of adding additional material to equalize the density of the parent metal and the weld metal. In the area of ultrasonics, they have attempted to develop a tomographic method for measuring the three-dimensional shape of defects.

. Application of Welding
Professor K. Nishigiuchi, Associate Professor T. Ohji

. Welding Physics
Professor H. Maruo, Associate Professor I. Miyamoto

Professor Maruo's research can be broadly grouped into four areas *viz.* laser materials processing, physics of arc welding, solid state welding, and plasma spraying. The laser studies include fundamentals of beam absorption on solids and liquids, deep penetration mechanisms, welding and cutting of ceramics, and surface treatment. The work on arc welding includes use of a transistorized pulsed current gas metal arc supply to study drop detachment. They have shown that the average droplet temperature increases from just above the melting point of steel at 30 A weld current to a maximum of 2000°C at currents above 200 A. These measured values appear to have been made more carefully than any previous values and they are consistent with several recent theoretical analyses which suggest the temperature of the droplet is limited to this value due to heat losses caused by vaporization. Finally, a force balance on the droplets as a function of droplet volume gives a qualitative explanation for the globular to spray transition.

Diffusion welding and plasma spraying of ceramics and metals is underway but appears to be in early stages of development.

. Welding Metallurgy
Professor Y. Nakao, Associate Professor K. Nishimoto

Professor Nakao's research includes studies of crack susceptibility and toughness improvements in low alloy steels, austenitic stainless steels, high nitrogen stainless steels, ferritic stainless clad overlays and nickel base superalloys. Of particular interest are attempts to understand heat-affected zone structure and toughness in multipass low alloy steels through study of transformations of the martensite-austenite constituents; development of interlayer clad metals to reduce carbon contamination of ferritic stainless steel overlays and precipitation of gamma prime and carbides in the heat-affected zones of superalloys. In a new program, they are brazing silicon nitride to tungsten using a newly patented 80% copper-chromium-cobalt amorphous alloy.

. Welding Mechanics
Professor K. Satoh, Associate Professor N. Toyoda

This koza is working on design procedures for reducing residual stresses and distortion, especially with regard to hydrogen crack susceptibility, the significance of weld defects, decision methods for repair given available nondestructive testing techniques, fracture behavior of steel of heterogeneous structure (i.e., weld zones), elevated temperature creep of Hastalloy X, low yield ratio dual phase plate steel, fracture of fiber reinforced composites and static strength criteria for welded joints. This particular area combining fracture mechanics and welding is one in which the Japanese welding community places much greater emphasis than that given in the United States.

A particularly interesting study by Professor Satoh is the project on fracture behavior of steel of heterogeneous structure. This is part of an International Institute of Welding program to develop reliable methods for evaluating the brittle fracture properties of weldments, which always contain a number of zones of varying hardness and toughness. Of particular concern is the usefulness of a crack opening displacement (COD) test for such heterogeneous specimens. There is a trend to require ever greater COD values (as large as 0.3 mm). It is felt that such requirements are very difficult to achieve and may be excessively conservative especially in weld zones. Professor Satoh and his associates are attempting to develop a new fracture criterion based on either a generalized COD contain specialized topics. In addition, third year students are required to have ten days to two weeks of industrial training during the summer vacation. Other practical training includes ten hours of laboratory exercises per week in the third year (see Table II) and a thesis in the fourth year. It is interesting to note that this program leads to more than 20 student/faculty contact hours per week over a four year period. This is approximately one-third more than is typical of a university in the United States. In establishing qualifications to become a certified welding supervisor, the Japan Welding Engineering Society requires only one year of practical training for Osaka Welding Engineering Department graduates while requiring three years of other graduates.

- Graduate Educational Program

The master's program requires two years of study, most of which is spent on a research thesis. Students must take 30 units of classroom instruction of which 10 units must be selected among 23 two-unit advanced welding topics.

Doctoral degrees can be earned in two ways. One is a three year research program at the university following the master's degree, and the second is an "industrial doctorate" in which engineers who have been working in industry under supervision of a faculty member submit a thesis to the department. There are currently only eight of the former students, five of whom are Chinese, two are Korean and one is Japanese. The reason for this distribution is that such university-trained doctoral students of Japanese origin generally go on to faculty positions in Japan because Japanese industry prefers master's degree graduates to doctoral graduates. Since the number of available faculty positions in Japan is very limited, the number of native Japanese doctoral students at universities must be closely controlled. As a result, a number of Japanese universities have doctoral programs which are becoming training grounds for foreign scientists, a fact which causes considerable concern to the Japanese. On the other hand, there is no restriction on the number of "industrial doctorates" and the Welding Engineering Department at Osaka University typically produces 10 to 15 such degrees each year. This is more than double the number of doctoral welding degrees produced each year in the United States which means that on a per capita basis, Japan has four times as many welding engineering doctorates as the United States.

- Research Programs

As noted above, the Department of Welding Engineering at Osaka University has eight "koza" or chairs. Each koza is established by the Ministry of Education to develop expertise and continuity in a specific area of the discipline, hence each koza has a name. In many cases, as the field develops over the years, the original title of the koza may not fit the actual research of the professor and his associates. In addition, the translation of the koza title into English sometimes loses some of its descriptive nature. As a result, in some cases, the research of each professor and his associates may not seem to fit the title of his koza. Furthermore, some senior professors are more lenient with their junior associates, thus permitting them to study topics of their own interest rather than following the professor's lead exactly. In the following descriptions, the work is organized by koza. There are a number of Japanese social customs that suggest this as the best, if not the most logical, technical organization of the research. In most cases, detailed descriptions of the research are not given. This is because the work may be either rather old or so new that results are not available, or in the case of electron beam, lasers, and ceramic/metal bonding, more comprehensive reviews are needed. These topics in Japan as a whole are planned for a subsequent issue of the *Scientific Bulletin*.

WELDING RESEARCH AND EDUCATION AT OSAKA UNIVERSITY

Thomas W. Eagar

INTRODUCTION

Osaka University, one of Japan's former imperial universities, was established in 1931. Today, there are 10,000 students at two campuses of which 25% are studying engineering. Although Tokyo University is generally acknowledged as the finest overall academic institution in Japan, many people now believe that Osaka University has the strongest individual programs in a number of areas, several of which include the engineering departments. Certainly, Osaka's location in the industrial heartland of Japan and the available space on campus have helped attract a number of new research programs and centers.

One of the unique programs is the Department of Welding Engineering and the associated Welding Research Institute. This department is unique in Japan even as the Ohio State University Welding Department is unique in the United States; however, Osaka University dominates the Japanese welding community much more strongly than Ohio State University dominates the U.S. welding community. One reason is the size of the welding effort at Osaka. There are 17 koza (chairs) consisting of a professor, an associate professor, and one or two research associates in each. Thus the total faculty and professional staff is sixty people giving Osaka University one of the greatest concentrations of welding researchers in the world. Some idea of the strength of this effort can be obtained when one considers that approximately 30% of the technical papers published in the *Journal of the Japan Welding Society* include an author from Osaka University.

For purposes of this report, the Department of Welding Engineering and the Welding Research Institute will be discussed separately. This is more than just an administrative convenience, for while the people in the department and in the institute work closely together, their fundamental charters are different and staff from each are quick to point out that they belong to one and not to the other.

DEPARTMENT OF WELDING ENGINEERING

The Department of Welding Engineering was established in 1944 and today is the sole educational center for welding in Japan, as organized by the Ministry of Education of the Japanese government. There are eight koza (chairs) of professors and their associates, with approximately 50 undergraduate students in each of the final three years of school. In addition, there are some 75 master's degree students in a two-year program and eight doctoral students. These graduate students are supervised and taught in cooperation with the Faculty of the Welding Research Institute.

- Undergraduate Educational Program

Since welding is an interdisciplinary field, people often question what subjects should be taught to the undergraduate students. Table I lists the course of study at Osaka University which is separated into required subjects and three sets of electives. The required subjects include a basic introduction to the field plus advanced subjects and a thesis, while the primary electives lay the basic physical and chemical foundations. The secondary electives cover the engineering aspects of welding while the tertiary electives

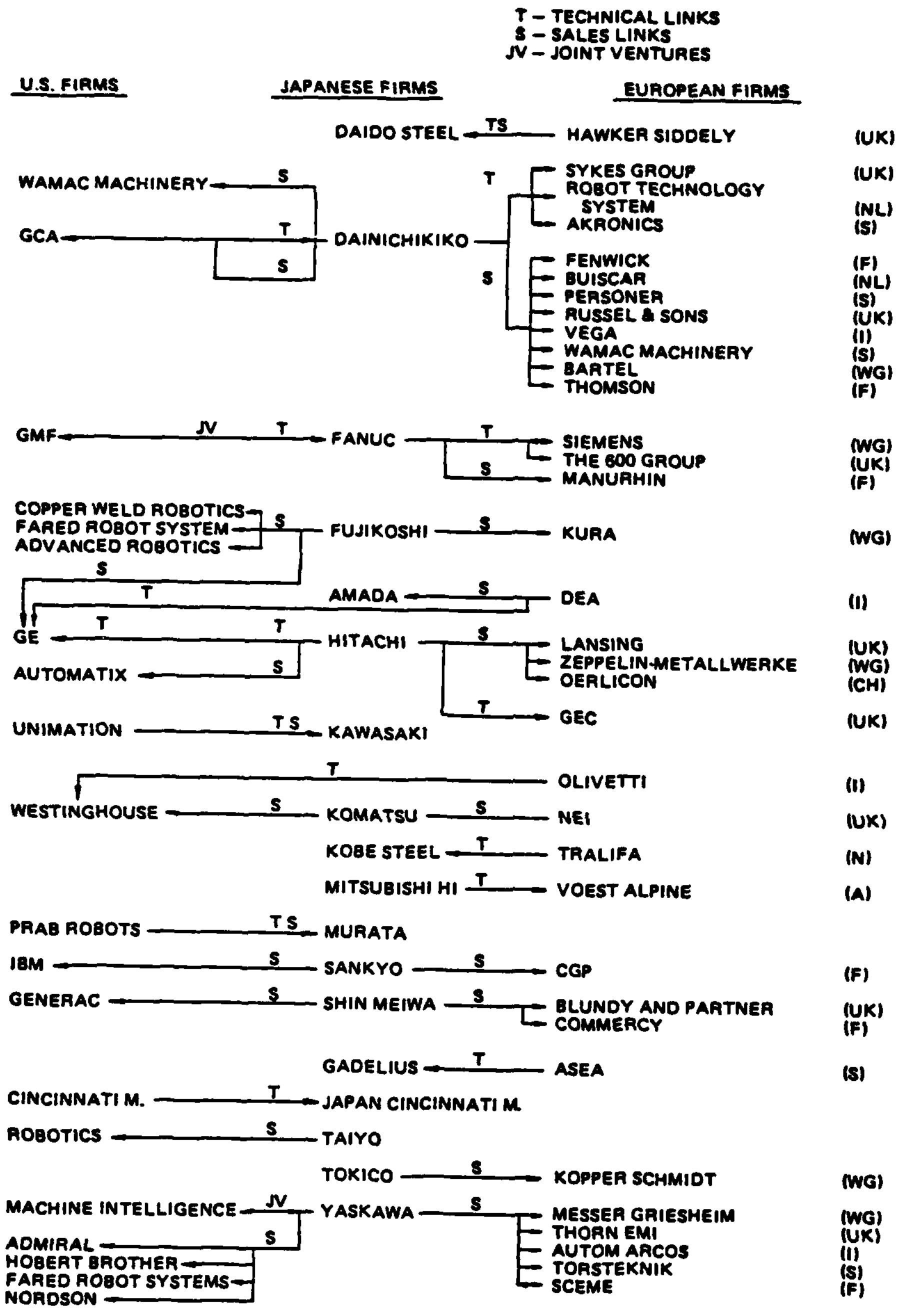

Figure 2. International Cooperation Links of Japanese Robot Manufacturers

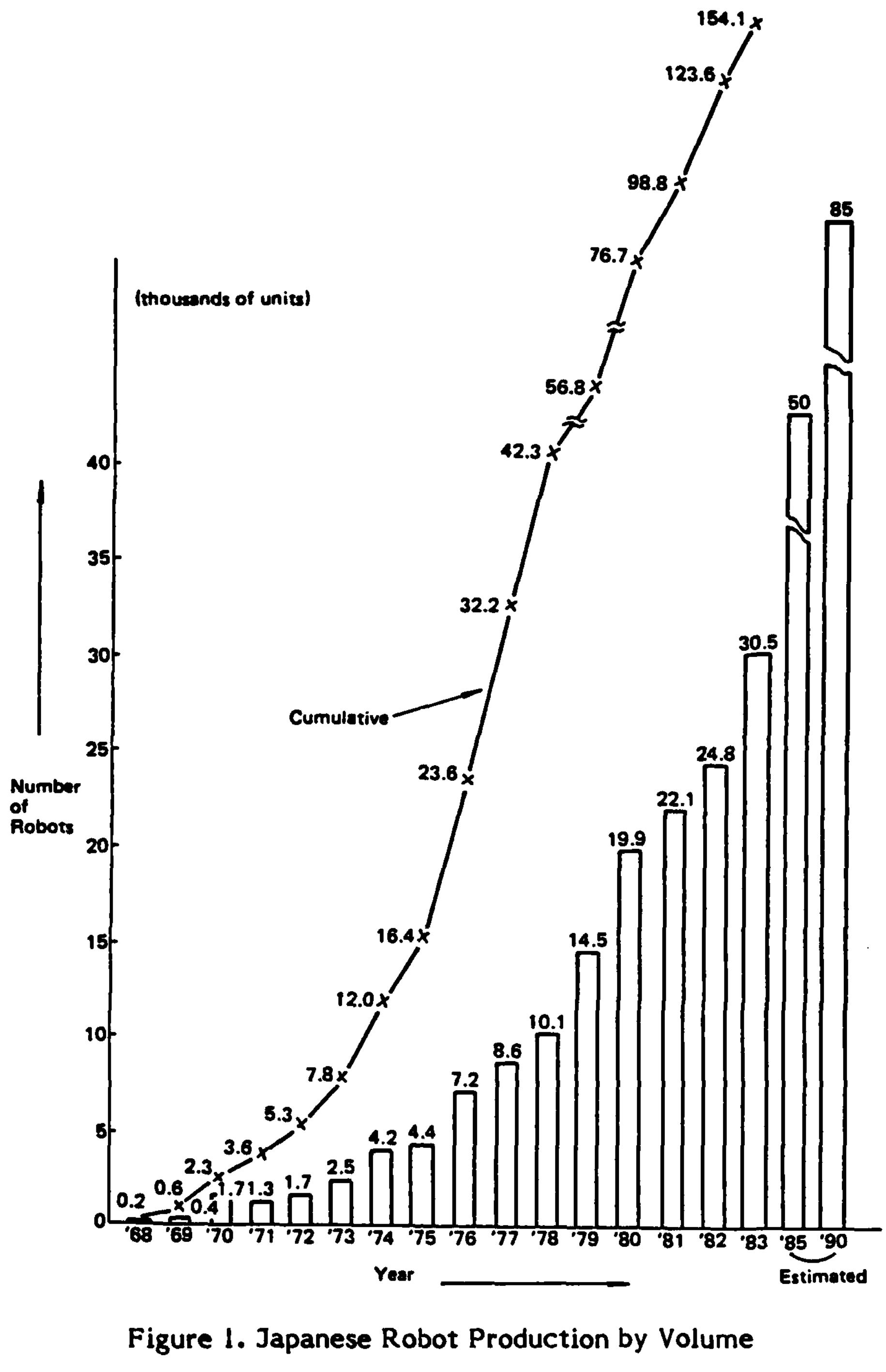

Figure 1. Japanese Robot Production by Volume

Many international links now exist between Japanese robot manufacturers and industrial firms in other countries. Figure 2, taken from the *Japan Computer Quarterly* [*60*, (1985)], depicts some of these ties. This list shows substantial cooperation among Japanese, American, and European companies. At a basic research level, there are some international projects, including at least one in an American national laboratory about to get underway. There is also a small but growing interchange of individual robotics scientists and technologists between Japan and other countries, with Americans being by far the most numerous visitors.

Nicholas A. Bond, Jr.
ONRFE/AFOSRFE

TABLE I

INDUSTRIAL ROBOT DELIVERIES DURING 1978-1983 BY INDUSTRY AND TYPE OF WORK PERFORMED

(Units: No. of robots)

Type of work	General purpose																Special purpose			Total
	1 Casting	2 Die-casting	3 Plastic molding	4 Heat processing	5 Forging	6 Pressing	Ark welding	7 Spot welding	Gas welding	8 Spraying	9 Plating	10 Cutting	11 Assembly	12 Inspecting	13 Shipment	14 Other uses	Ocean exploration	Nuclear power	Other uses	
Food processing														12	86	126				224
Textiles													5	4	17	613				639
Lumber products										61				2	2	37				92
Pulp and paper														8	40	18				66
Chemicals		5	16	1			75			1		5	186	4	59	317				669
Oil and coal products			94												23	81				198
Rubber products				10						1			10	9	36	50				116
Ceramic and stone products				15		1	3	2		7		20	7	11	43	306				415
Steel	16			1	72	13	26			1		71	26	9	130	536				901
Non-ferrous metals	66	2,320		3	12	66	2			5	1	24	28	4	20	84				2,635
Metal products	66	671			80	1,547	1,018	55		119	77	919	137	11	97	416				4,629
Boilers and motors	6						14			9		310	55			1				395
Construction machinery	1				1	12	430	2	1	29		61	19		4	20				580
Metal processing machines	300	61	7	1	3	295	282	2	2	4	1	6,077	416	9	54	100				7,614
Other general-use machines			1	1	1	42	327	17		22		203	213	6	35	364			2	1,234
Electric machines	2	414	5,967	4		1,579	487	132		192	21	2,570	12,292	164	227	937		1		24,979
Automobiles	214	695	449	29	24	1,834	3,132	5,592		506		4,839	2,752	70	112	836				21,086
Bicycles	1	37			1	52	152	50		1		42	92	4	39	24				495
Shipbuilding							29			3		1	2	3			1			39
Precision machinery		95	74	1		261	1	2		40	10	709	1,558	52	29	1,331				4,163
Synthetic			35,408			7	1			354			21	5	28	59				35,883
Other manufacturing	22	62	7	6		46	114	8	4	100	1	53	123	122	23	224			9	923
Other industries	1					11	24			19		2	70	56	47	148	6	176	47	607
For export		50	902		9	66	1,229	297		130		875	3,851	13	433	1,725				9,580
TOTAL	695	3,826	42,925	71	203	5,832	7,346	6,159	7	1,596	111	16,781	21,863	568	1,584	8,353	7	177	58	118,162

photoreactive materials (new materials)	0	340

(Budget: computed based on 250 yen = $1.00)

YOON SOO PARK
ONRFE/AFOSRFE

FUJITSU DEVELOPS A SUPERCOMPUTER WHICH IS THE FASTEST IN THE WORLD

For the first time in the world, Fujitsu has developed a supercomputer which exceeds 1.0 Gigaflops (one billion floating-point operations per second), and it has succeeded in the actual measurement of its performance at the Science and Technology Agency's National Aerospace Laboratory. The company will market it under the name of VP-400 (tentative name) during the first half of this year. It is hoped that Fujitsu, and thereby, Japan, by having developed a computer with the highest operation speed in the world, ahead of the United States, will attract worldwide attention. This will have the significant effect of raising Japan's aircraft development level but will also provide significant prestige to scientific and technological research.

According to Fujitsu, this supercomputer was developed to succeed the VP-200 supercomputer (which is already in operation at Kyoto University), by improving the hardware, i.e., doubling the pipeline thickness which carries out the high speed operations.

It is hoped that by putting the superhigh speed machine to practical use (which has twice the performance capacity of the VP-200) it will be possible to make contributions not only to the development of aircraft but also to research and development in science and technology, including weather forecasts, studies on nuclear energy, and nuclear fusion.

The National Aerospace Laboratory is planning to announce the results of research using the Fujitsu supercomputer at a meeting with the U.S. Aeronautics and Space Institute in the U.S. in June 1985. National Aerospace Laboratory Computing Center Manager, Hajime Miyoshi, says: "The development of aircraft by Japan is inferior to that by the U.S. both in experimental facilities and development expense. However, in the area of mathematical operations Japan ranks alongside the U.S. because of its supercomputers, and it has reached a level that is hoped will exceed the computer development of the U.S. At the present time, as aircraft development is shifting from that of independent development to joint development by various countries, the practical use of the domestic-produced superhigh speed computer is of great significance in the sense that it will serve as a probable bargaining tool."

(Paraphrased from a report in the *Nihon Keizai* on 8 January 1985).

JAPANESE ROBOT PRODUCTION BOOM CONTINUES

The first really big years in Japanese robotics came at the end of the 1970s; by 1980, some 20,000 units were being produced annually; by 1983, the productive count was 31,000 and the estimated total for last year was at least 40,000 (1984 new robot value was about 140 billion yen, or about $1.0 billion). Figure 1 shows this growth pattern.

A majority of Japanese robots are employed in the electric machinery and automobile industries. Table 1 gives a utilization breakdown by industry and by type of work performed; welding and cutting are still the most popular applications.

project themes to 14 from the present number of 12 beginning in 1985. The two new categories added are biodevices (biotechnology) and photoreactive materials (new materials). In the biodevice project, research focuses on:

- formation, processing and application of monomolecular protein film,
- information transmission mechanism in nerve cells and its mimic devices, and
- protein molecular devices which can memorize and switch.

The photoreactive materials are, (1) to develop high efficiency photochromic compounds, and (2) to elucidate PHB phenomenon and investigate high density optical recording materials (development of optical materials capable of recording 1000 times the existing materials). An annual budget of 85 million yen ($340,000) is earmarked for each project in 1985.

The program began in 1981 and each subproject is scheduled to last eight to ten years. The overall goal is to explore revolutionary basic technologies essential to the establishment of new industries which are expected to flourish in the 1990s. The fields selected are listed below with budget figures for 1984 and 1985.

Fourteen special categories have been selected:

	BUDGET ($U.S. thousands)	
NEW MATERIALS	$13,032	$14,112
high performance ceramics	3,452	3,856
synthetic membranes for new separation technology	2,108	2,228
synthetic metals	1,360	1,496
high performance plastics	1,204	1,192
advanced alloys with controlled crystalline structures	2,272	2,440
advanced composite materials	2,632	2,888
BIOTECHNOLOGY	4,804	5,008
bioreactors	1,812	1,780
large-scale cultivation	1,532	1,716
utilizing recombinant DNA	1,460	1,508
NEW ELECTRONIC DEVICES	5,912	6,340
superlattice devices	1,720	1,808
three-dimensional ICs	2,948	3,224
fortified ICs for extreme conditions	1,244	1,308
FY1985 ADDITION		
biodevices (biotechnology)	0	340

crystals and new properties caused by composition and spatial distributions of impurity concentrations,

- to explore the possibility of new alloy semiconductors with new physical constants and to develop new devices.

. Research Categories

The project is divided into the following six categories:

research on growth mechanisms and phase stability,

research on structures and new materials,

research on evaluation methods and defect structures,

research on physical properties and tailoring schemes,

research on thin films, and surface quantum effects and their applications, and

research on alloy devices and new process technology.

. Research Duration

Three years (April 1985 - March 1989)

. Budget

$2.4 million

. Organization

Coordinators 16

Researchers 45

. Project Director

Professor Akio Sasaki
Department of Electrical Engineering
Kyoto University
Kyoto 606, Japan
Tel: (075) 751-2111

YOON SOO PARK
ONRFE/AFOSRFE

R&D PROJECT ON BASIC TECHNOLOGY FOR NEW INDUSTRIES

The Ministry of International Trade and Industry (MITI) has announced the addition of two new research categories in one of their national projects entitled "The Research and Development Project of Basic Technology for New Industries." This brings the number of

Just as there is a tremendous demand by industry in the United States for graduates of welding engineering, graduates of welding engineering at Osaka University have an average of three job offers as compared with two for all students in the Faculty of Engineering. This shows that the program is strong and viable; however, one finds some of the same difficulties in Japan as in the United States. The best engineering students often choose other fields such as electrical engineering, and welding engineering students, while in high demand by industry, are not among the best engineering students. In addition, some people in Japan question whether an undergraduate education in a multidisciplinary field, such as welding, provides sufficient depth in any one area.

Japan's rapid industrialization of the past two decades provided strong incentive for growth of the department and establishment of the Welding Research Institute. The department expanded from four koza to eight in 1960 and the institute grew rapidly from 1972 to 1976; however, the current depressed state of the heavy fabrication and shipbuilding industry in Japan raises doubts about the long-term mission of the research institute. The demand for undergraduate and master's students will no doubt continue as some 60 trained welding engineers per year is much less than can be absorbed by industry. Indeed, in Japan as well as in the United States, industry commonly retrains a metallurgical or a mechanical engineer or a physicist to work on joining problems. It is likely that more welding engineers are produced in this way than are trained as undergraduates in either country. The question that arises is whether the declining heavy industry in Japan can absorb the tremendous amount of welding research that can be produced at Osaka University. Certainly, many more doctoral level students could be produced, but there is not a sufficient market for their level of skills. One wonders if the introduction of a growing number of nonwelding related topics such as laser processing, rapid solidification, and fusion energy are not a means of utilizing a laboratory that may be too large for the industrial base that it supports. Certainly there are many examples in the United States of national laboratories that have shifted their emphasis as the industrial needs change. It will be interesting to see both the rate of completion and the size of the future research centers listed in Table III. The Ultrahigh Energy Density Heat Source Center is by far the largest of its kind in the world; however, funding for the second center was delayed for several years and its completed size is much smaller; essentially only two rooms rather than the four story building of the first center. If one looks at the original organizational plan, one might have expected the Large Structures Laboratory to be the second center, but given the present low level of use of several such facilities at industrial laboratories in Japan, it is not surprising that the Ministry of Education might delay constructing another such facility.

The comments above are not meant to depreciate the Welding Research Institute in any way. As already noted, the quality of its facilities and staff are among the very best in the world. Rather, the above comments suggest that the goals and objectives of the Welding Research Institute must and are changing from the needs of the 1970s. The last two decades required knowledge of heavy fabrication in Japan. The future points to smaller, higher value added parts made of unconventional materials. It is significant to note that seven of the nine koza at the Welding Research Institute and at least two of the eight koza in the Department of Welding Engineering are now studying some form of ceramic to metal bonding. It is likely that additional "nontraditional" welding research will be undertaken in the future as the faculty adapt to Japan's changing needs.

Another changing trend is the encouragement of industrial interaction by the Ministry of Education. In the past, the Ministry held an official position that faculty were not to have direct contact with industrial problems. Now the Ministry is encouraging faculty to study more practical problems. It even seems that now the faculty may be the ones resisting such work rather than the Ministry.

A number of years ago, Japan decided to emphasize welding technology because they were so far behind other countries. By constant steady support, and because of strong leadership from several men and from professional societies, Japanese welding technology now leads the world. Many Japanese believe that it is this lead in fabrication technology that has helped them gain much of their reputation for a consistently high quality manufactured product. Through the establishment of a large program in both the Department of Welding Engineering and the Welding Research Institute, the Japanese are now leading in many areas of basic welding research. The faculty and facilities at Osaka University provide Japan with a scientific base for welding and joining that may be the best in the world. As Japan's industrial base changes to smaller, higher technology products, the welding faculty at Osaka University is changing to meet the future challenges of materials fabrication.

予 算 Budget

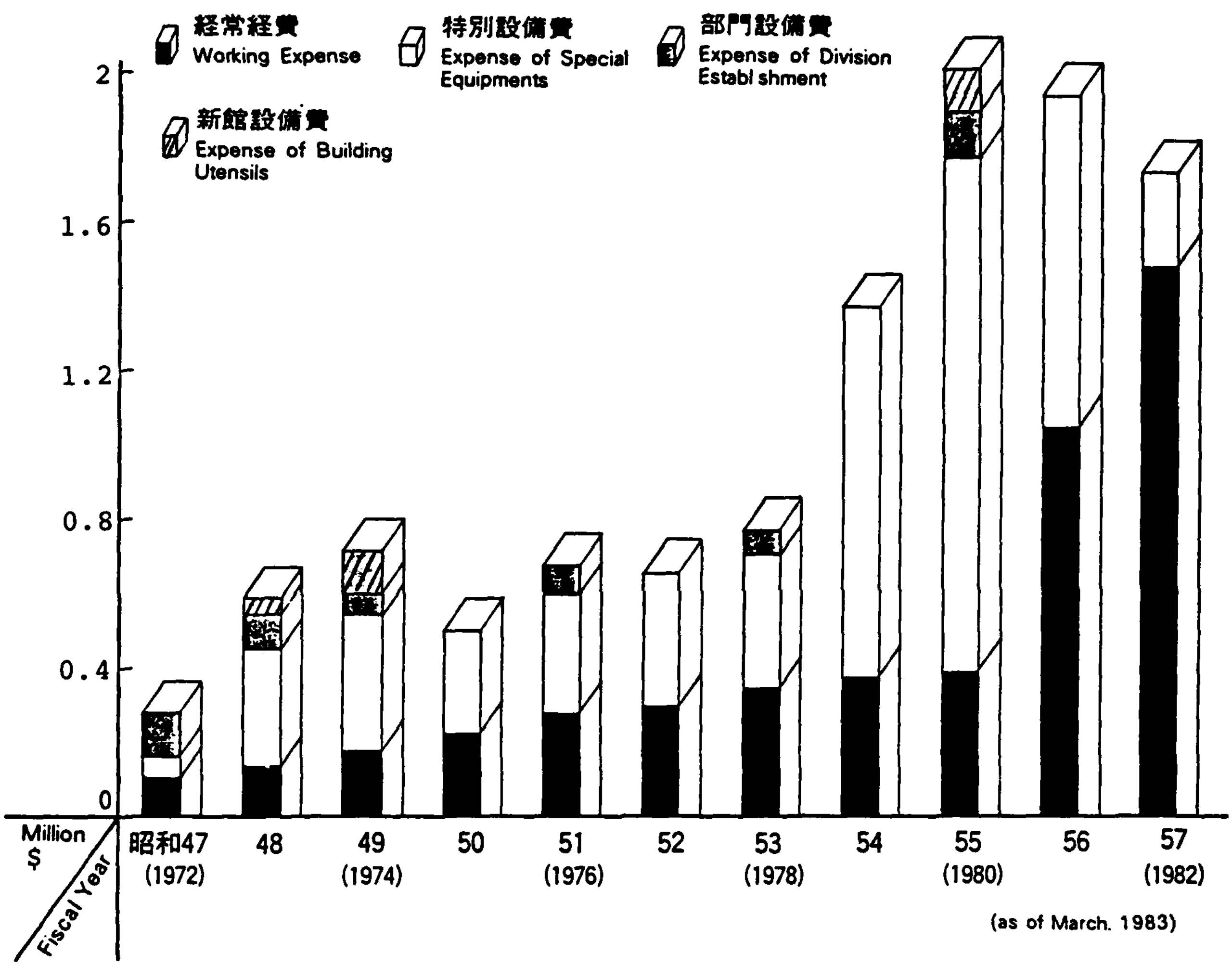

Figure 1. Welding Research Institute Budget. Note that these figures do not include salaries.

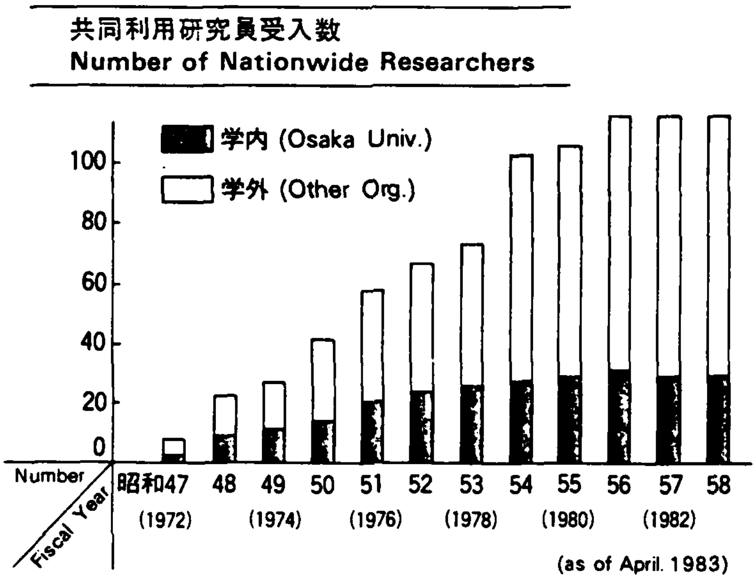

Figure 2. Number of persons pursuing research at the Welding Research Institute. Note that "other organizations" does not include persons from industry.

REFERENCES

Figures 1 and 2 are taken from the 1983 Handbook of the Welding Research Institute, Osaka University

TABLE I

UNDERGRADUATE COURSE OF STUDY FOR A WELDING ENGINEERING DEGREE AT OSAKA UNIVERSITY

REQUIREMENTS	UNITS
Experiments in Welding Engineering I	(4)
Experiments in Welding Engineering II	(3)
Exercise in Welding Metallurgy	(1)
Exercise in Welding Mechanics	(1)
Exercise in Computer Programming	(1)
Exercise in Electrical Engineering for Welding Processes	(1)
Exercise in Welding Physics	(1)
Experiments in Electrical Engineering	(1)
Design and Drawing of Machines	(1)
Graduate Subjects and Thesis	(22)
	36 out of 36 required

PRIMARY ELECTIVES	UNITS
Mathematical Analysis I	(2)
Mathematical Analysis II	(4)
Mathematical Analysis III	(2)
Numerical Analysis	(2)
Physical Chemistry for Welding I	(2)
Physical Chemistry for Welding II	(2)
Outline of Mechanical Engineering	(4)
Engineering Materials	(2)
Metal Physics I	(2)
Metal Physics II	(2)
Elasticity and Strength of Materials	(2)
Theory of Elasticity	(2)
Mechanical Behavior of Materials	(2)
Structural Dynamics	(2)
Heat and Mass Transfer I	(2)
Heat and Mass Transfer II	(2)
Quantum Mechanics	(2)
Statistical Mechanics	(2)
Computer Programming	(2)
	32 out of 42 required

SECONDARY ELECTIVES	UNITS
Outline of Welding Engineering	(2)
Physical Metallurgy for Welding I	(2)
Physical Metallurgy for Welding II	(2)
Chemical Metallurgy for Welding	(2)
Solidification Metallurgy for Welding	(2)

TABLE I (continued)

Materials Science for Welding	(2)
Theory of Welding Mechanics I	(2)
Theory of Welding Mechanics II	(2)
Theory of Welding Mechanics III	(2)
Electrical Engineering for Welding I	(2)
Electrical Engineering for Welding II	(2)
Electrical Engineering for Welding III	(2)
Physics of Welding Arc	(2)
Control Systems Engineering	(2)
Nondestructive Test Engineering	(2)
	22 out of 30 required

TERTIARY ELECTIVES	UNITS
Theory of Welding Design	(2)
Welding Machines and Apparatus	(2)
Welding Process I	(2)
Welding Process II	(2)
Welding Process III	(2)
Flame Machining	(2)
Theory of Metal Manufacturing	(2)
Test Engineering for Welding	(2)
Welding Management	(2)
Special Lecture	(2)
	14 out of 20 required

Total 104 units minimum plus,
24 units of humanities,
12 units of foreign language, and
33 units of natural sciences.

Note: Each unit corresponds to one contact (lecture) hour per week of a 15-week semester.

TABLE II

WELDING ENGINEERING DEPARTMENT AT OSAKA UNIVERSITY
THIRD YEAR STUDENT LABORATORIES

Practical training

- Shielded metal arc welding
- Semiautomatic CO_2-gas welding

Welding Metallurgy

- Analysis of chemical compositions of weld metal
- Solidification of welds of aluminum alloys
- Metallurgical structure of heat-affected zone of steel welds
- Hydrogen behavior in welds and its measurements

Welding mechanics

- Static strength and ductility of steel
- Welding deformation and residual stresses/strains
- Fracture toughness testing and fracture behavior of notched plates

Welding machines and processes

- Arc welding transformers
- Arc properties and bead formation in gas tungsten arc welding
- Metal transfer and bead formation in gas metal arc welding
- Nugget formation in spot welding
- Oxyfuel cutting

Nondestructive testing of welds

- Radiographic testing of welds
- Ultrasonic testing of welds

Note: Laboratory experience includes ten hours on each of these sixteen topics.

TABLE III

FACULTY ORGANIZATION AND RESEARCH CENTERS OF THE WELDING RESEARCH INSTITUTE

Faculty Chairs (Koza)

- Welding Energy Sources and Heat Transfer (1969)
- Heat and Mass Transfer (1970)
- Chemical Reactions (1971)
- Material Physics (1972)
- Elasticity and Plasticity (1973)
- Welding Instruments (1974)
- Welded Structures (1976)
- Fusion Welding (1978)
- Pressure Welding (1980)
- Thermal Cutting*

Centers

- Ultrahigh Energy Density Heat Sources (1979)
- Underwater Welding and Cutting (1984)
- Testing of Large Structures*
- Welding Data Processing and Information Analysis*
- Safety and Quality Assurance*

*Planned but not yet established.

Note: Years in parentheses show year koza or center was established.

TABLE IV

MAJOR EQUIPMENT OF THE WELDING RESEARCH INSTITUTE

1. Electron Microprobe X-ray Analyzer (50 kV)
2. Ion Probe Microanalyzer (10 kV)
3. Auger Electron Spectroscope
4. Electron Spin Resonance Spectrometer (10^4 Gauss)
5. Laser Raman Spectroscope
6. Automatic Ellipsometer
7. Scanning Electron Microscope
8. Transmission Electron Microscope (125 kV)
9. High Temperature Optical Microscope (Compression-tension Type)
10. UV-VIS-NIR Recording Spectrometer
11. Optical Multichannel Analyzer (OMA)
12. X-ray Diffractometers (Normal and Rotating-anode Types)
13. High Temperature X-ray Diffractometer for Liquid State Analysis
14. X-ray Apparatus with Image Amplifier (150 kV)
15. X-ray Stress Analyzer
16. Internal Friction Measurement Apparatus (Torsion Type)
17. High Speed Wave Form Analyzer
18. Remote Batch Station (MELCOM 70/25)
19. Minicomputer (MELCOM 70/30, HITAC E-800)
20. Drum Scanner Digital Image Input Device
21. Microcomputer Data Processing System
22. High Speed Cinematograph Image Processing System
23. CCT Diagram Measurement Apparatus
24. Weld Thermal-restraint Stress and Strain-cycles Simulator
25. Simultaneous Nitrogen/Oxygen Determinator
26. Atomic Absorption Spectrometer
27. 600 ton Horizontal Tensile Testing Machine
28. 300 ton Vertical-150 ton Horizontal Universal Testing Machine
29. 10 ton Displacement Controlled Testing Machine
30. Uniaxial Fatigue Testing Machine (30 ton, 5 ton)
31. Biaxial Fatigue Testing Machine (20 ton)
32. Fatigue Testing Machine for Structural Component (20 ton)
33. Drop-weight Test Apparatus (1200 ft lb)
34. Multiple Creep Rupture Apparatus
35. Weld Cracking Testers (VARESTRAINT, 100∼5 ton TRC-RRC, VDR, 5 ton Implant, etc.)
36. AE Detector
37. Automatic Ultrasonic Testing and Recording Apparatus
38. 300 kW, 600 kV Electron Beam Welder
39. 100 kW, 100 kV Electron Beam Welder
40. 100 kW, 300 kV Electron Beam Welder
41. Tandem Electron Beam Welder
42. High Power CO_2 Gas Laser Apparatus (2 sets)
43. Pulsed YAG Laser Apparatus (200 W)
44. Microwave Plasma Beam Generator (100 kW)
45. Millimeter Energy Beam Generator
46. Fusion Welders (ESW, EGW, SAW, GMAW, GTAW, PAW, etc.)

47. Analog Transistor Power Supply Source (800 A, 45 V)
48. Diffusion Welding Apparatus
49. Ultrasonic Welding and Soldering Apparatuses
50. Plasma Spraying Apparatus (80 kW)
51. Highly Concentrated Supersonic Flame Spraying Equipment
52. Automatic Dip Soldering Apparatus for Printed Circuit Board
53. Liquid Rapid Quenching Apparatus
54. Ion Nitriding Surface Treatment Apparatus
55. Ion Beam Thining Apparatus
56. Constant Extension Rate Tester for Stress Corrosion Cracking

INTERNATIONAL CONFERENCE ON QUALITY AND RELIABILITY IN WELDING, HANGZHOU, PEOPLE'S REPUBLIC OF CHINA

Thomas W. Eagar

INTRODUCTION

The Chinese Mechanical Engineering Society hosted an International Conference on Welding in Hangzhou, People's Republic of China from 6-8 September 1984. The conference was attended by nearly 300 people from 16 countries, with two-thirds of the attendees coming from China, 28 from Japan, 22 from West Germany, and 15 from the United States.

In his opening address, Professor J. L. Pan of Tsinghua University in Beijing, the conference chairman, noted that the China Welding Institution was formed in 1962 and today has 10,000 members organized into 15 technical committees corresponding to the Commissions of the International Institute of Welding. Professor Pan noted that there are currently over 20 universities in China with welding research and education programs. Judging from the list of Chinese participants at this conference, there are at least another 29 research institutes with interests in welding technology. A listing of Chinese universities and research institutes sending representatives to this conference is provided in Table I.

Chinese researchers submitted over 600 papers for this conference; however, only 106 were accepted with some 36 being presented to the attendees and the remainder given in a poster session. It is obvious that the Chinese have a very strong interest in welding technology and, in total, may have the largest number of welding researchers in the world.

CONFERENCE HIGHLIGHTS

There was one keynote paper from each of the following countries: People's Republic of China, France, West Germany, Japan, the United Kingdom, and the United States. A scheduled paper from the Soviet Union was published in the Proceedings but was not presented due to the absence of all Soviet attendees. The remainder of the conference was organized into four topical areas with approximately thirty presentations in each area. These included:

- special welding processes and brazing,
- weldability of metals and welding consumables,
- welding mechanics, quality assurance, design, and
- nondestructive testing, arc, electroslag, and pressure welding.

In his keynote lecture, Professor Pan described the development of pulsed current arc welding control techniques and equipment in China. Through the use of transistorized or silicon-controlled rectifier power sources with controlled wave shapes, the Chinese have reduced weld spatter in CO_2 shielded gas metal arc (GMA) welding; have improved metal transfer in argon shielded GMA with a dual or even triple step voltage-current characteristic (as compared with conventional flat or drooping power circuits); and have developed pulsed plasma arc welding with feedback control. It is clear from this paper that the Chinese have performed a large amount of research on welding power source design and they claim to have introduced a number of their advances into industrial production.

Among the papers on special joining processes, Professor Y. Arata of Osaka

University presented a study of diffusion bonding of aluminum alloys to calcia-stabilized zirconia ceramic. It was found that aluminum alloys containing magnesium performed best due to the ability of the magnesium to promote breakdown of aluminum oxide surface layers and reaction with the ceramic. Maximum bond strengths were on the order of 4 kg per mm^2.

In a more theoretical study, Professor K. Nishiguchi of Osaka University has developed a two-dimensional model of diffusion bonding from which he claims to assess the relative influence of plastic deformation, creep deformation, interfacial diffusion, and volumetric diffusion on the formation of the joint. The theoretical results are compared favorably with experimental results from copper to copper bonds.

In the area of high energy density welding processes, Mr. C. Peng *et al.* of the Chengdu Electric Welding Machine Research Institute have coupled five 100 W CO_2 laser cavities together with reflective lens optics. It is claimed that the resulting system is less complex, more compact, and lower cost than single resonant cavity systems of equal power while maintaining good beam stability.

In electron beam welding, Professor A. Halas of the Institute of Electron Technology in Wroclaw, Poland, claims to have discovered a correlation between deep penetration spiking behavior and ion beam current caused by metal vaporization from the beam hole. He believes that a control circuit can be developed to suppress spiking using this ion beam as a sensor; however, his paper does not present the actual application of such a circuit.

In an unpresented, but published paper, Professor O. K. Nazarenko of the Paton Welding Institute in Kiev, U.S.S.R., describes a fast recovery circuit for electron beam power supplies which are subject to arcing developed by the ion current. It is claimed that the system works at 140 kV, 120 kW with 0.5% voltage stability. This is apparently a version of the system which Hitachi, Ltd., in Japan, licensed from the Paton Institute to improve beam stability in their high power electron beam production facility. Some investigators in Japan consider beam breakdown due to arcing to be the most serious problem with deep penetration electron beam welding; hence, this Soviet technology could have significant practical consequences.

Two separate studies of the effect of nonmetallic inclusions on weld hydrogen cracking were reported. Professor Y. Kikuta of Osaka University found inclusions in the heat affected zone (HAZ) act as hydrogen traps and reduce the incidence of cracking. Furthermore, in his study, cerium additions had no effect on hydrogen embrittlement. The opposite trend was found by Professor Z. Y. Si of the Institute of Metal Research in Shenyang. He reported that rare earths (i.e., cerium) have a beneficial effect in reducing HAZ cold cracking; hence, these two papers tend to continue the debate in the literature over the effect of inclusions and cerium treatment on weld hydrogen cracking.

Dr. T. Shida reviewed the production experience gained by Hitachi, Ltd., on hot and cold cracking of steels welded by the deep penetration electron beam process. His results define limits on the composition of manganese, sulfur, phosphorus, carbon, and oxygen in these steels. A summary of these limits is given in Figures 1 through 5.

In another study of improved steels for pressure vessel applications, Dr. K. Bessyo of Sumitomo Metal Industries reported that additions of boron to normalized $2\frac{1}{4}$Cr-1Mo steels permits other modifications of the steel composition such as reduced carbon, manganese, copper, and nickel. The result is a steel of equivalent strength but with a reduction of weld preheat requirements of 75°C or more, with lower susceptibility to temper embrittlement. It was reported that Sumitomo already has had several successful production experiences with these new steels.

Professor C. Lundin of the University of Tennessee presented an excellent analysis of HAZ cracking in both partially ferritic and fully austenitic stainless steels. He has found that on cooling of the HAZ, the ferrite of partially ferritic welds can be reduced from its initial value of 5% to less than 1%. This can cause potential cracking problems. The experimental work is supported by a theoretical model of solid state ferrite transformation based upon the equilibrium phase diagram.

Drs. U. Mitra and C. S. Chai of the Massachusetts Institute of Technology presented a new theory for prediction of submerged arc weld metal composition based upon fundamental thermodynamic and kinetic principles. They show that the theory is applicable to a wide range of flux compositions and can predict experimental values of manganese and silicon with a correlation coefficient of approximately 0.90.

In a fundamental theoretical and experimental study of fracture in composite steel structures with a hard band of 1.5 to 6.0 mm width, Professor X. Tian of Harbin Institute of Technology, shows that the crack opening displacement (COD) value can be reduced significantly. This study has considerable value in interpreting tests of fracture resistance of weldments with high hardness HAZ's.

Among the papers on nondestructive testing, Professor L. Wu, also of Harbin Institute of Technology, presented their work on computer image analysis of x-ray films. Although such work is already commercialized on a more sophisticated level in the United States, the interesting feature of Professor Wu's study is that all of the analysis is done with a MZ-80 8-bit microcomputer, whereas in the United States much larger 16- and 32-bit minicomputers or mainframe computers are required for such analysis. Professor Wu's work is but one example of an intense Chinese interest in microprocessors and microcomputers and the seemingly greater effective use by the Chinese of limited computational power as compared with applications of computer technology in the United States. The Chinese seem to get the most from their limited computational facilities, whereas in the United States computational power is more abundant and engineers need not design such efficient software programs.

Professor M. Ushio of Osaka University presented an experimental analysis of pulsed current metal transfer in argon-carbon dioxide and pure carbon dioxide gas metal arc welding. He has developed pulsing parameters which eliminate spatter, thus increasing the potential use of this process in automated equipment. Since this research was performed with support from several Japanese companies, it is likely that the results will be commercialized in the near future.

In a joint paper with a Chinese researcher, Professor W. Giedt of the University of California at Davis presented infrared temperature measurements of the center of the weld pool surface. These were made immediately after arc termination. Using a heat flow model, they found a maximum temperature of 2000°C for 304 stainless steel, but only 1750°C for 303 stainless steel. The differences are no doubt related to different convective patterns in the weld pool; however, these experimental results are the opposite of those expected from theoretical models. It is clear that more experimental and theoretical work in this area is needed.

In one of the final papers of the conference, Professor Q. Wang of the Harbin Institute of Technology reported on frequency spectral analysis of the arc sound as a method of detecting weld defects. His results show significant changes in the sound spectra when gas tungsten arc welding or plasma arc welding of aluminum and titanium alloys; however, no relationship between the spectra and actual welding defects is presented.

In another significant paper, not submitted to this conference but published in the September 1984, *Transactions of the China Welding Institution*, Mr. J. Li of Tianjin University describes arc plasma diagnostics using pulsed laser holographic interferometry. This work is nearly identical to a large welding research program directed by Dr. J. Key at Idaho National Engineering Laboratory which is funded by the United States Department of Energy, Basic Energy Sciences. This paper clearly shows that the Chinese are performing welding research that is as current and as sophisticated as any research performed anywhere else in the world.

SUMMARY

This was an excellent international conference in which a number of new ideas or developments were presented from many countries. Perhaps the most impressive aspect is the rapid development of the quality of welding research in China. At a similar international welding conference held in Osaka, Japan, four years prior to this conference, several Chinese papers were presented; however, at that time it was obvious that the Chinese universities and research institutes lacked the analytical facilities and equipment to perform world class research. In the past four years that situation has changed dramatically. The facilities at the Institute of Metals Research in Shenyang are particularly impressive; they are easily of world-class standard. In general, the level of welding research at all Chinese universities and research institutes seems to have made great advances. Although this author has no direct evidence, it appears from the industrial welding equipment show held in conjunction with this conference that Chinese industrial welding technology still has some potential for advancement. Nevertheless, it is likely that the industrial welding technology will follow the growth of welding research in future years.

As part of their plan for modernization and industrialization, the Chinese place great emphasis on welding technology. This conference has demonstrated that they are rapidly developing the facilities and the people capable of making significant contributions to worldwide welding technology. It is the responsibility of other countries to recognize these achievements and to establish new friendships and cooperation with the Chinese welding community.

trainees actually wanted to practice a little more. In the second month, though, a slight slump in interest occurred; then at the third month the students again wanted to practice a little more than two hours a day. Extrapolating from such data, it might take the best part of a year to produce a fully-trained and fast two-stroke touch typist on the T-Code board.

Yamada originally was concerned that his trainees might rebel at the bare, big board presentation, and that they would prefer a more logically coherent organization. His fears were unfounded: the learners quickly adapted to the 40-key two-stroke coding setup, and did not often need any dictionary or other aids. One of the incidental data observations was that about 60% of log-on time during the computer-aided teaching was actually spent on keying practice behavior; that figure shows that the teaching system is pretty well suited to students, and does not provoke a lot of goofing-off behavior.

TYPING IN THE JAPANESE OFFICE OF THE FUTURE

Extrapolating his preliminary results toward a career typist concept, Yamada ends his monograph with a projection for the future. As seen in Figure 8, after a year or two of practice, a typist using the T-Code, or some variant of it, can be expected to type more than 300 strokes a minute (remember, that rate is about what skilled English typists now do). This means 150 Japanese characters per minute, which is nearly twice as fast as can be achieved on the kana-kanji word processor systems now being sold. No doubt champion typists, secretarial schools, special training routines in high schools, and many other developments would ensue, once the two-stroke-touch concept became popular. However, there is much plain inertia and it often seems, to an outsider, that the Japanese typing technology community is largely ignoring the ingenious work of Yamada and others.

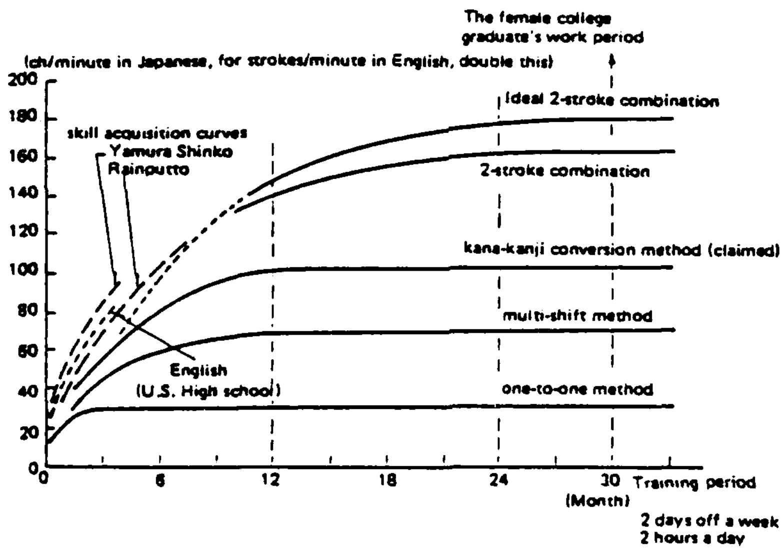

Figure 8. Schematic Learning Curves of Typing Speed for Various Input Methods under Production Conditions

analogies to this inside-out coding preference in the psychological literature; the issue deserves experimentation.

A practical bottom line, of course, for any input system revolves around questions of learnability and acceptability to operators, and the eventual use of the system in offices. Yamada and his colleagues already have trained a few operators, and have worked up a computer-aided training course. Each lesson in the training series has new characters in it; when the learner attains a certain speed error proficiency, another lesson is introduced which contains new characters. When that happens, the search time and errors will temporarily increase, but eventually the new characters will be emitted at the old (desired) rate. One would thus hypothesize a jagged but increasing learning curve over a training time of many hours. One of Yamada's subjects had the curve shown in Figure 7.

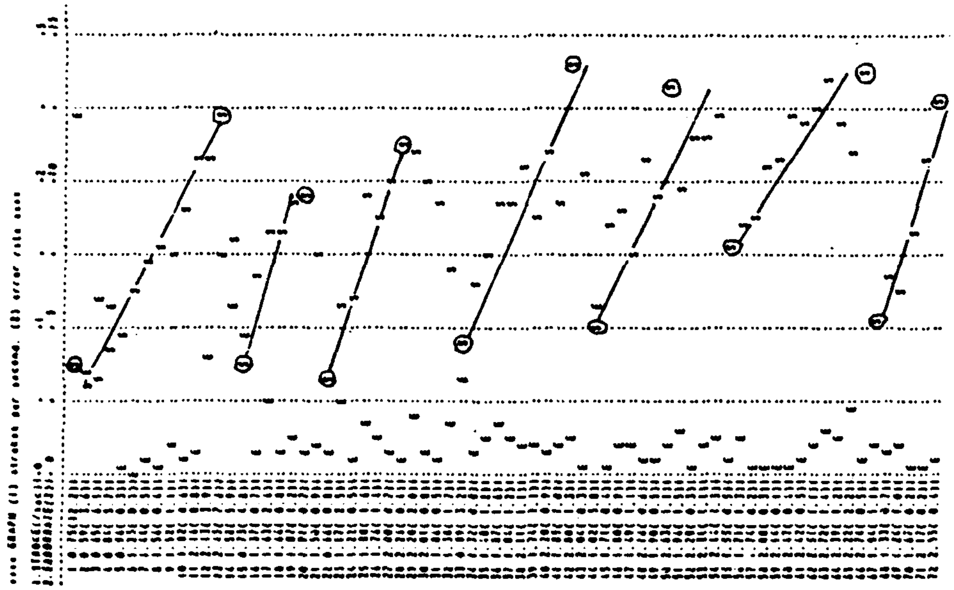

Figure 7. Learning Curves for T-Code Training

With 72 data points representing 72 hours of training, the response emission rates go up from less than a stroke per second to over two strokes per second. At least for this one subject, the improvement slopes are quite steep and they are fairly consistent over the seven lessons. Thus, the overall results are encouraging. It should be remarked here that there was no mnemonic coding to assist: the trainee learned directly from the large symbol array shown in Figure 6. We have no information about any personal coding tricks and shortcuts that the trainees may have developed for themselves. Surprisingly, few if any studies of English typing behavior have looked into how beginners in touch typing classes go about "learning the spots" (memorizing the symbols for each key).

Some practical experiences with the Yamada training regimen were also reported. Two hours a day of practice during the first month seemed to be about right; in fact, the

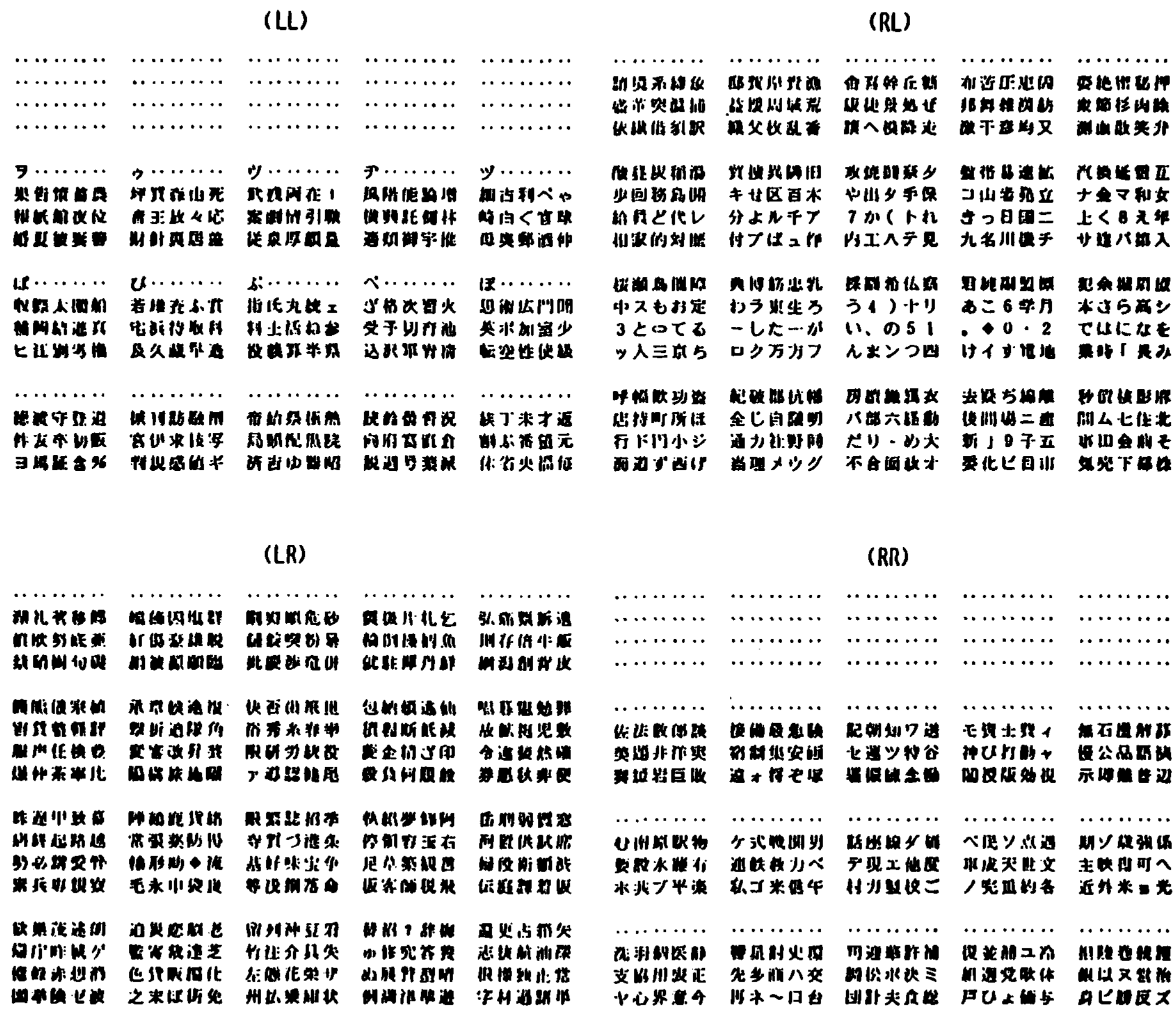

Figure 6. Inside Out Code Array for T-Codes

First it may be noticed that only 40 keys are used, and that same hand two-stroke keying in the top row is avoided. The 1200 characters possible with this T-Code keyboard are believed to cover 95% of the kanjis, and perhaps 98% of the total characters in a standard business or journalistic format. For alternate handstroking, R-L pairs get the most frequently used characters.

It should also be mentioned that the keying is inside-out. Thus, the first keystroke indicates not the block (of 20 characters) that the desired item is in, but rather the placement of an item inside that block. Thus to effect the 0 (numerical zero) entry, first the right middle finger in the home row is struck, then the index finger of the left hand. Originally Yamada assumed that outside-in (block first) coding would be best, but his trainees preferred inside-out during the learning phase. There seem to be no obvious

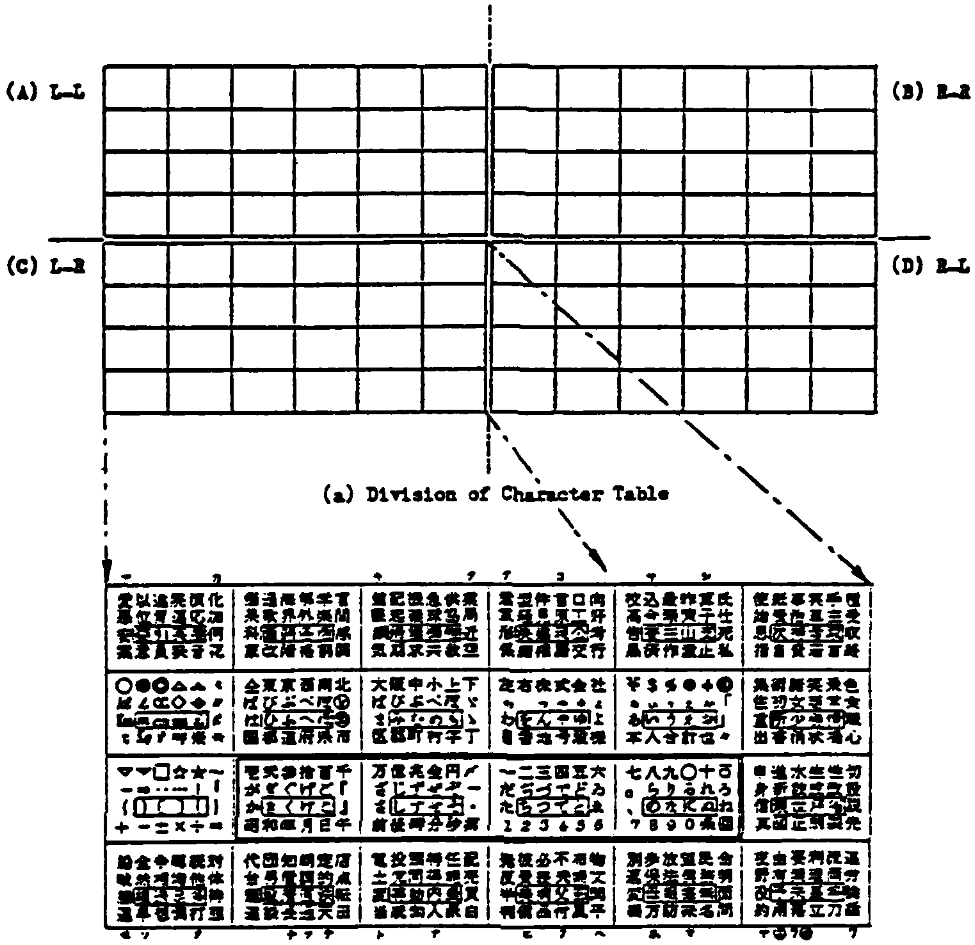

Figure 5. Code Array for 2-Stroke Codes

OPTIMIZED TWO-STROKE KANJI CODING

The Shinko code displayed in Figure 5 certainly can represent the 2304 characters in a 48x48 matrix. But Yamada wanted to go further than that: for one thing, he wanted to limit the basic character set to something less than two thousand so that he could have room for special symbols needed by a particular user. And then, more generally, he wanted to plan for the smoothest and fastest hand and finger motions; thus the little fingers are used slightly more than the (slow) ring fingers, and the arrangement is such as to favor stroke alternation between the hands. No attempt was made to provide any semantic or other controlled cognitive associations with the codes, as Yamada's concept is that working from overlearned "finger memory" is the efficient way to type. Though several code variants have been tried at Tokyo University, and no doubt other minor changes will be added, Yamada's "T-Code" keyboard, shown in Figure 6, is believed to be near optimal in many aspects.

finger loading than the conventional qwerty; improvement on the order of 25% is observed. Three Japanese curves for two-stroke systems are shown; Yamada gives the details in his monograph (Yamada, 1983). For present purposes, the main point is the remarkable similarity between touch typing rates in English and in Japanese. As noted by Yamada and others, it takes from 400 to 1000 hours of practice to become an expert English typist; these curves indicate that about the same stroking speed can be expected with two-stroke coded Japanese when trained for the same period.

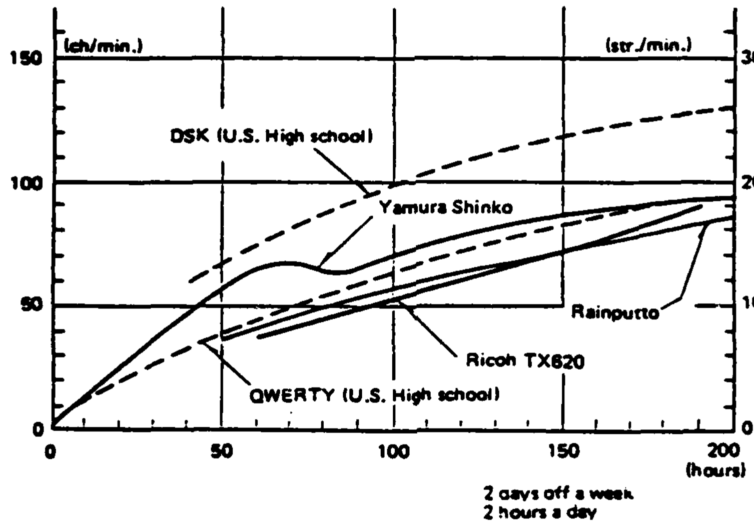

Figure 4. Schematic Comparison of Learning Curves:
Three Curves: Two-stroke Kanji Code Typing
Two Curves: English Typing (U.S. High School)

ACTUAL TWO-STROKE KANJI KEYBOARDS

Once the idea of a two-stroke kanji code keyboard is accepted as a realistic possibility, then attention can be directed to optimizing such things as hand and finger loadings, location of frequent characters between hands, alternations, and so forth. There are several ingenious ideas which have been discovered and rediscovered. The Shinko code system is shown in Figure 5. In this keyboard, the 2304 characters are broken down into four quadrants of 576 characters each; these 576, in turn, are split among 24 blocks each containing 24 characters. Items in the L-R quadrant are called up by first pressing a key with a left-hand finger to show the block (of 24 characters); then a subsequent right-hand press locates the desired character in that block. To type the number "2," for example, the typist would first press the middle finger of the left hand on the home row (shown in double outline), then hit the bottom row key with the index finger of the right hand.

Japanese language, a possible solution to the input problem is to code everything in kana and then have a special software system convert these to kanji. Such word processors as the Toshiba JW-10 are kana-to-kanji systems, and they have clever schemes for managing word segmentation (a Japanese verb may have a kanji root and a kana suffix or particle). The homophone problem is intrinsically severe, however, and accuracy rates are now in the 85-95% range (Yamada, 1982). The errors must be manually corrected, and in this activity the system aids the typist by displaying alternatives on the terminal until the proper one appears. An experimental system at Hitachi has an interesting refinement for resolving homophones. Provisions for the typist to input additional sound or structural information about a given kanji are made, and it appears that experienced typists eventually learn to supply this additional information, before the system says that the (kana) input is ambiguous. Again, it seems that a good typist wants the work to be relatively free of cognitive intervention. In any case, for the next few years, even the best kana-to-kanji systems will not be really high-speed typing systems, though they may well be the answer for nonprofessional typists who occasionally must enter input into a word processor.

TOUCH TYPING

Touch typing has been the practice in Western offices for so long that it is easy to forget just how remarkable the skill is, and how it has improved paperwork efficiency. An expert touch typist can type for some hours at a high rate without much fatigue or mental stress. This skilled work is done without looking at the keyboard, and with only occasional glances at the typed output. Stroke output rates are extraordinary: even the ordinary skilled secretary doing 50-60 words per minute will emit an average of three to six strokes each second. In champion Western typists, the number of strokes can go up to an incredible 15 or 18 per second; this performance is comparable to the execution of a piano arpeggio of 11 to 15 separately articulated notes in a second. There is also no doubt that the single keystroke itself is not the basic behavioral typing unit; rather, an expert typist knows several hundred, and perhaps several thousand, sequences of letters, syllables, and words, and it is these sequences that are strung together in a performance.

Japanese cannot be typed in a one-stroke touch system because there are so many characters. But two-stroke Japanese typing is quite feasible, even with the usual Western typewriter keyboard of 48 keys. Yamada begins his analysis this way: think of a big 48x48 matrix of kanji characters; in this 48x48 array there would be a total of 2304 separate kanjis, one to each cell. Then the 48 keys in a regular typewriter could be numbered, and a typist could activate any character as follows: the first key struck would be the row coordinate and the second key struck would be the column coordinate. Thus if the key under the right index finger in the home row was number 30, striking that key twice would activate the kanji found at the intersection of row 30 and column 30. All a skilled typist would have to do, then, would be to learn the 2304 two-stroke kanji code; and after sufficient practice these could be emitted at the usual high touch typing stroke rates, say 200 or more per minute.

An immediate objection can be urged to such a two-stroke scheme: nobody could, or would, memorize such a large code table. Fortunately, however, there are data which indicate that two-stroke Japanese typing is not only feasible, but is learned at about the same rate as English typing! These quite surprising facts are summarized in the graph of Figure 4 (taken from Yamada, 1983). The "qwerty" (standard keyboard) curve shown there was obtained by Thurstone in an American high school class; the asymptotic rate after 200 hours of practice was some 260 strokes per minute, equivalent to about 130 kanji characters (the Thurstone study, incidentally, is one of the classics of the psychology of learning). The SDK curve utilizes the Dvorak keyboard, which is more nearly optimal for

Chord keyboards for Japanese input require two or more keys to be pressed at once. For example, there might be about 150 large main keys; each of these has 12 or 15 characters engraved on it. There is a second and smaller shift keyboard with 12 keys. To print a character, you hit the main key containing the desired character, and at the same time you press another key on the shift keyboard. Figure 3 shows one such system which has been used for years in Japanese news service transmissions. These chord layouts can be considered to be partly touch systems: very frequently used characters can be put on the lower right areas of the main keys, and these are eventually learned well enough that there would be no need to look at the keyboard for some characters. Speeds up to 40-60 characters a minute can be attained after much practice. But there is still nothing approaching the easy rhythm and speed of Western typing, and the cognitive loading on the typist remains fairly high.

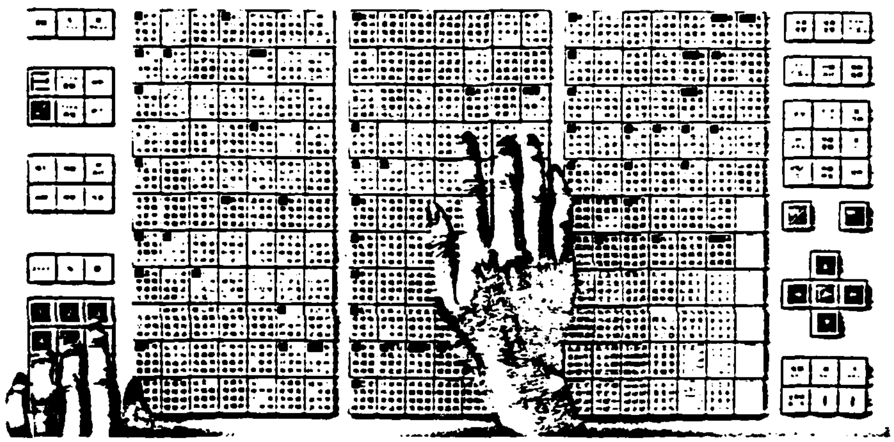

Figure 3. Multishift Keyboard:
Yokokawa's "Wordix" Word Processor

Perhaps the practical ultimate in chord-coded keyboards, in both the East and West, are the stenotyping machines which are used for court, legislative, and other official reporting. High transcribing speed can be attained by well-trained operators whose coded output is then decoded by computers and edited by the typist; but the speed comes from the cognitive part of it: the operator has a continual and demanding intellectual involvement, and must utilize a partly standard, partly idiosyncratic homophonic coding system. Thus, the speed does not come from the smooth rhythm of a highly efficient and effortless motor skill as in skilled English typing. Yamada notes that an average of about six stenotype keys are depressed at the same time. Thus the stenotyping system is limited to only the most determined people who can handle the incessant cognitive and homophonic loading. Many studies have documented the perceived stressfulness of the stenotyping job.

Since 90 or so kana characters supposedly can express all the spoken sounds of the

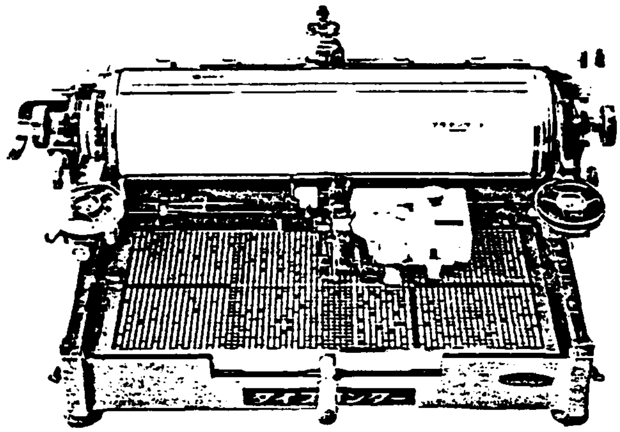

Figure 1. Wabun Typewriter: Hayasi's "Horse 55"

The heavy mechanical Wabun hardware has been improved by electronics technology; instead of a movable platen, an operator now has only to touch an electric pen to a matrix of characters, and hidden activating mechanisms do the actual printing. An illustration is the Oki Lettermate pen entry system shown in Figure 2. There are other systems where light touch keys are provided; one such machine has about 3500 keys or stops in the character matrix. Though much location learning would occur with experience, this is still essentially a visual system (it should be remembered that Western touch typists seldom look at the keys, and they check the copy only every sentence or so).

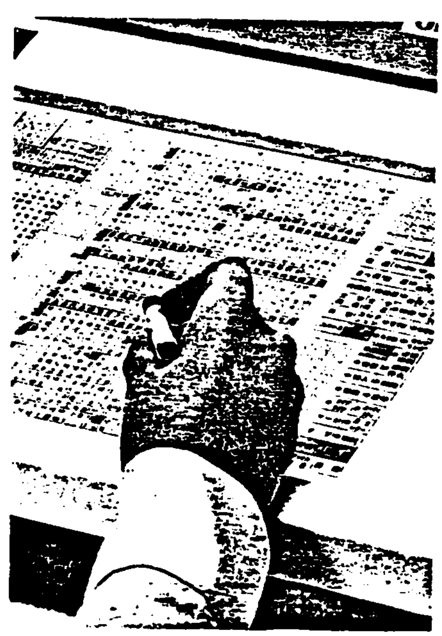

Figure 2. Pen Touch Keyboard: Oki's "Lettermate 80" Word Processor (about one-*half* area shown)

YAMADA'S REMARKABLE KEYBOARD

Nicholas A. Bond, Jr.

These days, a favorite pastime is the evaluation of Japanese technology compared to that of the West. Most such evaluations are mixed: the Japanese will be perceived as dominant in some areas, "behind, but catching up" in others, and so forth. In one respect, however, the West is really ahead, and that is in the efficiency of preparing a finished document from handwritten or dictated text. Take a business letter or report, which is written out by hand; in American or European offices, a rough draft which takes an hour or so to write will be transformed, within a few minutes, into a neatly typed and finished letter, well-spaced and pleasantly situated on the page. This happens because there is a tremendous pool of competent typists in the West (two to four million in the U.S. alone), and the input problem has been essentially solved by providing machines that permit rapid and accurate touch typing of several dozen words per minute.

The Japanese office situation is quite different. There are essentially no pure touch typists in Japan, and so much of the preparation of neat documents from handwritten text is often done by a very inefficient process that is partially hunt-and-peck. In many offices, preparation of handwritten letters and other documents is still farmed out to printing shops. Word processors have helped, but there is still a great need for something equivalent to fast Western touch typing. Also, some observers believe that this office document inefficiency has favored the overstaffing of Japanese offices with college graduates who do nothing but prepare documents by hand, thus contributing to the drain on productivity.

At the University of Tokyo, Hisao Yamada has been facilitating the task faced by a typist in Japan. His project has been extremely broad, ranging from the hemispherical lateralization of different typing activities to the design of optimal keyboards for rapid Japanese language input. For present purposes, we merely sketch out his approach and some of his nearly incredible results (a complete monographic treatment is available in Cooper, 1983). Certainly Yamada's eventual goal is clear enough: he wants Japanese offices to enjoy the same kind of skilled, high-speed, and relatively effortless typing that takes place in the West.

The problems with the Japanese writing system are quite evident, and were mentioned earlier in connection with the automatic character reading problem. There are some thousands of kanji characters, plus more than a hundred kana, alphamerics, and other symbols; all of these are mixed together in a typical Japanese sentence. In regular Japanese text, maybe 40% of the material will be written in kanjis, with the rest being composed of kana, alphamerics, and punctuation marks. No wonder, then, that much of Japanese typing has been a rather slow hunt-and-peck operation. The machine prototype is the old Wabun typewriter, shown in Figure 1, which is still a widely used machine though it was first marketed over 70 years ago. The Wabun has two or three thousand metal character stumps in the matrix, and to activate a single character, the operator moves a central platen assembly over to the character desired, then presses a handle. Since the movable locator is heavy and only one character can be printed at a time, nothing like a smooth fast rhythm can be achieved by an operator. An input of thirty characters per minute is about as good as you can get, and Wabun typists often have a high job turnover.

Central Iron and Steel Research Institute	Beijing
General Research Institute of Mining and Metallurgy	Beijing
Shanxi Research Institute of Building and Construction	Shanxi
Shandong Petroleum Institute	Shandong
Shanghai Power Plant Equipment Research Institute	Shanghai
Research Institute Baotou	Nei Monggol
Shanghai Iron and Steel Research Institute	Shanghai
Fujian Research Institute of Mechanical Engineering	Fuzhou
Luoyang Shipbuilding Material Research Institute	Luoyang
Shanghai Shipbuilding Technology Research Institute	Shanghai
Research Institute of Machinery	Beijing

TABLE I

CHINESE UNIVERSITIES AND RESEARCH INSTITUTES PERFORMING WELDING RESEARCH AS JUDGED FROM CONFERENCE ATTENDANCE LIST

Universities	Location (Province or City)
Chongqing University	Sichuan
Jiaotong University	Shanghai
Harbin Institute of Technology	Harbin
Xi'an Institute of Metallurgy	Xi'an
Gansu University of Technology	Lanzhou
Qinghua University	Beijing
Huazhong University of Science and Technology	Wuhan
Beijing Polytechnic University	Beijing
Xi'an Jiaotong University	Xi'an
Tianjin University	Tianjin
Xibei Polytechnical University	Xi'an
Jilin Institute of Technology	Changchun
Zhejiang University	Hangzhou
Huanan University of Science and Technology	Guangzhou
Taiyuan Institute of Technology	Shanxi
Shandong Institute of Technology	Jinan
Anhui Institute of Technology	Wuhu

Research Institutes	Location (Province or City)
Electric Power Construction Research Institute	-
Anshan Iron and Steel Research Institute	Anshan
Zhengzhou Research Institute of Mechanical Engineering	Zhengzhou
Shengyang Institute of Mechanical and Electrical Engineering	Shengyang
Huadong Institute of Chemical Engineering	Ahanghai
Institute of Metal Research	Shenyang
Beijing Research Institute of Material and Technology	Beijing
Beijing Aeronautical Manufacturing Technology Research Institute	Beijing
China Academy of Railway Science	Beijing
Harbin Research Institute of Welding	Harbin
Chengdu Electric Welding Machine Research Institute	Chengdu
Nanchang Aeronautical Engineering Institute	Nanchang
Shenyang Research Institute of Foundry	Shenyang
General Research Institute of Building and Construction	Beijing
Shenyang Institute of Computing Technology	Shenyang
Research Institute of Mechanical Science	Beijing
Institute of Aeronautical Materials	Beijing
Wuhan Institute of Water Transport	Wuhan

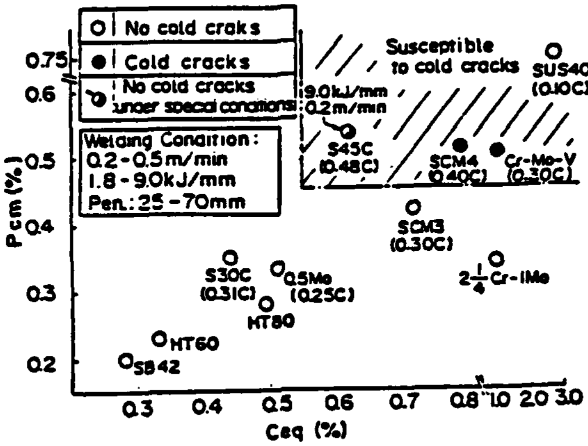

Figure 5. Effects of Ceq and Pcm on electron beam welded steel plates on occurrence of cold cracks.

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Figures are from "Quality and Reliability in Welding," *Proceedings of the International Conference on Quality and Reliability in Welding*, Volume 2, Welding Institution of the Chinese Mechanical Engineering Society, Hangzhou, People's Republic of China, 6-8 September 1984.

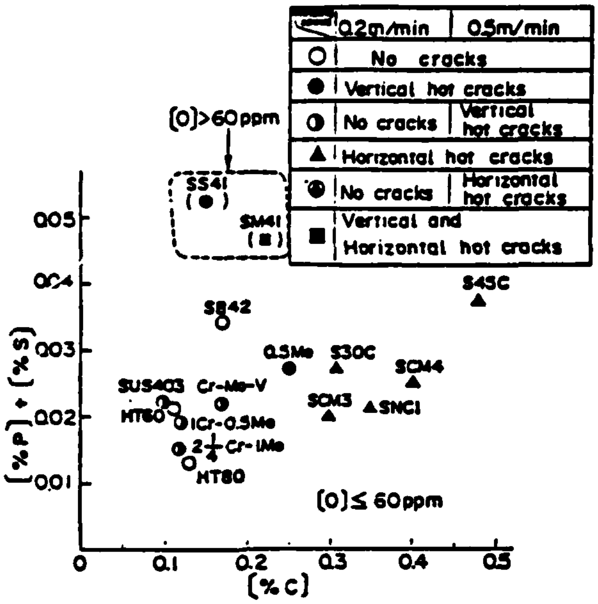

Figure 3. Effects of [%C] and [%P]+[%S] composition of electron beam welded steel plates on occurrence of hot cracks.

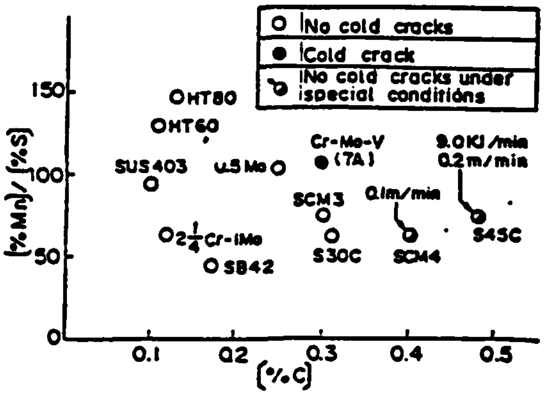

Figure 4. Effects of [%C] and [%Mn]/[%S] composition of electron beam welded steel plates on occurrence of cold cracks.

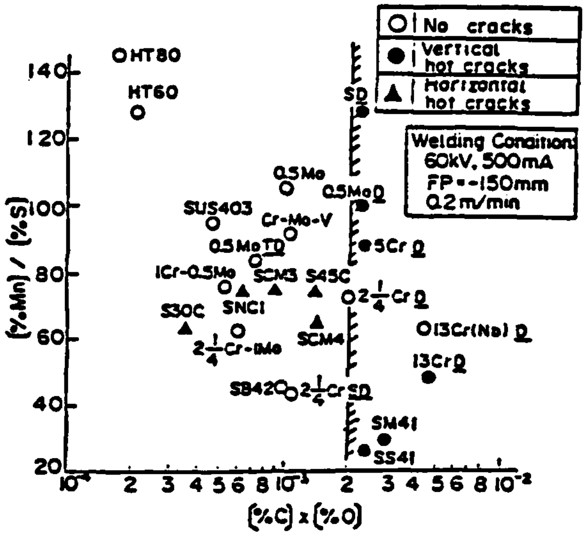

Figure 1. Effects of [%C]x[%0] and [%Mn]/[%S] composition of electron beam welded steel plates on occurrence of weld hot cracks.

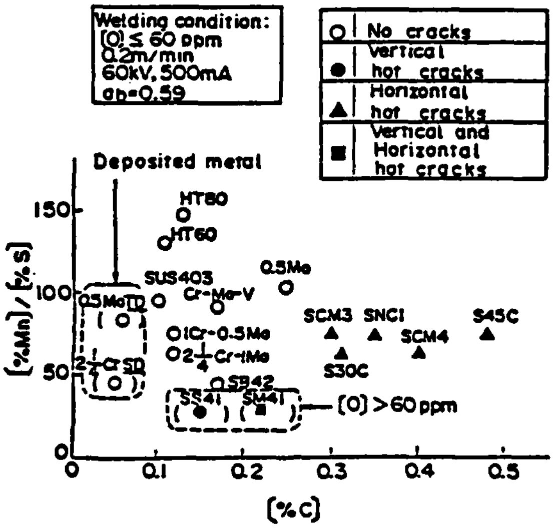

Figure 2. Effects of [%C] and [%Mn]/[%S] composition of electron beam welded steel plates on occurrence of weld hot cracks.

Yamada is almost certainly right in his analyses of the social effects of having expert typists in Japanese offices. In the West, efficient secretaries are highly valued, and they are well-paid enough in money and status to make a skilled secretarial career reasonably attractive to many people. Since there are few such semiprofessional people in Japanese offices now, it would be something of a jolt for the average office manager to have to train his typists for some months, and to give them status as semiprofessionals. One could well expect, though, that a few good demonstrations and the experience of increased office productivity would be decisive. Ninety years ago in American offices there were rather few typewriters, or even telephones!

It may be then that in a few years when Yamada's research is more widely appreciated, large Japanese offices will have a cadre of semiprofessional two-stroke touch typists for heavy routine input typing, along with some variant of kana-kanji word processors for use by semiskilled secretaries and by others (engineers, executives, professionals) who must occasionally enter verbal material but who will not undergo months of special training. This two-tier system is getting to be the standard pattern in many Western offices, particularly those associated with technical matters. But even with a word processor terminal on every desk, there hopefully will emerge in Japan definite, fast touch typing secretarial occupations; an exploitation of the Yamada technology would hasten that two-tier concept in Japan.

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A QUICK TOUR OF AI RESEARCH IN JAPAN

Clancy Hatleberg and Nicholas A. Bond, Jr.

Under the stimulus of major new federal funding, artificial intelligence (AI) work in America is now rather a boom industry with many new firms, centers, and projects on the scene. In fact, some leaders in the domain already have begun to worry whether AI can meet all the heavy expectations now being expressed by American government and corporate sponsors.

The Japanese AI effort is perhaps an order of magnitude smaller than the present U.S.A. level of involvement. And despite widely-publicized and well-funded projects like Fuchi's fifth generation computer group, the government money expenditure on Japanese AI has not changed very much over the past few years. There is some significant AI work all over Japan, however. The work breaks down by source into government laboratories, universities, and company laboratories; but the Japanese AI community is still small enough for there to be much communication across projects. Nearly all major Japanese investigators frequently travel to America where they visit laboratories and attend technical meetings. Many have done graduate or postdoctoral work on American projects. American journals, such as the *IEEE Transactions on Pattern Recognition and Machine Intelligence* are required reading in the Japanese AI community. An American visitor will be struck with the detailed Japanese knowledge of American published work in AI.

This report is a summary of several visits to Japanese laboratories. The intent was to explore a sample of the best AI projects (a preliminary library survey had indicated that most high quality work in Asia was being done in Japan, so other countries were not included on this tour). All the visits were made in early June 1984. Usually, the authors were accompanied by a native Japanese science adviser who could give language assistance. In all cases, however, the Japanese investigators were quite fluent in English, and had published in both English and Japanese.

IMAGING AND EXPERT SYSTEMS

Many ad hoc techniques have been developed over the last 25 years for analyzing images. Known variously as pictorial pattern recognition, image analysis, image understanding, scene analysis and computer vision, the areas of application include document processing, character recognition, microscopy, radiology, industrial automation, inspection, "robot vision," remote sensing, navigation, and reconnaissance. A large assortment of techniques is now available for solving practical problems in this area. Each involves the construction of abstract scene descriptions on the basis of information extracted from images or image sequences.

At the Medical Information System Development Center in Tokyo, Japan, Dr. Takeo Imai is using such pattern recognition techniques for classifying chromosomes, identifying cancer cells, and conducting medical analysis. The program for identifying cancer cells at the center involves optical scanning of specimen plates for density differences. The data set thus generated is compared to normal and malignant cell distributions to determine whether the cell is suspicious or normal. A variety of discriminant procedures have been tried out. Remarkably similar cancer-cell work has been reported from the AEG-Telefunken Research Institute in West Germany. West German health authorities must inspect more than three million specimens for cancer signs every year. To automate this labor-intensive task, Telefunken uses a "FAZY-TAN" system with three processing stages.

Prescreening is accomplished by an image pickup device using microscopic images of cytological specimens, thus producing a sequence of half-tone images each containing a set of events such as epithelial cells, blood cells, or cell clumps. The segmented cells are inspected and classified by a single cell classifier (SCC) which produces estimation values of the cells being normal, suspicious, or malignant. In this way, a single cell image is mapped into the SCC decision space, the resulting distribution is analyzed, and a figure of estimated malignancy is calculated for the entire specimen. Both the German and Japanese systems are nearly automatic; no human operator is employed to "tweak up" the display, to separate material in clumps, or to circle a particularly clean sample cell or nucleus. (Like the Germans, the Japanese did not seem to want to have humans in the processing loop at all!)

To classify chromosomes at the Tokyo Center, researchers use optical scanning techniques to locate chromosomes and then to represent them rather abstractly, with both end and intersection nodes. Length ratios for chromosome arms are computed and compared to actual ratios for identification purposes. Chromosomes that cannot be identified in this way are rejected and presented as undefined.

Again, similar results come from Europe. In 1982, Abmayr and Höbel of Munich described a classification process. They used exponentially growing mouse L-fibroblasts, and compared densitometric features such as nucleus statistics, morphological characteristics, textural, and chromation features to determine the discriminating power of those attributes. Their results indicated that different phases of the cell cycle could be distinguished by image processing on the basis of nuclear morphology. In several countries, then, the approach is very much the same, with correct discrimination percentages in the 80s; as yet there is no universally accepted set of detailed scoring techniques. Dozens of candidate features and transforms may be used, so the methods are computer-intensive.

At the Tokyo University Hospital Computer Center, medical consultation systems are one of the major applications of AI research. The most famous American system of this kind is MYCIN, developed at Stanford University; its capability for selecting antimicrobial therapy for meningitis and for bacteremia is comparable to that achieved by the best professional specialists (Shortliffe, 1976; Yu *et al.* 1979). The MYCIN production rule structure has been used as a basic model by other projects, including some in Japan. Dr. Shigekoto Kaihara is constructing several knowledge-based systems. One called MECS-AI is a general purpose system which can load and access information from any diagnostic data base. It can be tailor-made by a user for nearly any domain. On the other hand, ANTICIPATOR is intended to facilitate the practical prescription of antibiotics. Both systems use knowledge representation schemes based on production rules, and they also feature tabular displays for the practitioner. MECS-AI is currently programmed in UTILISP, a dialect of LISP developed at the University of Tokyo Computer Center, while ANTICIPATOR is implemented in PROLOG.

MECS-AI was designed to implement an effective inference capability along with strategies for evaluating the effects of missing data and data reliability. MECS-AI also provides a facility to retrieve table format information from rules. When the rule evaluator encounters a retrieval form, it searches through a designated table for types that match retrieval keys. When the proper table is found, variables in the retrieval form are bound to corresponding values in the retrieval triples. The bound values can be referred to the main body of the rule, thus the table represents knowledge that can be utilized to make inferences. A "time-chunking" representation treats separate patient visits, test days, and the like as a stream of discrete events which also is bound by certain rules.

In MECS-AI, the knowledge base is separated from the inference engine (rule evaluator). Every knowledge source consists of an "apply condition" and a collection of inference rules. Currently, the largest MECS-AI system contains more than 100 rules. This may be compared with American systems such as General Electric-DELTA for the diagnosis of troubles in diesel locomotives, which contains over 1200 rules (Bonissone and Johnson, 1984).

To use the ANTICIPATOR system for prescribing appropriate antibiotics, a fairly accurate diagnosis must first be made, but the corresponding microbial cause need not be known. Appropriate statistics from a stored array of tables are printed out, to show the most likely bacterium involved. Once a bacterium or family of bacterium candidates is chosen, an antibiotic efficiency table appears on the screen. Figure 1 shows such a table. In the example, aminoglicoside medications (MCR, TOB) are the best; but their renal toxicity causes them to be shown in the "Attention Required" set. PIPC, which does not have the toxic effects, is recommended. The right hand side of Table 1 is an explanation; it will be seen from the display that the effectiveness of drug PIPC is good against most of the prospective causes, and does not have the undesirable side effects of AMK and LMOX. (The table shown is a real one, not an example specially cranked up for demonstration.)

ANTICIPATOR has several features that make it user friendly to doctors: for example, as now used in the hospital, it deals with relatively small and well-clarified domains, it provides detailed explanations and cautions, while still leaving the final selection up to the clinician user. Further development to include drug dosage and drug combinations is now actively underway. Perhaps the most unusual feature of all is that the system is now actually being used all the time by the Tokyo University doctors! This implementation feature alone should make ANTICIPATOR an intriguing system to Americans.

Knowledge engineering is a new research area which underlies practical intelligent computer systems. At Tokyo University and the Tokyo University of Science, Drs. Setsuo Ohsuga and Fumio Mizoguchi have produced intelligent or expert systems for CAD/CAM application, language translation, and consultation. Dr. Mizoguchi has developed an expert system that can be used for ophthalmological (glaucoma) diagnosis and another consultation-type system for auto repair trouble shooting. Here, the initial input could be simply that the car will not start. The system then begins a series of queries designed to elicit the requisite information necessary to determine the cause of the problem. These queries and responses are cataloged in a display window in the upper right of the output. After enough information has been elicited, the program can arrive at a finding based on rules. The demonstrations now running present relatively unsophisticated diagnostic results (rundown battery); but clearly the processing capabilities in the program have gone far beyond these simple demonstrations. (Incidentally, the authors were not able to locate a single computer-aided diagnostic system being used in Japanese garages.)

Another expert system that Dr. Mizoguchi is developing is an English-to-Japanese language translator. English words and sentence structure are compared semantically to an English/Japanese dictionary and the sentence structure compared syntactically to grammatical rules. As a result, complete (but relatively simple!) sentences often appear to be translated according to meaning. As configured now, this system works in a cheap OKI 800 model 30, 8 K microcomputer, using Stiff Upper LISP programming language. The process can differentiate and translate sentences such as, "I take a bus to the zoo, and I take a book to the zoo" correctly into Japanese. (More advanced Japanese-English translation systems by Fujitsu and NTT will be described in later *Bulletin* articles.)

Dr. Ohsuga is researching conceptual ideas for incorporating knowledge engineering into CAD/CAM applications. According to him, the greatest contribution of knowledge engineering to this field may be the realization of efficient model building and general simulation models. If successful, the products of this research would prevent every CAD/CAM project from "starting over at square one."

Recently in the field of pattern recognition and image processing, much attention has been paid to the design of image data base systems. The association of a pictorial and graphical data base with man/machine interaction may be approached in various ways. At the Electrotechnical Laboratory in Tsukuba, Drs. Yoshabi Shirai and Hideyuki Tamura are using basic image processing algorithms for location displays and object recognition.

The Electrotechnical Laboratory (ETL) is one of 16 research institutes that belong to the Agency of Industrial Service and Technology, Ministry of International Trade and Industry. It is composed of 13 research divisions, one special research section, the Research Planning Office, Technical Information Office, External Affairs Division and the Osaka Branch. ETL is the largest single government research laboratory in Japan, with a 1984 budget of over 8,600 million yen ($35 million) and a staff of 709 members, of which 559 are actually involved in research. ETL conducts both fundamental and applied research with emphasis on electronics, information processing, energy, and standards and measurements. It is one of the world's leading laboratories in speech recognition, and has issued dozens of research reports on that topic.

The Information Sciences Division at ETL aims at highly flexible abilities in pattern recognition and natural language understanding. A widely-known product is the Subroutine Package for Image Data Enhancement and Recognition (SPIDER). SPIDER originated in 1978 as a means of standardizing and distributing many of the image processing algorithms. It was prepared, tested, and delivered within 20 months, a remarkably short time for such a complex package. SPIDER's scope of application extends over remote sensory of earth resources, biomedical image processing, material inspection, industrial robot vision, and optical character reading; there are even provisions for the identification of fingerprints and seal impressions. It is used all over the world.

SPIDER is composed of three different program groups. The first is a program group of image processing algorithms constituting the central body of SPIDER. There are over 400 subroutines or junction subprograms in the group; for example, there are 18 for detecting edge and line elements (Sobel, Prewitt, Hueckel, etc.) A user can insert a digital picture and submit it to the standard edge-enhancer models in a few minutes. Another part is the List Processing Package which contains 28 subroutines for numerical computation and list processing. The last group is the service programs which do the bookkeeping and handling of secondary information in the source programs.

ETL scientists can demonstrate elements of their packages right in the laboratory halls. One such program for location displays involves encoding light to dark areas from a passageway TV monitor. The resulting pattern can be displayed on a separate monitor, and is now used for robot vision to avoid hallway collisions. This system now has a dynamic range of some six meters. Another program is used for object recognition. Here a video scanner detects the intensity of reflected returns from a narrow projection ray. These intensities are translated into areas of equal position for which equations of planes are determined. These planes are then matched to memory for identification purposes. The present system can successfully identify pulleys, cam rods, and pistons, either when these are in any orientation singly, or are piled together in a bin. Other programs can be directly applied to industrial robots, that can then locate holes in plates and pick up appropriate nuts and bolts and afix them in place. As an amusing demonstration of these capabilities, ETL a few years ago showed a "two-handed" version which could locate boards accurately and so could construct a simple three-sided stool using a saw, hammer, and nails.

Recently, a new patterning algorithm has been developed by Katsuhiko Sakaue and Mikio Takagi at ETL for the separation of particles, in complex pictures of overlapping units. The algorithm uses both parallel and iterative techniques to separate the particles. First, some tentative edge-bounding pixels are extracted from the original digital picture. From these first edges, a centroid is tentatively assumed, an enveloping circular curve is grown, and the program assumes the center of the particle is at the centroid. There is then an iterative process wherein the previous centroid information is used to fan out a series of overlapping circles. Parameters in these are adjusted until no better separation can be achieved under the model. Some extensions to moving pattern segmentation are already underway. The top part of Figure 2 shows one iterative history on particle image data. The ingenious circle-growing procedure could, of course, be adapted to any noncircular particle wherein information was available about the known or expected true shape, such as in polygonal crystals. Inconsistency is gradually removed as the iteration proceeds. This method has been applied to automatic detection of overlapping pancreatic cell nuclei, and to noisy pictures of carbon particles.

CAD/CAM

A flood of technological innovation aimed at enhancing productivity and product quality has greatly influenced the Japanese automobile industry in recent years. These developments have ranged from car electronics to computer-aided design (CAD) and computer-aided manufacturing (CAM). Toyota Motors has been a leader in the integration of these CAD/CAM systems to assure high product quality and improved productivity. Now nearly all Toyota body part development processes, from style design to die manufacturing, are assisted by means of CAD/CAM operations.

Conventional styling and body engineering techniques formerly were based on the creation of many three-dimensional models and the production and correction of detailed drawings, with much empirical lofting of complex curves. These techniques require long lead times and have many built-in proclivities to operator error. Today at Toyota there are four major CAD/CAM systems that have been integrated for body development. COSMOS supports style design and die-face design; CADETT assists body structural design and welding tool layout; TINCA aims toward the manufacture of master models and stamping dies, while VESTA supports structural analysis. An extremely accurate model-geometry data base is created in each of these systems, and is transferred freely between processes from design to manufacturing.

In the style design process, the first step in the body development process, car shapes are created on interactive graphic display terminals instead of on the more costly and time-consuming clay model method. Thus, many styling proposals of good quality can be generated and evaluated in a short period. According to Toyota engineers, geometric requirements and interferences can be discovered very quickly and conveniently.

In the body structural design process, the next step in body development, almost all of the body parts are designed on interactive graphic displays instead of conventional drafting boards. The parts are represented by three-dimensional wire frame geometrics which can then be analyzed by the VESTA program for strength. Mathematical expression of contours is done by Japanese modifications of the Bezier method.

As a result of these advanced CAD/CAM techniques, Toyota claims to have reduced the weight of their vehicles without sacrificing strength or durability. Here, the VESTA system has played a central role. The VESTA system employs a very large-scale FACOM M-830S computer on which body characteristics such as strength, stiffness, vibration, and heat transfer of body components and fully trimmed bodies are evaluated by the finite element method. In some cases, these analytical models can be tested through computer simulations, thus reducing radically the time it formerly took for conventional experiments with expensive prototypes. Though it is difficult to pinpoint exactly what benefits accrue from a big complex aiding system, Toyota is extremely enthusiastic, and has many plans for extending the CAD/CAM approach throughout the corporation. The programs themselves are hundreds of thousands of statements long and are regarded as a prime company asset. Toyota plans involvement of people at all levels with CAD/CAM. Engineering students at the company-owned Toyota Technical Institute nearby, for example, have CAD/CAM theory and application courses in their engineering curriculum, and Toyota specialists in this area are well-regarded around the world. Tool and die specialists from the factories are right now encapsulating their knowledge about deep-draw dies into certain parts of the CAD/CAM program set.

FACTORY PROCESSES

Mitsubishi Electric is a branch of one of the largest companies in Japan, (or in the world). Its industrial position is supported by extensive R&D activities in nine major research facilities. While the emphasis is on electronics, there are large divisions on energy, new materials, and new functional devices.

The Central Research Laboratory (CRL) of Mitsubishi Electric is near Osaka, and it includes the Product Development Laboratory, Manufacturing Development Laboratory, and the Materials Engineering Laboratory. Out of a total staff of 1200, 950 members are scientific and technical people. The Central Research Laboratory's corporate charge is familiar: the establishment of basic technologies needed for existing and new products, along with technical support and assistance for manufacturing plants and sales offices in the Mitsubishi domain.

In the area of factory automation, CRL is engaged in the development and commercialization of an ideal manufacturing process. An eventual transformation of the manufacturing process toward full-scale automation is assumed; and the first step is recognized as the integration of computers with NC and programmable controller equipment. Beyond these more or less obvious goals, ever more complex CAD and vision sensor-equipped robots will be key parts of computer-integrated manufacturing systems. Though the word "integration" is probably overused as much at CRL as in other places, there really is a commitment to a vertically integrated, design-to-product concept.

Already, CRL has produced a special automatic recovery package for power system restoration using a knowledge-based system. Although computer systems are common in Japanese power system control of the preventive and emergency states, they have been slow in penetrating into restorative applications. The implicit reason for this seems to have been that the problem solving ability of a human being is obviously so far superior to a computer that very few efforts have been made to program around such a human ability; when crises arise, you rely on the human. CRL's approach was to use heuristic programming with a knowledge-based system to manage a large-scale and complex power system. All the knowledge required in solving a power system problem under constraints is represented by means of a property list or a set of production rules. The property list has a standard form (object attribute value). For instance, if the voltage of BUS-A is 275,400 volts, this knowledge is stored in the knowledge base as the triple (BUS-A voltage 275,400). A rule has a premise, action, and subject. The subject part means a context type to which the rule is applicable. If the premise part is true, the action part is performed. For example, if a component is not charged and is not faulted, then it is concluded that the component must be restored.

The standard trouble-shooting strategy is to restore all elements which had been energized before the emergency situation. For example, one scheme is to energize a bus through the list sequence which fed the bus before the fault. However, if that line is faulted permanently and unable to feed the bus, the bus is energized with a standby line. If a bus performs under either pattern, it is concluded that the bus can be restored. The line is then checked automatically for an overload condition prior to engaging the bus. From informal comments by research staff, one would infer that structured programming type of control is used in partitioning and assembling program modules in a given power system application. As in America, there are technical controversies over the generality of the programs which are produced. The customer is often more interested in results for a particular installation, whereas the system programmers seek generality and elegance.

At the Kyoto University Automation Research Laboratory, Dr. Hideo Hanafusa is actively involved in a full spectrum of robot automation research into prehension and handling by robot hands, the analysis and control of multiarticulated robot arms, and hydraulic and pneumatic servomechanisms for robot arm control. An adaptive control scheme has been developed for the automatic positioning of an adaptive prehensile robot hand. The robot hand has three fingers equipped with pneumatic sensors at their tips. The positioning process is characterized by the scanning of the pneumatic sensors. The fingers open gradually during this process as the hand is driven according to the output of the three sensors in combination to the center of a held object, say a cylinder. The positioning process is constantly analyzed and the final positioning errors are compensated.

A further evolution in Hanafusa's laboratory produced a robot with elastic fingers adapted to assembly processes. Here, the handling force and rigidity of the prehension system are adjustable by finger control. The three fingers are driven by three individual motors through coil springs. Arbitrary prehension characteristics are obtained by synchronizing the motor movements with the finger movements. Thus, the hand can grip objects with various shapes at various prehension rigidities. In practical use, the hand might be applied to assembly processes where the hand transfers something along a predetermined path by a sequence of point-to-point controls. When the hand arrives near a programmed task position, the prehension forces and rigidities are adjusted to grip the object and perform the task smoothly, even if the hand is not perfectly centered at the position.

In the area of controlling multiarticulated robot arms, Dr. Hanafusa has developed redundancy for articulated arms by the addition of a wrist mechanism for partition control of position and orientation, thus alleviating autonomous pattern tracing with scanner feedback. Consider the human arm, which has more degrees of freedom than needed to move in three-dimensional space. Thus, with sufficient loop feedback the arm can move while holding an object stationary. Using this principle, Hanafusa produced UJI-BOT, an articulated armed robot. The robot has an ingenious wrist mechanism, thus giving the arm the requisite extra degree of freedom to move while holding a gripped object stationary. The application might allow industrial robots to move down a line holding a work piece stationary while manuevering the arm around assembly line obstacles. (According to the Hanafusa group, the mathematics of path finding become very complex when there are several moving elements in the field, and there is as yet no general method for computing collision-free paths. Configuration space methods can be formulated, but computational demands are heavy in the three-dimensional case.)

In the area of hydraulic and pneumatic servomechanisms for robot control, Dr. Hanafusa's research involves computer controls of nonlinear servomechanisms, with theoretical and practical studies on compensating for low damping characteristics. Here, electrohydraulic servomechanisms are widely used for heavy-duty articulated robot arm controls. The nonlinear characteristics of the arm construction, coupled with poor static rigidity and the low natural frequency of the hydraulic driving system, are being investigated to improve dynamic characteristics and to reduce interaction effects.

For autonomous trajectory control, Hanafusa's group has designed a special proximity sensor using light emitting diodes (LEDS). Thirty infrared LEDs are arranged in a circle (radius = 35 mm). Light from each LED is turned on and off separately. An optical system projects these beams of light on a surface, and it concentrates the reflected light on a P-N conjunction semiconductor, which then produces photoelectric current in proportion to the energy of reflected light. Through appropriate geometrical computations, an object trajectory can be detected on the objective plane. Figure 3 shows the reflective geometry; in the picture, Lens 1 is converging the LED beam on the surface, while Lens 2 is concentrating the reflected beams onto the photosensitive semiconductor. Figure 4 gives a block diagram of the whole sensor system. As depicted, a distant host computer drives the whole thing, but there is a Z8-03 chip right in the sensor for close-in analysis.

Nippon Telegraph and Telephone (NTT) has several large laboratories near Tokyo. There are numerous devices with an AI flavor, as noted in a previous *Bulletin* article [*Bulletin*, *9*, (3) 1 (1984)], a working Kanji reading machine is now being evaluated; it reads handprinted Chinese-Japanese characters with high accuracy. Researchers at NTT Laboratories also have produced a practical pageturner which certainly can be credited with some AI capabilities. While any engineer could envision a system of rollers or fingers which could turn the pages of a document, the page-turning problem becomes extremely difficult when the paper size, thickness, and quality are variable. Adaptive logical programs to estimate paper thickness and friction coefficients were required; three small servo motors with good stiffness characteristics do the effector work. The NTT working model can handle almost any kind of binding and can tolerate a wide range of paper parameters. The performance resembles that of human fingers: three or four seconds per page, without damaging the paper. NTT is now pursuing the linkage of visual recognition devices with the pageturner system. NTT work on the "office of the future" will probably have elements that would come under an AI heading. Their high-resolution TV tubes, for instance, will be good possibilities for AI-enhanced displays.

Among the most grandiose projects in the world is the Information Network System (INS) which NTT is now planning. With an estimated cost of $130 billion, INS will operate as a nationwide network based on optical fiber cable and communication satellites. Cheap home banking, home shopping, individualized education, teleconferencing, and office work-at-home facilities are already being designed. Though the network concept has been around for years and has been partially implemented in France and Britain, Japan may be the first to achieve a really national system. (Despite the obvious implications of this shift toward an information-oriented society, there seems to be rather little Japanese research on exactly what the social impacts will be. Electronics firms, for example, are concentrating on the development of specific products, but may not be doing general social studies of the information society era.)

AN EVALUATIVE COMMENT

Impressions based on whirlwind tours are, of course, inevitably selective and risky. We content ourselves here with offering a few general remarks, which we think are appropriate despite the limitations of our survey.

One is that we may expect the Japanese effort in AI to be one of rather steady growth, with no spectacular booms in sight. Typical money amounts for government AI contracts with universities, and for in-house funded AI projects in industrial laboratories, are rather small by U.S. standards. There are not many graduate students in AI programs, nor are there enough AI experts to create the dozens of small AI firms which are now seen in America. Japan R&D responds rather quickly when commercial markets open up; thus, in the robotics area, it has been shown that when the robot market took off in 1981, within about two years the annual number of robot patents nearly doubled. The markets for multiarticulated arms and the associated control systems are right at the edge of rapid growth now, and the Japanese have much experience in the domain so we can expect a more rapid pace in that particular area.

A second observation is that research in Western countries continues to exert a strong and often dominant influence over AI work in Japan. The extent of this influence varies across special domains, but is most apparent in theoretical areas. Perhaps there is no Japanese equivalent to the MIT effort to integrate physiological and AI perception models, to the SRI-Xerox work on the "deep structure" of physical systems, or to the Stanford research on diagnostics, for example; and as far as we nonexperts could tell, the optimization and discriminant mathematical models used by Japanese analysts would be quite familiar to American researchers. It is in the transitional phases between theory and first complex application, however, that Japanese capabilities are often unexcelled. Careful and patient testing of alternatives can provide valuable experience, and can produce a cadre of dedicated and competent specialists. In other areas, the Japanese have shown that a succession of many little incremental improvements, steadily driven by market opportunities and pressures, can amount to a decisive lead position in a technology. There is reason to think this is already happening in certain areas of AI. Again the best example may be in the robotics area, where Japanese firms have about fifty major technology agreements with American and European companies. In the great majority of these, information flows out from Japan to the participating partners.

Since we have noted above that Japanese AI research often strongly resembles that done in the West, and thus might be termed imitative, maybe this is a good place to say something about scientific creativity, and its presence or absence in Japan. A cliché is that Japanese scientists and technologists are not as creative as their best Western colleagues. Indeed, the Japanese themselves often seem to believe this. The Japanese government has recently funded a large program to foster creativity, and receiving a contract under that program is a very high prestige award. There are also many semiofficial Japanese competitions in which supposedly creative people and teams are honored, and are given substantial money prizes. In all this, the ideal creative scientist is perceived as one whose performance resembles that of the great scientists of the West; that is, the key is extraordinary originality, perhaps combined with virtuoso qualities of technique, esthetics, and generality. Even under optimal support and nurturing conditions, extremely few such people ever appear in the world, and these few carry the burden of innovation.

An alternative view of creativity, however, can be set forth, and it may fit better into a Japanese context. On this view, someone who effectively develops ideas or hints from outside sources can be showing creative behavior. The careful assembly and sifting of ideas, the determined absorbing of information, the critical testing, elaboration, and refining of concepts--there is plenty of room for creativity in such pursuits. And one can argue, as some experts do, that this Japanese kind of creativity is what the world needs most.

An interpretation of the power of this Japanese-style creativity comes from Makoto Kikuchi, now Director of Research for Sony Corporation. Himself an eminent and innovative semiconductor scientist, Kikuchi recalls that in the early days of the transistor, some truly extraordinary intellect and persistence was required. It took Shockley 12 years at Bell Labs to get the transistor effect. After that pathbreaking work, there was a rush of follow up work all over the world, and eventually the technology became rather mature and entrenched; really new developments were harder to come by. In these circumstances, a well-conceived elaboration-and-refinement creativity is what produced the lower prices, the higher reliability, the new applications, and the wider market that all of us now enjoy. Perhaps it was in the nature of things, then, for a mature technology to slow down, and for Japan nearly to catch up with the West in less than forty years. And since this Japanese style creativity can be learned, conveyed, and realized more predictably than the individual Western style or Einstein creativity, it is the type that can really spread through the world; or so Kikuchi (1984) would claim.

However the arguments over creativity are mounted or settled, continuing Japanese scientific progress undoubtedly has its own character, and its own vitality. Simple minded assumptions about Japanese imitativeness and its low Nobel prize batting average are quite beside the point.

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EXPLANATION TABLE

What do you want to do?
Valid replies → NEW CASE, CASE-PROFILE, COUNSEL, END, and others. (HELP for details)-1 EXPLAIN PIPC AMK LMOX

COMPLICATED-URINARY-SYSTEM

			PIPC	AMK	LMOX
PROBABILITY					
	P. AERUGINOSA	28.5%	++	+++	+
	E. COLI	18.1%	+++	+++	+++
	PROTEUS	15.9%	VARIES	VARIES	VARIES
	SERRATA	14.3%	++	++	++
	KLEBSIELLA	6.1%	++	+++	+++
	ENTEROBACTER	6.1%	++	++	+++
	CITROBACTER	6.1%	---	++	+++
KINETICS					
	RENAL-SYSTEM		+++	+++	+++
MEDICATION ROUTE			I	I	I

****
WARNINGS
****

PIPC

Level 1: (as BROAD-SEMISYNTHESIZED-PENICILLINS) (May cause diarrhea by p.o. medication.)
Level 1: (as PENICILLINS) (Drug irritation)

AMK

Level 4: (as AMK) (Contraindication of renal toxic drug to renal disorder)
Level 2: (as AMK) (Renal-disturbance)
Level 1: (as AMK) (Nerve-system-disturbance)

LMOX

Level 5: (as OXACEPHEM) (Not preferred if any other shows enough efficiency)
Level 1: (as CEPHEMS) (Drug irritation)

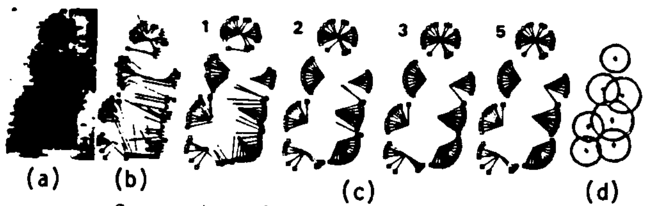
RECOMMENDATION TABLE

Recommendation

PROBABILITY SELECTION BY STATISTICS

RECOMMENDED	ATTENTION REQUIRED	SPECIALITIES
	MCR TOB AMK GM SISO	
PIPC		CPZ LMOX CMX CTX CZX
FOM		

Figure 1. Typical Output from ANTICIPATOR System



Separation of Overlapping Particles.
(a) Original Picture, (b) Initial Values,
(c) Iterative Process, (d) Result.

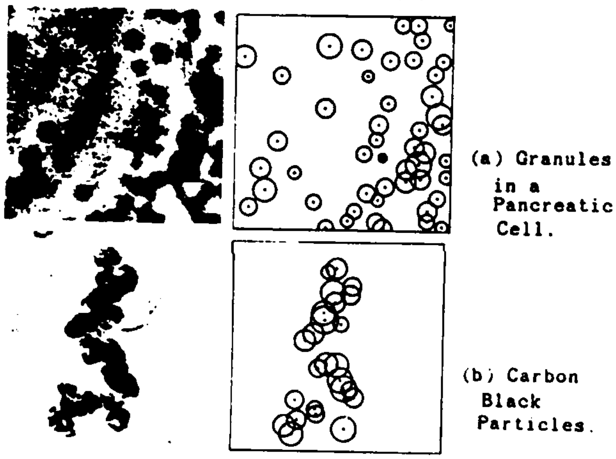


Figure 2. ETL Centroid Procedure for Particle Separation

accomplishments include:

. Characterization of Bulk Crystals

Fatigue and recovery effects of the 0.65 eV emission band in GaAs

In this work, the characteristic photoluminescence (PL) fatigue and recovery effects have been examined on a typical emission band centered around 0.65 eV, believed to be associated with the main deep donor EL2 in undoped Czochralski-grown GaAs crystals. They have found, for the first time, a characteristic recovery effect in the fatigue emission band under continuous irradiation of Ar laser (514.5 μm) excitation. The recovery was explained as a result of an optical transition from the metastable state of the EL2 level to the conduction band using a configuration coordinate (CC) diagram. Various lattice relaxations induced by the microdefects responsible for the EL2 level will produce a wide variety of observed fatigue and recovery rates. From these observations, they favor the idea that the EL2 level is due to As atom aggregates.

Characterization of deep levels in GaAs by the twofold excitation modulated photoluminescence technique

To assess the deep levels in In-doped GaAs bulk crystals, twofold excitation modulated PL spectroscopy was developed. This spectroscopy technique is based on the analysis of PL variation induced by the below bandgap excitation (BGE) in addition to the above bandgap excitation (AGE) using the modulation technique. With this technique, both radiative and nonradiative recombination processes in deep levels in semiconductors can be studied. Using this technique, they observed a drastic enhancement effect for the near band edge emission in LEC-grown crystals but not in HB-grown crystals. The enhancement cannot be counterbalanced with a slight suppression in the deep level luminescence. From these observations, they have concluded that the LEC-grown crystals contain a considerable amount of nonradiative deep centers.

. III-V Devices

Heterojunction GaAs MIS-like FET

A heterojunction GaAs MIS-like FET-SISFET (semiconductor insulator semiconductor FET) has been fabricated. The SISFET has an n^+-GaAs/undoped GaAlAs/undoped GaAs structure grown by MBE on a SI LEC (100) GaAs substrate. In the structure, the n^+-GaAs is used as a gate and an undoped GaAlAs as an insulator. The structure can withstand a high temperature annealing for a self-aligned gate processing and is analogous to a Si-MOSFET having a heavily doped polysilicon gate. The self-aligned structure was obtained using the ion implantation technique. The SISFET operates as a normal off-type FET with the threshold voltage of +0.035 V and the transconductance of 170 mS/mm at 77 K. (Unlike HEMTs, since it employs undoped GaAlAs, no impurities diffuse into the heterointerface during the annealing. Therefore, a high electron mobility at the heterointerface can be retained even after annealing.) The device exhibited a small dispersion of the threshold voltages over a large number of samples (0.031 V for 41 samples) and appear very attractive for high speed LSI applications.

GaAs ballistic FET

superconducting electric power transmission
amorphous magnetic materials with low hysterisis and eddy current loss
potassium turbine power generation
latent heat storage

- National R&D Programs (Large-scale Projects)

  High-performance flexible manufacturing system complex provided with lasers

  Optical measurement and control system

  - optical components

  High speed computer system for scientific and technological uses

  - ultrahigh speed memory and logic devices
  - parallel processing

  Robotics for extreme work

- R&D of Basic Technology for Future Industries

  New materials

  - electrically conductive polymer materials

  New functional devices

  - superlattice devices
  - three-dimensional ICs
  - refractory semiconductor devices

- Special Research Projects

  industrial standardization
  metrology and inspection technology
  ocean development technology
  bionics technology
  new materials technology
  electronics technology
  space technology
  peaceful utilization technology of atomic power
  pollution control technology
  ITIT (Institute for Transfer of Industrial Technology) related research

RECENT ACCOMPLISHMENTS

- Activities in III-V Compound Semiconductors

A variety of activities related to III-V compound semiconductors is underway throughout the laboratory in support of national projects such as the "Optical Measurement and Control System," the "High Speed Computer Systems for Scientific and Technological Applications," and "Basic Technology for Future Industries." Some recent

RECENT PROGRESS IN ELECTRONIC RESEARCH AT THE ELECTROTECHNICAL LABORATORY

Yoon Soo Park

INTRODUCTION

The Electrotechnical Laboratory (ETL), located in the Tsukuba "Science City," Ibaraki, Japan, is the largest national research institute in Japan devoted to basic and applied research in the areas of electronics, information processing, energy, and standards and measurements. As one of 16 research institutions belonging to the Agency of Industrial Science and Technology of the Ministry of International Trade and Industry (MITI), ETL not only conducts its own internal resources, but also oversees and coordinates government-sponsored research and development in industry and advises the government on technology options. Since its establishment in 1891, and relocation to its present site in 1981, the ETL has played a key role in the progress of science and technology in Japan.

The Electrotechnical Laboratory employs some 709 members (of which 559 are involved in research) at an annual operating budget of 8.6 billion yen ($34.4 million). It consists of 13 research divisions, a special section on Josephson computer technology, an Osaka Branch and other administrative support offices (see Appendix 1).

RESEARCH PROJECTS AT ETL

The research themes presently being pursued at ETL are summarized below. ETL engages in and coordinates national research and development projects. Special research projects aiming at establishing basic technology for future development and pioneering research is conducted systematically by organized groups.

- Major R&D Items at ETL

. R&D on New Energy Technology (Sunshine Project)

Solar energy technology

solar thermal power generation
photovoltaic power generation

Other researches

exploratory research (ocean thermal energy conversion; superconducting magnets)
supporting research (total energy systems)

. R&D on Energy Conservation Technology (Moonlight Project)

Large-scale energy conservation technology

magnetohydrodynamic (MHC) power generation
power storage with advanced batteries
power generation by fuel cells

Leading and basic R&D on energy conservation technology

- Kyungbook National University

Department of Physics	Professor B. H. Rah	Photovoltaic effects of GaAs and InP, LPE growth of AlGaAs
	Professor T. S. Park	Infrared defectors

- Jeonbuk National University

Department of Physics	Professor Y. K. Kim	LPE growth of GaAlAs
	Professor H. J. Lee	Transport properties of III-V compounds
	Professor Y. J. Shin	Luminescence of II-VI compounds
	Professor H. S. Kang	Crystal growth and optical properties of II-VI

- Korea University

Department of Material Science	Professor I. H. Choi	MOCVD growth of GaAs

APPENDIX II

UNIVERSITY AND RESEARCH INSTITUTES IN KOREA ACTIVELY ENGAGED IN SEMICONDUCTOR R&D

- Korea Advanced Institute of Science and Technology

Department of Physics	Professor C. C. Lee	Transport and optical properties of amorphous and crystalline Si
Department of Electrical Engineering	Professor Y. S. Kwon	LPE growth of GaTs, Inp, HgCdTe
	Professor C. K. Kim	Silicon processing and devices

- Seoul National University

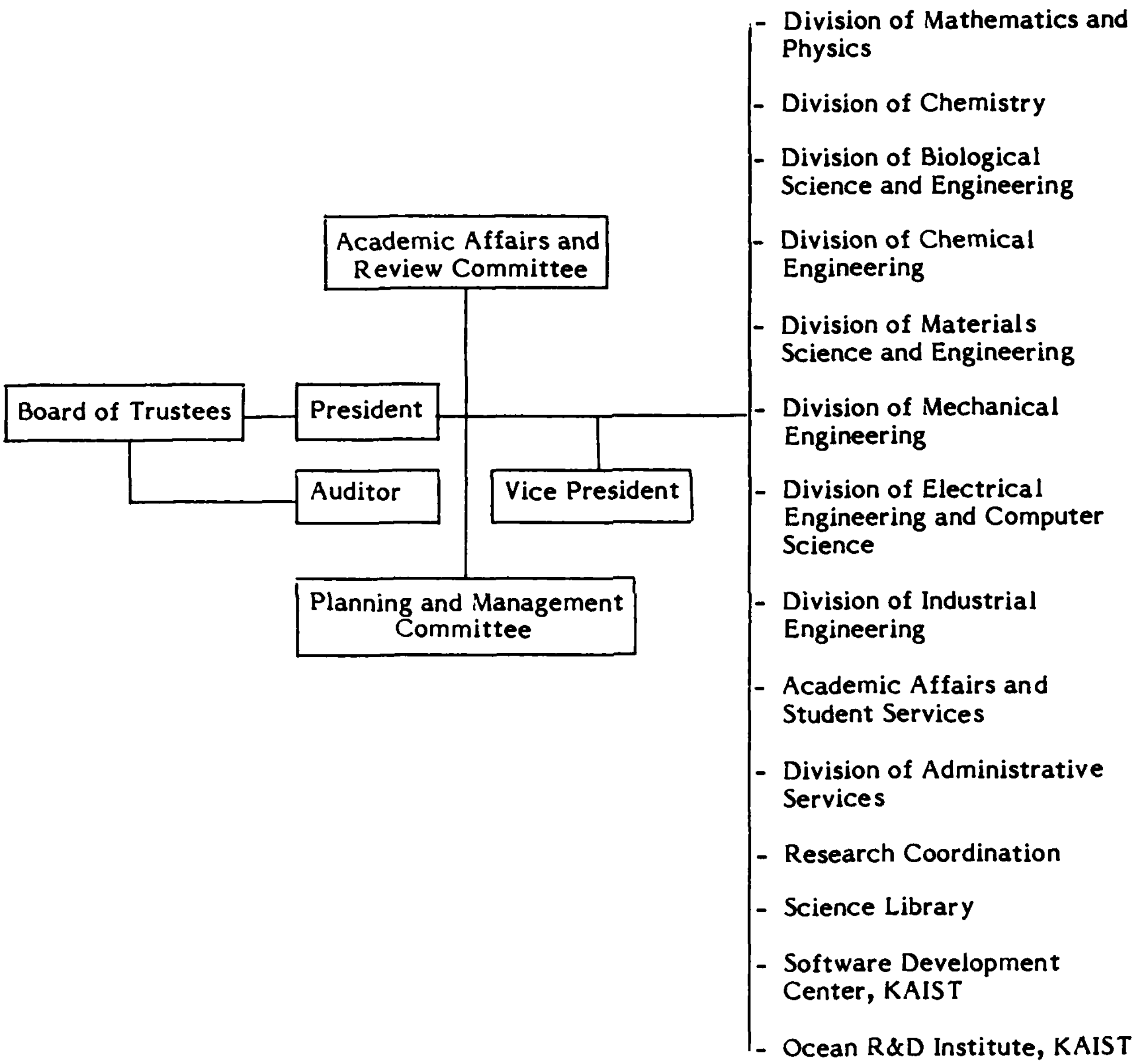
Department of Physics	Professor J. C. Woo	Laser scattering spectroscopy of semiconductors, NMR, and EPR
	Professor J. H. Lee	Photoluminescence of CdTe
	Professor B. D. Choe	LPE growth of GaAs, GaP and GaAlAs, research on laser diodes
	Professor S. I. Kwun	Infrared spectroscopy of solids
	Professor S. J. Oh	Electron spectoscopy
	Professor C. K. Khim	Deep level spectroscopy
Department of Electrical Engineering	Professor J. D. Lee	Si devices and processing

- Yonsei University

Department of Physics	Professor C. H. Chung	Crystal growth of CdTe, ZnSe, HgCdTe, and InP
	Professor C. K. Kim	Theoretical solid state physics--dielectric properties and electronic structure of semiconductors, metal-nonmetal transitions

APPENDIX I

KOREA ADVANCED INSTITUTE OF SCIENCE AND TECHNOLOGY*



*Provided through the courtesty of KAIST future activities regarding technology transfer.

SUMMARY

To meet the need for establishing a local semiconductor industry and to develop a more sophisticated technology-intensive electronic industry from the simple assembly-type manufacture, the new materials technology program in Si and GaAs was initiated at KAIST. If the Korean electronics industry is to remain competitive in the world market, it is imperative that the domestic industry become self-sufficient in the production and processing of semiconductor materials.

Since the initiation of the UNDP project in March 1979, the project has progressed through the cooperative efforts of UNDP and KAIST personnel. Although some difficulties in the procurement of equipment and in the training of the personnel were encountered, impressive progress has been made in the growth of both Si and GaAs single crystals and the epitaxial layers of GaAs, in the establishment of material characterization facilities, in the transfer of materials growth and processing technologies to domestic industries, and in the collaborative efforts in the materials characterization and device fabrication activities with universities and research institutions.

For the first time in Korea, defect-free, high quality silicon single crystals of three to four-inch diameter and high purity, GaAs single crystals of two-inch diameter and GaAs epitaxial layers by both vapor phase epitaxial (VPE) and metal-organic chemical vapor deposition (MOCVD) techniques have been grown by KAIST scientists and technicians. The quality of Si and GaAs materials grown at KAIST is comparable to that of the crystals available in the world market.

Although the initial aim of the program has been brought to fruition, additional and continuing support is needed in establishing adequate and competitive research efforts to cope with technical advances being made in advanced countries. The characterization capabilities at KAIST should be expanded and strengthened.

the field effect transistor (FET) for amplification at frequencies above which a silicon bipolar transistor can be utilized is also anticipated.

To meet this challenge facing future Korean electronics industries, KAIST-SML has acquired growth reactions for both epitaxial and bulk crystals. The vapor phase epitaxial (VPE) and metal-organic vapor deposition (MOCVD) reactors for epitaxial growth and the horizontal Bridgman reactor for bulk crystal growth have been procured through the support of UNDP. Installation and testing of the three reactors were completed at the end of December 1982.

The crystal growth facility for the HB techniques was completed in December 1981, and by December 1982, eight growth runs of undoped GaAs using a one-inch boat had been made.

Though many difficulties were encountered during the course of crystal growth, the problems were resolved one by one and the growth technique was perfected. One of the difficulties was the breakage of the grown crystals and silica boats at the end of the run due to boat wetting. The causes of boat wetting were traced and undoped GaAs boules of two-inch diameter are now routinely grown in the laboratory. As of 30 June 1984, about five boules of two-inch diameter had been grown.

In recent years, the metal-organic chemical vapor deposition (MOCVD) procedure to grow epitaxial compound semiconductors has generated great interest and activity because of its many advantages such as flexibility, high purity, ease of fabrication of multilayer structures, sharper junction abruptness, larger area and adaptability to mass production.

The MOCVD reactor system was delivered in July 1981, and has been operational since the spring of 1983. Epitaxial layers of uniform thickness were obtained. As of 30 June 1982, a total of 70 runs had been made.

The vertical vapor phase epitaxy (VPE) reactor, which can provide epitaxial layers of GaAsl-x Px for LED fabrication, has been installed and tested. The reactor is based on the hydride VPE technique ($Ga\text{-}HCl\text{-}AsH_3\text{-}PH_3\text{-}H_2$). The system was delivered in July 1981. The final test run was made in April 1984.

- Cooperative Efforts

The purpose of the materials program at KAIST was to acquire and develop the technologies needed for the production and processing of semiconductor materials for domestic industries. The transfer of semiconductor materials and processing technology to industry has been strongly emphasized.

Efforts to transfer semiconductor materials and processing technology to industry has been intensified. In addition, contacts have been made regarding utilization of the KAIST-grown materials, device processing, and fabrication. Wafers from KAIST were made available in reasonable quantities to all interacting organizations--universities, research institutes, and industries--for evaluation and use. The flow of information among the interacting organizations was established. The interacting organizations which are actively engaged in semiconductor research in Korea are listed in Appendix II.

Feedback of information, from materials characterization to crystal growth and from device processing and testing and, in the opposite direction, from crystal growth to materials characterization to device processing and testing will form an essential basis for x-ray single crystal analyzer.

- Research Activities

. Silicon Semiconductor Materials

Silicon-based electronics was first introduced to Korea manufacturing in 1966-67 when several U.S. companies established assembly operations. From this beginning, the Si technology-based electronics industry has steadily grown and is currently in the throes of a dramatic evolution, both in terms of level of technology and wafer fabrication capacity, and as a result of entry into semiconductor manufacture by the country's leading industrial conglomates such as Daewoo, Hyundai, Samsung, and the Lucky group. Total investment by these companies in 1983-84 was expected to be $300-500 million. Korea will soon become a nation with a dynamic semiconductor industry competitive in a technology-based world economy.

In view of the anticipated increase in domestic demand of silicon single crystal wafers, the materials growth project undertaken by UNIDO/KAIST is expected to provide the much sought after leadership in the application of the silicon materials technology.

In addition, Korea is known to have abundant deposits of good quality silicon ore which is the raw material used for single crystal silicon. If a production facility to produce high purity polycrystalline silicon is established, the domestic availability of raw materials will make the Korean semiconductor industries much more competitive in the world market.

Single crystals of silicon used in today's electronics are produced either by the Czochralski (CZ) method or by the float-zone (FZ) method. At present, about 80% of silicon single crystals are produced, worldwide, by the Czochralski method. At KAIST, because of the need to grow crystals of large diameter, the CZ method is being adopted.

In order to develop single crystal silicon growth technology, KAIST-SML installed the Czochralski silicon puller and made successful test runs in November 1980. Four test runs were made and four single crystals of three- and four-inch diameter were grown. These were the first silicon single crystals grown in Korea and two of the three-inch diameter single crystals were free of crystalline defects. Since the first test runs, the staff of SML has been routinely pulling Si boules of three to four-inch diameter. As of 30 April 1984, about 50 boules of varying sizes and lengths were produced.

- GaAs Materials

The last decade has seen a great increase in worldwide activities related to the growth and characterization of III-V compound semiconductors--notably GaAs--because of the need for LEDs, laser diodes, high speed microwave devices, and logic and analog ICs. However, GaAs technology can be considered a new, emerging technology in Korea. In contrast to silicon device manufacturing industries, only a few companies are engaged in assembly-type production of LEDs. Recognizing the importance of the technology of GaAs for future electronic industrial growth in Korea, the research goals involving GaAs materials growth and characterization have been proposed in the UNDP project document.

It is anticipated that the demand for LEDs will continue to increase for display applications. The use of LEDs and laser diodes as potential light sources for optical communications is expected to increase considerably within a few years. Increased use of

- developing techniques for device application (doping, wafering, oxidation, and other processing procedures),

- study of microdefects,

- GaAs crystal growth by horizontal Bridgman method,

- epitaxial growth of III-V by VPE and MO-CVD methods,

- characterization of above materials by various measurements, i.e., 4-point probe, spreading resistance, Hall effect, IR spectroscopy, x-ray,

- basic device fabrication and characterization of their properties, i.e., I-V, C-V curve, carrier lifetime measurements.

SML has begun to extend the ingot diameter to five inches and to reduce the microdefect concentration in Si crystals. In the near future, SML will be able to produce laser diodes, ICs, optoelectronic and microwave devices using the multilayer growth technique.

- Facility

With the support of UNDP, KAIST-SML acquired certain pieces of equipment essential for the growth, processing, and characterization of Si and GaAs.

. Silicon Crystal Growth Facility

The facility is equipped with a Czochralski silicon puller which has a capacity to grow a single crystal of six-inch diameter and 20 kg in weight.

. GaAs Crystal Growth Facility

The facility houses a horizontal Bridgman (HB) grower, a research vapor phase epitaxial (VPE) reactor, a metal-organic chemical vapor deposition (MOCVD) growth system.

. Wafer Processing Facility

The facility is equipped with a surface grind machine, ingot slicer, and wafer polishing machine. In addition, processing equipment used for wet etching, chemomechanical polishing, bonding, annealing, and cleaning have been installed.

. Materials Characterization Facility

The facility is furnished with up-to-date instruments for measurement and analysis for physical, electrical, and optical properties of grown crystals. These include:

a C-V plotter,
a spreading resistance measurement system,
a noncontact thickness meter,
a noncontact resistivity meter,
optical microscopes,
electrical conductivity and Hall measurement systems,

the cooperative efforts of UNDP and KAIST personnel. Although some difficulties in the procurement of equipment and in personnel training has been encountered, impressive progress has been made in the growth of both Si and GaAs single crystals and the epitaxial layers of GaAs; in the establishment of material characterization facilities; in the transfer of materials growth and processing technologies to domestic industries; and in the collaborative efforts in the materials characterization and device fabrication activities with universities and research institutions.

- Current Status of the KAIST-SML Materials Research Organization

Semiconductor Materials Laboratory
Division of Mathematics and Physics
Korean Advanced Institute of Science and Technology
P.O. Box 131, Dong Dae Mun, Seoul, Korea
Tele: 67-8801-9 (Ext. 3161)

Since the initial article on the Korea Advanced Institute of Science and Technology by Dr. M. J. Koczak in the *Scientific Bulletin*, [*Bulletin*, *8*, (2) 13 (1983)], the KAIST has undergone another phase of reorganization to fulfill the original goals of consolidation of the Korean Institute of Science and Technology (KIST) and the Korea Advanced Institute of Science (KAIS). Accordingly, the new organization structure is provided in Appendix I.

. History

The laboratory was established as the Solid State Physics Laboratory in March 1967. The laboratory was renamed the Semiconductor Materials Laboratory in February 1972.

Manpower:

Head	Suk-ki Min
Faculty research members	18
Senior researchers	two
junior researchers	seven
technicians	three
guest researchers	five
secretary	one
Temporary consulting research members	five
domestic	three
foreign	two

. Current activities

Research and development in the field of semiconductor materials are centered mainly on silicon and III-V compound single crystal growing techniques and on their application technologies. The following research and development activities are being carried out at SML:

- crystal growth of Si by Czochralski pulling method, At the same time, the Korean government strongly felt the need for establishing a domestic semiconductor technology base. If the Korean electronics industry is to remain competitive in the world market, it is felt that the domestic industry should become self-sufficient in the production and processing of semiconductor materials. In order to develop a more sophisticated technology and an intensive electronics industry apart from the simple assembly-type industries, the Korean government has sought the assistance of UNDP in initiating new materials technology in Si and GaAs. On 14 December 1978, the UNDP project document, ROK/75/019, on "Semiconductor Materials Technology," was signed by the government of the Republic of Korea and the United Nations Development Program.

- Program Objectives and Scope

The purpose of the project is to acquire and develop the technologies for the production of semiconductor materials through the domestic electronic industry.

More specifically, the task calls for:

- establishment of the institutional capability at KAIST, including facilities and staff, for the acquisition and development of silicon and GaAs materials technologies:

    silicon materials technology

        single crystal ingot growth
        wafer processing

    GaAs materials technology

        single crystal ingot growth
        wafer processing
        epitaxial growth

- transfer of semiconductor materials manufacturing technology developed at KAIST to industry.

Semiconducting materials of silicon and GaAs are specifically selected as strategic materials because they are today's most widely used and are the basic semiconductor materials for electronic devices.

Silicon- and GaAs-based solid state electronics have become the key to modern technology. Dislocation-free silicon single crystals are in great demand for low power devices; LSI and VLSI applications are needed for logic and control electronics. The current worldwide demand for silicon ICs offers tremendous opportunity and challenge for the Korean electronics industry and is a strong impetus for single crystal materials growth activities in Korea. The recent dramatic entry into the semiconductor business by four major Korean conglomerates further provides an opportunity for KAIST to transfer technical knowhow; KAIST feels that the decision to establish semiconductor materials technology is correct and well-justified.

- Implementation of Program Objectives

Since the projects initiation in March 1979, significant progress has been made with

SEMICONDUCTOR RESEARCH AT THE KOREA ADVANCED INSTITUTE OF SCIENCE AND TECHNOLOGY

Yoon Soo Park

INTRODUCTION

At the beginning of 1979, the Korea Advanced Institute of Science and Technology (KAIST) initiated and since then has been conducting an ambitious program to establish a technology base for self-sufficiency in Si and GaAs semiconductor electronic materials to meet the needs of South Korean industries. With technical and financial support from UNDP/UNIDO (United Nations Development Program/United Nations Industrial Development Organization), remarkable progress has been made in this undertaking and the effort has been fruitful.

Recently activities related to the growth, processing, and characterization of Si, and GaAs, and related III-V compound semiconductors have increased because of the need for large-scale, high-speed, and highly complex devices and integrated circuits. The field of optoelectronics has also experienced widespread interest, primarily as a result of advances in the performance and reliability of epitaxial III-V material structures. The types of III-V materials for use in optical communication systems are constantly being refined and improved.

In response to this increased interest and challenge and, in particular, to the critical need and demand of Korean electronics industries for materials growth and supply, the Semiconductor Materials Laboratory (SML) at KAIST has established the technology of growing bulk single crystals of both Si and GaAs and expitaxial layers of GaAs and related III-V compound semiconductors.

Unfortunately, the entire domestic supply of electronic materials has been and is still dependent upon foreign sources. If these sources were severed for one reason or another, the domestic producers of electronic devices would be forced to develop their own crystal growth technology and apparatus. Such a state of affairs, if it should occur, would be truly chaotic and detrimental to the future welfare of Korean electronic industries and the health of the Korean economy as a whole. The Korean electronics industries are most concerned with this problem.

UNITED NATIONS DEVELOPMENT PROGRAM

- Historical Background

Since the implementation of the first five-year economic development plan in 1962, South Korea has undergone phenomenal economic growth which has transformed the country from an agricultural nation into a semi-industrial nation. In parallel with other manufacturing industries, South Korea's electronics industry has also shown a remarkable growth rate, particularly during the period of 1969-1974.

Recognizing the significant contribution of the Korean electronics industry to the nation's economic growth, the Korean government has designated it as a strategic industry under the fourth five-year economic development plan (1977-1981), and rendered positive assistance and support to the technical development activities of the Korean electronics industry.

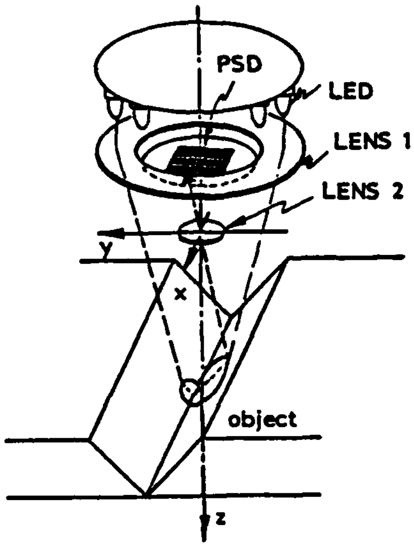


Figure 3. New Optical Proximity Sensor

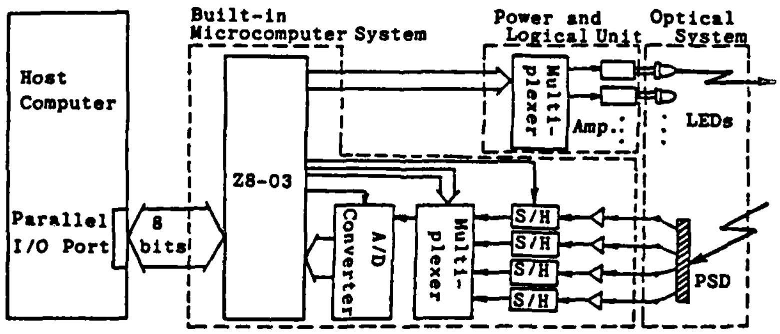


Figure 4. Schematic Diagram of Built-in Microcomputer System

The laboratory is involved with the Monte Carlo simulation of submicron GaAs FETs to evaluate performance and principle of operation. Using the two-dimensional Monte Carlo particle simulation, the electrical properties of a GaAs FET having a 0.25 μm source-drain distance, a 0.25 μm gate length, the channel of 0.25 μm length and 0.1 μm thickness doped with $N_d = 7 \times 10^{16} cm^{-3}$ were predicted. The simulation shows the drain current i_{ds}, transconductance g_m, and the current-gain cutoff frequency f_t of 3.3 mA/20 μm, 600 mS/mm, and 160 GHz, respectively. In contrast to a long channel FET, the high electric field is observed in the vicinity of the source which could account for the large drain current. In the ballistic FET, the saturation current is caused by the two-dimensional effect of the gate, while in the long channel FET a stationary high-field domain dominates the saturation mechanism. The drain current is controlled by the gate voltage through the modulation of the depletion layer thickness and the electron velocity.

CHIRP superlattice--new negative resistance device

A novel superlattice device structure has been proposed by ETL workers. It is called a CHIRP (coherent heterointerface for reflection and penetration) device which offers possible application as a negative resistance device. The CHIRP diode is made of a superlattice consisting of alternating thin layers of two different semiconductors such as GaAlAs/GaAs with a gradually changing periodicity sandwiched in between two highly-doped semiconductors, emitter and collector. In such an aperiodic structure device, at a certain bias of the electric field E_b, the injected electrons encounter the minigap of the superlattice at the interface between the injector and the superlattice, and are reflected at the interface. A strong dip in I-V characteristics, therefore, is expected by the electron reflection. For instance, the minigap of 35 meV repels almost completely the injected electrons if the barrier of the minigap is more than 1000Å.

In the CHIRP diode, the diode parameters such as the width and the position of the current dip are controlled almost independently by changing E_o (the conduction band edge discontinuity between two semiconductor materials) and E_b. The ultimate limit to the response time estimated by a computer simulation shows the time elapse of ∿6.1 ps by a reflecting electron for the CHIRP superlattice which have the minigap of 35 meV (corresponding to a $GaAs/Ga_{0.95}Al_{0.05}As$ superlattice with 50% GaAs duty ratio), E_o of 50 meV, and E_b of 6.67 kV/cm.

Because of the design flexibility and high frequency operation capability, the CHIRP devices are considered very attractive as a negative resistance diode.

. Growth of III-V materials

Extensive growth activities of III-V layers using MBE are being conducted at ETL. Activities include growth of superlattice structures, MQW structures for optoelectronic devices, and basic studies on the MBE technique. ETL has just installed a OMVPE reactor and is to begin growth activities soon.

Arsenic passivation for MBE growth interruption

In MBE, it is a well-known problem that a "metamorphic layer" is formed at the growth-interrupted interface, causing depletion of carriers, which will produce an electrically high-resistant nonohmic interface. At the solid state device section, to eliminate the metamorphic layer, an amorphous (a-As) passivation technique is being tried. The technique involves:

deposition of a-As in the MBE system and sample processing outside the MBE system, deposition of an a-As and second epitaxial layer in the MBE system.

When the carrier concentration depth profiles of the growth-interrupted n-type GaAs:Si samples with As-passivation were measured with the C-V technique, no interfacial carrier depletion at the interface were observed in contrast to an air-exposed growth-interrupted n-GaAs:Si. Experiments show the protection of the surface with As-passivation against air, heat treatment, (180°C) in room air and deionized water.

Phase locked epitaxy (PLE) growth

Phase-lock epitaxy (PLE) growth of GaAs and $Al_xGa_{1-x}As$, which they first reported on at the 16th Conference on Solid State Devices and Materials, 30 August-1 September 1984, Kobe, is still continuing in the Solid State Device Section. Strong intensity oscillations over more than 400 periods were observed in the reflection high energy electron diffraction (RHEED) from GaAs and $Al_xGa_{1-x}As$ during MBE growth. A period of the RHEED oscillations corresponded to one monolayer thickness (2.83Å in GaAs). By analyzing the phase of the RHEED oscillations by a computer and with the molecular beam shutters operated at a particular phase, superlattice structures with an integral number of monolayers were realized. Using these oscillations, the impining rates of Ga and Al and even the Al mole fraction X of $Al_xGa_{1-x}As$ can be accurately determined.

By PLE $(GaAs)_2$ $(AlAs)_2$ bilayer superlattices are grown and Raman scattering spectra of the bilayer superlattices showed splitted lines which are characteristic in the superlattice structures. The advantage of the PLE method over the conventional time measurement is that with PLE the fluctuations of the molecular beams, seen immediately following the cell shutter opening, do not affect the multilayer structures since the number of monolayers are controlled by the number of oscillations.

- Lithography

. X-ray lithography using synchrotron radiation

Recently, great interest has been generated in the use of synchrotron radiation (SR) as an x-ray source for microlithography because of its high collimation and brightness. Synchrotron radiation has great potential as a source for high resolution volume production of microcircuit patterns.

The laboratory is actively engaged in research and development on SR lithography using the 600 MeV electron storage ring. The useful spectral range of SR from the ring lies between 10 and 1000Å. Currently, ETL is involved with experiments to study the factors which determine the resolution and throughout they are employing various resists such as PMMA, EBR-9, PGMA, and CMS-EX.

. Fine-pattern definition with focused ion beam and its application to x-ray mask fabrication

A new pattern definition method using atomic intermixing induced by focused ion beam (FIBs) is being developed. The sample, consisting of double layers of 8 nm Al and 203 nm Au, was first irradiated with a 0.2 μm diameter 50 keV Ga FIB. As a result of irradiation, the intermixed Al-Au, which provides a higher sputtering rate than the top Al layers, is formed. By ion milling the layers with 4 keV Xe ions in an O_2 ambient of 5×10^{-3} Pa, grooves with a width less than a quarter micron are successfully formed. With the use of tnis method, x-ray masks were fabricated. From the fabricated mask, steep patterns narrower than 0.2 μm were transferred to PMMA coated on Si substrates with synchrotron radiation.

PROGRESS IN THE LARGE-SCALE PROJECT, "OPTICAL MEASUREMENT AND CONTROL SYSTEM"

In order to carry out the MITI-sponsored large-scale project, entitled "Optical Measurement and Control System," (the optoelectronic project), the Engineering Research Association of Optoelectronics Applied Systems was established with 14 members of various industrial corporations. In October 1981, the association established the Optoelectronics Joint Research Laboratory (OEJRL) with approximately 50 scientists pooled from nine participating members of industrial corporations (approximately six scientists from each company) including Fujitsu, Hitachi, NEC, Toshiba, Mitsubishi Electric, Matsushita, Furukawa, Oki, and Sumitomo Electric.

The program goal is to develop a sophisticated optical measurement and control system permitting massive volume of data, including picture images, to be measured and controlled safely and reliably despite an adverse environment. The program emphasizes the development of optoelectronic integrated circuits (OEICs), in which both optical and electronic elements are integrated monolithically. OEICs call for a new technology involving the development of:

- improved crystal growth techniques capable of producing large-scale high quality substrates of compound semiconductors such as GaAs,

- advanced techniques for IC pattern processing, and

- quality control methods refined enough to evaluate the products of the foregoing two processes.

The project is a eight year program which began in 1979 at a total projected budget of 18 billion yen ($72 million at ¥250=$1.00). The funding level for 1984 is about $9.3 million.

ETL has been contributing to the program through pioneering studies in the following areas:

research on optical measurement technology

shortwavelength visible laser diodes
SiC high temperature optoelectronic devices

research on optical transmission technology

self-coupling effects of semiconductor laser diodes research on optical control technology

magneto-optic devices
basic technology for optical I/O Si ICs
guided wave control technology

research on optoelectronic process technology

quadrapole electron beam exposure technology
fabrication technology of high-quality optoelectronic materials
evaluation technology of optoelectronic materials--experimental technique of EXFAFS using synchrotron radiation

Some of the recent accomplishments at ETC are summarized below:

- Shortwavelength visible laser diodes

In this research project, shortwavelength visible laser diodes (LDs) oscillating below 6800Å are being examined. To realize shortwavelength LDs, two approaches are being taken:

wide, direct bandgap materials such as ZnSeTe, ZnSTe, GaInP, and AlGaInP are being investigated as active layers, and

a quantum well structure is employed in active layers.

To grow shortwavelength LD materials and quantum well structures, the MBE technique is being adopted. Current MBE growth activities include:

growth and characterization of ZnSe,

fabrication of surface-emitting laser diodes using a high-reflectivity GaAs/AlGaAs multilayer reflector,

fabrication of single and multiquantum well GaAs/AlGaAs LDs,

demonstration of quantized Hall effect devices using a selectively doped GaAs/AlGaAs heterostructure for a resistivity standard,

growth and characterization of GaAs/AlAs monolayer superlattice (MSL),

high-quality ZnSe thin films grown by MBE

(High-quality and high-purity undoped ZnSe thin films have been grown by MBE at the substrate temperature of ~ 280°C. The electron mobility value as high as 6.9×10^3 cm/Vs at 30 K was obtained. It is the highest value ever obtained in ZnSe epitaxial films. The concentration of charged defects $[N_i]$ is found to be ~ 1×10^{16} cm^{-3}. The goal of the ZnSe growth program is to achieve high conductivity p-type layers for ZnSe p-n junction diodes.)

- Distributed feedback surface emitting laser diode with a multilayered heterostructure

A distributed feedback (DFB) surface emitting laser diode (SELD) was fabricated, for the first time, using a $Al_{0.03}Ga_{0.7}As/GaAs$ multilayered structure grown by MBE. Surface emitting lasing was confirmed both by optical pumping and current injection. The SELD consists of an upper reflector and a lower reflector of 20 and 30 pairs of $Al_{0.03}Ga_{0.7}As$ (64 nm) and GaAs (60 nm) layers, respectively, with a period of half-optical length. A GaAs layer with a double thickness inserted between the upper and lower reflectors serves as a phase shifter. The AlGaAs/GaAs multilayer is n-type except for the undoped lower 10 pairs. In order to obtain a DFB laser operation, a p-junction perpendicular to the multilayer, which forms an optical cavity, is introduced by Zn-diffusion. The Zn-diffusion also produced the mixing of the AlGaAs/GaAs multilayer which served as the carrier confinement barrier for the injected electrons in GaAs. The threshold current of 120 mA at 150 K was achieved with the 3 μm wide and 6 μm thick optical cavity.

- SiC High Temperature Optoelectronic Devices

ETL is involved with the development of high quality SiC crystal technology with the aim of achieving high temperature optoelectronic devices. Since SiC crystals have wide bandgap energies, light emitting devices in the visible spectral region can be made. As a long-term project, ETL is also exploring the possibility of making high speed devices, because of a large saturated drift velocity of electrons in SiC. Their current research places emphasis on controlling polytypes and conduction types, and on developing the processing technology.

For crystal growth, they are currently involved with growing 3C-SiC and 6H-SiC polytypes. Several growth techniques are being employed:

. Molecular and ion beam epitaxy

In this approach, SiC films are epitaxially grown on heated substrates using silicon molecular beams and 100-300 eV carbon ion beams. Also, 3C-SiC are grown at 800°C using C ion and Si molecular beams. They have also grown 3C-SiC on sapphire and Si substrates by reactive molecular epitaxy using Si and C_2H_2 beams.

. Liquid phase epitaxy

By liquid phase epitaxy (a dip method), good quality 6H-SiC are obtained which show strong broad emission at room temperature.

. Chemical vapor deposition

Both 6H-SiC and 3C-SiC are grown by this technique using monosilane and propane gases onto GC-SiC. Metal organics such as triethylboron (TEB) and triethylaluminum (TEA) are used as p-type dopant gases. Undoped layers normally exhibit n-type conduction. The p-n junction diodes obtained by successive deposition of undoped n-layers and Al- or B-doped p-layers showed good I-V characteristics and electroluminescence properties. Emission peaks at 6000Å and 4700Å are observed for B- and Al-doped layers, respectively, at room temperature in the electroluminescence spectra.

. Sublimation method for substrate crystal growth

In view of the lack of good quality 6H-SiC substrates, ETL is pursuing the growth of

6H-SiC substrates using the sublimation method. Recently, they have grown a good quality 6H-SiC at a growth rate of 100 μm/h in a low argon pressure of 1 Torr maintained for two-five hours. Initially, Ar pressure was kept at 100 Torr for 30 min and gradually reduced to 1 Torr in 30 min.

The process technology for SiC is also being investigated at ETL, since the device fabrication technology of SiC is not well established because of its high chemical and thermal stability and hardness.

They are also contemplating fabrication of heteroepitaxial structure devices involving different polytypes of different bandgap energies and refractive indices. Since different polytypes have nearly the same lattice constants, such heterostructures involving polytypes can be stacked without lattice mismatch.

- Basic Technology for Optical I/O Si Integrated Circuits

Efforts are being expended in developing a basic technology to integrate new electro-optic devices with silicon signal processing devices on the silicon substrates. The aim of the research is to link optical transmission lines through an electro-optic device with optical input/output (I/O) interfaces.

To obtain the light emitting and detecting devices on a Si substrate, MBE technology is being employed. Specifically, GaP epitaxial layers as light emitting material and silicon multilayers as light detectors are grown on a Si substrate. Heteroepitaxy growth of GaP on Si is chosen because of negligible lattice mismatch between GaP and Si (a_{Si} =5.4309A and a_{GaP}=5.4495A).

Recent accomplishments include:

establishment of Si surface cleaning at a temperature of 800°C,

formation of ohmic contacts to n- and p-GaP by laser annealing,

growth of GaP films on a Si substrate at growth temperatures as low as 300°C,

growth of a Si multilayer n-p structure. Also, 80 periodic layers of 260A in thickness have been grown; p-type layers were obtained by Ga-doping and n-type layers by Sb-doping.

- Fabrication Technology of High-quality Optoelectronic Materials

The aim of this research is to develop a highly innovative fabrication and crystal growth technology for future OEICs. The research activities are specifically directed toward minimizing undesirable interactions between electronic and optical devices in the monolithic OEICs. Precise control of the stoichiometry, the thickness of the epitaxial layer, and a highly-controlled doping method are required for the realization of high quality optoelectronic materials.

In this research, ETL has developed an integrated system combining the MBE method and the ion implantation method. They combined the Riber-2300 MBE system with the 30 keV ion implanter. The system consists of an analysis chamber, preparation chambers, growth chamber, and ion implanter. In order to avoid the radiation damage caused by ion implantation and the subsequent annealing process, they have developed a technique to carry out ion implantation during MBE growth.

- Evaluation Technology of Optoelectronic Materials

In their research, new evaluation techniques to analyze impurities and crystalline defects such as dislocations, point defects, precipitates, etc., in the bulk and the surface and interface of the compound semiconductor crystals are being developed. To fabricate solid state optoelectronic devices with high efficiency and high reliability, it is necessary to characterize materials as precisely as possible.

Two evaluation techniques are primarily developed in the investigation:

the chemical etching technique followed by a high resolution microscope to study crystal defects at the surface, and

the fluorescent x-ray EXAFS (extended x-ray absorption fine structure) for the structural analysis of small amounts of impurities in the material.

In conjunction with these techniques, conventional techniques such as photoluminescence and x-ray measurements are also employed for impurity and defect analysis.

Recent investigations have established a correlation between the 0.65 eV PL band (EL2) and the distribution of etch pit density (EPD) in undoped semi-insulating LEC GaAs crystals. It is also found that there exists a linear relationship between the x-ray diffraction intensity and the EPD in GaAs.

As a structural analysis tool, the EXAFS technique in the x-ray fluorescence yield as well as the absorption spectrum has been applied to obtain information on local atomic arrangements around x-ray absorbing atoms in the materials. Using synchrotron radiation as an excitation source, a dilute species of $\sim 10^{15} cm^{-3}$ can be measured.

Currently, a technique is being developed to apply EXAFS to thin films and dilute systems which are not accessible by the usual transmission method. The technique employs a novel multidetector system (MDS) at a focused beam line using a bent cylindrical mirror. Structural studies of nickel silicide formation on Si (100) by MDS demonstrate that probing of very thin films of a few tens of angstrom is possible.

CONCLUSION

The research activities of ETL, as manifested by research subjects listed, encompasses a wide range of basic and applied research. Since its inception in 1891, ETL has made a great contribution to the advancement of science and technology in Japan. The laboratory is well-equipped; there is an abundance of equipment that give visitors a "one man per machine" impression. Scientists are highly competent and they take great pride in their work. Like other laboratories in Japan, scientists work without technician or secretarial support. They do their entire experiments, machining, drawing, and typing, etc. All the scientists, without exception, said they wish they had more time to "think," to be free from those undesirable routine chores. Nevertheless, ETL is truly playing a leading role in the shaping of science and technology in Japan.

ACKNOWLEDGEMENTS

I would like to express my sincere thanks to Dr. T. Yao who acted as my host during

my visits to ETL and to all the scientists (see Appendix II) who participated in the discussions for their generous time and hospitality.

APPENDIX I

ORGANIZATION OF THE ELECTROTECHNICAL LABORATORY

Organization*

Director
Itaru TODORIKI

Deputy Director
Kohei SATO

Research Planning Office

Fundamental Science Division
- *Electron Physics Section*
- *Low Temperature Physics Section*
- *Applied Physics Section*
- *Device Fundamentals Section*
- *Cryoelectronics Section*

Materials Division
- *Magnetic Materials Section*
- *Electronic Refractory Materials Section*
- *Amorphous Materials Section*
- *Electronic Chemistry Section*
- *Material Fundamentals Section*

Electronic Device Division
- *Solid State Device Section*
- *Semiconductor Device Section*
- *Three-Dimensional Device Section*
- *Reliability Section*
- *Electron- and Ion-Beam Section*

Information Sciences Division
- *Bionics Section*
- *Image Processing Section*
- *Speech Processing Section*
- *Machine Inference Section*

Computer Systems Division
- *Computer Architecture Section*
- *Memory Systems Section*
- *Man-Machine Systems Section*
- *Analogue Information Section*

Computer Science Division
- *Information Systems Section*
- *Language Processing Section*
- *Programming Research Section*
- *Mathematical Engineering Section*

Automatic Control Division
- *Systems and Control Section*
- *Computer Vision Section*
- *Information and Control Section*
- *Logical Systems Section*

Radio- and Opto-Electronics Division
- *Laser Section*
- *Optoelectronics Section*
- *Radio Electronics Section*
- *Fabrication Technology Section*

Quantum Technology Division
- *Applied Optics Section*
- *Radiation Metrology Section*
- *High Energy Radiation Section*
- *Radiation Physics Section*

Advanced Technology Division
- *Space Environment Engineering Section*
- *Cryogenic Engineering Section*
- *High Temperature Engineering Section*
- *High Energy Section*

Energy Division
- *Solar Energy Applications Section*
- *Ocean Energy Section*
- *Plasma Section*
- *Superconductor Applications Section*

Energy Systems Division
- *Energy Conversion Section*
- *Energy Transport Section*
- *Energy Storage Section*
- *Systems Engineering Section*

Standards and Measurements Division
- *Electrical Standards Section*
- *Quantum Metrology Section*
- *Acoustics Section*

Special Section on Josephson Computer Technology

Technical Information Office

General Affairs Division

Osaka Branch
- *Industrial Measurement Section*
- *Standard Measurement Section*

*Courtesy of the Electrotechnical Laboratory, 1 April 1984

APPENDIX II

A SUMMARY OF TOPICS DISCUSSED AND INDIVIDUALS WHO PARTICIPATED IN THE DISCUSSIONS AT ETL

Topics discussed	Scientist
Outline of national project--R&D of optical measurement and control system	Dr. J. Shimada, Director, Radio- and Optoelectronics Division
Characterization of bulk crystals Characterization of deep levels in GaAs by twofold excitation modulated photoluminesence technique	Dr. T. Tajima
Heterojunction GaAs MIS-like FET GaAs ballistic FET	Dr. K. Matsumoto Dr. N. Hashizume
CHIRP superlattice--new negative resistance device	Dr. K. Tomizawa Dr. N. Hashizume
Arsenic passivation for MBE growth interruption	Dr. N. J. Kawai
Phase-lock epitaxy (PLE) growth	Dr. Ohta
X-ray lithography using synchrotron radiation Fine pattern definition with focused ion beams and its application to x-ray mask fabrication	Dr. K. Hoh
Shortwavelength visible laser diodes, high-quality ZnSe thin films grown by MBE distributed feedback surface emitting laser diode with a multilayered heterostructure	Dr. Yao Dr. M. Ogura
SiC high temperature optoelectronic devices	Dr. K. Endo
Fabrication technology of high quality opto-electronic materials	Dr. Y. Makita
Evaluation technology of optoelectronic materials	Dr. O. Yanagi Dr. T. Matsushita

SOME RECENT ADVANCES IN PLASMA MEMBRANE RESEARCH AS EXPRESSED AT THE THIRD INTERNATIONAL CONGRESS ON CELL BIOLOGY

P. F. Iampietro

It seems that an increasing number of important international scientific meetings are being held in the Pacific area, primarily in Australia and Japan. This may be indicative of the increasingly important role these countries are playing in the scientific community. Japan has made enormous advances in its research programs in the last three-four decades, and today, in several areas, is considered among the world leaders. In cell biology, several Japanese scientists achieved prominence beginning in the last quarter of the 19th century, during the Meiji Restoration, and in recent years Japan has declared itself to be very serious in its quest for leadership in biological research. Several areas have been "targeted" for increased emphasis over the next five-ten years. It is not surprising that biotechnology (genetic engineering, recombinant DNA, and other related areas) occupies an important position in that plan. Although the research overall is not as advanced as in the United States and several European countries, Japan, nevertheless, has shown evidence of some very innovative work. Scientists worldwide are paying much more attention to research being conducted in Japan and are now much more willing to travel long distances to attend meetings here.

INTERNATIONAL CONGRESS ON CELL BIOLOGY

About 3000 persons attended the congress which was held from 26-31 August 1984 in Tokyo, Japan. Two thousand three hundred seventy-four people from 52 countries had applied for advance registration. The largest number (502) to come from outside the host country came from the United States with West Germany (57), India (47), Australia (42), the People's Republic of China (39), and France (36) accounting for 219 participants. It was interesting to note that the Soviet Union sent only eight people while China had 39. This most certainly cannot represent a true picture of the amount of research being performed in cell biology in the two countries. South Korea, which is geographically near Japan, had only nine members. As far as is known there were no Korean scientists at the International Physiological Congress that was held in Australia in 1983. Of course, the largest number of participants were from Japan (over 1300 members).

SCIENTIFIC PROGRAM

The science of cell biology is concerned with understanding the structure and function of all living cells. It therefore encompasses many disciplines and requires an integrative approach to achieve its goal.

The organization of a meeting with scientists of such diverse expertise is a difficult undertaking. The approximately 1700 papers and posters presented were scheduled over five days including two evenings. In addition, there were 12 postcongress satellite meetings, four plenary lectures, two technology workshops, and two film sessions.

The presented papers were organized under the general headings of:

- Genomes and Gene Engineering, Membranes, Organelles,
- Cytoskeleton and Cell Motility,
- Cell Sociology, and
- Cell Pathology and Aging.

The poster sessions were arranged under somewhat the same headings as follows:

- Genomes,
- Organelles,
- Membranes,
- Extracellular Matrix,
- Specialized Cell Systems,
- Growth and Differentiation,
- Bioengineering and New Technology,
- Contractile and Cytoskeletal Elements,
- Cell Pathology,
- Transformation and Aging, and an
- Others category.

Each of the symposium and poster sessions were further divided into several subgroupings. This listing indicates the diversity of the material presented. However, a sizable portion of the congress was devoted to things genetic such as gene organization and expression, gene regulation, genetic engineering, chromosome mapping, transcription, etc.; probably an indication of the increasing interest in these areas of research worldwide. Plasma membranes, another area currently enjoying a great deal of interest in the worldwide scientific community, occupied three symposium sessions.

Since several symposia were conducted simultaneously, it was necessary to make a choice as to which sessions would be attended. A report had been prepared earlier on membrane research in Japan [*Scientific Bulletin*, *9*, (3) 54 (1984)], therefore, I decided to attend the membrane symposia. This afforded an opportunity, not only of obtaining more information on Japanese research, but also of sampling membrane research in other countries.

- Plasma Membrane I: Structure of Integral Proteins

The papers in this session, as the titles specifies, were concerned with the structure of protein components of membranes with particular attention to channels. The proteins (oligmers) forming cell-to-cell channels are sensitive to Ca^{2+} concentration. In the absence of Ca^{2+}, the subunits of the oligmers are tilted tangentially about the axis of the channel and with high calcium ion concentration they are nearly parallel to the axis.

Matrix porin (in *E. Coli*) displays voltage-gated channel opening events. It is suggested that the association of monomers into the proper trimer configuration might be the critical step in membrane insertions of the trimer.

The structure of the protein Na, K-ATPase has not been firmly established. Na, K-ATPase penetrates the lipid layers of membranes and provides transport for Na^+ and K^+. Recent work indicates that the ATPase contains monomer, trimer, and hexamer forms all having enzyme activities but the molecular weight could not be determined.

The structure of the acetylcholine receptor is funnel-shaped and has a central ion channel that crosses the lipid bilayer and has five similar subunits surrounding the ion channel.

- Plasma Membrane II: Cell Surface Molecules and Cell Proliferation

Cell growth factors mediate their biological activity through high affinity receptors in the cell membrane. The receptors have been found to be glycoprotein or glycolipid in nature. The papers in this session were primarily concerned with a description of these receptors and their affinities for the growth factors, epidermal growth factor (EGF), and platelet-derived growth factor (PDGF).

The membrane receptor for EGF is a glycoprotein which has several attributes: an extracellular portion containing the EGF binding site, a transmembrane region, a tyrosine specific kinase activity and autophosphorylation sites. Determination of amino acid sequences revealed striking similarities to an oncogene.

The receptor for PDGF (platelet-derived growth factor) has been purified and has been shown to have intrinsic tyrosine kinase activity. The purified receptor also phosphorylates phosphotidylinositol. The amino acid sequence of this receptor has a striking homology to the putative transforming protein of the simian sarcoma virus.

The receptor for transferrin (a growth factor for cultured cells) is a cell surface glycoprotein. Transferrin is bound to the receptor which mediates the transfer of iron across the cell membrane. It has been shown that in normal tissues transferrin receptors are found only in limited sites, whereas in malignant tissues the receptors are widely distributed. Antibodies which antagonize the receptor can inhibit transferrin-mediated cell growth.

Cell growth was shown to be dependent on pH inside the cell. Growth factors activate plasma membrane Na^+/H^+ antiports which in turn allows regulation of pH_i through increased binding of H^+ inside the cell. Therefore, pH_i becomes more alkaline which provides an environment which is permissive for DNA replication and growth.

Cell surface glycosylation plays a role in at least two important cell activities:

- cell-cell recognition,
- regulation of localization, organization, and conformation of enzymes and membrane proteins.

A specific glycolipid may regulate the growth factor receptor function while a shifting of glycosylations from globo to lactoseries may be important as recognition sites during embryogenesis.

- Plasma Membrane III: Mechanism of Regionalization

The plasma membrane regionalizes into a number of domains which are important in the morphological differentiation of the cell. The membrane proteins within these domains serve a variety of purposes but the most described are those concerned with binding of extracellular ligands. However, the factors which control the movements of the proteins to the restrictions of their domains and the factors which determine the limits of the domains are not well understood. The papers in this session provided information about the regionalization of plasma membranes and the characterization of the proteins within those regions.

Artificial lipid membranes are being employed in an attempt to understand phospholipid metabolism and remodeling which occurs when secretory cells are stimulated. Several phospholipids have been associated with membrane functions, possibly involving a change in physical properties of the plasma membrane lipid microdomains from highly charged entities to uncharged ones.

Na, K-ATPase may be one of the most essential components of animal cell membranes. The significance of Na, K-ATPase activity in macrophages has not been firmly established. The enzyme has been found to be localized in certain domains of the membrane. The relationship of Na, K-ATPase activity in some cell fractions to Fc receptor binding sites changed with macrophage activity; Na, K-ATPase activity decreased while Fc activity did not.

A hypothesis was put forth to explain how the regionalization of plasma membranes into specific domains and the differentiation of the cell occurs. Newly synthesized proteins are somehow directed to their respective regions by some signals, as yet not fully explained. The "bioassembly line" (BAL) hypothesis matches a gene product to a BAL at the nuclear level. An "addressing signal" is required for the matching. A low MW RNA mediates the match. The RNA molecules which give rise to proteins localized in the same domain are characterized by a common addressing signal.

- Polypeptide Receptors: Structure and Functions

Cell surface receptors play a key role in initiating cell signaling activity. A number of chemical entities (hormones, neurotransmitters, etc.) exert their effects on target cells through the mediation of receptors. Receptors, in turn, are also the target of regulation and the number and activity of receptors can be modified, which then alters the ability of the transmitter to exert its effect. This session dealt primarily with the description of the structure and function of some receptors.

The receptor for insulin is regulated by isoproterenol, an antagonist to insulin, by an uncoupling of tyrosine kinase activity. The decrease in kinase activity is correlated with desensitization of the receptor. The change in receptor activity is expressed in two ways,

- the number of cell surface receptors is altered, or
- a structural alteration occurs which leads to decreased affinity for insulin.

Cells may have the ability to modulate the number of cell surface receptors according to the physiological state of the cell. When cells are exposed to insulin, the number of cell surface receptors is decreased by an increased rate of deactivation of the receptors. Synthesis remains unchanged. In the diabetic rat, abnormalities within the receptor itself rather than other factors seem to be responsible for the decreased insulin-stimulated receptor autophosphorylation.

It is possible that the various functional properties of the cell surface receptors for PGDF are regulated by phosphorylation. Two possible mechanisms a-e; autophosphorylation on tyrosine residues, and phosphorylation on serine residues.

- Receptor-mediated Endocytosis and Coated Vesicles

One of the fundamental properties of all nucleated animal cells is the ability to ingest proteins from the extracellular fluid surrounding the cell. The process requires a cell surface receptor to which the protein is bound. The portion of the membrane containing the bound protein then folds inward and pinches off inside the cell thus ingesting the protein. The pinched-off segment is called an endocytic vesicle. The entire process or mechanism is termed receptor-mediated endocytosis. This is the mechanism by which some nutrients, toxins, viruses, plasma proteins, and hormones are delivered to cells. All

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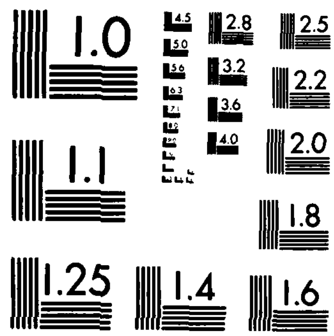
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of the entities must be protein or protein-bound. Receptor-mediated endocytosis is of great relevance to certain human diseases.

Cholesterol which carries low density lipoprotein (LDL) can be bound to LDL receptors located in coated pits on the cell surface. The LDL is then delivered to lysosomes within the cell which degrade the LDL. The freed cholesterol is thereby made available for new membrane synthesis. When there is a defect in the LDL receptor which prevents the uptake of LDL-cholesterol, an abnormal condition occurs (hypercholesterolemia).

The transferrin receptor (a growth-related cell surface receptor) binds transferrin by endocytosis. Transferrin is a dimeric transmembrane glycoprotein with several N-asparagine-linked oligosaccharides. Receptor-mediated endocytosis of many entities requires acidification of the endocytic vesicles for release of ligands from receptors, or for release of iron from transferrin. The receptor for yolk IgG has an optimum pH of 6.

- Endocytosis of Toxins, Viruses, and Bacteria

The entry of toxins, viruses, and bacteria into cells is achieved through receptor-mediated endocytosis. After attaching to the cell surface, engulfment is facilitated by a low pH environment. It is postulated that when a ligand-receptor union is formed, a signal can proceed from the cell surface (receptor) to the cell which alters the function of the cell to receive the molecule at the receptor. Diptheria toxin structure is important in allowing entry into the cell. The C-terminal region is required for binding to cell surface receptors. Most toxin preparations also have hydrophobic regions which may be important for entry. Low pH induces exposure of the hydrophobic protein domains which may then insert themselves into the membrane and facilitate the transfer of the enzymatically active toxin chain or the virus genome into the cytosol. A pH gradient across the membrane may also be important for entry. Reutilization of unoccupied receptors is possible since low pH promotes dissociation of some ligand-receptor complexes thereby allowing the receptor to recycle to the cell surface where it can again form a complex. Receptosomes and ligands in the cytosol may experience one of three fates:

- EGF and its receptor are destroyed by hyposomes,
- transferrin and its receptor are both returned to the cell surface, and
- macroglobulins are destroyed by lysosomes while its receptor is returned to the cell surface.

- Proton Pumps

The maintenance of ion disequilibria requires a source of energy which may be derived from the conversion of radiant energy or through chemical bond energy. The energy is utilized by membrane "pumps" which provide the mechanism for maintenance of the ion gradients. The maintenance of gradients can serve a variety of purposes important to cell function. The plasma membrane of plant cells is equipped with a protein pump which is electrogenic in nature. For example, in *Neurospora* the pump normally functions at a membrane potential greater than -180 mV. The pump is accelerated by low cytoplasmic pH (6.5). The pump drives the uptake of sugars and amino acids by creating a large electrochemical gradient when protons are pumped out of the cell. The H^+-ATPase is very similar to the Na^+-K^+- and Ca^{++}-ATPases of animal cells.

There are two electrogenic pumps in the pea hypocotyle, one is on the outer pump on the cell membrane organ surface and the other pump is on the cell membrane at the boundary of dish-like parenchyma symblasts and xylem. Both pumps are respiration sensitive. The outer pump functions to regulate cell pH and to control enlongation growth. The other pump is related to the absorption of nutrients from xylem.

The electrogenic H^+ pump of *Chara* is dependent on metabolism of the cell. During illumination and photosynthesis, the cell membrane hyperpolarizes and depolarizes during inhibition of photosynthesis. The pump has a high affinity for ATP and anoxia causes both a decrease in polarization of the membrane and a decrease in ATP.

In oat roots, two types of H^+-ATPases have been identified. One type is stimulated by K^+ and the other by anions. The anion-sensitive H^+-ATPase may be primarily found in the tonoplast membrane and also possibly with endoplasmic reticulum and Golgi membranes.

The tonoplast of latex contains two H^+ pumps, an active ATPase electrogenic pump which causes an inflow of protons in the vacuole and which has a passive component which can be neutralized by KCl and is Donnan-balance related. The tonoplast also contains a redox system (NADH plus an exogenous acceptor) which causes an outflow of electrogenic H^+ from the vacuole to cytosol. The operation of these opposing pumps requires an optimum pH of about 6.5 for the ATPase and about 7.5 for the redox system. This range of pHs is the physiological range within which the cell contents varies.

In yeast, vacuolar membrane ATPase differs from plasma membrane ATPase. The vacuolar enzyme requires Mg^{2+} ion for normal function while the plasma membrane ATPase does not. Optimal pH also differs; the former is 6.9 and the latter 6.0. Mitochondrial ATPase from the same strain of yeast is 9.5. The vacuolar enzyme appears to be a unique H^+-translocating ATPase which is different from mitochondrial or plasma membrane enzymes.

- Calcium Transport Across Cell Membranes

Calcium ions play an important role in activities of cells. The movement of Ca^{2+} ions across plasma membranes can occur via several avenues. The mechanisms involved in the transport of Ca^{2+} across cell membranes and the factors which can modify that transport were discussed in this session.

Calcium moves across plasma membranes through Ca^{2+} channels (into the cell), via a Ca^{2+}-pumping ATPase (out of the cell) and an Na/Ca exchanger (usually out of the cell). Additionally, in excitable tissue, Ca^{2+} entry may also occur through Na^+ channels and via the Na/Ca exchanger. In the squid giant axon, when Na channels are blocked by TTX, all Ca^{2+} entry into the cell during depolarization is blocked if internal Na concentration is below 15 mM. This is evidence that there are no Ca^{2+} channels in the giant axon as there are in nerve terminals. Substances which block Ca^{2+} channels have no effect on Ca^{2+} entry during depolarization.

The ATPase Ca^{2+}-pumping system has been proposed to control cytoplasmic Ca^{2+} at rest since it has a low pumping velocity, while the exchanger system (Na/Ca) is thought to control ejection of the large loads of Ca^{2+} that enter the cell during stimulation since it has a much higher pumping velocity. ATPase is present in all cells studied.

In skeletal muscle cells, the sarcoplasm is most likely the most important source of Ca^{2+} during stimulation. Calcium ion itself can induce Ca^{2+} release during a change in membrane potential. Mg ion inhibits the calcium-induced release of calcium probably by competition.

The developing embryo of *Ascidia* has been studied to determine the sequence of the development of ionic channels. Changes in ionic channels occurred almost synchronously during development. It appears that early changes, up to the tail bud stage, seem to be maternally regulated while changes after Stage 4 required new transcription.

- Cell-to-Cell Channels

Where cells form junctions, channels develop through which a variety of molecules may pass from cell to cell. A single cell may form channels with several of its neighbors and the channels are made up of contributions from both cell membranes of the junction. The formation of the channels depends on a phosphorylation which is cyclic AMP-dependent. When an increase in cyclic AMP is experimentally enduced, the number of channels increases. Channels can be suppressed by tumor promotors. Electrical coupling between cells was almost completely prevented by TPA added to the culture medium. If electrical coupling had already been established when TPA was added, decoupling occurred. TPA and other compounds suppress channel formation or function without significantly affecting membrane properties of the cell. TPA may bind cellular receptors.

The cell-to-cell channel permeability in some vertebrates changes in response to a rise in cytoplasmic Ca^{2+} near the channel or to a change in pH. Membrane potential is another controlling factor.

SUMMARY

This report has focused on a small portion of the congress concerned primarily with activities of the cell which occur at or within the plasma membrane. The Japanese scientific community has been very active in this area of research and has made some significant contributions toward our understanding of the structure and mechanisms of cell membranes. The work presented by the Japanese certainly ranks with that of world leaders in this and other areas of biology.

PROGRESS REPORT ON JAPANESE COMPUTER PROJECTS

K. O. Bowman

INTRODUCTION

On behalf of the Office of Naval Research, Far East, Department of the Navy, I visited several installations in Japan during September and October 1984, to observe the development and use of supercomputers in that country, and to assess current research and development efforts in other computer projects. I accepted this assignment recognizing that I am not a bona fide computer scientist and that a computer scientist might question the Japanese scientists more thoroughly and perhaps interpret their responses somewhat differently. On the other hand, I am not unfamiliar with the subject, having been an ardent user of computers for more than 20 years. Moreover, I understand and speak Japanese, and being able to converse with the Japanese in their own language was a great advantage which possibly compensated for my lack of expertise in the subject.

In the report that follows, I first discuss Japan's current research on logical computers (also identified as artificial intelligence research) and then the development work now being performed on parallel processors. In the final section, I describe how supercomputers (vector computers), which are already being manufactured commerically in Japan, are being put to use and developed further.

It is worth noting at this point that success in the development and application of advanced computers is of vital importance to Japan. It is well-known that the country must import almost all of its raw materials so that exported goods are made from imported goods. With rising labor costs, this scheme is becoming less successful than it has been in the past, and the market is shifting toward the production of exportable goods that do not require raw materials--namely, new technologies. Japan's dedication to the development of computer technology and work in related fields was apparent to me throughout my visit. Of course, the Japanese have been technology-oriented for a long time and their interests cover many fields. They are particularly progressive in biotechnology, for example, and just this past September, Japanese marine biologists announced that they had been successful in growing and hatching female-only salt water fish. They had been successful earlier in growing and hatching clear water fish of a preselected sex, but to do the same thing with salt water fish was a breakthrough. The reason for preselecting the sex is that female fish grow to be about four times larger than male fish, and thus they are much more marketable.

DEVELOPMENT OF JAPANESE PROJECTS

In Japan, basic research in almost any field is carried out under the direction of the Ministry of Education, Science and Culture, and research and development is primarily the concern of the Ministry of International Trade and Industry (MITI). I met with Mr. T. Watanabe of MITI and learned of the "structural concept" used by MITI for carrying out a particular mission. First, the world market is researched. After that, decisions are made by a committee on the direction of the project. Next, personnel who are to participate in the project are selected from universities, government laboratories, and industry. And finally, financial support for the project by industry is determined. At present, there are many ongoing projects in numerous areas.

THE FUTURE INFORMATION TECHNOLOGY PROJECT

A major MITI-sponsored project under which computer research and development is carried out is identified as the "Future Information Technology Project." It began in 1966 and will continue until 1990; this project actually consists of nine separate development projects in the following areas.

- very high performance computer systems, (This work was contracted to Hitachi, Ltd., during the years 1966-1970.)

- PIPS--pattern information processing systems, (This work, under contract to Toshiba Corporation, is based on the recognition of Chinese characters.)

- VLSI--very large scale integrated circuits, (This work is performed at Nippon Electric Company.)

- fourth generation computer system,

- optoelectronics application,

- basic technology for next generation industries,

- supercomputers--vector computers,

- fifth generation computer system project--logical computers (artificial intelligence research),

- robotics.

The first four projects have already been completed, and the results of projects two, three, and four are now being applied in project eight. Project eight will be followed by the development of the sixth generation computer system; however, this project is considered by the Agency of Science Technology to be a pure science project and not a research and development project. Directions being considered for the project include modeling the human brain, developing biochips and optics, and modeling psychology.

ARTIFICIAL INTELLIGENCE RESEARCH

As noted above, the fifth generation computer system project consists of the development of logical computers and is also known as the artificial intelligence research program. Japan's announcement of this project has aroused great interest throughout the world. I will not describe the objectives of the project here, but they can be found in *Scientific Bulletin* articles by Richard Dolen [*Bulletin, 7,* (3) 63 (1982)], G. Lindamood [*Bulletin, 8,* (3) 16 (1983)], and R. Mendez [*Bulletin, 9,* (4) 77 (1984)].

For foreign visitors interested in artificial intelligence, access to the Institute for New Generation Computer Technology (ICOT), at Tokyo, is highly desirable but not always easily arranged. Proper introductions in Japan are very important, and I was fortunate to have Mr. Watanabe of MITI arrange a visit for me to ICOT on October 3.

The institute opened its doors in 1982, and since then they have made significant progress in the development of the PSI machine (personal sequential inference), several of which have already been made by Mitsubishi, and the relational data base machine, which has been made by Toshiba.

The PSI machine uses a logical language (a PROLOG-like language called KLO) and Dr. K. Fuchi, director of ICOT and an initial planner of the fifth generation computer system and ICOT, feels that this is the key for the development of the next generation of computers. Dr. H. Aiso, a professor at Keio University and one of the initial planners of ICOT, says that the Japanese language is natural for a logical machine because it can be identified with only about 200 categories. At present, the PSI machine is a SIM (sequential inference machine) but it is to be converted to a PIM (parallel inference machine) in the future, with the final version to be completed by 1990.

On the day I visited ICOT, the researchers were very busy preparing for a demonstration at the forthcoming International Conference on the Fifth Generation Computer, which was to begin on November 6 in Tokyo. I will make no attempt to describe the ICOT program here, instead referring the reader to an article written by Dr. R. Mendez and published in the *Scientific Bulletin* [*Bulletin, 9,* (4) 77 (1984)]. I will say, however, that my visit reinforced my perception (shared by others) that ICOT has already contributed significantly to the country's artificial intelligence program.

Artificial intelligence research is also conducted at the Sakai Research Laboratory of Kyoto University, where I visited Dr. Y. Ariki and his students. They showed me their research on information processing. Professor T. Sakai, for whom the laboratory is named, is the major professor of this laboratory, (the research laboratory of a university is named after their major professor), but I missed seeing him because he was away attending the Japan Information Processing Society meeting in Sendai.

The research topics at Sakai Research Laboratory are:

- automatic speech processing,
- picture processing and image understanding, and
- document understanding.

The research is based on a pattern recognition concept, and it has led to a theory called MOLD (mesh-oriented line drawing), which works with sets of legal patterns (from two to 3910 patterns, but usually only 66). When this theory is applied, the computer can recognize and identify as many as nine different languages, differentiate between different types of articles, and recognize subject matter. In a step-by-step demonstration for me, the Sakai group showed how they could use MOLD to separate each article from a page of newspaper. The same principles are applied to voice recognition. (Their computer is connected to the Data Processing Center at Kyoto University.)

Most of the research at Sakai Research Laboratory has been described both in Japanese publications and in English publications, some of which are listed in the reference section.

A third group I found to be actively pursuing artificial intelligence research was located at Oita University. They, too, are investigating pattern and voice recognition. In particular, they are working on transmitting voice signals without changing the pitch. This work is carried out by using assembly language on the the FACOM (256 K machine). The program at Oita University is directed by Professor R. Nagai. At both Kyoto University and Oita University, a great deal of effort is devoted to accumulating large data bases.

PARALLEL PROCESSORS

While not part of MITI's Future Information Technology Project, the development of parallel processors is being considered by Japan's principal computer manufacturers. Few, however, are willing to talk about their work in this area.

Two computers based on parallel processing should be noted: the SIGMA-1, which is being developed at the Electrotechnical Laboratory; and the PAX-128, which is the second and most recently completed of a series of computers being developed at the Tsukuba University.

The development of SIGMA-1 falls under the project called "The National Project of the High-speed Computing System for Scientific and Technological Use," a MITI project whose ultimate goal is to develop a 10-Gflops performance computer by the year 1989. Six computer manufacturers are participating in the project: Hitachi, Fujitsu, NEC, Mitsubishi, Toshiba, and Oki. Concurrent with this project, research is under way on new device technology. Among the devices now receiving attention are the Josephson junction device, the high electron mobility transistor (HEMT) device, and the gallium arsenide (GaAs) device. Hitachi has a newly developed Josephson integrated circuit which can be operated at high current density and may offer the world's fastest switching speed (5.6 ps).

SIGMA-1 is a prototype large-scale data flow computer that was started in 1982 and is already functional, but will continue to be improved until 1987. The development group, headed by Dr. H. Kashiwagi, studied the feasibility of parallel computer architecture, and they selected the data flow structure because it has the potential for exploiting all the parallelism in a program.

The generic problems encountered in designing the parallel computers such as the SIGMA-1 are usually associated with the following:

- construction of a large and fast matching memory at a reasonable cost,
- construction and management of a structure memory,
- network construction,
- interruption, error and exception handling,
- limitation of the length of the context that consists of I (iteration counter), LN (link number that indicates the entry of the link register), D (displacement of the operation), and FLG (flag that indicates the operation of the matching unit and the input port of the packet),
- inefficiency due to insufficient parallelism.

In SIGMA-1, some of these difficulties are overcome by adopting the following architectural features:

- two short stage pipelines in a processing element,
- chained hashing hardware for the matching memory unit,
- array-oriented structure memory,
- sticky packet mechanism for holding loop invariants,
- interrupt handling using a privileged packet,
- hierarchical communication network (or multilevel network).

The design goal for the SIGMA-1 computer is for it to have more than 200 processing elements (32 groups, each with eight processing elements) and to have an average speed of 100 Mflops. It is already operating at this speed with fewer processing elements.

The SIGMA-1 development group is currently evaluating the performance of the data flow principle with the software simulator on the DEC 20/60 and VAX-11/750 computers.

They have also performed a benchmark study, using as their standards Livermore Loops 1, 3, 11, and 12. The SIGMA-1 computer uses the language EMIL (intermediate data flow language), which has the ability to describe the data flow graphs, and therefore, for the benchmark study Livermore Loops were written in the EMIL language and tested on the current version of SIGMA-1. The results were mixed, with saturation of the performance occurring after 50 processing elements had been used. The main reason was insufficient parallelism in the benchmark programs themselves; that is, the iterating loops in the programs could not really use the available parallelism. Architectural bottlenecks, poor management, and tuning among the communication network, etc. (poor design), were also cited as contributing to the inefficiency. The computer performance improved as the problem size increased.

The development of the SIGMA-1 includes the current careful design of an improved computer configuration based on benchmark studies of the crossbar network, the hierarchical network, and the four by four router network with redundancy. From simulation results, the crossbar network seems more efficient than the hierarchical network. The preliminary version of the new architectural design will be evaluated in 1984.

The developers already know that when the final version of the prototype SIGMA-1 data flow computer with 200-scale processing elements (redesigned by large-scale integration technology) goes into operation in 1987, its average speed of 100 Mflops will not be as fast as that of more conventional computers. Thus, it probably will not be utilized for "practical computing." However, plans have been made to increase the speed of the SIGMA-1 to that of conventional computers by 1989.

Major applications for the SIGMA-1 computer are expected to be in the fields of numerical weather forecasting and climate studies, in wind tunnel simulations for aerodynamics studies, and in plasma simulation to aid in the design and construction of experimental fusion nuclear reactors.

The results of the SIGMA-1 research project are being published both in English and in Japanese, and publications on the results obtained with the latest design of processing elements can be anticipated early next year (see references).

As noted above, the PAX-128 machine at Tsukuba University is one of a series of two-dimensional array processor units (MIMD, multiple instruction multiple data type machine) that are currently being built. The individual machines are identified as PACS-32, PAX-128, and PAX-64, with the number in each case specifying the number of processing units in the computer. (Each unit consists of an 8-bit microprocessor, an arithmetic processor, and a 32 K memory.) PACS-32 was built first and then PAX-128; PAX-64, now under construction, will use faster elements.

These computers are not large-scale computers like SIGMA-1, but their architectural concept and initial simulation results are worth noting. They utilize two-dimensional arrays, and communication is limited to nearest-neighbor processing units. The development groups claim that this type of architecture is close to nature itself and that the computation will proceed in parallel in all processors and will retain the speed gain that is nearly proportional to the number of processors. They report the speed of the PAX-128 computer to be about 3.84 Mflops.

While visiting Tsububa University, I noticed that a Texas Instrument minicomputer TI990/20 with 50 MB disk memory was being used as the host computer. In fact, U.S.-made computers were being used as host computers in most of the research institutions I visited.

The reason, I was told, is that the software for U.S. computers is much better than the software for Japanese computers. However, the Japanese are rapidly developing software now, and thus this situation may change shortly.

The Tsukuba University group considers the architecture of their computers to be most suitable for solving partial differential equations and for handling nuclear radiation transport codes, and they report a 78-99% efficiency. The applications they are considering include solving the two-dimensional Poisson equation, performing three-dimensional Boiling Water Reactor core calculations and one-dimensional aerodynamics calculations, carrying out Monte Carlo simulations of plasma particles, and performing molecular dynamics calculations, as well as solving ordinary differential equations (see references).

SUPERCOMPUTERS

The development of supercomputers in Japan has reached the point that they are now being manufactured commercially. Fujitsu's supercomputer VP-100/200 and Hitachi's S810 have both been in operation since last year, and the Nippon Electric Company's SX-2 is to appear by the middle of next year.

Japanese researchers, like many U.S. researchers, reject the suggestion by some that the technology for developing fast VLSI circuits has reached its limit, and their VLSI circuitry research and vector computer research continue. In addition, the memory capacity of RAM has been expanding rapidly. According to a paper published in the *Hitachi Review* ("Recent Advancement and Future Trends of VLSI for Computers" by K. Taniguchi *et al.*), Japan's continuing VLSI circuitry research will result in circuits that are increasingly cheaper and smaller and that have higher densities than those now available; moreover, they will be more reliable and will utilize less power.

Specific areas of VLSI research include studies of bipolar memory VLSI circuits, complementary metal oxide semiconductors (CMOS), and MOSVLSI and custom-made VLSI circuits. Professor H. Aiso of Keio University has designed a three-dimensional VLSI circuit for solving differential equations. In general, custom-made VLSI circuits are expected to be expensive, but Japanese manufacturers (and U.S. manufacturers, as well) believe that they will eventually be constructed relatively cheaply by using computer design automation capabilities.

Some benchmark studies of the S810/20 and VP-200 computers and comparisons with the Cray-1 computer have been carried out by the manufacturers and also by Dr. Y. Karaki of Tokyo University, by Dr. R. Mendez of New York University, and by Dr. Jack Dongarra of Argonne National Laboratory. (I am advised that others in the U.S. have also performed benchmark studies for these computers, but I am not familiar with their work.)

Table I, which compares the S810/20 machine with Hitachi's earlier M200H machine, is taken from Dr. Karaki's report. [Dr. Mendez' study has already been reported in the *Scientific Bulletin, 9,* (4) 77 (1984), and Dr. Dongarra's results have not yet been published.] The M200H machine has speeds of 24 to 48 Mflops, compared to the S810/20 computer's 630 to 800 Mflops. Hitachi programs were used for all the comparisons, and, in general, the S810/20 machine was 10 times faster than M200H machine. An outstanding feature of the S810/20 computer is that its compiler will vectorize the recursive DO and nested IF statements; however, this capability may not be unique to the S810/20, but I am not aware that any other compiler has this feature.

Hitachi S810/20 computers are in operation both at the Hitachi Central Research Laboratory in Kokubunji (on the outskirts of Tokyo) and at the Computing Center at Tokyo University. I visited the Hitachi Central Research Laboratory on September 27. The laboratory is one of seven Hitachi laboratories It has about 1200 employees, of which 870 are engaged in research.

At the Hitachi laboratory, I was very much impressed by the research of Hosumi Hamada on the representation of real numbers. Most of us who have been frustrated in our attempts to control overflow/underflow on IBM machines would appreciate his research. His method is based on the double exponential cut of real numbers; its algorithm has already been developed for minicomputers and will be implemented in large computers in the future (see references).

From my observations, Hitachi is not vigorously pursuing the development of software packages. It maintains a separate laboratory, System Development Laboratory in Kawasaki for software development, and while the laboratory has 320 employees, it seems that they are primarily interested in the development of specialized languages suitable f r vector/parallel processors. A noteworthy example is a program called DEQSOL, which is a language for solving differential equations. DEQSOL was developed to utilize vector/parallel processors with the finite difference method and the finite element method. Hitachi considers DEQSOL to be superior to other existing packages, such as ELLPACK, ITPACK, FISHPACK, etc. The DEQSOL translator will produce a FORTRAN code which is suitable for vector machines. Hitachi's benchmark study of this package showed that it was four to six times more efficient than existing codes. DEQSOL was designed for future research projects (see Figure 1).

On 1 October, I visited Dr. Karaki at the Computing Center of Tokyo University, accompanied by Dr. M. Shibuya of Keio University. As I have said above, the center uses one of the Hitachi S810/20 computers. The computer replaces an earlier Hitachi computer that was installed at the center in 1966 as part of a computing center network program sponsored by the Science Council of Japan and the Ministry of Education. The program, initiated in 1965, involved computing centers at seven national universities, and was to be used for pure scientific research. (As part of the same program, the Data Processing Center of Kyoto University installed an early Fujitsu computer in 1969, and I learned of the network when I visited that center the same year. When I returned in 1977, all seven universities had computing centers, but they still were not communicating with each other. By contrast, I discovered during my most recent visit that the network is fully operational and that the Computing Center at Tokyo University itself operates with 168 dedicated lines, 1245 public telephone lines, and 27 remote stations around the Kanto area.)

Dr. Karaki is a enthusiastic computer science researcher who is very proud of the "Japanese supercomputer"--that is, the S810/20. Calling himself a "supercomputerist," Dr. Karaki is active in promoting the use of supercomputers by organizing informative symposiums and pushing for the publication of the proceedings. See the references for his most recent efforts. All these publications are in Japanese. His article that appeared as Workshop Report *3* is particularly noteworthy in that it gives many examples of the performance of new supercomputers.

Dr. Karaki has also published several articles on his benchmark studies in which he compared the S810/20 computer with the Cray-1 (see "Super Speed Japanese Computers," *Nikkei Computer*, March 1984; and "Trend of Formula Translator," *Computers Today* 1984/7, *2*, both in Japanese). It is to be noted, however, that his information on the Cray-1 is relatively old (results published in 1981), while his data on the S810/20 is 1984 data.

Even so, the performance of the S810/20 is quite impressive. (See Table II.)

I visited the Fujitsu research and production complex on October 12. It employs approximately 3000 workers, one-third of whom work on hardware, including the VP-100/200 supercomputer. I learned later (from Dr. K. Miura at the Kyoto University Data Processing Center) that Fujitsu is very aggressive both in marketing and in testing their VP computers. Before a computer is shipped it must undergo 70 testing steps over a period of two months, 24 hours a day. Fujitsu claims that the compiler for their supercomputer is superior to others.

Fujitsu's benchmark study on the work on triangularization algorithms for systematic matrix was presented at Oxford, U.K., in August 1984, using three methods: Gauss elimination, Cholesky decomposition by inner product method, and Cholesky decomposition by middle product method. Their results (see Table III and references), indicated that the best method for vectorization was the third method.

In contrast to Hitachi, Fujitsu is very serious about the development of software packages for their computers--to the extent that approximately 2000 of their workers at their research and production complex are developing software. Their main activities are developing general purpose system control programs, network software, on-line data base systems, language processing programs, and native language/graphic/voice processing programs.

Fujitsu also has a group of researchers developing software for statistics and mathematics (for example, the SSL library). The problems of general interest are matrix operation, such as problems of solving partial differential equations with different methods.

In 1972, Fujitsu established the International Institute for Advanced Study of Social Information Science, an organization devoted to research for the next generation information intensive society, including statistical research. In 1982, they developed the statistical package called ANALYST (Analyzer for Statistical Data) and it is in use for interactive or batch modes. It is a user friendly statistical program with output in Japanese characters. Another program currently being written is a Japanese version of SPEAKEASY, a program originally developed in the U.S. for nonlinear least square problems.

Two Fujitsu programs (Atlas I and Atlas II) translate English into Japanese and Japanese into English, respectively. Input of the original document is by voice or through the keyboard. In my opinion, these programs would be much more valuable if they could accept photographic input. Atlas I is now available and Atlas II will be available early next year. While Atlas II has some faults, it would be worthwhile to have it since the Japanese increasingly are producing technical documents written in their native language.

In spite of the Fujitsu effort, it is generally accepted by the Japanese that their software development programs lag behind U.S. programs. Even so, the largest computing centers are using their own numerical analysis packages. The Computing Center at Tokyo University has such a package, but since it has not been compared with IMSL or NAG, the quality of the package has not been determined.

A prominent user of the Fujitsu VP-100 computer is the Data Processing Center of Kyoto University. As noted earlier, this center is one of seven national centers comprising a computing network. The VP-100 replaced an earlier Fujitsu computer at the center in May 1984.

I visited the center at Kyoto University on September 12 and found it to be the most advanced computing facility I have ever seen. For example, the printer will automatically cut and separate the jobs, which are then carried by conveyer to a rotary table for pickup. The operation is more or less automatic and no attendee is needed in the machine room. There is very little downtime and if shutdown occurs, the machine will shut down itself.

Dr. Miura of the Data Processing Center pointed out that they are heavily involved in testing the VP-100 computer. While I was there, I saw about 11 computers in various stages of testing. Research topics at the center included computer systems image processing, kanji processing, numerical analysis, and data base acquisition. The center publishes the *Bulletin of the Data Processing Center* six times each year.

The announcement of the third Japanese supercomputer, the SX-2, by the Nippon Electric Company (NEC) was made in April 1984. It is expected to have a speed of 1.3 Gflops, four pipe lines, and 16 vector units. The diagrams in Figure 2a through 2c show the configurations of all three of the Japanese supercomputers. The architectures of the Fujitsu and NEC machines are similar to each other and different from the Hitachi machine. Scalar operation of the Hitachi machine is slower than the Fujitsu machine.

CONCLUDING REMARKS

Having family and professional contacts in Japan, I visit the country about every six or seven years. (My earlier visits were in 1963, 1969, 1970, 1977, and 1978.) Each time I visit I notice many changes, both in the countryside and in the people. During the 1969-1970 period, Japan had serious problems with pollution, and some significant industrial recoveries with the rigorous practice of quality control after the disaster of the war period (for example, production of the world's largest oil tankers). The problem of pollution was very acute with the rapid growth of industry. At times, siren alarms like those used for air raids warned people to stay inside buildings. The whole country looked gray. However, when I returned in 1977 and 1978, the pollution problems had almost been solved. Once again, people could fish in the river running through Tokyo, which was unthinkable in 1970. One of my friends, T. Yoneyama, General Manager of Hachioji Factory, Konishiroku, Ltd., told me that "it was very expensive, but it was well worth the effort." I cannot help but note that this is another example of Japanese technology.

At that same time, there was a noticeable improvement in the Japanese economy, and the country was experiencing great success in the international market. For example, the Toyota Company was exporting one-half of the automobiles they produced. On the other hand, Japan recognized the U.S. still held the edge in most scientific accomplishments and in overall industrial production.

During my most recent visit, I noticed much more dynamic activity in the research and development community and a total commitment to making Japan the most technology-oriented country in the world. In recent years, the number of international conferences held in Japan has increased dramatically. Moreover, Japan has adopted policies to encourage Japanese scientists in their work. The government (and industry) believe that if scientists are to perform high quality research, they must be happy in their environment and free of worry. I was particularly impressed with the emphasis on the environment at the Hitachi Central Research Laboratory. Most of the region is now covered with commercial and private buildings, but a large area around the Hitachi Laboratory has been preserved.

The money being invested in research and development by the government and

NINTH INTERNATIONAL CONFERENCE ON INFRARED AND MILLIMETER WAVES

Sung M. Lee

The Ninth International Conference on Infrared and Millimeter Waves was held 22-26 October 1984 in Takarazuka, Prefecture of Osaka, Japan. The Japan Society of Applied Physics was the primary sponsor of the conference with four other organizations taking part as cosponsors: the Institute of Electronics and Communication Engineers of Japan, the Spectroscopical Society of Japan, the IEEE Society of Microwave Theory and Techniques, and the International Union of Radio Science.

The conference was initiated in 1974 in Atlanta, Georgia, as an annual international event. The meeting site alternated between the United States and Europe until this year when an exception was made and the ninth meeting was held in Japan. Professor Hiroshi Yoshinaga of Osaka University, conference chairman, remarked in his opening address that this departure from the past practice had caused apprehension among the organizing committee members from Japan. The concern was that many potential participants from the U.S. and European continent might find Japan too remote for the conference and thereby render the meeting too regional. As it turned out, the meeting was a big success. This ninth conference was the largest of the annual meetings thus far and attracted nearly 400 participants from 20 countries. Some 300 papers were presented. Professor Kenneth J. Button, general chairman of the conference, and the organizing committee members are to be congratulated for the tremendous job that they did in making this such a success. Not only were the proceedings of the meeting sessions expertly handled, but all other peripheral aspects of an international meeting were efficiently and pleasantly managed.

One side benefit of participating in a conference of this type is the opportunity it offers to make a visit to nearby research facilities. This conference was no exception in this respect. I visited Osaka University to have a look at some of its research laboratories. This report includes comments on one such laboratory.

THE CONFERENCE

The morning and afternoon sessions were organized in such a way that one or more invited speakers gave talks at plenary sessions that lasted one and one-half hours. These sessions were followed by four parallel sessions of contributed papers which were grouped by subject matter. The time schedule of these sessions is shown in the accompanying table.

The sessions which had most of the scheduled papers (12 of 14 papers) contributed by U.S.S.R. authors had to be cancelled as these authors did not attend the conference.

With several parallel sessions taking place at once, it was not possible to hear all the papers that appeared interesting. The wide range of topics that were covered by the authors was impressive. It ranged from astronomical radio spectroscopy to the effect of low frequency radiation on plant roots; from highly sophisticated technology development for spectroscopic application to military-oriented imaging devices or even to such applications as a means of reducing waiting time for an elevator to arrive in a building. From the 552-page *Conference Digest* provided to each participant, I had to pick papers that were of significant interest. A sampling of these are summarized below (I should mention that these samplings indicate only my own prejudice which comes from my position and interests and inherent curiosity about things with which I am not familiar).

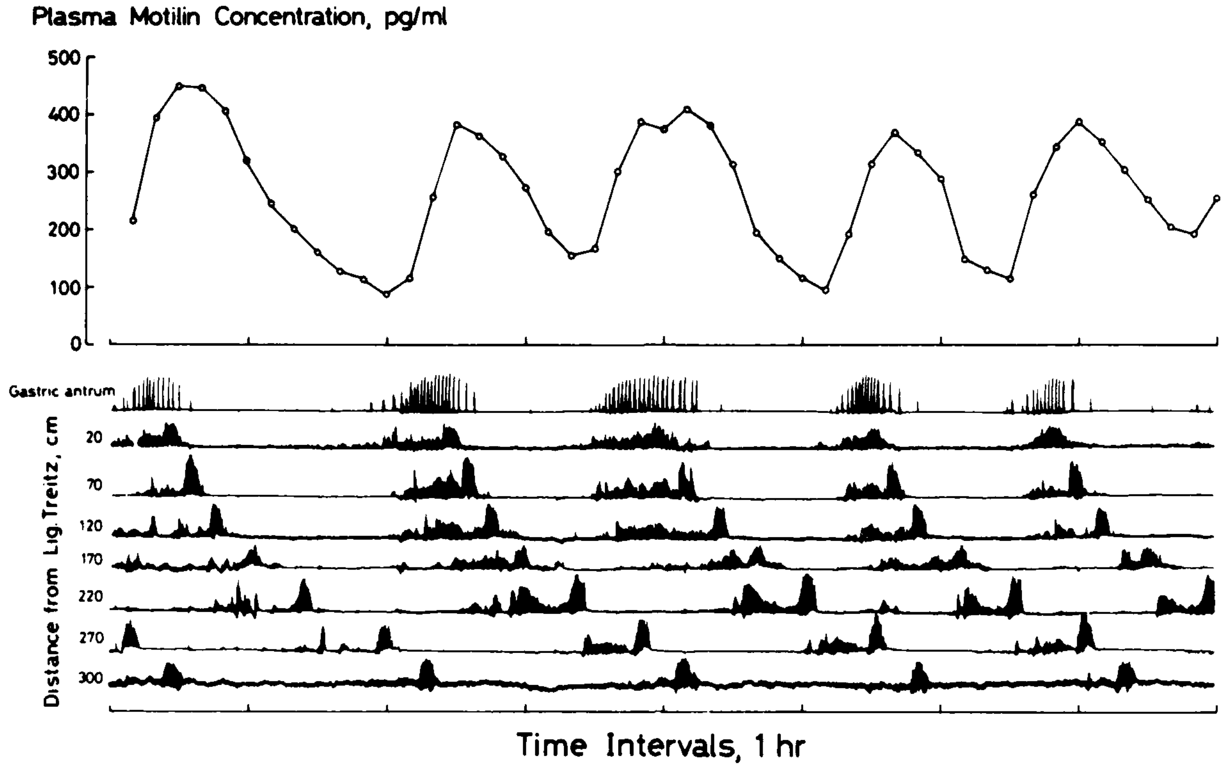


Figure 1. Eight hour changes in the plasma motilin concentration (upper panel) and in contractile activity in the stomach and the small intestine (lower panel) in a conscious dog. Note coincident regular occurrence of each cycle of migrating contractions in the stomach with the increase in the plasma motilin concentration. ["Interdigestive motor activity in health and disease." Itoh and Sekiguchi, *Scand. J. Gastroent, 18,* Suppl. (82) 121-134, (1983)].

THE LABORATORY FOR GASTROENTEROLOGY AT GUMMA UNIVERSITY

K. O. Bowman

The Laboratory for Gastroenterology is a unit of the Medical Center at Gumma National University in Maebashi, Japan. Directed by Professor Zen Itoh, it is well-known for its work in gastrointestinal motor activity. When Itoh established the laboratory in 1970, a main technique was the measurement of gastrointestinal motor activity by strain gage transducers implanted in the serosal surface. Such implantations may have a long useful life, and they offer convenient recording, display, and computerized analysis of data.

Itoh soon confirmed that the pattern of motor activity in his fasted dogs was identical with Szurszewski's interdigestive migrating myoelectric complex (IMC). Thus, Itoh's motor curves matched the relatively constant IMC intervals of about 100 minutes, stronger IMC contractile forces in the interdigestive state, and so forth. Another early finding was the effect of synthetic motilin in IMC; given intravenously every 20 or 30 minutes, the drug produced the characteristic IMC pattern. Reportedly, this was one of the clearest examples of a substance circulating in the blood having a direct effect on gastrointestinal activity.

The original motilin work was extended in collaboration with another research group, headed by N. Yanaihara at Shizuoka University. The joint research showed that immunoreactive motilin (IRM) concentration in the plasma was highly correlated with IMC in the stomach. Figure 1 shows some data on this mechanism.

Other findings of Itoh's laboratory relate to interdigestive changes occurring in the upper digestive organs. The lower esophageal sphincter, a mechanical sphincter located between the esophagus and the stomach, was the uppermost site of gastrointestinal tract contractions in association with the IMC in the stomach. Secondly, it was confirmed that pancreatic secretions increase in association with the IMC in the stomach and the doudenum, especially in the secretion of enzymes. A third finding concerned the gall bladder; it was demonstrated that the gall bladder contracts in close association with the IMC in the duodenum. The contractions were later found to be critical to intra gall bladder bile concentration, and thus relevant to the pathogenesis of gallstones.

Recently, while investigating the side effects of antibiotics on the gastrointestinal tract, Dr. Itoh's group reported the unexpected observation that erythromycin, one of the most widely used macrolide antibiotics, mimics motilin exactly when it is given in a dose of 50 μ/kg hr to dogs.[1] This effect also occurs in humans. As a result of this observation, Japanese and European developers of new antibiotics have been asking the laboratory to evaluate the side effects of their products on the gastrointestinal tract. To date, more than 60% of newly developed antibiotics which Itoh's group has tested have been prohibited from clinical use, because they have been found to induce side effects in the gastrointestinal tract. Reportedly, these measurements are of particular value to Japanese pharmaceutical authorities and companies.

[1] "Erythromycin mimics exogenous motilin in gastrointestinal contractile activity in the dog," Itoh Z., Nakaya M., Suzuki T., Arai H., and Wakabayashi K. *Am. J. Physiol* (1984) (in press).

TABLE III

PERFORMANCE MEASUREMENTS OF SOME APPLICATION PROGRAMS ON VP-200

Program No.	Description of Programs	Computation Time Scalar (Sec)	Computation Time Vector (Sec)	Performance Ratio
1	Matrix Multiplication (Order: 100)	307.66	4.08	75.4
2	Linear Equation Solver			
	(Order: 100)	.141	.01	14.1
	(Order: 256)	2.27	.056	40.6
3	Molecular Dynamics (High Density Liquid)	144.22	9.97	14.5
4	Simplified Marker and Cell (Poiseuille Flow)	137.0	15.8	8.7

One and two are taken from the subroutine package or part of programs. Three and four are complete programs.

TABLE IIb

COMPARISON BY LIVERMORE LOOPS (MFLOPS, VECTORIZING FORTRAN)

No.	Do Loops	CDC Cyber205 Pipelines	CRAY CRAY-1	HITACHI S 810/20	FACOM VP-200	FACOM VP-100
		AP	AP	AP	AP	AP
1	Hydro excerpt	79.08	70.33	298.14	326.43	187.07
2	MLR, Inner product)	87.98	48.08	328.77	178.06	104.56
3	Inner product	88.03	66.78	332.18	331.12	168.46
4	Banded lin. eq.	12.17	39.59	112.81	87.98	73.57
5	Tri-diag. el. (6)	5.55	7.84	35.77	9.98	10.00
6	Tri-diag. el. (a)	6.53	6.47	36.02	9.52	9.52
7	Eq. of state ex.	51.04	82.54	349.09	326.11	189.99
8	P.D.E. integrat.	15.72	41.89	155.33	90.43	86.34
9	Integer predict.	47.32	80.09	331.70	257.38	161.51
10	Difference pred.	23.51	20.46	61.98	84.80	50.06
11	First sum.	7.60	5.83	34.61	4.76	4.76
12	First diff.	86.22	23.13	111.37	114.17	58.82
13	2-D p. pusher	2.00	3.58	9.66	6.22	6.12
14	1-D p. pusher	4.26	7.23	10.89	13.86	12.90
	Total Mflops Average No. of Loops (14)	36.93	35.99	157.74	131.48	80.26
	Time of Computation	Oct 1982	1981	Jan 1984	1984	Jan 1984
	Place	CDC	Cray	Tokyo U.	Numazu	Nagoya U.

TABLE IIa

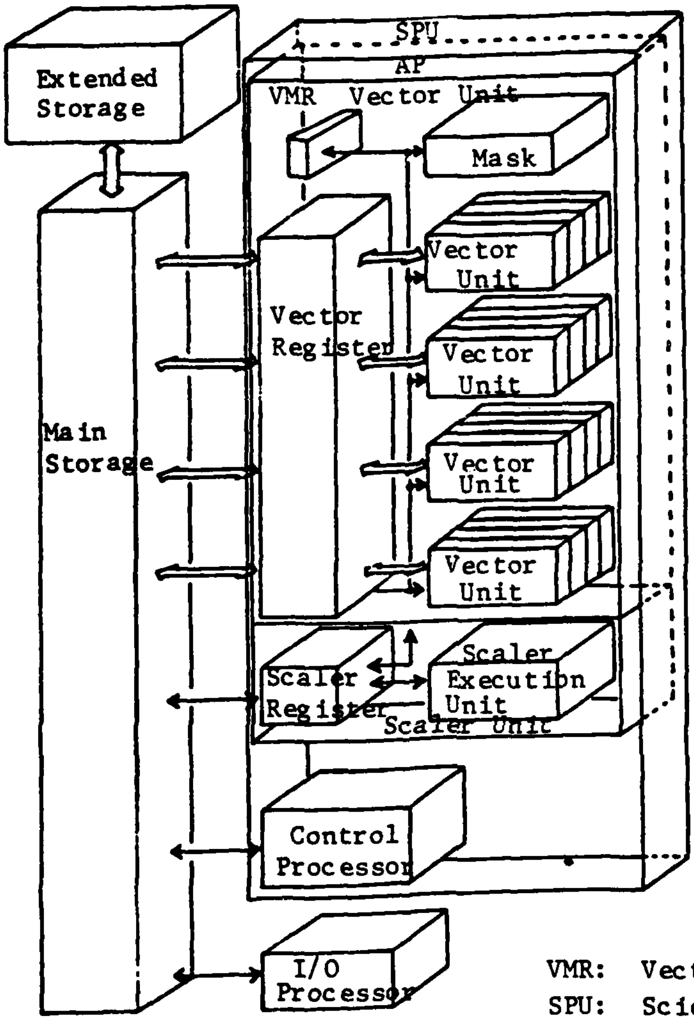
COMPARISON BY LIVERMORE LOOPS (MFLOPS, ORIGINAL FORTRAN)

No.	DO LOOPS	CDC Cyber 205	CRAY CRAY-1	IBM 3081-K	HITACHI S 810/20	FACOM VP-100
		AP	AP	SMP	AP	AP
1	Hydro excerpt	73.7	69.4	2.9	246.8	186.6
2	MLR, Inner product	12.3	40.3	3.3	255.3	104.3
3	Inner product	87.1	27.5	2.9	213.3	170.5
4	Banded lin. eq.	3.3	3.6	2.0	60.6	61.1
5	Tri-diag. el. (b)	7.0	7.2	2.5	4.9	8.1
6	Tri-diag. el. (a)	5.2	6.7	1.8	4.2	8.3
7	Eq. of state ex.	50.2	78.0	3.8	254.6	192.1
8	P.D.E. Integrat..	14.8	13.3	2.9	77.5	87.9
9	Integer predict.	11.0	56.7	4.3	226.7	144.1
10	Difference pred.	4.9	29.2	2.3	57.9	28.9
11	First sum.	8.6	2.7	1.7	9.8	3.7
12	First diff.	84.4	23.0	2.0	106.4	70.1
13	2-D p. pusher	2.3	3.6	1.0	4.2	6.1
14	1-D p. pusher	4.3	6.1	1.5	7.8	7.2
Total Mflops Average No. of Loops (14)		26.4	26.2	2.5	109.3	77.1

TABLE I

EXAMPLE OF S810 PERFORMANCE

Benchmark Program	Execution Time (Sec)		Ratio
	S 810/20	M-200H	
Thermal Conduction Simulation	10	734	73.4
Three-Dimensional Device CAD	434	4978	11.5
Crystal Growth Simulation	409	5380	13.2
Vertical Recording Simulation	531	6056	11.4
Weather Prediction	72	262	3.6
Typhoon Simulation	168	780	4.6
Plasma Particle Simulation	19	112	5.9



VMR: Vector Mask Register
SPU: Scientific Processing Unit
AP: Array Processor
Each vector unit is consisted with add, mult/div, logical and shift.

Figure 2c. SX-2 System Block Diagram

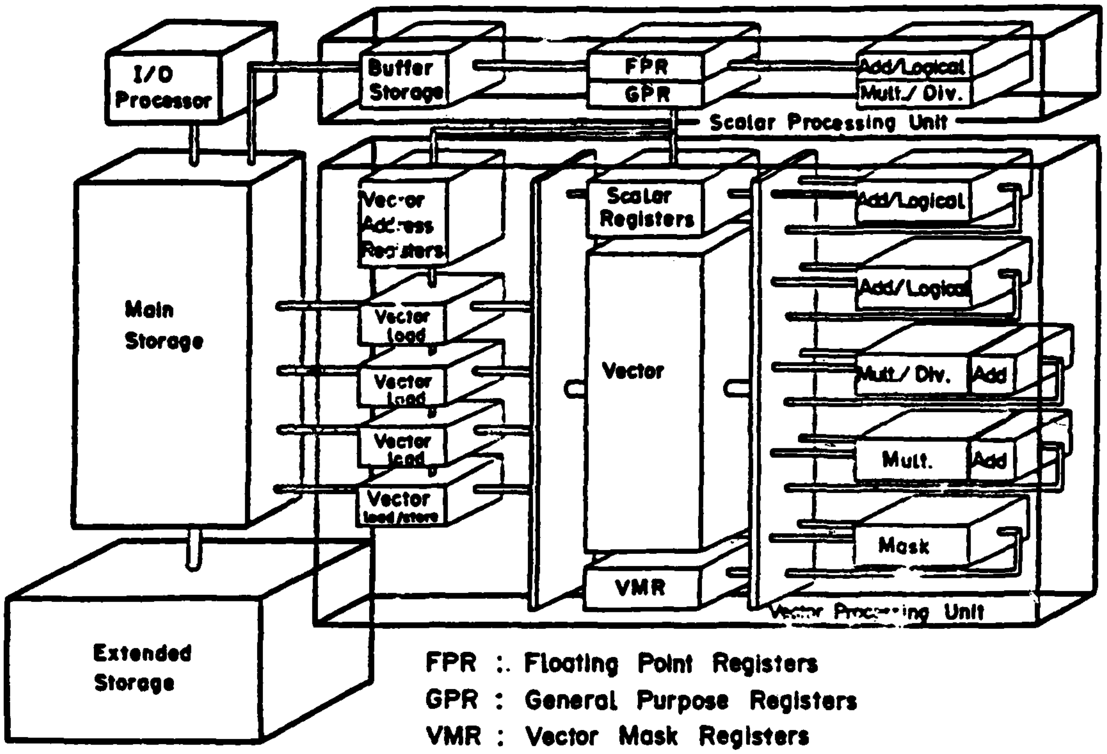


Figure 2b. Hitachi S810 (Model 10) Block Diagram

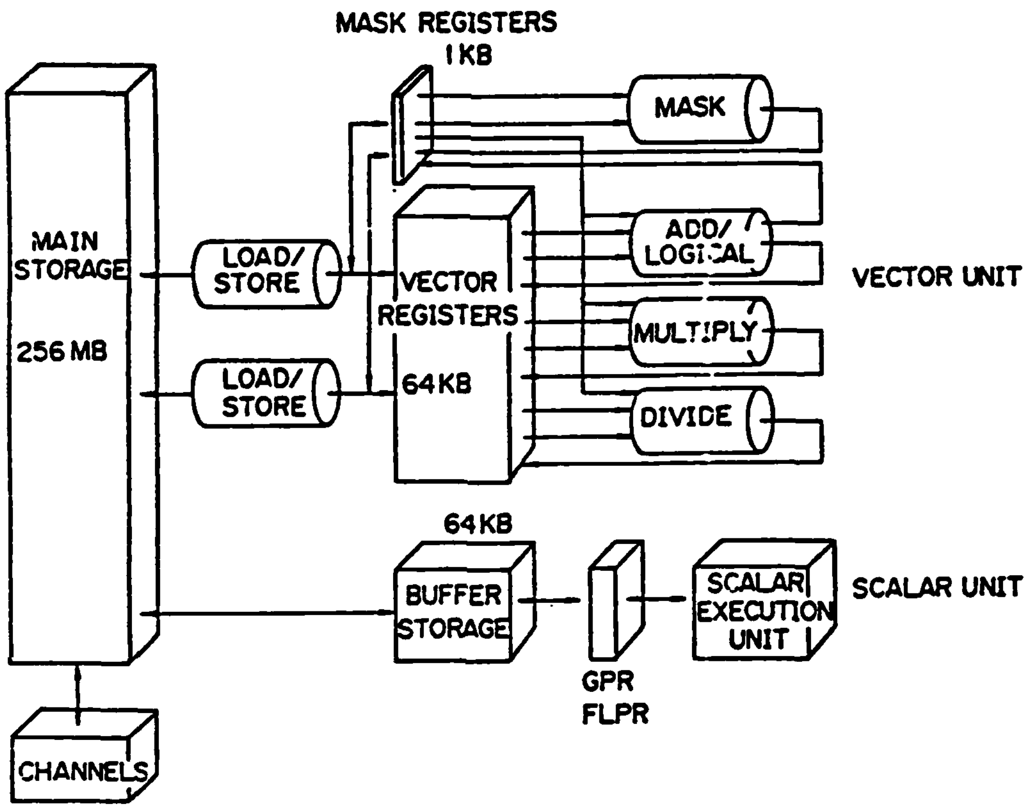


Figure 2a. FACOM Vector Processor Block Diagram

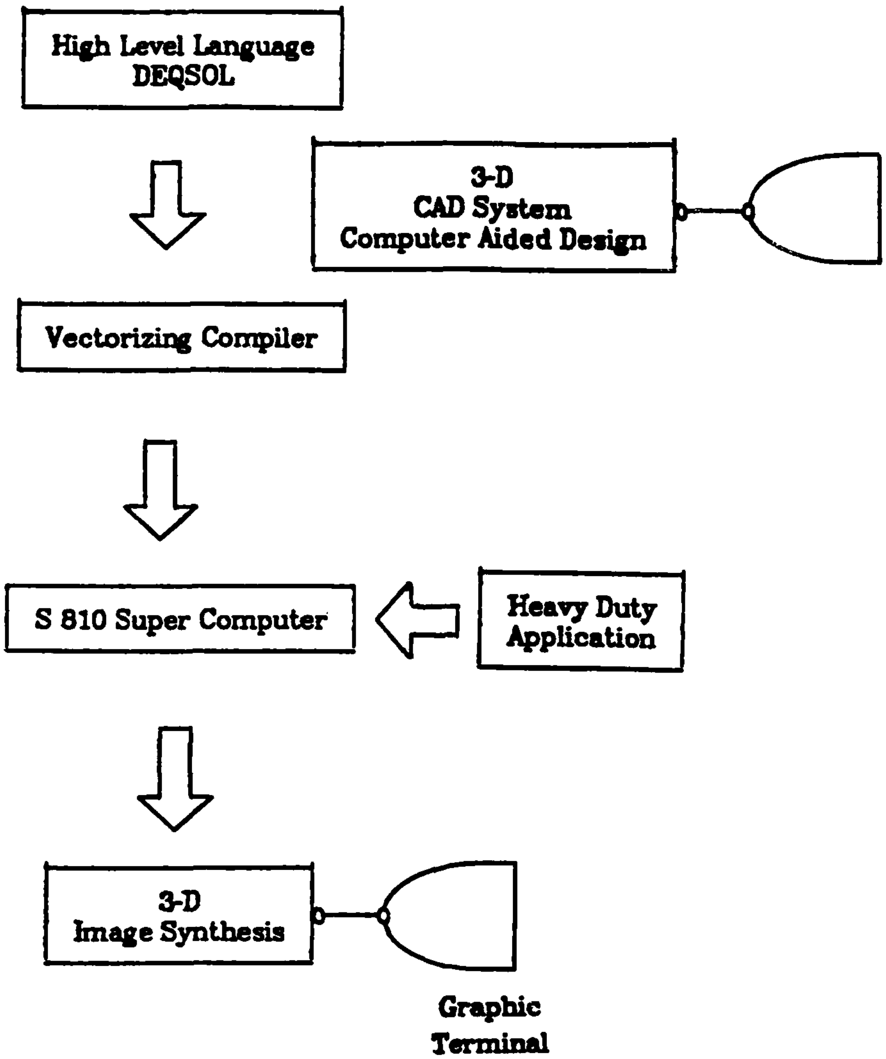


Figure 1. Research Area of Supercomputer Software at Hitachi Central Research Laboratory

"Load Follow Simulation of Three-dimensional Boiling Water Reactor Core by PACS-32 Parallel Microprocessor System," Hoshino, T. and Shirakawa, T. *Nuclear Technology, 56,* 465-477 (1982).

"Scientific Parallel Computer PAX-128," Shirakawa, T. *J. At. Energy Soc. Japan, 26,* (3) 199-204 (1984) (in Japanese).

"Parallel Computer PAX-128," Shirakawa, T. *et al. Journal of Electronic Communication Society of Japan, J67-D,* (8) 853-860 (1984) (in Japanese).

"URR: Universal Representation of Real Numbers," Hamada, Hozumi. *New Generation Computing, 1,* 205-209 (1983).

"Data Length Independent Real Number Representation Based on Double Exponential Cut II," Hamada, Hozumi. *Journal of Information Processing Society, 24,* 149-156 (1983) (in Japanese).

"DEQSOL: A Numerical Simulation Language for Vector/Parallel Processors," Umetani, Y., *et al.* Hitachi, Ltd., submitted for publication (1984).

"FACOM Vector Processor System: VP-100/VP-200," Miura, K. and Uchida, K. *NATO ASI Series, F7,* Springer-Verlag, 1984.

"Supervector Performance without Toil-Fortran Implemented Vector Algorithms on the VP-100/200," Matsuura, T. and Miura, K. *Proceedings of Vector and Parallel Processing in Computational Science,* August 1984, Oxford, U. K.

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"Dreams and Expectations of Supercomputers," Y. Karaki. Supercomputer Workshop, Report *2*, August 1983.

"Performance and Trial Report of Supercomputers," Y. Karaki. Supercomputer Workshop, Report *3*, August, 1984.

"MOLD (Mesh-Oriented Line Drawing) Theory--A Representation of the Line Drawings," Minou, M. and Sakai, T. *IECE Transaction, J65-D*, 928-935 (1982) (in Japanese).

"An Efficient Input Method of Drawings by Detecting Characteristic Patterns," Lin, X. *et al. Proceedings of Electronic Communication Society Meeting*, 57-64 (1983) (in Japanese).

"A Method for Document Digitizer by Real Time Assembling of Mosaic Pictures," Okada, Y. and Sakai, T. *System Computers Controls, 13*, 74-80 (1982).

"Classification of Nine Kinds of Characters Based on the Statistics of Legal Patterns," Matsuse, T., Minou, M. and Sakai, T. *Proceedings of the Electronic Communication Society Meeting*, 5-72 (1983) (in Japanese).

"Classification of the Image Quality and Noise Removal Method for Bilevel Line Drawings," Minou, M. and Sakai, T. *Journal of the Information Processing Society, 24*, 182-190 (1983) (in Japanese).

"MACSYM: A Hierarchical Parallel Image Processing System for Event-driven Pattern Understanding of Documents," Inagaki, K. *et al. Pattern Recognition, 17*, 85-108 (1984).

"Japanese Superspeed Computer Project," Kashiwagi, H. and Miura, K. *Proceedings of Advanced in Reactor Computation*, 28-30 March 1983, Salt Lake City, Utah.

"SIGMA-1: A Data Flow Computer for Scientific Computations," Yuba, T., Shimada, T., Hiraki, K. and Kashiwagi, H. *Proceedings of Vector and Parallel Processing Computer Science*, August 1984, Oxford, England.

"An Architecture of a Data Flow Machine and its Evaluation," Shimada, T., Hiraki, K. and Nishida, K. *Proceedings of the COMPCON 1984*, IEEE Computer Society, 27 February-1 March 1984.

"A Hardware Design of the SIGMA-1, A Data Flow Computer for Scientific Computation," Hiraki, K., Shimada, T. and Nishida, K. *Proceedings of the ICPP*, 1984.

"Evaluation of Scientific Data Flow Computer SIGMA-1 by Numerical Simulation," Shimada, T., Sekiguch, C., Hiraki, K. and Nishida, K. *Proceedings of Japan Information Processing Society Meeting*, September 1984, Sendai (in Japanese).

"PACS: A Parallel Microprocessor Array for Scientific Calculations," Hoshino, T. *et al. ACM Transactions on Computer Systems, 1*, (3) 195-221 (1983).

industry is also increasing, as is the cooperation between government, industry, and the educational institutions. And in all their planning, quality control is a primary concern. In order to achieve the highest standards in quality, many Japanese companies make most of the components going into their products. It appeared to me that all of these trends seem to directly impact on the entire Japanese population. They are demanding, and receiving, higher quality products, and the majority of the people in Japan now consider themselves to be in the "middle" class and to be reasonably satisified.

With respect to computer research and development, my personal feelings are that the Japanese machines are superior to their United States counterparts in many cases. In all the computer centers I visited, I found very little downtime, and the computers usually operate without attendants. All the manufacturers claim high reliability and easy maintenance for their computers, and the machines have built-in maintenance features such as a stage tracer and error logout. Of course, the performance of computers is not determined by hardware alone, but also by the compiler used with the computers and the structures of the programs applied. Additional benchmark studies should be performed, and I would like very much to be involved in them myself. In particular I would like to compare the Japanese computers with the Cray-1 and Cyber 205 computers.

- Free-electron Lasers

In recent years, free-electron lasers (FEL) have been gaining significant attention. This is not surprising since FEL is a powerful source of electromagnetic radiation capable of operating efficiently over a broad band of frequencies that can be used in different areas of scientific investigation.

Louis R. Elias presented a tutorial paper on a submillimeter FEL which focuses on the work being conducted at the University of California at Santa Barbara. He described the UCSB system that incorporates a new type of electromagnetic resonator which is designed to optimize net gain amplification. The highlights of the present capability of this system are:

continuous tunability	$500\,\text{Å} > \lambda < 1$ mm
high laser power	$< P > > 1$ MW
high operating efficiency	$e > 20\%$
optical resolution	$\Delta\lambda/\lambda_\Delta < 10^{-5}$

- Infrared Detectors and Thermal Imaging

Recent developments in cadmium-mercury-telluride infrared detectors as applied to imaging was summarized by C. T. Elliot based on the work at the Royal Signals and Radar Establishment, United Kingdom Ministry of Defense. This topic has been a subject of intense research and development during recent years.

Elliot's paper described the improved spatial resolution in thermal imaging achieved by modified geometry of two-dimensional array system optics; for example, the tapered-horn Sprite detector. The paper also described the progress being made in the effort of replacing mirror scanning of thermal imaging systems with electronic scanning by means of CMT diode/silicon hybrid arrays. This type of photovoltaic hybrids for electronically-addressed starring arrays have a capability up to 10,000 elements. The development of photoconductive devices to reduce cryogenic requirements was also presented. Currently, the device facilitates enhanced detectivity at (for 3-5 μm) or just below (for 8-12 μm) ambient temperature.

In a related area of technology, I. C. Carmichael and P. N. Griffith, also of U.K. Royal Signals and Radar Establishment, described their work on a bistatically-integrated laser range finder and thermal imaging system. The system uses two optical apertures, one for a pulsed carbon dioxide laser transmitter and one as a common collector for both the thermal imager and the return laser pulse.

These subjects have an obvious military application; however, this will not be the first example of how a potential military application has spurred rapid technology development to the forefront of knowledge.

- Atmospheric Propagation

A. V. Sokolov, of the Institute of Radioengineering and Electronics of the U.S.S.R. Academy of Sciences, presented a summary of work by him and his colleagues on infrared and millimeter wave propagation in the atmosphere. He presented results of measurements made in a clear atmosphere as well as the effects of various naturally occurring aerosols in the absorption and scattering of IR and millimeters wave. As is usual for these types of measurements, the details of path characterization was lacking. Professor Sokolov also mentioned that measurements in falling snow were made, but not included, in this presentation. The abstracts of the seven papers containing the material of this presentation are fairly extensive and interested readers of this topic are advised to refer to the *Conference Digest.*

- Long Wave Radiation and Plant Biology

It appears that the Max-Planck-Institut für Festkorperforschung is something of a hotbed of research on the biological effect of long wave irradiation.

F. Keilman described a nonthermal, resonant-type effect of millimeter waves (41782 $\pm$ 1 MHz) on a significantly increased growth rate of the yeast when irradiated above a threshold intensity of 1 mw/cm². He speculated on a theory based on magnetic excitation, population dynamics, and chemical reactivity of as yet unidentified transient molecules.

In a similar vein, F. Kremer *et al.* described experiments in which a broadband (40-80 GHz) nonthermal effect of low intensity millimeter wave radiation on the puffing of giant chromosomes was conducted. A reduction in size of a specific gene locus (Balbianiring BR2) was the observed result. A possible explanation of this effect was offered based on H. Frohlich's theory of coherent electric vibration in biological systems.

Another experiment by F. Kremer and his co-workers has shown a nonresonant type, thermal effect on the growth rate of cress roots when they were irradiated by mmw (56 $\pm$ 0.01 GHz) of very low intensity (2 mw/cm²). This effect, which is reversible, appeared to be almost instantaneous, showing a significant reduction in growth rate ($\sim$70%) within 100 seconds of irradiation. This effect was observed to be dependent on the polarization of the irradiating waves.

- Infrared Astronomical Satellite

F. J. Low, University of Arizona, presented a series of fascinating photographs and discussed the infrared astronomical satellite (IRAS) mission that produced them. To the uninitiated, like myself, not only the technological complexity and details associated with the satellite operation but also the data reduction technique were quite overpowering. The author stated that, since 1983, 20,000 galaxies have been collated in the data base generated so far by the IRAS mission.

- Cubic Crystals with Point Defects

A. J. Sievers described the work at Cornell University on the far infrared absorption of Ag^+ in KI. The Ag^+ impurity induced infrared spectrum in KI is characterized by a sharp absorption line at 17.3 cm^{-1} along with additional features, principally the gap mode and the combination bands. Sievers *et al.* observed that these impurity-induced vibrational absorption lines decrease in strength and new nonresonant absorption with different characteristic frequencies (at 69 cm^{-1} and 78.5 cm^{-1}) grow as the temperature is increased from 1.2 to 10 K.

It is known that at low temperatures the Ag^+ ion acts as a substitutional impurity at a normal lattice site. This experimental observation can be explained if we accept Siever's theory that two elastic configurations occur in the lattice-defect systems. At low temperature the Ag^+ ion in KI is on center and resonant mode absorption is expected to be observed. As the temperature is increased, a second elastic configuration in which the Ag^+ ion is arranged off center becomes populated at the energy value of 24 K above the ground state. This a very interesting explanation for an equally interesting experimental observation.

These are some samples of the topics covered at this conference. They should help emphasize the wide ranging scope of the meeting. I personally found the meeting enlightening and educational.

OSAKA UNIVERSITY

- Laboratory of Instrumentation and Measurement Engineering, Department of Applied Physics

The laboratory is one of the six programs within the Department of Applied Physics, Faculty of Engineering. The laboratory is chaired by Professor Shigeo Minami, who also serves this year as the chairman of the Department of Applied Physics. The laboratory is staffed by three other faculty members, some 20 research staff members and students, six visiting scholars from foreign countries and an office staff.

The visit to the laboratory made it visibly obvious that there is a strong sense of esprit de corps among these people cutting across the boundaries of traditional ranks. This was hardly surprising to me as I have been well acquainted with Professor Minami since I was a graduate student at Ohio State University. His dedication to scientific research is matched only by his devotion to his students and junior colleagues. They, in turn, seem to respond in kind. I was told that it was not uncommon to find someone in the laboratory at any time of the day or night. The result is a high level of research productivity. The group has a substantial publication record (although Professor Minami expressed his dissatisfaction over this, unjustifiably in my view) and laboratory-bench prototype instruments have developed from the group's ideas.

The research is aimed at the "development of principles and applications of scientific instrumentation using unconventional techniques formed by the combination of optical engineering, spectroscopic measurement, microcomputer and electronics technology, and signal and data processing." The research is intended to be applied to a wide range of science in general. The biennial report of the laboratory summarizes the research activity as follows:

> Current research projects include the application of the spark discharge source to the solid sample atomizer for the induction coupled plasma discharge (ICP) spectroscopy and the development of a time-resolved microscopic spectrophotometer system with lifetime mapping capability. Earlier research concerned with computer controlled analytical instruments have now been extended to development of the laboratory automation systems characterized by distributed multiprocessor configuration. New projects have been initiated concerned with optical and digital signal processing, such as superresolution, deconvolution, and curve resolution of spectroscopic data by numerical methods, computerized qualitative and quantitative analyses from unknown mixtures based on multivariate analysis, the development of unconventional Fourier transform spectrometric systems, tomographic optical microscope imaging, optical fiber sensors, optical phase conjugation, and multiband spectral imaging and analysis. The development of a new excitation-emission matrix fluorophotometer and a high performance liquid chromatography system are also the laboratory research themes.

The topics of current research projects are listed below:

- Spectrometry and Related Instrumentation

    photodiode array Fourier transform spectrometry
    multiband spectral imaging
    time-resolved spectrometry
    microspectrofluorometry
    IR microradiometry
    excitation-emission matrix fluorospectrometry
    multichannel spectrophotometric detection in HPLC

- Atomic Spectroscopy

    atomic absorption and fluorescence spectroscopy
    spectroscopy of spark discharge

- Numerical Analysis and Data Processing in Instrumentation

    superresolution
    tomographic reconstruction
    deconvolution smoothing
    component spectral curve estimation
    peak separation by curve fitting

- Optical Signal Processing and Measurement

    optical four-wave mixing with photorefractive crystals
    optical fiber sensors
    tomographic optical microscope imaging

- Laboratory Automation

    development of microcomputer-based intelligent instruments

    approach to distributed function processor configurations for intelligent measuring systems

    feasibility study on applicability of general purpose personal computers to laboratory automation

One interesting question arises in connection with the type of research environment which encourages application of novel ideas and its end results which is often some type of instrumentation development. This question relates to invention right and patent. Professor Minami told me that the university is continuing to hold the longstanding view that the instrumentation developed by any laboratory is open to the public, but with due expectation that anyone gaining knowledge of the development would act at a high level of professional ethics. Thus, there is no formal licensing procedure that the laboratory is bound to follow. He stated, however, that with increasing interaction with industrial companies, particularly foreign companies, this practice may require a more thorough review.

The visit to the laboratory was enjoyable and enlightening. For more information contact:

Professor Shigeo Minami
Laboratory of Instrumentation and
Measurement Engineering
Department of Applied Physics
Osaka University
Suita
Osaka 565, Japan

SIXTEENTH TURBULENCE SYMPOSIUM

Francis R. Hama

INTRODUCTION

I have reported before on Japanese research activities in turbulence; in particular, I summarized the 1981 Turbulence Symposium in an earlier issue of the *Bulletin* [*Scientific Bulletin*, *6*, (3) 66 (1981)]. The symposium has always been an active and informal affair, and has attracted high-level attendance. Until last year it had been held on the Komaba campus of the University of Tokyo, with Professor Hiroshi Sato as the chief organizer and promoter. Upon Professor Sato's retirement this year, the symposium has been radically reorganized. According to reports, this result comes from longstanding (50 years?) "political" conflicts within the University of Tokyo. In any event, the Turbulence Symposium is now conducted under the auspices of the Japan Society of Fluid Mechanics, and it was held this year at the private Chuo University on 26-28 July 1984. As it turned out, the meeting place was very suitable and the meeting itself ran very smoothly under the supervision of Professor Taizo Hayashi, symposium chairman. It was an all-Japanese affair, and my translation of the titles of the presented papers is as follows:

PROGRAM

Title	Author
- 26 July	
Development of a probe-type LDV by use of light fiber.	M. Sawamoto, M. Hino, T. Yamashita, and K. Hironaga
Transition in a two-dimensional plume.	T. Wakitani and H. Yoshinobu
Turbulence characteristics in jets and plumes.	H. Ishigaki
Diffusion of a heated jet in a turbulent recirculation zone.	M. Kiya, N. Tamura, and M. Kakitani
Large-scale structure in a complex jet.	K. Toyoda, Y. Shirahama, and Y. Kobayashi
Observation of the wake behind a circular cylinder placed in a thermal boundary surface.	H. Makita, T.Suzuki, and M. Yamamoto
Wake structure behind a horizontal circular cylinder in a thermally stratified flow.	K. Tanaka
Coherent turbulent structure in a stratified shear flow.	A. Murota and K. Nakatsuji

Title	Author
Simulation of a two-dimensional jet by the discrete vortex method.	T. Hasegawa, M. Kurata, M. Yamaguchi, and N. Oiwa
Effect of initial disturbances on turbulent mixing layers.	S. Inoue and H. Oguchi
On transition in the Poiseuille flow.	K. Horiuchi
Direct numerical simulation of a three-dimensional turbulent flow between parallel plates.	T. Kawamura
Numerical simulation of turbulent flows around a structure--applications of LES and two-equation model.	S. Murakami, A. Mochida and I. Hibi
Numerical prediction of a large-scale vortex behind a two-dimensional backward-facing step.	T. Kobayashi, M. Kano, and T. Ishiwara
Stability analysis of the boundary layer around a circular cylinder.	H. Takeda
Vorton mechanics.	S. Kuwabara
Derivation of statistical mechanics of the equation system of turbulent shear flows.	A. Yoshizawa
Validity of the k-ϵ model for an asymmetric turbulent flow.	M. Nishijima and A. Yoshizawa
A k-ϵ -$k\theta$ model for a thermal turbulent shear flow.	M. Nishijima and A. Yoshizawa
Energy spectrum of two-dimensional turbulence.	M. Yamamoto
- 27 July	
Fundamental frequency of the disturbance in the transition process due to spectral developments in the flow between two rotating spheres.	Y. Tsuchida.
Modulated wavy vortical flows between coaxial rotating cylinders.	M. Ohji
Transition process in a flexible tube.	M. Arakawa and Y. Matsunobu
Three-dimensional disturbance accompanying T-S waves.	M. Asai and M. Nishioka

Title	Author
Two-dimensional turbulence structure due to the disturbance given by a vibrating thin plate.	K. Miyata, N. Ishida, and I. Nakamura
Experiments on the turbulent spots.	H. Komoda and N. Handa
Visualization of the generation process of a turbulent spot.	T. Matsui and M. Okude
The structure of turbulent boundary layer over a d-type rough surface.	H. Osaka and Y. Kageyama
The structure of turbulent boundary layer deformed by a thin plate.	S. Takagi and N. Ohji
Nonlinear characteristics of two-dimensional T-S waves with a large amplitude.	F. R. Hama
Coherent vortex structure in drift current.	M. Hino, K. Nadaoka, and T. Sumi
Spatial characteristics of the flow behind a body.	R. Watanabe, H. Nakajima, and N. Yoshizawa
Three-dimensional structure of the coherent motion in turbulent boundary layers.	M. Ichijo, Y. Kobashi, and S. Iida
Large-scale vertical structure in the turbulent boundary layer formed by a wall jet.	H. Makita and K. Sassa
Growing process of the coherent motion in turbulent boundary layers.	Y. Fukunishi
Breakdown phenomena of a swirling flow and its structure after the breakdown.	S. Uchida
Spiral flow of the turbulent pipe flow.	K. Hori, S. Murata, S. Takarada, and T. Marui
Nonequilibrium turbulent boundary layer.	I. Tani and T. Motohashi
The structure of turbulent boundary layer with a density gradient.	H. Sato, Y. Onda, and S. Takaki

Title	Author
- 28 July	
Unsteady separation along a convex wall and sound generation.	F. Sakao
Wake behind a wedge placed in a two-dimensional jet.	O. Mochizuki and H. Yamada
Temperature distribution in the thermal boundary layer of thermal free-convection flow.	N. Tamai and T. Asaeda
Experiment on the thermal convection in a torus.	T. Sano
Eddy viscosity model of the bottom turbulent boundary layer caused by waves.	T. Asano, H. Godo, and Y. Iwagaki
Experimental investigation of the turbulent structure in plunging breakers.	T. Aono and S. Hattori
Reynolds stress in the wave field accompanying breakers.	T. Asakai
Investigations of turbulence characteristics in the meandering air flow.	M. Tanaka and S. Ikeda
Visualization of longitudinal vortices in the wall turbulent flow.	H. Ohnari, T. Saga and T. Saito
Visualization of open-channel turbulent flow and its local correlation analysis.	T. Utami and T. Ueno
Measurement of open-channel turbulent flow by two-color argon laser velocimeter.	I. Nezu
Experimental investigations of the structure of longitudinal vortices in an open-channel water flow.	T. Hayashi, M. Ohashi, and Y. Kotani

Frankly, most of the presentations were interesting; those held on 27 July were quite impressive. The meeting was well-attended with over 200 participants each day. I was particularly impressed by the numerical simulations of turbulent flows presentations of Horiuchi and Kawamura; the experimental investigations of the spectral developments in the Taylor instability presentation by Tsuchida and Ohji; the continued elegant measurements of Asai and Nishioka which is said to have definitively confirmed Herbert's three-dimensional theory; and the three excellent experimental papers by Miyata *et al.*, Komoda *et al.*, and Takagi *et al.* I thought also that Utami's ingenious use of a laser beam and its quantitative data analyses in a turbulent flow were extremely interesting.

Overall, the quality of the presented papers were very high and original and may be favorably compared to the top-notch papers presented at the American Physical Society's Fluid Dynamics Division meeting.

Incidentally, the Japan Society of Fluid Mechanics, which may be considered a counterpart of the American Physical Society's Fluid Dynamics Division, has been publishing, in Japanese, a quarterly journal entitled *Nagare*. Each issue includes highly authoritative survey articles and a few solid original papers. They have now decided to publish an additional journal, an English translation of original contributions. This should be welcomed by researchers abroad.

SYMPOSIUM: "WHAT IS TURBULENCE?"

The nationwide research project, "Clarification and Control of Turbulent Phenomena," has recently been concluded after three years of cooperative effort and a total budget expenditure of 463,100,000 yen. I described it also in my earlier article in this *Bulletin*. To commemorate its conclusion, an open symposium was held on 26 and 27 October 1984. Although I did not personally attend the symposium, its program below may provide a general view of the project.

Title	Author
- Program	
Direct numerical simulation of turbulent flows.	T. Kawamura
Numerical simulation of turbulent Poiseuille flow.	K. Horiuchi
One-dimensional mapping and power spectrum.	Y. Takahashi
Reduced description of dissipative dynamic systems.	T. Yamada
Nonlinear diffusive wave motion with instability and dissipation.	T. Kawahara
A thought on turbulence modeling.	T. Taniuchi
Motions of a group of vortex filaments.	H. Hashimoto
Atmospheric large-scale turbulence.	R. Kimura
Turbulence in atmospheric boundary layer.	O. Tsukamoto
Vortex--stability and breakdown.	S. Uchida
Transition in a free-convection plume.	H. Yoshinobu
Transition into turbulence in a two-dimensional Poiseuille flow.	M. Nishioka
Measurements and data reduction.	H. Komoda
Coherent structure in turbulent shear flows.	Y. Kobashi
Buildings and wind turbulence.	H. Ishizaki
River turbulence.	T. Hayashi

- General Lectures

What is turbulence? by T. Tatsumi,
Flow visualization, by S. Taneda, and
Turbulence on the ocean surface, by Y. Toba.

The presentations will be published later both in Japanese and in English; the latter is to be distributed worldwide. For further information on the Sixteenth Turbulence Symposium contact:

Professor Taizo Hayashi
Faculty of Science and Technology
Chuo University
1-13-27 Kasuga
Bunkyo-ku, Tokyo 112

or if information on the publication is desired --the *Nagare* is published by the:

Japan Society of Fluid Mechanics (Nippon Ryutai Rikigaku Kai)
Physics Department
Keio University
4-1-1 Hiyoshi
Kohoku-ku, Yokohama 223

The managing secretary is Professor Yasuo Matsunobu. Its English version will appear in 1985. Each paper presented at the Turbulence Symposium (July) is to be summarized in five pages of handwritten Japanese, photoreproduced and published as a special edition of the *Nagare*.

The proceedings of the symposium, 'What is Turbulence' (October) will be printed in English also and should be available in late spring 1985 through:

Professor Tomomasa Tatsumi
Dean of the Faculty of Science
Kyoto University
Oiwake-cho, Kitashirakawa
Sakyo-ku, Kyoto 606

TECHNIQUES FOR PRODUCING STRONG MAGNETIC FIELDS

M. Frank Rose

It is very difficult to produce stable and reproducible magnetic fields greater than 1 MG. The technique usually employed is to use the "CNARE" effect which is to seed a magnetic field in a region bounded by a metallic conductor and subsequently compress the metallic conductor. If this can be done on a time scale short in comparison to the decay of eddy currents, a large magnetic field will be produced which can subsequently be used for a variety of fundamental studies. The difficulty associated with the use of explosives for this purpose makes it necessary to have specialized facilities, elaborate safety precautions, and it adds tremendously to the cost of an experiment. In addition, due to the catastrophic nature of explosives, the experiments are not highly reproducible.

An alternative to the explosive technique is to use a "magneform process" in which a closed metallic liner is transformer-coupled to a primary coil through which a large current is discharged. A schematic of this procedure is shown in Figure 1.

Initially, current I flows through the primary coil. Current, i_{ML}, is induced in the liner which produces a magnetic field linking the liner and flows in such a direction that it opposes the initial field produced by the primary coil. As a consequence of these two fields, there is an enormous force acting to crush the liner. As the liner crushes, the flux is confined to a smaller volume. Because flux is conserved (magnetic field-area product is constant) there is a subsequent increase in the magnetic field. In this way, fields of several megagauss can be obtained repeatedly and reliably in a laboratory environment.

We recently visited such facilities at the University of Tokyo. Professor G. Kodo, formerly of the Institute for Solid State Physics and now at the Tohoku University, was our host and had been the engineer in charge of building the facility.

Table 1 summarizes the facilities capabilities at the high field facility. The capacitors were manufactured by the Japanese firm of Nichicon. The banks were well constructed, operated reliably, and had been in use for several years with continual upgrading. The capacitor banks were located several meters from the experimental chamber. The banks were ignition switched and current feeds to the experimental chamber consisted of low induction coaxial lines.

The region of high field was surrounded by an armored box with suitable ports for diagnostics. To date, the maximum fields produced have been on the order of 3 MG. Facilities of this type are capable of 20-30 experiments per day and offer a degree of flexibility not achievable using explosive techniques. At present, drive coils do not last for more than eight-ten experiments due to the enormous dynamic stresses which develop during the compression stage. The drive coil consists of a single turn machined from a solid copper, or copper alloy block. These coils were typically 6-10 cm in diameter.

These facilities are currently being used in the study of a wide variety of fundamental phenomena. Several papers have appeared in the open literature dealing with such phenomena as cyclotron resonance and Faraday rotation in InSb, CdS, GaAs, and Ge. They have also published papers dealing with magnetophonon resonance in N-GaAs, Au_4V, and Fe_3Pt.

Further details of this excellent facility and its experimental results can be found in the following references:

- "Transverse Magnetophonon Resonance in N-GaAs under Pulsed High Magnetic Fields," G. Kido and N. Miura. *Journal of the Physical Society of Japan, 52,* (5) 1734-1739 (1983).

- "Ultra-high Magnetic Fields Facilities in Institute for Solid State Physics, University of Tokyo, G. Kido *et al. Proc. of the International Symposium on High Field Magnetism, Osako Japan, 1982* (ed. M. Date).

- "Production of Magnetic Fields in Megagauss Region and Related Measuring Techniques," S. Chikazumi, *et al. IEEE Trans. on Magnetics, 14,* (5) 577-585 (1978).

- "Technique for Measuring Infrared Cyclotron Resonance in Ultraviolet Magnetic Fields," G. Kido *et al. J. Phys E: Scientific Instruments, 9,* 587-592 (1976).

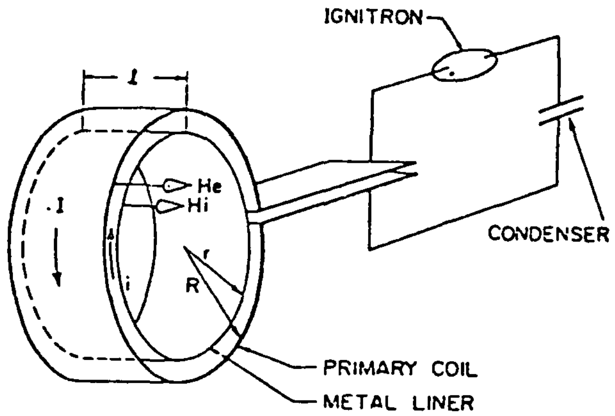


Figure 1. Coil system R: radius of the primary coil, r: radius of the liner, ℓ: the length of the liner, I: the current in the primary coil, i: the current in the liner, H_e, H_i: external and inside fields adjacent to the liner.

1985 Continued

Date	Title	Site	For Information, contact
September 3-7	'85 Fluid Power International Exhibition	Tokyo, Japan	The Nihon Kogyo Shimbun Company, Ltd. 1-7-2, Ohtemachi Chiyoda-ku, Tokyo 100
September 3-7	Japan Home Show: Home Automation '85	Osaka, Japan	Japan Management Association Kyoritsu Building 3-1-22, Shiba-koen Minato-ku, Tokyo 105
September 4-11	The 11th International Teletraffic Congress ITC-11	Kyoto, Japan	ITC-11 Committee Musashino Electrical Communication Laboratory 3-9-11, Midorimachi Musashino, Tokyo 180
September 5-10	The 10th Asian and Oceanic Congress of Obstetrics and Gynecology	Colombo, Sri Lanka	Conference Section 10th Asian and Oceanic Congress P.O. Box 1048 Colombo, Sri Lanka
September 6-10	1985 Annual Conference of the IIC (International Institute of Communications)	Tokyo, Japan	International Relations Department Japan Broadcasting Corporation 2-2-1, Jinnan Shibuya-ku, Tokyo 150
September 9-10	'85 International Conference on Advanced Robotics ('85 ICAR)	Tokyo, Japan	Japan Industrial Robot Association Kikai Shinko Kaikan Building 3-5-8, Shiba-koen Minato-ku, Tokyo 105
September 10-13	The 3rd International Cell Culture Congress	Sendai, Japan	Professor S. Yamane Research Institute for Tuberculosis and Cancer Tohoku University 4-1, Seiko-cho Sendai, Miyagi 980
September 11-13	The 15th International Symposium on Industrial Robots (15th ISIR)	Tokyo, Japan	Japan Industrial Robot Association Kikai Shinko Kaikan Building 3-5-8, Shiba-koen Minato-ku Tokyo 105

Date	Title	Site	For Information, contact
August 29-31	CHDL '85-IFIP (The 7th International Symposium on Computer Hardware Description Languages and Their Applications. International Federation of Information Processing)	Tokyo Japan	Information Processing Society of Japan Kikai Shinko Kaikan Building 3-5-8, Shiba-koen Minato-ku, Tokyo 105
August (tentative)	Coastal Engineering Conference	Melbourne, Australia	The Conference Manager Australia The Institution of Engineers, Australia 11 National Circuit Barton, A.C.T. 2600
August (tentative)	International Association Hydraulic Resources Conference	Melbourne, Australia	The Conference Manager The Institution of Engineers, Australia 11 National Circuit Barton, A.C.T. 2600
August (tentative)	The 21st Congress for IAHR (International Association for Hydraulic Research)	Melbourne, Australia	Mr. Robin Vickery Institute of Engineers Australia 11 National Circuit Barton, A.C.T. 2600
August (tentative)	The 8th IUPAC Conference on Physical Organic Chemistry	Tokyo, Japan	Professor M. Oki Department of Chemistry Faculty of Science University of Tokyo 7-3-1, Hongo Bunkyo-ku, Tokyo 112
August (tentative)	International Academy of Chest Physicians and Surgeons Meeting	Sydney, Australia	Dr. Julian Lee Royal Prince Alfred Hospital Medical Center 100 Carillon Avenue Newtown, N.S.W. 2042
September 3-7	'85 International Chemical Plant Engineering Exhibition	Tokyo, Japan	Japan Management Association Kyoritsu Building 3-1-22, Shiba-koen Minato-ku, Tokyo 105

1985 Continued

Date	Title	Site	For Information, contact
August 18-23	The 8th International Conference on Chemical Education	Tokyo, Japan	The Chemical Society of Japan 1-5, Kanda-Surugadai Chiyoda-ku, Tokyo 101
August 19-24	1985 International Symposium on Lepton and Photon Interactions at High Energies	Kyoto, Japan	Research Institute for Fundamental Physics Kyoto University Oiwake-cho, Kita-shirakawa Sakyo-ku, Kyoto 606
August 19-30	The 23rd General Assembly of IASPEI (International Association of Seismology and Physics of the Earth's Interior)	Tokyo, Japan	Professor Ryosuke Satoh Department of Earth Physics Faculty of Science University of Tokyo 2-11-16, Yayoi Bunkyo-ku, Tokyo 113
August 25-30	The 10th International Congress of Lymphology	Adelaide, Australia	Dr. Neil B. Piller Flinders Medical Center Level 7 Bedford Park, S.A. 5042
August 25-31	The XV International Grassland Congress	Kyoto, Japan	The Japanese Society of Grassland Science National Grassland Research Institute 768 Nishi-nasuno-machi Nasu-gun, Tochigi 329-27
August 26-28	VLSI '85-International Conference on Very Large Scale Integrated Circuits	Tokyo, Japan	Information Processing Society of Japan Kikai Shinko Kaikan Building 3-5-8, Shiba-koen Minato-ku, Tokyo 105
August 26-30	The 6th International Symposium on Polarization Phenomena in Nuclear Physics	Osaka, Japan	Professor M. Kondo Research Center of Nuclear Physics Osaka University Yamadaoka, Suita, Osaka 530

1985 Continued

Date	Title	Site	For Information, contact
	The 5th International Congress on Plant and Animal Breeding		
July 3-5	The 5th Hokkaido Scientific Instruments Exhibition The 3rd Hokkaido Measurement Instruments Exhibition	Sapporo, Japan	The Nihon Kogyo Shimbun Company, Ltd. 1-7-2, Ohtemachi Chiyoda-ku, Tokyo 100
July 9-11	International Federation of Automatic Control: The 1st Symposium on Automatic Control for Mineral Resource Development	Brisbane, Australia	Professor Alban J. Lynch Julius Kruttschnitt Mineral Research Center University of Queensland Isles Road, Indooroopilly Queensland, 4068
July 14-20	The 6th International Congress for Ultrasound in Medicine and Biology	Sydney, Australia	Dr. R. Jellins P.O. Box R374 Royal Exchange Sydney, N.S.W. 2000
July (tentative)	Japan Construction Exhibition	Tokyo, Japan	Japan Construction Mechanization Association Kikai Shinko Kaikan 3-5-8, Shiba-koen Minato-ku, Tokyo 105
August 4-9	The 12th International Conference on Photochemistry	Tokyo, Japan	Dr. Kin-ichi Obi Department of Chemistry Tokyo Institute of Technology 2-12-1, Ookayama Meguro-ku, Tokyo 152
August 6-8	ISGF 85: The 4th International Symposium	Sapporo, Japan	ISGF 85, Institute of Low Temperature Science Hokkaido University Sapporo, Hokkaido 060
August 11-16	The 6th International Meeting on Ferroelectricity	Kobe, Japan	Professor Koichi Toyoda Research Institute of Electronics Shizuoka University 3-5-1 Johoku Shizuoka, 432

1985 Continued

Date	Title	Site	For Information, contact
June 11-14	Factory Automation Show '85 LA Systems Show Inter New Matex '85 Sensoring Systems Show '85 CAD/CAM Systems Show	Tokyo, Japan	The Nihon Kogyo Shimbun Company, Ltd. 1-7-2, Ohtemachi Chiyoda-ku, Tokyo 100
June 17-20	Biotex '85	Tokyo, Japan	The Nihon Kogyo Shimbun Company, Ltd. 1-7-2, Ohtemachi Chiyoda-ku, Tokyo 100
June 23-28	The 14th International Congress of Chemotherapy	Kyoto, Japan	Professor K. Sakai, The Second Division of Surgery Medical School Hospital (attached to) Osaka City University 1-5-7, Asahi-cho Abeno-ku, Osaka 545
June (tentative)	Semicon Osaka '85	Osaka, Japan	Secretariat Marcom International, Inc. Akasaka-Omotemachi Building, Room 705 4-8-19, Akasaka Minato-ku, Tokyo 107
June (tentative)	The 22nd Light Printing Exhibition	Tokyo, Japan	Tokyo Keiinsatsu Kogyokai Nitto Building 3-2, Kanda-Jimbocho Chiyoda-ku, Tokyo 101
June (tentative)	Microcomputer Show '85	Osaka, Japan	Japan Electonic Industry Development Association Kikai Shinko Kaikan 3-5-8, Shiba-koen Minato-ku, Tokyo 105
June (tentative)	Society for the Advancement of Breeding Researches in Asia and Oceania	Bangkok, Thailand	Dr. Prasan Yingchol Faculty of Agriculture Kasetsart University Bangkok 9, Thailand

1985 Continued

Date	Title	Site	For Information, contact
May 27-29	International Convention on QC Circles	Tokyo, Japan	Union of Japanese Scientists and Engineers 5-10-11, Sendagaya Shibuya-ku, Tokyo 151
May 27-31	The 10th Congress of the International Association for Accident and Traffic Medicine	Tokyo, Japan	Dr. Shinpachi Nishikawa Japan Traffic Science Council Sunshine Building 1-9, Rokubancho Chiyoda-ku, Tokyo 102
May 28-30	The 22nd All Japan Optical Measuring Instruments Fair	Tokyo, Japan	Japan Optical Measuring Instruments Manufacturers Association Kikai Shinko Kaikan 3-5-8, Shiba-koen Minato-ku, Tokyo 105
May 27-Jun 1	The 23rd IFLA World Congress Japan	Tokyo and Kobe, Japan	XXIII International Field Landscape Architecture World Congress Japan Organizing Committee Shisei Kaikan 1-3, Hibiya-koen Chiyoda-ku, Tokyo 100
June 5-7	1985 International Symposium on Circuits and Systems	Kyoto, Japan	Professor Shoji Shinoda Faculty of Engineering Science Chuo University 1-13-27 Kasuga Bunkyo-ku, Tokyo 112
June 6-10	'85 Electrical Construction Exhibition	Osaka, Japan	Japan Electrical Construction Association, Inc. Tokyo Dengyo Kaikan Building, 1-7-8, Moto-Akasaka Minato-ku, Tokyo 107
June 10-13	The 15th JPCA Show '85	Tokyo, Japan	Japan Printed Circuit Association Kamiyacho Building, 6th Floor 5-12-12, Toranomon Minato-ku, Tokyo 105

1985 Continued

Date	Title	Site	For Information, contact
May 15-21	Japanmec '85 Factory Mechatronics '85	Osaka, Japan	Osaka International Trade Fair Commission 58 Hashizume-cho Uchihonmachi Higashi-ku, Osaka 540
May 19-25	The 16th Congress of the International League against Rheumatism	Sydney, Australia	Australian Arthritis and Rheumatism Foundation 12th floor, Wynyard House 291 George Street Sydney, N.S.W. 2000
May 20-24	The 3rd Conference on Steel Development	Melbourne, Australia	Australian Institute of Steel Construction P.O. Box 434 Milsons Point, N.S.W. 2061
May 22-24	Silicon Island '85	Kitakyushu, Japan	The Nihon Kogyo Shimbun Company, Ltd. 1-7-2, Ohtemachi Chiyoda-ku, Tokyo 100
May 22-25	Microcomputer Show '85	Tokyo, Japan	Japan Electronic Industry Development Association Kikai Shinko Kaikan 3-5-8, Shiba-koen Minato-ku, Tokyo 105
May 23-25	'85 General Exhibition of Medical Instruments	Tokyo, Japan	The Medical Instrument Society of Japan Ikakikai Kaikan 3-39-15, Hongo Bunkyo-ku, Tokyo 113
May 24-26	The 15th Hamamatsu Environment Preserving Machinery and Equipment Exhibition '85 Robot and Labor-saving Machine Exhibition	Hamamatsu, Japan	The Nihon Kogyo Shimbun Company, Ltd. 2-4-9, Umeda Kita-ku, Osaka 530
May 25-28	'85 Hiroshima International Metalworking Machines Exhibition	Hiroshima, Japan	The Industrial Daily News Matsukawa Building 2-3, Matsukawa-cho Hiroshima, 730

Date	Title	Site	For Information, contact
April 20-21	Tokyo Radio-control Show	Tokyo, Japan	Nippon Engine Mokei Kogyokai Showa-Building 4-14-13, Kuramae Taito-ku, Tokyo 111
April 23-26	Computer Graphics Tokyo '85	Tokyo, Japan	Professor Tosiyasu L. Kunii Department of Information Science Faculty of Science University of Tokyo 7-3-1, Hongo Bunkyo-ku, Tokyo 112
April (tentative)	Carbon Transport in Major World Rivers	Tianjin, People's Republic of China	Professor J.W.M. La Riviere Institute for Hydraulic Environmental Engineering P.O. Box 3015 Oude Delft 95, 2601 DA, Delft, The Netherlands
May 11-16	The 13th Congress of the Council of Mining and Metallurgical Institutions	Canberra, Australia	Council of Mining and Metallurgical Institutions 44 Portland Place London W1N 4BR U.K.
May 13-17	1985 Metals Congress	Victoria, Australia	Dr. A. Brownrigg, 1985 Congress Victorian Branch A.I.M. 191 Royal Parade Parkville, Victoria 3052
May 14-16	1985 Symposium on VLSI Technology	Shima, Japan	Professor Shoji Tanaka Faculty of Engineering University of Tokyo 7-3-1, Hongo Bunkyo-ku, Tokyo 112
May 15-18	The 12th Modern Scientific Instruments Show	Nagoya, Japan	The Nihon Kogyo Shimbun Company, Ltd. 1-7-2, Ohtemachi Chiyoda-ku, Tokyo 100

INTERNATIONAL MEETINGS AND EXHIBITIONS IN THE FAR EAST

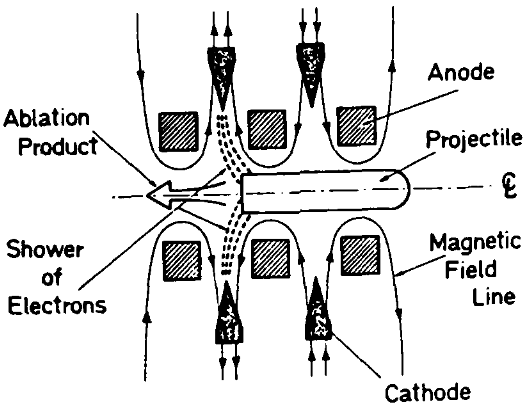
1985-1988

Compiled by Tsugio Satoh

The Australian Academy of Science, the Japan Convention Bureau, and the Science Council of Japan are the primary sources for this list. Readers are asked to notify us of any upcoming international meetings and exhibitions in the Far East which have not yet been included in this report.

1985

Date	Title	Site	For Information, contact
April 2-6	Wire Tokyo 85: The 2nd International Wire Exhibition	Tokyo, Japan	Dr. Frank Hodgson Director of Public Relations Mack-Brooks Exhibitions 62 Victoria Street St. Albans AL1 3XT U.K.
April 9-12	Communications Tokyo '85	Tokyo, Japan	Communication Industries Association of Japan Sankei Building, Annex 8F 1-7-2, Ohtemachi Chiyoda-ku, Tokyo 103
April 10-11	World Teleport Conference II	Tokyo, Japan	World Trade Center of Japan 2-4-1, Hamamatsu-cho Minato-ku, Tokyo 105
April 12-16	Intermex '85 '85 CAD/CAM/CAE Systems Show '85 Engineering Design Efficiency Exhibition Ceramex '85 Japan Mould '85	Tokyo, Japan	The Industrial Daily News 1-8-10, Kudan-kita Chiyoda-ku,Tokyo 102
April 15-19	Eighth Australian Symposium on Analytical Chemistry	Melbourne, Australia	Eighth ASAC G.P.O. Box 1929 Canberra, A.C.T. 2601



The annular cathodes are pulsed from external stores to produce an electron shower of sufficient energy to ablate the projectile base. Each cathode must be pulsed in sequence and at an optimum time which is determined by the projectile position as it travels through the array. Superimposed on the array is a "cusp" magnetic field which guides the ablation plasma through the cusp producing forward thrust. If the ablation products have a constant velocity relative to the projectile, the equation of motion becomes that of a simple rocket:

$$V = U \ln \frac{Mo}{M}$$

where V is the projective velocity, U is the velocity of the ablation products, Mo and M are the initial and instantaneous mass of the projectile.

Simple calculations of the beam-projectile interaction indicate that high Z materials will be needed. The ablation plasma temperature should be on the order of 100 eV and allow velocities on the order of 40-100 km/s for accelerator lengths of several meters.

This work is all theoretical. However, there is interest in building experimental versions in the future. The reference material cited below describes in detail the ABLAC accelerator concept.

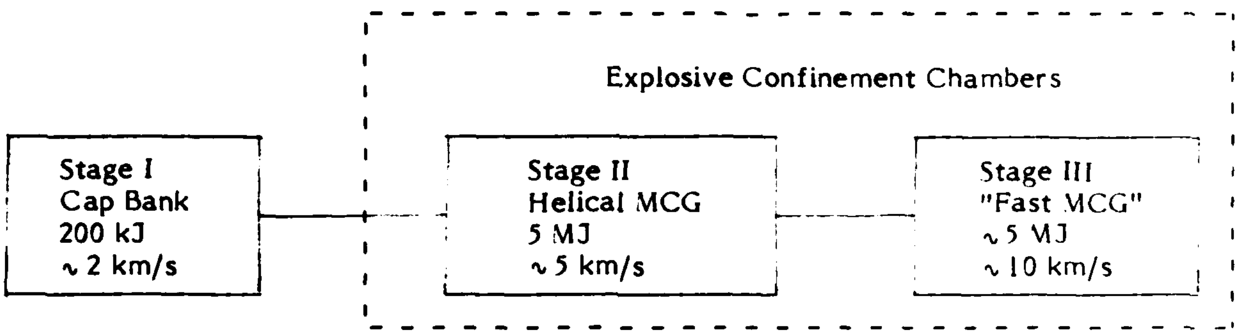
- "Ablation Acceleration of Macroparticles in Spiral Magnetic Fields," K. Ikuta. *Journal of the Physical Society of Japan, 50,* (12) 4035-4038 (1981).

- "Ablation Accelerator (ABLAC) as Driver for Impact Fusion," K. Ikuta *et al. Japanese Journal of Applied Physics, 23,* (6) 732-734 (1984).

- National Chemical Laboratory for Industry

The second group building rail guns is the National Chemical Laboratory for Industry located at Tsukuba and is headed by M. Kusakabe. Their approach to the problem is also to use multistaging to achieve high velocity. The National Chemical Laboratory has several explosive confinement vessels which allow the use of modest magnetocummulative generators in a laboratory environment. The gun under construction is a three-stage device. The first stage is capacitively powered by a 200 kJ capacitor bank and is designed to accelerate a 30 gm projectile to a velocity of 2 km/s. The second stage will be inside the explosive confinement building and is powered by a helical MCG generating 5 MJ of energy. The projectile is calculated to achieve an exit velocity of 5 km/s into the third stage. The third stage uses 20 kg of explosive in a fast MCG of the "gull wing" type to accelerate the projectile to a final velocity of 20 km/s. This gun is in the final stages of construction and should have the following characteristics:

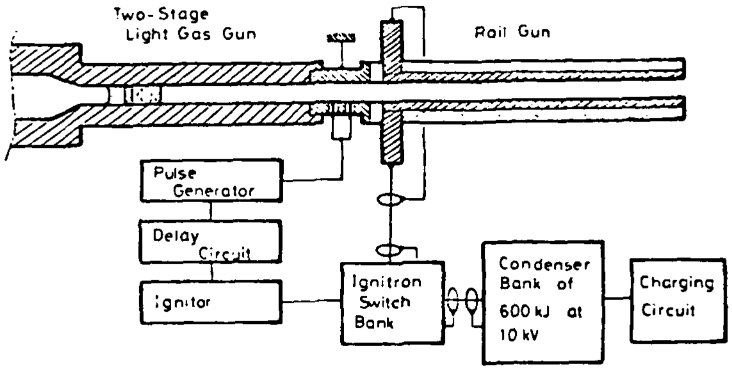
bore	25 mm square cross section
length	2 m (first stage)
rail material	copper
injection velocity	2 km/s
power	capacitor bank and MCG
projectile mass	30 gms
projectile material	lexan
goal	20 km/s
application	material studies



- ABLAC

There is at least one other technique of interest for achieving high velocity macroparticles. This work is theoretical in nature and is similar to concepts proposed at NRL several years ago. The basic concept is to use high current/modest energy electron beams to ablate the base of a projectile in hopes of achieving velocities high enough to achieve impact fusion from a suitable target. The proposed machine, called ABLAC, is described in a paper by K. Ikuta *et al.*, entitled "Abalation Accelerator as a Driver for Impact Fusion." The figure below shows schematically the operating principle.

capacitor bank manufactured by the Maxwell Laboratories in the U.S.A. The bank can be segmented into 300 kJ modules. The schematic of the device is shown below.



Professor Sawaoka has modeled and calculated the benefits of segmenting the rail system and driving each segment with an optimally matched store. He plans to do this in the future but hopes to achieve 15 km/s with the existing airgun-electric rail gun system. Achievements to date are listed below:

bore	8 mm round shape
length	2 m
rail material	brass
injection system	light gas gun at 3 km/s
power source	600 kJ capacitor bank (Maxwell)
projectile material	polyethylene/lexan
goal	1 gram at 2 km/s
application	basic materials studies under high pressure

They have conducted several experiments and hope to reach 20 km/s next year.

Professor Sawaoka is leaving the group to do a six-month sabbatical at the New Mexico Institute of Mining and Technology at Socorro, New Mexico. The following publications by his group gives more detail.

- "Progress in Shock Wave Research at Research Laboratory of Engineering Materials," A. Sawaoka *et al. Report of the Research Laboratory of Engineering Materials, 9,* Tokyo Institute of Technology, 1984.

- "Status of Electromagnetic Mass-accelerator Development and Prospect of Application to Impact Fusion Research," S. Usuba *et al. Report of the Research Laboratory of Engineering Materials, 8,* Tokyo Institute of Technology, 1983.

- Status of Electromagnetic Mass-accelerator Development and Prospect of Applications to High Pressure Research," S. Usuba *et al. Shock Waves in Condensed Matter--1983,* Elsevier Science Publishers 1984.

- "Development of a Rail Gun Accelerator Combined with a Two-stage Light Gas Gun," S. Usuba *et al. IEEE Trans. on Magnetics, 20,* No. 2, March 1984.

ELECTROMAGNETIC MASS DRIVERS

M. Frank Rose and M. Kristiansen

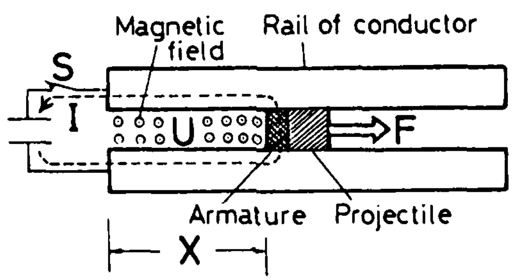
INTRODUCTION

Fundamental limits associated with the expansion of gases make it difficult to build gun systems with muzzle velocities greater than a few kilometers per second. A simple look at electromagnetics suggests that there should be no limit to the velocity achievable using the magnetic forces produced by large currents. This subject, in the form of electrically driven rail guns, is of considerable interest in the U.S.A. in such areas as inertial confinement fusion, military guns, high strain rate forming, and as a concept in the strategic defense initiative.

In Japan, we visited three groups who were actively engaged in electrically accelerating projectiles to high velocities for inertial confinement fusion or basic material studies under extreme pressures.

DISCUSSION

The major approach seems to be the electric railgun as illustrated below.



Electrical current I is allowed to flow through the rail conductor, through the plasma armature, and out the second rail. The system can be powered by several suitable sources such as capacitor banks, explosive generators, or homopolar/inductor storage systems. The force produced is proportional to the magnetic field and the current flowing in the system. The force is therefore proportional to the square of the current I and pushes the armature/projectile system down the barrel.

- Tokyo Institute of Technology

There are two groups in Japan building rail guns of this type. One group is at the Tokyo Institute of Technology and is headed by Professor Akira Sawaoka, and has as its goal the acceleration of several grams to velocities as high as 20 km/s.

One of the problems with rail guns is the erosion produced when the arc is struck behind the projectile. To solve this, Professor Sawaoka has used a two-stage light gas gun to accelerate the projectile initially to a velocity on the order of 3 km/s. In addition, the higher injection velocity produces a better match for energy transfer from the storage bank to the projectile kinetic energy. The electrical stage is powered by a 600 kJ/10 kV

TABLE I

SPECIFICATION OF CONDENSER BANKS

System	I	II	III
AIM	3 MG	5 MG	10 MG
C_F			
Capacitance	0.64 mF	1.25 mF	6.25 mF
Operating voltage	1-30 kV	4-40 kV	4-40 kV
Maximum stored energy	0.3 MJ	1 MJ	5 MJ
Switching element	ignitron	air gap	air gap
Number of SW	10	24	120
Diversion circuit	without	with	with
C_S			
Capacitance	8.6 mF	30 mF	
Maximum stored energy	77 kJ	1.5 MJ	
Switching element	ignitron	ignitron	
Liner dimensions (mm)	66 x 20 x 1 - 1.5	80 x 20 x 1.5 - 3	100 x 30 x 3 - 5

1985 Continued

Date	Title	Site	For Information, contact
September 12-16	Autotech '85: International Exhibition of Industrial Robots	Tokyo, Japan	The Industrial Daily News 1-8-10, Kudan-kita Chiyoda-ku, Tokyo 102
September 12-18	The 3rd Osaka International Textile Machinery Show	Osaka, Japan	Osaka International Trade Fair Commission Osaka Kokusai Hotel 58, Uchihonmachi Hashizume-cho Higashi-ku, Osaka 540
September 21-25	World Congress III of Chemical Engineering	Tokyo, Japan	Secretariat, the Society of Chemical Engineers Kyoritsu Building 6-19, Kohinata 4-chome Bunkyo-ku, Tokyo 112
September 24-27	Optoelectronics Show	Tokyo, Japan	The Nihon Kogyo Shimbun Company, Ltd. 1-7-2, Ohtemachi Chiyoda-ku, Tokyo 100
September 26-30	Osaka Mechatronics Fair Intermex '85 Autotec '85 Laser Show '85 Osaka Engineering Design Efficiency Exhibition '85 CAD/CAM/CAE System Show Japan Mold and Die '85	Osaka, Japan	The Industrial Daily News 2-1, Kyobashi-maenocho Higashi-ku, Osaka 540
September (tentative)	'85 Vacuum General Exhibition	Tokyo, Japan	The Nihon Kogyo Shimbun Company, Ltd. 1-7-2, Ohtemachi Chiyoda-ku, Tokyo 100

1985 Continued

Date	Title	Site	For Information, contact
September (tentative)	'85 Safety and Security Exhibition	Tokyo, Japan	The Nihon Kogyo Shimbun Company, Ltd. 1-7-2, Ohtemachi Chiyoda-ku, Tokyo 100
September (tentative)	Japan Office Environment Exhibition	Tokyo, Japan	Japan Management Association Kyoritsu Building 3-1-22, Shiba-koen Minato-ku, Tokyo 105
September 30-October 4	The 5th International Congress of Medical Librarianship	Tokyo, Japan	Medical Information Center Keio University 35, Shinanomachi Shinjuku-ku, Tokyo 160
October 6-10	International Society and Federation of Cardiology: The 7th International Symposium on Arterio-sclerosis	Melbourne, Australia	Dr. P. J. Nestel Baker Medical Research Institute Commercial Road Prahran, Victoria 3184
October 14-16	International Committee of Foundry Technical Association	Melbourne, Australia	Dr. Neil McGaw Australian Foundry Institute Materials Division, RMIT P.O. Box 360 Carlton South Victoria, 3053
October 14-16	Zinc '85-International Symposium on Extractive Metallurgy of Zinc	Undecided, Japan	The Mining and Metal-lurgical Institute of Japan 8-5-4, Ginza Chuo-ku, Tokyo 104
October 14-17	International Seminar on Laterite	Undecided, Japan	The Mining and Metal-lurgical Institute of Japan 8-5-4, Ginza Chuo-ku, Tokyo 104
October 14-18	The 52nd International Foundry Congress	Melbourne, Australia	Mr. N. J. Shaw P.O. BOX 368, Carlton South Victoria, 3053

1985 Continued

Date	Title	Site	For Information, contact
October 15-18	International Rubber Conference	Kyoto, Japan	The Society of Rubber Industry, Japan Tobu Building 1-5-26, Motoakasaka Minato-ku, Tokyo 107
October 19-21	The 4th International Congress of Oriental Medicine	Kyoto, Japan	International Congress Service, Inc. New Kyoto Center Building Higashi-shiokoji Shimogyo-ku, Kyoto 600
October 19-22	The 5th International Symposium on Rats with Spontaneous Hypertension and Related Studies	Kyoto, Japan	Professor Yukio Iemori Shimane Medical University 89-1, Shioji-cho Izumo, Shimane 693
October 30-31	International Dairy Federation Seminar on Milk Production	Melbourne, Australia	Mr. Robert Gray Australian Dairy Corporation P.O. Box 330 Prahran Victoria, 3181
November 4-7	HSLA Steels '85 (High Strength Low Alloy)	Beijing, People's Republic of China	Chinese Society of Metals 46 Dongsizi Dajie Beijing
November 11-15	The 14th Asia Conference on Occupational Health	Manila, Philippines	Dr. Benite Reverente Philippine Occupational and Industrial Medical Association c/o Bayview Plaza Medical Clinic Roxas Boulevard Metro Manila
December (tentative)	Joint Congress of the Asian and Pacific Federation of Surgeons	Karachi, Pakistan	Dr. F. U. Baquai Baquai Hospital, III-B Nazimabad, Karachi

1985 Continued

Date	Title	Site	For Information, contact
December (tentative)	International Conference for Plastic and Reconstructive Surgery: The 4th Congress of Asian-Pacific Section	Manila, Philippines	Dr. Jess Lizardo Philippine Association Plastic Surgeons P.O. Box 519 Greenhills, San Juan Manila
December (tentative)	International Astronomical Union Symposium on Instrumentation and Research Programs for Small Telescopes	Christchurch, New Zealand	Dr. J. Hearnshaw Department of Physics University of Canterbury Christchurch, 1
(Undecided)	APAA: The 7th General Assembly 1985 (APAA: Asian Patent Attorneys Association)	Undecided	Japan Asian Patent Attorneys Association Fuji Building 3-2-3, Marunouchi Chiyoda-ku, Tokyo 100

1986

Date	Title	Site	For Information, contact
February 16-21	The 5th World Congress of the International Rehabilitation Medicine Association	Manila, Philippines	Dr. Tyrone Reyes Chairman, IRMA V Philippine Congress Organization Center P.O. BOX 4486 Metro Manila
March 16-21	The 10th International Congress of Prestressed Concrete	New Delhi, India	Mr. C. R. Alimchandani Stup Consultant, Ltd. 1004-5-7 Raheja Chambers 213 Nariman Point Bombay 420-021
March (tentative)	The 2nd Asian Pacific Congress on Legal Medicine and Forensic Sciences	Adelaide, Australia	Dr. Andrew Scott Forensic Science Center Divett Place, Adelaide S.A. 5000
March (tentative)	The 6th Conference of the De Bakey International Surgical Society	Melbourne, Australia	Dr. D. G. Macleish 96 Grattan Street Carlton Victoria, 3053

Date	Title	Site	For Information, contact
April 8-11	1986 International Conference on Acoustics, Speech, and Signal Processing	Tokyo, Japan	Simul International, Inc. Kowa Building No. 9, 1-8-10 Akasaka Minato-ku, Tokyo 107
May 11-17	Congress of the International Society of Haematology and the International Society of Blood Transfusions	Sydney, Australia	Dr. I. Cooper, President Haematology Society of Australia Cancer Institute 481 Little Londsdale Street Melbourne, Victoria 3001
July 12-19	International Institute of Welding Annual Assembly 1986	Tokyo, Japan	Dr. Takuro Kobayashi Japan Welding Society 10-11, Kanda-Sakumacho Chiyoda-ku, Tokyo 101
July 21-25	The 4th International Congress of Toxicology	Tokyo, Japan	Dr. Yutaka Kasuya Department of Pharmacy University of Tokyo 7-3-1, Hongo Bunkyo-ku, Tokyo 113
August 3-7	The 20th Congress of the International Association of Logopedics and Phoniatrics	Tokyo, Japan	Japan Society of Logopedics and Phoniatrics 7-3-1 Hongo Bunkyo-ku, Tokyo 113
August 24-29	The 8th IUPAC Conference on Physical Organization Chemistry	Tokyo, Japan	Dr. Michinori Ohki Faculty of Science University of Tokyo 7-3-1, Hongo Bunkyo-ku, Tokyo 113
August 24-30	International Conference on Atomic Physics and Few-body Systems (The 10th International Conference on Atomic Physics. The 11th International Conference on Few-body Systems in Particle and Nuclear Physics)	Tokyo, Japan	Dr. Tsutomu Watabe The Institute of Physical and Chemical Research 2-1, Hirosawa Wako, Saitama 351

1986 Continued

Date	Title	Site	For Information, contact
August 28-30	International Conference on Atomic Physics and Few-body Systems (The 10th International Conference on Atomic Physics. The 11th International Conference on Few-body Systems in Particle and Nuclear Physics)	Sendai, Japan	Dr. Tsutomu Watabe The Institute of Physical and Chemical Research 2-1, Hirosawa Wako, Saitama 351
August 25-29	The 12th International Congress of the International Association of Sedimentologists	Canberra, Australia	Professor K.A.W. Crook Department of Geology Australian National University P.O. Box 4 Canberra, A.C.T. 2600
August 26-30	International Conference on Martensitic Transformations (ICOMAT-86) in Commemoration of JIM 50th Anniversary	Nara, Japan	ICOMAT-86 The Japan Institute of Metals (JIM) Aoba, Aramaki Sendai 980
August 25-29	The 7th World Congress on Air Quality	Sydney, Australia	Mr. K. Sullivan Clean Air Society of Australia and New Zealand P.O. Box 191 Eastwood, N.S.W. 2122
August (tentative)	The 13th International Conference on High-Energy Accelerators	Tsukuba, Japan	Professor Ken Kikuchi Institute of High Energy Physics Ohhocho, Tsukuba-gun Ibaraki 305
August 31-September 7	The 11th International Congress of Electron Microscopy	Kyoto, Japan	Department of Anatomy Faculty of Medicine Kyoto University Yoshida-konoecho Sakyo-ku, Kyoto 606
September 9-11	The Third International Conference on the Science and Technology: Zirconia	Tokyo, Japan	The Ceramics Society of Japan 2-22-17 Hyakunincho Shinjuku-ku, Tokyo 160

1986 Continued

Date	Title	Site	For Information, contact
September 21-25	The World Congress of Chemical Engineering	Tokyo, Japan	The Society of Chemical Engineers, Japan Japan Kyoritsu Kaikan 4-6-19, Honhinata Bunkyo-ku, Tokyo 112
September 22-26	The 9th International Meeting of the International Union of Phlebology	Kyoto, Japan	Professor S. Sakakuchi Hamamatsu University School of Medicine 2nd Surgery Department 3600, Handa-cho Hamamatsu, Shizuoka 431-31
September (tentative)	The 8th International Congress of Psychosomatic Obstetrics and Gynecology	Melbourne, Australia	Dr. L. Dennerstein Department of Psychiatry University of Melbourne c/o Royal Melbourne Hospital Parkville, Melbourne 3052
October 20-25	The 11th International Conference on Cyclotrons and Their Applications	Tokyo, Japan	Dr. Yasuo Hirao Institute for Nuclear Study University of Tokyo 3-2-1, Midori-cho Tanashi, Tokyo 188
November 5-10	The 3rd Congress of the International Federation of Society for Surgery of the Hands	Tokyo, Japan	Secretariat of the Congress Cresent Plaza 103 2-4-6, Minami-Aoyama Minato-ku,Tokyo 107
Undecided	International Microbiological Congress	Perth, Australia	Australian Academy of Science P.O. Box 783 Canberra, A.C.T. 2601

1987

Date	Title	Site	For Information, contact
March 22-27	The 6th World Conference on Smoking and Health	Kitakyushu, Japan	Dr. Kawano Kitakyushu Municipal Yahata Hospital 4-18-1 Nishi-hommachi Yahata-higashi-ku Kitakyushu, Fukuoka 805

1988

Date	Title	Site	For Information, contact
April 26- May 3	The 3rd World Biomaterial Congress	Kyoto, Japan	Professor H. Kawahara Department of Dentistry Osaka Dental University 1-47 Kyobashi Higashi-ku, Osaka 540
May (tentative)	The 4th Printed Circuit World Congress	Tokyo, Japan	Japan Printed Circuit Association (JPCA) Tashiro Building 5-11-10 Toranomon Minato-ku, Tokyo 105

- NOTICE -

The Office of Naval Research/Air Force Office of Scientific Research, Liaison Office, Far East is located on the second floor of Bldg #1, Akasaka Press Center and bears the following mail identification:

Mailing address:	Office of Naval Research/Air Force Office of Scientific Research Liaison Office, Far East APO San Francisco 96503
Local Address:	ONR Far East/AFOSR Far East Akasaka Press Center 7-23-17, Roppongi Minato-ku, Tokyo 106
Telephone numbers:	Civilian 03-401-8924 Autovon 229-3236 Telex 242-7125 SANTEL J

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