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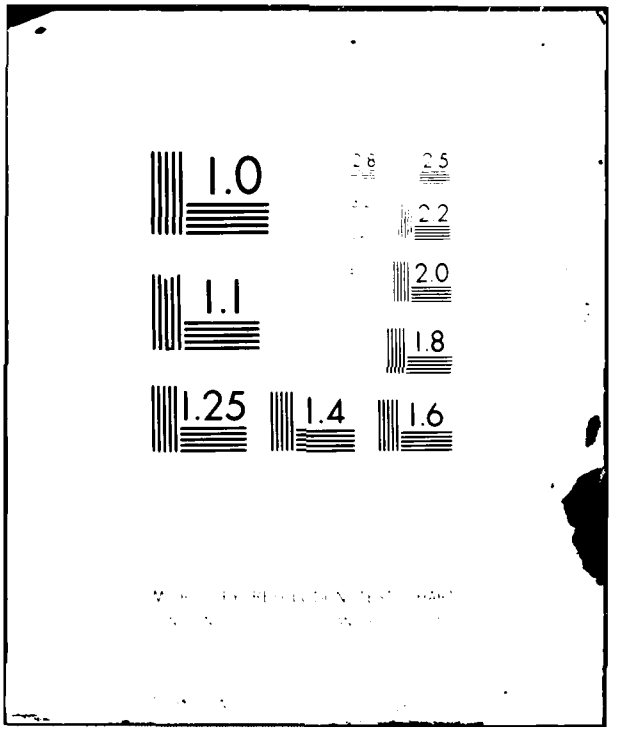
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This is a quarterly publication presenting articles covering recent developments in Far Eastern (particularly Japanese) scientific research. It is hoped that these reports (which do not constitute part of the scientific literature) will prove to be 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,

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20. Abstract (cont.)

with certain reports also being contributed by visiting stateside scientists. Occasionally a regional scientist will be invited to submit an article covering his own work, considered to be of special interest.

CONTRIBUTORS

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Haruo Kuroda, Professor of Chemistry at the University of Tokyo, is a renowned expert in the spectroscopy of chemical compounds. He is an elected member of the Science Council of Japan, and presently serves as co-principal investigator of the US-Japan cooperative research program entitled "Development of the Design of Molecular Structure."

Donald E. Polk, a metallurgist, has been on the faculty of Northeastern University since 1974. He has had industrial research experience at Allied Corporation since completing his graduate work at Harvard University in applied physics and materials science. He is presently with the Office of Naval Research, directing research programs on amorphous materials.

Francis A. Richards was Professor of Oceanography at the University of Washington, and currently is Scientific Director at ONR London. Dr. Richards' research interests in chemical oceanography include analysis of seawater, plankton pigments, oxygen-deficient and sulfide-bearing environments in the ocean, and interrelationships among the branches of oceanography through chemistry. He served on the staff of ONR Tokyo from 1977 to 1979 and again in the summers of 1980 and 1981.

Seikon Sakiyama, Science Advisor of ONR Far East, has had considerable industrial experience in laboratory chemistry, electronic instrumentation, and quality control methodology. His interests include computer science, linguistics, and energy technology.

George Sandoz, a metallurgist, was assigned temporarily as a liaison scientist at ONR Tokyo from January 1981 to September 1981. Dr. Sandoz also served as the Director for Science with the Office of Naval Research Branch Office in Chicago. Dr. Sandoz' interests are in materials technology; hydrogen embrittlement, stress corrosion cracking, carbide stability, fracture, fatigue, and high temperature of environmental effects.

CONTENTS

Cover: The famous original monkey carvings "Hear no Evil, Speak no Evil, See no Evil," are located at the Sacred Stable in the Middle Court of the Toshogu Shrine at Nikko, Japan. The Toshogu Shrine, which is the mausoleum of the famous Ieyasu Tokugawa, the first of the *Shogun*, is the most elaborate and lavishly decorated in Japan. Photograph by Erin Moore.

FOURTH INTERNATIONAL CONFERENCE ON RAPIDLY QUENCHED METALS

Donald E. Polk

The Fourth International Conference on Rapidly Quenched Metals (RQ4) was held in Sendai, Japan on 24-28 August, 1981. The size of the Conference has grown considerably, paralleling the increased industrial interest in this field, also labelled Rapid Solidification Technology. A total of 407 papers were presented, orally and in poster sessions, as compared to 130 papers at the preceding RQ3 conference in England in 1978. Somewhat more than half of the papers (~218) were given by non-Japanese attendees who comprised about one-third of the ~600 registrants; it is certain that even more foreign scientists would have attended if it were not for the attendant great distance and high cost of travel. The Conference Chairman, Professor T. Masumoto, and the Secretary General, Professor K. Hashimoto, both of Tohoku University, deserve plaudits for overseeing a pleasant and stimulating, well-organized conference.

The large number of papers were accommodated by holding concurrent (typically three to five) sessions. Further, 90 minutes were set aside on four afternoons for the viewing of poster presentations. Additional discussions on specific topics were accommodated within scheduled workshop periods.

Research reported at the meeting spanned a wide range of alloy types and physical properties since the only unifying thread was that the metal had been processed using a rapid solidification process, i.e., one which produced cooling rate of $\sim 10^4$ °C/sec or greater. The greatest interest centered on amorphous metals made by liquid quench techniques which produce cooling rates of about 10^5 -10^6 °C/sec, though cystalline materials, vapor deposited alloys, etc. were also of interest. Topical areas and the number of papers in each were:

- preparation/processing techniques (40),
- structural studies/modelling (54),
- glass formation and stability, relaxation and crystallization (80),
- magnetic behavior (107),
- superconductivity (15),
- electronic properties (19),
- mechanical properties (21),
- catalysis (4),
- corrosion (11),
- crystalline metals (30),
- metals containing hydrogen (16).

The concentration on magnetic behavior is due in part to the great interest in using the soft ferromagnetism of Fe and Co rich amorphous metals in a wide range of devices; the large number of studies related to the stability of the amorphous metal derive from the commercial and scientific importance of this topic for the metastable amorphous metals.

Several companies presented displays concerning the commercial utilization of amorphous metals, and these are surveyed below.

Following RQ4, a Satellite Symposium organized by Professor Mizoguchi was held at Gakushuin University in Tokyo on Monday, 31 August 1981. The program, listed at the end of the report, presented reviews of the state-of-the-art of selected topics related to metallic glasses.

TECHNICAL PROGRAM

Given the large number and diversity of papers presented at RQ4, no attempt will be made to present an overall summary of the technical content of the presentations. Rather, highlights of some specific papers will be presented; the selection is somewhat arbitrary (hopefully of more general interest, but also ones which I had heard or seen presented) and thus does not reflect one way or the other on the bulk of papers which have been omitted. Camera-ready copies were handed in by authors, and the complete proceedings should be available shortly.

A method for producing ribbons of amorphous metals which has been most widely used is the rapid solidification process labelled melt spinning wherein a stream of the molten metal is contacted with a single high conductivity quench surface moving at high speed, e.g., a 30 cm diameter disk made of a copper beryllium alloy rotating at 2000 rpm. One drawback to this method is that the ribbon does not nave a uniform thickness, due in part to the inclusion of gas pockets between the quenched metal and the quench substrate. Thus, a large number of laboratories in Japan are attempting to perfect a double roller manufacturing process in order to produce rapidly quenched ribbons having two "smooth" surfaces and hence uniform thickness, highly desirable for many potential magnetic applications.

Several papers were concerned with the double roller quenching process. J. Ishihara and I. Ikuta, Hitachi Research Laboratory, Hitachi Ltd. used double rollers of 100 mm diameter and crucibles with single or multiple round holes. The round stream formed a pool on one roll (i.e., the metal was not injected directly at the nip) and thus needed to spread sideways to the ribbon shape. Ribbons formed this way had a nonuniform thickness, being reduced at the center and the edges. The variation in thickness was found to decrease as the distance between the nozzle and the roll decreased, with the thickness variation becoming negligible as the nozzle to roll distance decreased to 0.5 mm.

M. Sakata and T. Ishibashi, Central Research Laboratory, The Furukawa Electric Company, Ltd., reported on their double roll apparatus which also included a metal belt. At the top, the belt wrapped against one of the rollers so that it and the second working roller form a nip which shapes the molten metal to a ribbon. Below the nip, the belt is wrapped against the working roll so as to maintain thermal contact with the quenched metal. This longer contact time can be especially important for the formation of amorphous metals which need to be cooled quickly to below the glass transition temperature, a relatively low temperature relative to the liquidus temperature; one problem with using the conventional two roller technique for glass forming alloys is that the alloy leaves the nip at too high a temperature. Ribbon thickness can be controlled, e.g., to within 0.002 mm for a average thickness of 0.030 mm. Ribbons of amorphous $Co_{.71}$ $Fe_{.04}$ $Si_{.10}$ $B_{.15}$ were produced; such materials are of interest for use in magnetic heads.

K. Miyazawa, T. Choh, and M. Inouye of Nagoya University reported on the effect of varying the process parameters (roll rotation speed, roll separation, melt flow rate) on the crystalline ribbons of a Pb-Sb eutectic alloy. Other industrial laboratories are also utilizing double roll techniques. Sony is reportedly producing amorphous ribbons for magnetic heads using this technique. Hitachi Metals is producing amorphous tape, e.g., $Co_{.9}$ $Ar_{.10}$, with a double roll technique. Other companies, e.g., Kawasaki Steel, are using the double roll technique to make crystalline Fe-6.5%Si alloys.

A new method of making amorphous metal wires also received attention at the meeting. I. Ohnaka, *et al.*, of Osaka University described the "in-rotating-liquid spinning method" wherein a molten metal jet, shaped by a round hole in the crucible, is injected into a liquid layer coating the inner surface of a rotating drum. The relative speed of the drum, and hence water, and the free jet was found to be a critical factor as to whether or not a continuous, relatively uniform wire was formed; best results were obtained when the drum speed was in the range of 1.1 to 1.3 times that of the jet. Wires had circular cross-sections for jet sizes below ~ 100 μm. Water was found to produce the best quench for diameters below ~100 μm; $MgCl_2$ and LiCl were added to the water to suppress boiling for diameters up to ~200 μm. Pd and Fe based amorphous metal wires were produced. T. Masumoto of Tohoku University, *et al.*, further explored the alloy system and size limitations of the process. Wires were made for a wide variety of alloy systems, including Pd-Si, Pd-Cu-Si, Fe-Si-B, Fe-P-C, Co-Si-B, and Fe-Si-B and other alloys. However, Ni-Si-B could not be formed as a wire even though it has a critical cooling rate similar to that of other alloys successfully processed; instead, a "powder" was formed. Thus, the formation of an amorphous wire depends not only on the critical cooling rate but also on other factors, possibly melt viscosity, surface tension, and the formation of a surface oxide to stabilize the jet. A. Inoue of Tohoku University, *et al.*, identified the compositional region for which wires of ~100 μm diameter can be produced. Microhardness and tensile strength were measured, e.g., 1100 DPN and 3450 MPa (~ 500Ksi) for amorphous $Co_{72.5}Si_{12.5}B_{15}$. The wires were found to have fluctuations in the diameter of up to ~10%. The wires could be cold drawn significantly without intermediate annealing treatments, e.g., from 130 to 50 μm, while retaining their high strength. The maximum strength observed was 4000 MPa (~ 580Ksi) for $(Co_{.95}Ta_{.05})_{72.5}Si_{12.5}B_{15}$. Amorphous wires of the appropriate compositions can be of particular interest because they can combine very high strength with soft ferromagnetism or excellent corrosion resistance.

M. Yoshimura and S. Somiya, Tokyo Institute of Technology, used a "Xenon arc-image furnace" to rapidly melt refractory metals and ceramics. In a 10 kW Xw short arc lamp (Ushio Inc), most of the light energy is concentrated at the point of one of the electrodes (~ 75% of the energy in an arc spot 2.3 mm in diameter). Shaped mirrors are used to collect and focus this light to an image spot 4.2 mm in diameter. The system is about 18% efficient, leading to an energy density of ~10 kW/cm^2. High melting temperature materials such as Mo (2617°C) and ZrO_2 (2715°C) could be melted in a time of the order of a second to globules of 1 to 4 mm diameter in almost point contact with a water cooled copper support. Such droplets could be rapidly quenched using the hammer and anvil technique; this was done, e.g., for Fe_2O_3+Y_2O_3 mixtures which always crystallized. This heat source can also be used to do surface melting, e.g., it was used to melt a ceramic surface which resolidified rapidly to a crackfree material with a 500A grain size.

In a presentation of a paper by M. Hagiwara and H. Tomioka (Unitaka Ltd.) and A. Inoue and T. Masumoto (Tohoku University), an innovative method was used to determine the effect of alloying elements on the critical maximum ribbon thickness (i.e., minimum cooling rate) for the formation of an amorphous phase upon melt spinning. A braking mechanism was incorporated into the apparatus such that the rapidly rotating (e.g., 5000 rpm) disc used as the quench substrate could be stopped in a short time (e.g., 1 to 2 s). Since substrate speed is one of the factors controlling ribbon thickness, squirting the molten alloy onto the substrate during the deceleration period led to a ribbon of varying thickness (e.g., 20 to 400 μm). Thus, the structure as a function of ribbon thickness could be determined from one run, providing a significant savings in time. Results were given for the addition of various metals to $Fe_{75}Si_{10}B_{15}$ and $Co_{72.5}Si_{12.5}B_{15}$; replacement of Fe or Co with small amounts of Ta, Nb, W and Mo enhanced the glass forming ability, while replacement of Fe or Co by Cr, V, Mn, Ti, Zr, and Al decreased it.

R. E. Maringer and L. F. Vassamillet, Battelle Columbus Laboratories, reported on the utilization of selective leeching to alter the composition as well as microstructure and properties of melt spun ribbons. Amorphous Fe and/or Ni rich alloys, containing B and Si at the typical level of ~20 at%, were heated to about 700°C and above in an environment containing oxygen; the boron and silicon diffuse to the surface where they preferentially oxidize. Removal of the oxide can leave behind a ductile metal with small grain size, a high degree of preferred orientation, and good mechanical properties. Similarly, a wet H atmosphere was used to deplete C from Fe alloys. Crystalline materials with strengths up to 300 kg/mm^2 were obtained; typical grain size were ~1 μm. It was noted that the approach might be useful in obtaining melt spun ribbons of alloys which could not be otherwise readily melt spun, since the addition of the metalloids often enhances "spinnability," and in preparing ribbons having desired preferred crystal orientation, e.g., for the Fe-6% Si alloys.

Y. Yoshizawa and H. Fujimori, Tohoku University, investigated the magnetic properties of amorphous $(Fe_{1-x}Co_x)_{70}Si_{15}B_{15}$ made by a high rate triode dc sputtering technique. Previous studies of sputtered amorphous films had found the coercivity to be rather large compared to those made by melt quenching techniques. Thin films of very soft ferromagnetic materials having flux densities exceeding that of the soft ferrites may be quite useful, e.g., in high frequency applications. Further, a wider range of compositions with an increased spectrum of desirable magnetic properties would be expected to be available when the amorphous alloys are prepared by sputtering; it is expected that sputtering can more readily avoid the inclusion of a small amount of crystallites in an amorphous alloy and thus can be used to prepare fully homogeneous alloys over a wider composition range than can liquid quenching. Bulk deposites which were about 300 μm thick and had been removed from the substrate and properly annealed to relieve stresses exhibited the very small coercivity (~.003 to .008 Oe) typical of melt quenched ribbons. However, thin films (~10 μm thick) attached to the substrate have coercivities of 0.1 to 1 Oe even after stress relieve annealing. Coercivities of the thin films can be understood as being the result of magnetic anisotropy resulting from the deposition process and/or the magnetostriction of the film, since the film and substrate had different thermal expansion coefficients; domain wall pinning at surfaces may also increase the coercivity of the films.

As alluded to earlier, selected Fe-rich amorphous alloys are undergoing extensive study to evaluate their suitability for transformer applications for example in distribution transformers, etc., which operate in the range of 60 to 100 Hz; compositions and "low" temperature annealing are optimized to minimize hysteresis losses. Such material has a coarse domain structure, however, which leads to excessive losses when used in the 50-100 kHz range. A. Datta *et al.*, Allied Chemical, reported on the use of a "high" temperature anneal to improve the performance at high frequencies; other investigators have also reported on a similar approach. As opposed to the "low" temperature annealing, the preferred "high" temperature annealing produces partial crystallization (e.g., 1 to 3%) of the alloy; the precipitates refine the size of the magnetic domains, thereby reducing eddy current losses. For preferred alloys such as $Fe_{79}B_{16}Si_5$, the precipitate is α-Fe.

It is likely that some applications of amorphous metals will come about because they can possess an unusual combination of properties such as corrosion resistance with soft ferromagnetism and/or excellent mechanical properties; one such promising application is as the active element for magnetic separation where the corrosion resistance and readily formed ribbon shape are important in addition to the magnetic behavior and toughness. Y.S. Yang *et al.*, Central Iron and Steel Research Institute, Beijing, used ribbons of amorphous $Fe_{75}Cr_5P_{13}C_7$ to remove Fe_2O_3 from kaolin clay. The initial 2% Fe_2O_3 level could be reduced to 0.8% in one pass when the slurry was passed through the randomly packed amorphous ribbons.

The great bulk of the studies on magnetic properties of amorphous metals have focussed on alloys of the type (Fe, Co, Ni)$_{70-85}$(B, C, Si, P)$_{15-30}$, in part because of their high saturation magnetization and low cost, both crucial for an application such as a distribution transformer. However, increasing attention is being paid to iron and cobalt rich alloys where the alloying elements which make glass formation possible are the early transition metals; about a dozen papers at the conference were concerned with amorphous alloys such as $Fe_{90}Zr_{10}$, $Co_{90}Zr_{10}$, and $Co_{85}Nb_{12}B_3$. H. Sakakima *et al.*, Matsushita Electric Industrial Company, Ltd. reported on the magnetic behavior of liquid quenched Co-Nb-B alloys. In addition to magnetic properties, the wear and corrosion resistance of alloys are important determinants of their suitability for use as the core of magnetic heads. While the wear resistance of the matalloid rich alloys is better than that of permalloy, it is lower than that of sendust and ferrite. By contrast, the Co-Nb-B alloys have very high wear rersistance, e.g., five times that of sendust. The good wear resistance of these alloys is related to their good corrosion resistance in moist air, which can be improved further by the addition of some Cr. The alloys have high permeability ($\mu_o > 10{,}000$) though a reduced saturation (e.g., $B_S \simeq 11{,}500$ G) compared to the metalloid rich alloys.

The excellent corrosion resistance of amorphous Fe alloys containing Cr, in particular the resistance to pitting in the presence of Cl^-, has been widely reported. K. Kobayashi, Japan Metals and Chemicals Company, Ltd., and K. Asami and K. Hashimoto, Tohoku University, studied the behavior of about one hundred (Fe-Cr-Mo)-(P, C, Si, B) alloys in HCl solutions. Crystalline stainless steels or high nickel alloys can not passivate spontaneously even in 1 N HCl. For sufficiently high levels of both Cr and Mo, however, amorphous alloys such as $Fe_{45}Cr_{25}Mo_{10}P_{13}C_7$ would passivate spontaneously in 6N HCl even at 80 °C; alloys of lower Cr passivate if the Mo content is increased, e.g., a 5Cr, 15Mo combination. Further, they resisted pitting corrosion up to the transpassive region of chromium. A hydrated chromium oxyhydroxide film deficient in molybdenum passivated the surface; the metal immediately below this film was enriched in molybdenum. Increasing the metalloid content also tended to improve the corrosion resistance; their effectiveness increased in the order B, Si, C, and P. The improvement of corrosion resistance compared to crystalline materials was ascribed not just to the lack of grain boundaries but is related to the fact that the surface film on the amorphous alloys is both very uniform and richer in Cr.

T. Tsuru, S. X. Zhang, and R.M. Latanision, Massachusetts Institute of Technology, presented data comparing several Cr-Ni-Mo stainless steels in their standard wrought condition to their microcrystalline (grain size ~ 1 μm) form. In chloride free environments, the two forms exhibited essentially identical electrochemical behavior. However, the microcrystalline alloys were found to be far more resistant both to pitting and crevice corrosion in the presence of Cl^- and to stress corrosion cracking in a boiling $MgCl_2$ solution.

INDUSTRIAL DISPLAYS

Eight companies presented displays highlighting their efforts to develop rapidly quenched metals for use in commercial products; the majority of these efforts depend upon the soft ferromagnetism of the amorphous alloys.

The Matsushita Electric Industrial Company (products include Panasonic) display highlighted three uses for amorphous ferromagnetic alloys. The first is magnetic shielding for items such as a differential yoke, amplifiers and magnetic devices where the as-formed ribbons or sheets have the desired shape. The amorphous alloys can achieve 3 to 10 times better shielding than conventional Ni-Fe permalloy alloys: shielding advantages are

especially good at high frequency. The second is used for magnetic switches or magnetic field sensors; the high permeability and high magnetic induction of the alloys are desirable. Third to be cited was use in magnetic heads, e.g., audio heads and read/write computer heads. Advantages include outstanding frequency response, low distortion, and high corrosion resistance for proper alloy selection.

Sony also highlighted the use of the amorphous alloys for magnetic heads, citing heads used to duplicate music tapes where the advantages of low noise, high sensitivity, and low distortion are important. The magnetostrictive properties of the amorphous alloys would be the basis of their use as magnetostrictive delay lines in high performance, low cost data tablets. In the data tablet, a drawing or writing on a pressure sensitive surface is picked up and, for example, displayed on a video screen.

Hitachi cited three applications of amorphous metals. In video tape recorder heads for metal powder tape, a 4 to 8 dB improvement in the signal to noise ratio is achieved when a composite of an amorphous alloy and ferrite is used. The improved quality can be used to lengthen the playing time. Thin amorphous magnetostrictive ribbons, of corrosion resistant compositions, can be used to sense frost, e.g., on the evaporator of a refrigerating machine, and thus save energy. An acoustic wave propagating through the ribbon is sensitive to the solid frost but not to liquid water. Also highlighted were the advantages of amorphous alloys for use in high gradient magnetic filters, e.g., to remove magnetic particles such as iron oxide from water: ferromagnetic amorphous alloys containing chromium have excellent corrosion resistance, the sharp edges of as prepared ribbons lead to a high magnetic field gradient which has a high attraction even for small particles, there is a high efficiency for back flashing due to the low coercive force, and the high strength of such ribbons makes a matrix of such material resistance to damage such as consolidation. The amorphous alloys are reported to be superior to the conventional 18% Cr steel for the removal of Fe_3O_4.

Osaka Transformer displayed a 10 kVA, 6,600 V to 210/105 V transformer using an amorphous core made from ribbon manufactured by Allied. The unit had an energy loss of 13 watts vs. a 40 watt loss for a similar conventional unit using 3% Si steel.

Toshiba focussed on the use of amorphous alloys for high frequency transformers, thermal sensors (based on the increase in permeability as the temperature increases), and low noise, highly reliable magnetic amplifier type switching regulators.

The Rare Metallic Company/Mitsui Mining and Smelting Company display contained examples of available melting stock, e.g., Ni-B and Fe-P, relevant to the production of amorphous metals.

Unitaka displayed amorphous metal wires, made by the direct water quench casting method discussed at RQ4, of a variety of Fe/Ni-metalloid compositions. The compositions can be selected to give otherwise unavailable combinations of mechanical, magnetic, and corrosion resistant properties. The use of composite balls of an organic fiber (such as polyester) and ferromagnetic amorphous wires for magnetic filtration was demonstrated.

The Allied display focussed on applications of their Metglas amorphous metal foil. Displayed was an energy efficient 3 phase, 4 pole, 60 Hz ac motor and a high efficiency 15 kVA transformer developed for a demonstration solar electric house. A 440 Hz airborne 3 phase transformer was claimed to have 82% less core loss, 22% less weight, and 32% less volume than that of the same power capacity and copper efficiency presently used in the F-14. Also cited were woven fabric for magnetic shielding, a hydrophone based on a toroid

of their 2605 Co ribbon, and Metglas-epoxy composites as well as the use of the amorphous brazing foils, e.g., for superalloy fabrication for engines and for a honeycomb of inconel 625.

General Electric presented a graphic display showing the energy savings which could be achieved by using amorphous metals in, e.g., induction motors and distribution transformers.

APPENDIX I

RQ4 SATELLITE SYMPOSIUM PROGRAM:

"PERSPECTIVE IN AMORPHOUS METALLIC MATERIAL SCIENCES"

- "Metallic Glasses - Remembrances and Prospects," P. Duwez (California Institute of Technology)
- "Theory of Amorphous Alloys: Structure, Thermodynamics, Elementary Excitations," H. Hafner (Technische Universitat Wien)
- "Creep, Diffusion, and Structural Relaxation in Metallic Glasses," F. Spaepen (Harvard University)
- "A New Model Glass Transition and Its Implication to the Sub-sub-T_g Stability of Glassy Metals," H. S. Chen (Bell Laboratory)
- "Chemical Bonding Effects in Amorphous Alloys: Experiments and Models," G. S. Cargill III (IBM T. J. Watson Research Center)
- "The Science Necessary for Some Application of Amorphous Metallic Alloys in Magnetic Devices," F. E. Luborsky (General Electric)
- "Anelastic Properties of Metallic Glasses," H. U. Kunzi (Universitat Basel)

VISITS TO SOME JAPANESE INDUSTRIAL LABORATORIES WORKING ON RAPID SOLIDIFICATION TECHNOLOGY (RST)

Donald E. Polk

Following the Fourth International Conference on Rapidly Quenched Metals (Sendai, 24-28 August 1981), visits were made to six industrial laboratories where research related to rapidly solidified alloys was being carried out. The companies which were visited include: Sumitomo Special Metals Company, Ltd; Nippon Steel Corporation; Kawasaki Steel Corporation; Matsushita Electric Industrial Company, Ltd; and two laboratories of Hitachi, Ltd. All of these efforts appear to have begun because of the interest in the soft magnetic behavior of amorphous alloys; while this generally remains the focus, other materials made by RST are also being investigated. In addition, several other interesting, non-RST efforts at these laboratories are discussed.

MATSUSHITA ELECTRIC INDUSTRIAL CO.

Dr. Harufumi Senno hosted my visit to the Materials Research Laboratory of Matsushita Electric Industrial Company Ltd., Kadoma, Osaka 571, Japan. Dr. Senno heads the Magnetic Material Section which encompasses 17 individuals.

One effort within the group has focussed on amorphous alloys, aimed primarily at optimizing these materials for use in magnetic recording heads. Thus, they seek alloys having high magnetic induction, high permeability, and good wear and corrosion resistance. Some efforts continue on (Fe,Co)-(Si,B) alloys, such as the zero magnetostriction alloy $(Co_{.94}Fe_{.06})_{75}Si_{15}B_{10}$. Such alloys are superior to the high wear rate permalloy presently used in some heads but wear faster than, e.g., Sendust (in wt%, ~85Fe10Si5Al) now used in professional systems. The wear in these (Co,Fe)-(Si,B) alloys is related to their only moderate resistance to corrosion in a moist atmosphere.

The new thrust within this effort has developed from the observation that alloys such as $Fe_{90}Zr_{10}$ can be quenched to a glass. Similar type alloys can be made using Ti and Nb rather than Zr, but these binaries are more difficult to quench to a glass, so small amounts of B can be added to make glass formation easier. Current efforts focus on the Co-Nb-B system, e.g., $Co_{85}Nb_{12}B_3$, which is reported to have excellent wear resistance, e.g., five times that of Sendust. These alloys have excellent corrosion resistance and form a passive surface film in air, though this has not yet been studied in detail; as expected, added Cr further improves the corrosion resistance. The Co-Nb-B alloys are reportedly superior to the $Co_{90}Zr_{10}$ alloy (which in turn has better wear resistance than (Fe,Co)-(Si,B) alloys) which is less resistant to corrosion in the presence of water. The Co-Nb-B, unlike Co-Zr, has a negative magnetostriction which can be compensated by the addition of Fe or Mn. The saturation magnetizations of the Co-Nb-B alloys are ~8,500 gauss. Additional efforts will explore the variation of the Nb level and will examine binary Co-Nb made by a sputtering technique. While appearing to have excellent properties, cost considerations will apparently control whether or not such alloys are introduced into their products.

Sendust is also being processed by RST processes since, as conventionally produced, it is brittle and difficult to fabricate to the desired sheet form. Ribbons made by the single roll technique have a rough free surface with substantial oxidation; ribbons made by the double roll technique have much smoother surfaces while remaining free of cracks. However, ribbons were still brittle even for grain sizes as small as 5 to 7 μm.

The view was expressed that Sendust alloys now look less attractive as compared to the Co-Nb-B alloys. However, both Sendust and the amorphous alloys are being developed because of their higher magnetic induction, highly desirable for the new metal powder or evaporated metal tapes, while ferrite is satisfactory for the heads for the older iron oxide tapes. This driving force may decrease since Matsushita has developed a very thin evaporated metal tape having high coercivity for which a ferrite head is satisfactory.

Some work has continued on the fabrication of crystalline 6.5%Si-Fe by a RST technique. This alloy composition has relatively low magnetostriction and has low hysteresis loss. It is a possible replacement for 3%Si-Fe because of its potentially lower hysteresis losses. While the 6.5% alloy as conventionally cast has limited ductility and can not be readily formed into a sheet, the RST ribbon is formed directly in the desired shape and, in addition, has good toughness. The 6.5% Si alloy may be preferrable to amorphous Fe-B-Si alloys for use in distribution transformers because of its lower cost (it contains no B) and higher thermal stability. Heat treatments and rolling are being used to control texture, and getting the optimum crystalline texture in the ribbon remains the greatest problem. Current losses for the higher Si alloys are about the same as that for textured 3%Si-Fe.

An effort to investigate the use of Al-Mg alloys (e.g., 11 at% Mg) made by liquid quenching for use as diaphragms in loudspeakers is also underway. The addition of Mg reduces the density; the figure of merit for a "vibrating reed" application is $v/\rho = \sqrt{E/\rho}/\rho)$ where v = acoustic velocity, E = Young's modulus and ρ= density. The desired foil thickness of 10 to 50 μm is a good match for that easily formed using RST processes; a double roll technique could be used to produce the required surface smoothness.

The Magnetic Materials section also is doing research on rare earth cobalt and Mn-Al-C permanent magnets. The Mn-Al-C alloys having a $(BH)_{max}$=8 MGOe have been produced in the laboratory; pilot plant production with a $(BH)_{max}$ of 5 to 6 MGOe has begun, and the magnets are being used, e.g., in speakers and motors. The Mn-Al-C magnets have higher performance than the ferrites but, unlike the Alnicos which they can also replace in some applications, do not contain the critical element Co. Processing of the Mn-Al-C remains difficult (i.e., the required high temperature extrusion), but is projected that its cost may decline to only ~50% above that of the ferrites.

NIPPON STEEL CORPORATION

The visit to the Fundamental Research Laboratories, Nippon Steel Corporation, 1618 Ida, Nakahara-ku, Kawasaki 211, Japan, was organized by Dr. Takashi Sato, head of the Amorphous Material Group of the laboratories Fundamental Research Laboratory - Special section. Dr. Ryutaro Matsumoto, Manager of the Special section, and Dr. Kenichi Yukawa, Chief Researcher of the Chemical Research Center section, also participated in most of the discussions.

The main effort at Nippon Steel involving RST is an effort to scale up the production capability and select the optimized composition to make amorphous Fe-B-Si-C ribbon for use, e.g., as the core of a distribution transformer. The Japan Research and Development Corporation has given Nippon Steel a five year, $9,000,000 contact to support that effort. Work is being done in Kawasaki as well as at the Process Technology R&D Laboratories in Kyushu. Efforts are aimed at producing 15 cm wide ribbon with a 500 Kg batch process. This effort does not currently involve formal collaboration with another company, but other companies, including a transformer manufacture, are expected to join the effort at a later date.

Both single roll and double roll processes are being investigated, though it was suggested that the double roll is "difficult" to use, especially for wide amorphous ribbons of Fe-rich alloys. Further, the increased surface smoothness achievable with the double roll is believed to be more important for foil used in magnetic heads than for that used in transformer cores.

The magnetic properties and ease of glass formation as a function of the B,Si and C content in Fe rich alloys were studied extensively, as has been done by others because of the importance of this system. Optimum compositions (low core loss, easy glass formation) are given by $Fe_{84-x}B_{16-x}Si_{2x}$, including an alloy such as $Fe_{78}B_{10}Si_{12}$. Alloys of reduced boron content with higher silicon content are desirable because they are less costly and may be outside of previous patents, but they have somewhat reduced saturation magnetization and are more sensitive to oxidation during processing, leading to surface problems.

The eventual use of the Fe-B-Si-C type alloys in distribution transformers is viewed as uncertain because of projections that their cost will be about three times that of 3%Si-Fe. An evaluation of the lower cost 6.5%Si-Fe will begin.

Other work has begun on RST fabrication of:

- corrosion resistant materials;
- magnetic filter materials (in collaboration with the Daido Steel Research Laboratory in Nagoya); and
- fiber reinforced composites.

The composites work now focusses on the use of, e.g., Fe-Cr-P fibers to reinforce concrete. A market for 2-3,000 tons/year in Japan is projected if the fibers were available at below $2/Kg, feasible since raw materials would cost ~ $.50/Kg.

KAWASAKI STEEL CORPORATION

The Kawasaki Steel Corporation Research Laboratories are at 1, Kawasaki-cho, Chiba, Japan, next to their Chiba Works plant. Kawasaki is Japan's third largest steelmaker and is one of Japan's two manufacturers of 3%Si steel (the other being Nippon Steel, the largest steelmaker). Discussions were with Dr. Hiroshi Shimanaka, General Manager of the No. 3 Department of the Research Laboratories, Yo Ito, Chief of the Silicon Steel Laboratory (a part of the No. 3 Department), and Takahiro Kan, Research Associate in the Silicon Steel Laboratory. Current efforts involve five researchers and six workers.

Both the amorphous Fe-metalloid alloys and the 6.5%Si-Fe are being studied, as would be expected since both are potential replacements for 3%Si-Fe in transformer cores. Their efforts have focussed on the 6.5%Si iron, motivated by projections that this material made by a RST direct casting method (the high quench rate is not necessary to the final product) could cost only ~65% of oriented 3%Si steel which is now made by a complex rolling and annealing process. Both single roll and double roll quench techniques are being investigated, though the double roll technique is preferred for the crystalline ribbon of the optimum 100 μm thickness. A major problem is selecting appropriate materials for the nozzle and the rollers which have a sufficiently long lifetime when used for the high melting 6.5%Si-Fe alloy.

Though the cast alloy of this composition is quite brittle, the melt spun ribbons are ductile and can be plastically deformed to make a 180° sharp bend. Best magnetic properties were obtained after annealing in vacuum at high temperatures, e.g., 1100 to 1200°C. The annealing produced grain growth and enhanced the quenched in (100)[Ouv] texture, i.e., (100) planes are parallel to the ribbon surface while the [100] axes are distributed at random within the plane of the ribbon. For the vacuum annealed 6.5% Si-Fe ribbons, the observed core loss was 0.8 W/Kg at 15/50 (Kgauss/cycles) and 0.25 W/Kg at 10/50; typical losses for oriented 3% Si-Fe were given as ~1 W/Kg at 15/50. Small samples of the 6% Si-Fe ribbon had losses of ~0.2 to 0.3 W/Kg at 12.5/ 50, similar to that achieved for amorphous alloys. Improving the [100] texture along the ribbon could lead to achieving such low losses for all of the ribbon.

The single roller technique has been found to be preferable for production of amorphous alloys at Kawasaki, due to the longer contact time. The maximum saturation magnetization achieved by them for the amorphous alloys is reported to be only 16 Kgauss. The amorphous Fe-B-Si-C alloys are getting less attention at Kawasaki, compared to 6.5% Si-Fe, because of the high cost of the boron included in the preferred amorphous alloy compositions.

SUMITOMO SPECIAL METALS COMPANY, LTD.

Drs. Masateru Nose and Kiyoyuki Esashi hosted the visit to the Research and Development Department, Sumitomo Special Metals Company, Ltd., 19-1, 2-chome, Minamisuita, Suita, Osaka 564, Japan. Sumitomo Special Metals specializes in the manufacture of a wide spectrum of alloys for the electronic industry and is about 50% owned by Sumitomo Metals Incorporated. Seven individuals are involved in RST R&D at the Suita works.

Efforts at Sumitomo are focussed on advanced processing techniques, the production of new alloys, and the use of a RST process as a convenient, economical way to make strips of known alloys. For example, a new, "unique" process to make ribbons with two smooth surfaces is being developed.

One effort has involved Sendust, which as mentioned earlier is difficult to form in a thin sheet by conventional methods because of its lack of ductility. The use of an RST technique plus the addition of other elements have allowed production of Sendust strip with improved mechanical properties while maintaining about the same magnetic properties. The alloy is not fully ductile but it is somewhat tougher and can be handled more readily; the strength normally obtained has been doubled to ~50 to 60 Kg/mm^2.

Another effort has focussed on the development of amorphous alloys based on $Co_{90}Zr_{10}$ for applications such as magnetic heads. Alloy compositions include those wherein Fe and or Ni are substituted for Co; additionally, elements such as Mo, Cr, and Nb as well as small amounts of B and Si are added to enhance magnetic properties and processibility.

Sumitomo customers have been requesting such new materials, and it is likely that samples of the Sendust and $Co_{90}Zr_{10}$ - based alloys will be sold early in 1982.

Standard Permalloy containing Si and B is being processed by RST. The addition of silicon and boron mechanically hardens the alloy and increases the processability of the alloy.

Ni-Cr, heat re isting alloys are being processed by RST, in this case just as a convenient way of making thin strip. Spring alloys (Cu-Be, Cu-Ni-Al, Cu-Mn) are also being processed, where mechanical properties and low resistivity are of interest. Stainless steels containing boron, of use in atomic power plants, are being investigated; higher boron contents and improved mechanical properties can be achieved. Miscellaneous other, not disclosed specialty alloys are also being investigated.

HITACHI, LTD.

Drs. Shinji Takayama and Hiroshi Yamamoto of the 2nd Department were visited at the Central Research Laboratory, Hitachi, Ltd., Kokubunji, Tokyo 185, Japan. The Central Research Laboratory is concerned primarily with electronics, in particular, computers; the limited materials research efforts support the main thrust.

The RST effort at this lab has concentrated on the magnetic properties of amorphous alloys. The Fe-B-Si-C alloys are being studied, in part because Hitachi produces distribution transformers. Fe-Ni based amorphous alloys, having high permeability and a square hysteresis loop, are being developed for high frequency uses.

A significant effort is developing amorphous $Co_{90}Zr_{10}$ based alloys for, e.g., use in magnetic heads since they exhibit better wear and corrosion behavior than amorphous Fe-B-Si alloys. Amorphous Co-Zr is preferred to Fe-Zr since it is easier to form and has a higher magnetic saturation. Using a special slit orifice, Co-Zr ribbons having a surface roughness and thickness variation of $\pm$ 1 μm (e.g. for ~ 1 cm wide ribbon) have been made at Hitachi, Ltd. using a double roll technique. A current problem is that the roller surface becomes damaged after processing only small amounts of the alloy. Elements such as Mo, W, and Cr are added to optimize properties, while boron also may or may not be included; alloying elements can be used to achieve zero magnetostriction. Co-Ti alloys are being studied as well.

The Hitachi Research Laboratory of Hitachi, Ltd. is at 4026 Kuji-cho, Hitachi-shi, Ibaraki-ken, 319-12 Japan. The visit was hosted by Dr. Tetsuo Kuroda; discussions included Dr. Tetsuroh Minemura, Takeo Kikuchi, Mitsuo Chigasaki, Joo Ishihara, and Tomio Iizuka. Currently, eight individuals are involved with RST R&D; it is planned to increase this to 20-30 in a couple of years.

Current efforts include the RST production of foils as insert materials for brazing, e.g., superalloys. Al-Si alloys having the eutectic composition are used for joining aluminum, as in the production of home appliances. Ni-B alloys are being developed for neutron absorbers; ductile alloys of high B content are produced. Amorphous Fe-Cr alloys are being developed for use in magnetic separators, e.g., to remove Fe_3O_4 and (nonmagnetic) Fe_2O_3 in nuclear power or steel making plants. Nb and Ti are being added to ferritic steels; heat treatment of the alloy after RST processing is used to precipitate (Nb,Ti)-carbides.

Other recent developments include "Gradia," a wear resistant alloy wherein graphite (e.g., 20 vol %) is dispersed in a metal (e.g., Cu or Al) matrix. Argon arc welding of a powder feed is used to produce wear resistant coatings (Fe12.5V2.8C5Cr through Fe27.5V5.8C5Cr) containing VC particles (2 to 5 μm size, respectively). Wear resistance is reduced by a factor of 2 to 10 compared to a 18%W, 1%Mo, 4%Cr tool steel. An inert gas low pressure casting process has been developed to produce high strength, high precision aluminum parts. Carbon fibercopper composites have been developed for uses requiring, e.g., good thermal and electrical conductivities or nonmagnetic materials combined with

high strength or wear resistance. Two layer, Ni-Al coatings superior to Pt-Al below 850°C have been developed. High strength silicon carbide ceramics (flexural strength of 60 to 110 Kg/mm^2) and electrically insulating, high thermal conductivity silicon carbide ceramics are being produced.

Hitachi Metals, Ltd., the metal producing subsidiary of Hitachi Ltd., has two separate research labs also working in RST at Yakin-Kenkyujo, 2, 2107, Yasugi-machi, Yasugi-shi, Shimane-ken 692, Japan (including tool steels) and Jisei-Zairyo-Kenkyusho, 5200, Mishiri, Kumagai-shi, Saitama-ken 360, Japan (including magnetic materials).

METALS RESEARCH IN CHINA

George Sandoz

INTRODUCTION

Preparations for the trip had begun some eight months earlier with letters of inquiry, introduction, and conversations with colleagues who had previously visited China or who had worked with Chinese students. A lengthy preparation is apparently essential to a successful admission and reception in China as an official visitor. Moreover, I was admitted as an individual who was to "lecture." The Chinese arrange the itinerary for the most part. This apparently requires clearance from a variety of government offices. The trip could not have been made without the help, advice and introductions provided by Professor G. Ansell (Renseallear Polytechnic Institute), Professor Charles McMahon (University of Pennsylvania), Professor Peter Strutt (University of Connecticut) and Dr. B. Rath (Naval Research Laboratory).

My itinerary, arranged by Professor C. M. Hsiao of Beijing University of Iron and Steel Technology, included the following organizations:

- Institute of Metals Research, Shenyang
- Beijing University of Iron and Steel Technology
- Central Iron and Steel Research Institute, Beijing
- General Research Institute for Nonferrous Metals, Beijing
- Beijing Metallurgical Research Institute
- Shanghai Research Institute of Metallurgy
- Shanghai Institute of Ceramics
- Shanghai Iron and Steel Research Institute

I was originally scheduled to visit the Northeast Institute of Technology in Shenyang but did not visit the institute. I was also scheduled to visit the Central South Institute of Mining and Metallurgy and the Research Institute of Mining and Metallurgy in Changsha, but I was unable to travel to Changsha. Visits four and five in the above list were substituted for the Changsha visits and both were worthwhile.

In the following a brief description of each visit is given.

INSTITUTE OF METAL RESEARCH - SHENYANG

The Institute of Metal Research in Shenyang is under the control of the Chinese Academy of Sciences (Academia Sinica). Located in industrial Manchuria, the institute as founded in 1951 initially served the iron and steel industry, specially steel plants and the machinery industry. In 1958 the institute, in response to calls for the "great leap forward," began work on the development of new materials (superalloys, graphite, high strength steels, ceramics, high temperature materials, refractory metals). This emphasis has continued for over 20 years, broken only by the "cultural revolution" (1966-1977).

Research institutes of the Academia Sinica in China are involved with education as well as research. The Institute of Metals Research in Shenyang has 700 technical people, 70 with the rank of associate professor and 12 full professors. Degrees will be granted in 1981 for the first time. It is now intended that the institute will be a graduate school granting M.S. and Ph.D. degrees.

There are 16 departments at the institute, as follows:

- Metal physics - internal friction, fatigue mechanisms
- Surface science
- Amorphous metals and effects of rare earths in steel
- High-strength steel - special melting practice, inclusions, electroslag
- Low temperature technology and physical properties - superconductivity, emissivity, mechanical properties
- Superalloys - jet engine and industrial turbine alloys, special casting and solidification technics, precision casting
- Powder metallurgy - spray coating, ceramic coating (SiC and $Si_3 N_4$), rapid solidification processing (RSP) (being initiated)
- Refractory metals and titanium alloys - phase diagrams
- Graphite - graphite structures for dental materials (jaw)
- Corrosion protection - stress corrosion cracking, protection of super alloys and refractory metals from oxidation
- Welding and joining - plasma arc, electron beam, laser (beginning), vacuum brazing and diffusion
- Mechanical working - superplasticity and computer simulation of mechanical working processes
- Mechanical testing - creep, residual stress, acoustic emission,
- Failure analysis - fracture
- Chemical analysis - including instrumentation
- Technology - design of scientific instrumentation, repair and maintenance

The institute receives about 8.5 million yuan ($6 million) annually exclusive of building funds. About two thirds is from Academia Sinica, the remainder from the Ministry of Metallurgical Industries. Of the total, one million dollars is for salaries, or about $800 per worker per year.

On a tour of the laboratory, I was shown a lot of equipment. A vacuum brazing and welding department is, among other things, used for brazing graphite to titanium. Auger electron spectroscopy and other instrumentation is being employed to study fracture surfaces of nickel. At present, the segregation of sulfur and nitrogen on the 100 plane of nickel single crystals is being studied. Apparently two new surface structures have been found and reported in Surface Science.

An x-ray diffraction apparatus is being used to study surface texture of metals and oxides on metals, and to measure residual stresses. It has been found that texture influences both the entrance of hydrogen (and therefore hydrogen embrittlement) and the resistance to oxidation. The addition of rare earths to iron-chromium-aluminum alloys eliminates surface texture, which is, in this case, beneficial. In the case of hydrogen embrittlement, texture is related to dislocations and easier diffusion of hydrogen.

There are projects involving use of the scanning electron microscope related to fracture and fatigue processes and embrittlement mechanisms. One project involves *in situ* observation of tensile fractures as effected by hydrogen. A paper will be presented at the Joint Conference on Metal Physics to be held in Beijing in November 1981. Another paper will discuss crack propagation in pearlite under dynamic conditions. About 40 American scientists are expected to attend this conference. The American Society for Metals is the joint sponsor.

In the acoustic emission laboratory, crack propagation in quartz glass is being

studied. A double-torsion, constant-K specimen is used. A linear relation between acoustic events and crack growth rate has been observed. Variables studied are temperature and moisture. A paper on the results by Wan Yao-Quang is ready for presentation at the International Conference on Glass to be held in Beijing in August 1981. Several scientists from the United States, Germany, and Japan are scheduled to attend.

The fatigue laboratory is studying low-cycle fatigue crack initiation and propagation in pure aluminum, titanium alloys, and high-strength steel. A paper entitled "Some Microscopic Features and Mechanisms of Fatigue Behavior in Metals," by Wang Zhon-Quang will also be presented at the Joint Conference on Metal Physics in Beijing, November 1981.

A laser pulse method is being used to determine specific heats of alloys and ceramics to 1000°C and thermal diffusivity to 2500°C. Thermal conductivity is also measured.

The laboratory is becoming well-equipped with respect to melting equipment. There are 50 kg and 200 kg vacuum induction furnaces and a 500 kg air [illegible] furnace. An electroslag furnace is under construction and a 1-ton consumable ar[illegible] will soon be operational. A 300 kW electron beam furnace is also under constr[illegible]

For metal working there is a 600-ton vertical extrusion pres[illegible] refractory metals, titanium alloys, and stainless steel tubing. A 600-ton forging [illegible] and a [illegible]-ton stamping press are under construction.

The diffusion welding laboratory provides a vacuum of [illegible] Torr at 1250°C in a 800 mm diameter working chamber. A heat treat furnace 1 x 4 meters in cross section treats titanium bars to 1350°C in vacuum of 10^{-5} Torr.

BEIJING UNIVERSITY OF IRON AND STEEL TECHNOLOGY

The Beijing University of Iron and Steel Technology was founded in 1953, although an earlier school of mining and metallurgy had existed as early as 1895. At the present time, there is an entire community of about 10,000 people living on the 130 acre campus. About 4000 are undergraduate students and 350 are graduates. The rest of the people are staff, workers, and administrators who also are provided housing. Only a few live off campus. In addition to the university activities, there are elementary and middle schools. Evening classes are provided for the workers.

The students are currently selected by a highly competitive national examination. This is a somewhat recent procedure. The 10 percent who win admission enjoy free tuition, lodging, and medical care, highly subsidized meals, and travel expenses. They are also guaranteed employment after graduation. This employment, however, may pay very little; according to Professor Ko, vice president in charge of the graduate school, the average university staff member receives 68 yuan per month (about $47). Highest salary would be about $250 per month.

The university is under joint control of the Ministry of Education, which manages the graduate school staff, and the Ministry of Metallurgical Industries (MMI) which manages the research funds. Some funds are also obtained from the State Commission of Science and Technology. The university also works closely with the various research institutes.

At present there are seven faculties at the university, as follows:

- Mining and mineral engineering

This faculty deals with ore benefication, mining processes, etc.

- Ferrous process metallurgy

  Major interests are iron and steel making processes, separation processes, and innoculation. There are deposits containing Nb, Ti, V and rare-earth metals in Inner Mongolia. The metals are being separated by selective oxidation methods. The rare earths are under study for addition to ductile iron as a possible substitute or supplement to the use of magnesium. China has deposits of magnesium ore, incidentally, but is short of the electric power required for production of the metal.

- Materials

  Special interest is on mechanical working of metals (tubing, sheet, etc.), precision metallurgy (special magnetic and electric alloys including silicon steel) and powder metallurgy (tool steels, boron nitride, and boron carbide for tools, synthetic diamonds).

- Mechanical Engineering

  This faculty is concerned with metallurgical plant equipment product engineering and moving machinery (such as blowers). Rolling mills have been developed to produce foil two microns thick.

- Automation and Control Engineering

  The interests are computer engineering (software), instrumentation, and automation engineering.

- Mangement Science

  This is a new faculty starting September 1981. A B. S. degree in management science and engineering will be offered.

- Metal Physics and Chemistry

  This faculty, headed by Professor Ko, has three important departments; metal physics, physical chemistry, and corrosion science and engineering.

The Department of Metal Physics is headed by Professor Chi-mei Hsiao who was principal host. Dr. Hsiao, who did all his graduate work in the United States and was employed there also before returning to China in 1957, works in the fields of fracture toughness, hydrogen embrittlement and stress corrosion cracking. A list of recent papers in English, which Hsiao has authored or coauthored, is given below:

- "A new engineering fracture toughness parameter $K_{ISCC}(\rho)$," *Scripta Met.*, *13*, 1057, (1979).

- "Hydrogen induced delayed plasticity and cracking," *Scripta Met.*, *13*, 1063, (1979).

- "Mechanism of stress corrosion cracking of steels in H-S," *Corrosion*, *36*, 475, (1980).

- "Some new aspects of hydrogen damage," Invited paper, Third International Conference on Effects of Hydrogen on Behavior of Materials, August 1980, Wyoming, U.S.A.

- "Calculation of the pressure inside the hydrogen induced cracks in silicon single crystals," *Scripta Met.*, *15*, 97, (1981).

- "Mechanism of SCC and hydrogen induced delayed cracking," Paper presented in *ICF 5* (1981), Cannes, France.

- "The mechanism of hydrogen embrittlement and stress corrosion cracking of titanium alloys," Paper will be presented in 8th International Congress of Corrosion, Frankfurt, West Germany, September 1981.

- "Some contributions to the understanding of hydrogen induced cracking," Invited paper, will be presented at the Sino-American Metallurgical Conference, November 1981.

The work features several interesting techniques which have been used to produce data of great value in deducing hydrogen embrittlement mechanisms. For example, it has been observed directly that "hydrogen induced delayed plasticity and cracking" takes place at crack tips of metals under stress. This is shown to result from diffusible hydrogen, which accumulates in and enlarges the plastic zone. Similar direct observations on the lattice parameter of titanium containing 100 ppm hydrogen near the stressed crack tip have shown the enrichment of hydrogen, the precipitation of hydride, and the eventual cracking along the hydride-matrix interface. Observations of single crystals of silicon grown in hydrogen have permitted calculation of the pressure of hydrogen inside the cracks which form on annealing (by counting the prismatic dislocation loops generated).

Hsaio visualizes that the hydrogen accumulates in the region of high stress until platelet hydrogen clusters develop. These clusters are proposed to produce pressure which adds to the externally applied load and enhances local yielding. This variation of the old hydrogen pressure theory agrees with the observations of reversibility and, in general, with the ideas which Beachem of the Naval Research Laboratory published in 1972.,

A tour of the laboratory showed an assortment of testing, analytical, and metal processing equipment entirely adequate for good research.

CENTRAL IRON AND STEEL RESEARCH INSTITUTE - BEIJING

The work of this institute is similar in scope to the Beijing University of Iron and Steel Technology described above, but the applied and production aspects are stronger. The equipment is adequate for some production as well as research in melting, welding, and powder metallurgy. The laboratories are studded with examples of home-designed and built equipment; for example, a 36 roll strip mill capable of producing foil only 1 micron thick. Metal powder (superalloys, stainless steel, iron) are produced in quantity using an atomizing spray process with an argon atmosphere. Hot isostatic pressing equipment is also available.

Amorphous metals are melt-spun into foil up to eight inches wide. Current studies are with iron, nickel, and cobalt base alloys to achieve alloys with higher magnetic saturation or higher permeability. The variables under study are composition and temperature of melt, wheel velocity, and wheel temperature. The quality of the surface of the foil is assessed by x-ray structure determinations. The amorphous metals group had

five papers accepted for presentation at the August 1981 RQ-4 meeting in Sendai, Japan.

There is a rather large corrosion test laboratory with autoclaves to test the stress corrosion cracking of stainless steel in high purity water at temperatures to 350°C and pressure to 150 atmospheres. There is also a high temperature and pressure (350°C, 150 atm) water test loop. Stress corrosion tests on stainless steel are also being conducted in solutions containing salt and sulfuric acid. One test involves dripping saltwater onto a specimen at 400-500°C. Some of the test results on type 304 stainless steel indicate that the crack induction time in boiling magnesium chloride is shorter than potential-time curves would predict.

The corrosion group under Ms. Zhang Shuan was exceedingly interested in work which has been published by the Naval Research Laboratory. Well-worn copies of these papers were the basis for many questions to obtain the most detailed information from me.

The institute publishes about 200 technical papers each year. Some of these appear in the Chinese Society for Metals monthly technical publication *Iron and Steel*. In the April issue, for example, five of the 16 papers were authored by people from this institute. There are also issued internal reports. The annual report of the institute provides abstracts of the papers. The scope and nature of the work may be gleaned by examining the titles listed for the 1980 abstracts, as follows:

HIGH TEMPERATURE ALLOYS

- Study on degassing mechanisms of high chromium Fe-Ni-Cr alloy
- A study of zigzag grain boundary in a Ni-Cr-Co base high alloyed wrought superalloy
- Reason analysis of notch sensitivity for incoloy 901 alloy
- Superplasticity in hot extruded P/M In 100 superalloy
- The investigation of long-term structure and properties stability of hot corrosion resistant Ni-base alloy with high chromium content
- Develop of transpiration air cooled blade-skin part
- The effect of rare-earth cerium on the oxidation resistance of Ni-Cr-Cu alloy
- An effective method of elimination of superalloy casting defects by HIP
- Phases in a Ni-20Cr-20Co-20W superalloy
- The phase behaviour and its influence on the mechanical properties in certain Ni-Cr-Co base superalloy
- The rules of the phase composition and precipitate in hafnium-bearing alloys

MATERIAL OF POWDER METALLURGY

- The investigation of the second-reduction of sponge iron powder with converting natural gas

- FT15 P/M high speed steel and its application
- On the fracture toughness of cemented carbides
- Effect of contact angle on the properties of strip during iron powder rolling
- Homogenity of the properties in longitudinal direction of the nickel porous by strip powder rolling
- A phase transition of cermet during double overlapping
- The technology of metal powder rolling and its application
- A preliminary study of the additives and the pressureless sintering of some sialon materials
- An investigation of physical parameter drifting mechanism of metal filter
- Bending load-deflection curves in WC-Co cemented carbide
- An investigation on cemented carbides with micrograin and strengthened binding phase

REFRACTORY METALS

- The study of hot isostatic pressing of powder In-100 Superalloy (-)
- An investigation on erosion problem of tungsten base nozzles for solid properlant rocket motor
- The binder phase composition of non-magnetic WC-10%Ni cemented carbide containing small amout of Cr(Cr_3C_2) Mo(Mo_2C), or Ta(TaC)
- The influence of increasing reduction in area on the property of doped tungsten wire
- Application of the elastic niobium alloy in the earthquake logging detector
- The identity of tensile properties and fracture toughness K_{IC} of heavy alloy (95W-3.5Ni-1.5Fe) after vacuum treatment
- Hot isostatic pressing of cemented carbide parts for the superpressure valve
- Discussion about Ni70Mn25Co5 catalysis material and some related problems

CORROSION AND COATING OF METALS

- The study of corrosion resistance of steel plate for warship hulls
- Effect of sulphide and neat treatment on localized corrosion of steel in sea water
- The effect of continuous galvanizing process on the adhesion of zinc coating for rimmed and silicon killed copper-containing steel

- The coated-calorized lance pipe and the application of the heat-resistant paste "SBTZ"
- The suitability of tinplate with various passivation films for canned mushroom production
- The influence of sulfide inclusions on pitting corrosion resistance of 00Cr18Ni5Mo3Si2 duplex phase stainless steel
- Research on the SCC behavior of duplex stainless steel using metallographic-fractographic technique
- On thermodynamics of thinning the intermediate layer for silicon killed copper-containing steels in hot dip aluminizing
- An approach to the H-induced crack as a defect
- Niobium action on intergranular corrosion of high silicon austenitic stainless steels
- Phase stability of PSR-1 coating alloy during long service duration of coated exhaust valves
- The relationship between localized rust layer and corrosion resistance of a sea water corrosion resistant low-alloy steel

WELDING

- Initial study of high basic sintered fluxes -- the basicity strength of the fluxes and the diffusible hydrogen content of deposited metal
- Study on the TLP bonding of the superalloy K18
- Study on causes of "whiskers" formation in resistance spot and seam welding in superalloy sheets
- Structure transformation feature in weld heat affected zone and their effects on the properties of the Bi-phase stainless steel 00Cr18Ni5Mo3Si
- An approach on the indirect testing methods of reheat cracking of the steels for the pressure vessel
- An investigation of the behavior of the diffusion of the boron in the superalloy K18 TLP bonding
- Study on solidification cracking fractograph of chromium-nickel austenitic stainless steel weld metal
- Analysis of cracks formed in weld zone of stainless steel tubes and study on their fracture morphology
- Columnar crystals and solidification cracks in the welding ARC crater

- Equi-axed dendrites in the welding ARC crater

- Present state of investigations into welding cold cracking of low alloy high-strength steels abroad

- The segregation of the primary austenite grain boundaries in the weld semi-melted zone and its effect on the fracture toughness

REFRACTORY MATERIALS

- Research of anti-slags properties of $CaO.Cr_2O_3$ refractory

- One part of research for MHD channel electrodes material - the properties of $La_{(1-x)}Ca_xCrO_3$

- Research on the ceramic member for television picture tube

- Hot repair of steel making vessel lining by dry gunning

CHEMICAL ANALYSIS

- Determination of oxygen in oxygen-free copper

- ZKG-I automatic hollow cathode light source

- Determination of dissolved nitrogen and aluminum nitride with fine particle size in silicon steel by hydrogen hot extraction method

- The formation of the third liquid phase in the solvent extraction and the application in separation and analysis

- A study and application of 2, 2, 4 - trimethylpentyldiol - 1, 3 in extraction of trace amounts of boron

- Simultaneous determination of micro-amounts of bismuth, lead, cadmium and zinc in nickel-base alloys by differential pulse anodic stripping voltammetry

- Effect of interference elements and single standard summing technique for the steel and alloy in the direct reading spectral analysis

MECHANICS

- The experimental research of constant strain controlled low cycle fatigue of steels

- The effects of specimen sizes on the fatigue crack propagation rates in three constructional steel

- Determination of cyclic stress-strain curve and study for defining life of fracture

- Study of fatigue crack initiation life of steel 40CrNiMo under various notch configuration

- Evaluation of low cycle fatigue properties of the steel 5NiCrMoV
- Effect of surface working on fatigue strength of four refractory alloys
- The fatigue crack propagation characteristic of cast nickel-base alloys 543, 544 at room temperature
- Using compliance method to determine fatigue crack propagation rate of steel Gc-4 in multiple fatigue impact testing
- The effects of temperature and environment on the fatigue crack propagation rates in 645-III steel under low stress and the threshold stress intensity range
- Study of methods to determine specified limit of creep for several alloys
- Study of the effects for the four current types of Charpy impact testing machines with different parameters on the impact values

PHYSICAL PROPERTIES

- A new design of automatic bridge for measuring ac magnetic properties (Analog Section)
- A study of a laser-pulse method for measuring heat capacity of small samples
- Small angle x-ray scattering analysis of particle size distribution of ultrafine powders (II)
- A study on properties and structure of KARMA alloy for foil strain gauge
- The continuous flow method for determining surface area and pore-size distribution

EXPERIMENTAL METHODS

- A digital centralization control temperature apparatus of the autoclave
- Control computer-154 computer's improvement of analog signal input and analog signal output
- Quantitative microanalysis of the crystal powder with x-ray diffraction metal
- A comparative study quantitative crack detection using the nondestructive eddy current testing method-frequency variation (eddy current) method for measuring surface crack depth of metal
- A device for determination of the linear expansion of iron oxide pellet under reducing atmospheres and high-temperature
- A new pyrometer in temperature measurement of an opaque surface
- Improvement of high-temperature viscosity measurement for rotating viscometer

- A new quick-micro thermocouple for temperature below 1350°C type Wreu-2-603
- Application of cold-cathode ionization vacuum gauge and its development
- Interference analyses in controlling temperature system of the JDK-10 minicomputers
- Researching and making differential automation electrical potential titration
- X-ray phase identification "index identification phase list" by computer auto search match
- A computing program for J-integral value of fracture toughness

NONDESTRUCTING TESTING

- Melting point method for quality inspection of brazing
- Detectivity of nonmetal inclusions during ultrasonic flaw

EQUIPMENT FOR EXPERIMENT

- Analysis of some technical problems in making threaded-type super-pressure vessel of 400mm in diameter with inferior materials
- The relation between ball sizes and grinding efficiency in Szegvari altritor
- A new hot corrosion test equipment-salt shower apparatus

SAMPLE MAKING

- Cutting processes of the low machinability materials
- Influence of cutting and grinding on machined surface

METALLURGICAL PHYSICOCHEMISTRY

- Activities of niobium and oxygen in iron melt

GENERAL RESEARCH INSTITUTE FOR NONFERROUS METALS - BEIJING

This institute, under the Ministry of Metallurgical Industries, is concerned mostly with applied research on nonferrous and rare-earth metals. Unfortunately, I obtained little information on the organization of the institute. On tour I saw a Japanese high voltage (1 million volts) electron microscope, the only such microscope in China according to the host. It is being used to study semiconductors, superconductors, and metals and alloys. It is equipped for *in situ* tensile stress application and studies of crack propagation at both room and elevated temperatures. In particular, Mr. Li Yong-Hung has been using the

instrument to study crack-tip plastic zones in titanium.

The corrosion group of thirteen, headed by Madam Lo De-qin, is studying the corrosion of titanium, zirconium, and rare-earth metals. One alloy of interest is Ti-7Al-4Mo for use as an aeronautical material. The concern is the resistance to stress corrosion cracking. Beta titanium alloys are also being studied with respect to corrosion and hydrogen permeation.

The corrosion group is further investigating the mechanisms of weld "decay" in equipment for the chemical industry.

The aforementioned work of Professor C. Hsaio of Beijing University of Iron and Steel Technology is conducted in part at the General Research Institute for Nonferrous Metallurgy by graduate students Huang Xian-ya and a Mr. Ling. Huang has been studying the pH of aqueous solutions near the crack tip region of Ti-6Al-4V and other alloys, including pure Ti. Using an Sb microelectrode as well as indicators he has found a pH of 1.7 to 2.0 in each alloy.

Since the observations of crack propagation in the optical microscope indicated a discontinuous cracking mode, it has been concluded that the mechanism of stress corrosion crack growth in titanium alloys cannot be active path corrosion. Careful examination at the base of the precrack in specimens, however, shows a small amount of intergranular corrosion, which is attributed to the active path mechanism. It is concluded that active path corrosion initiates stress corrosion cracking in titanium alloys, but a pH of about 2.0 is quickly developed by this corrosion whereupon a hydrogen embrittlement mechanism takes over. This work will be presented at the Eighth International Corrosion Congress in Frankfurt West Germany in September 1981. The paper, by Chi-mei Hsiao, Xian-ya Huang, De-ming Wang, and Zu-fang Zhu is cited in the earlier list of Hsiao's publications.

Dr. Ling is studying hydrogen permeation in commercially pure titanium. The effects of environmental conditions such as pH, concentration of chloride ion, potential and tensile stress are under study. It is hoped to resolve questions such as whether hydrogen is necessary for sustained load cracking. No papers have yet been produced.

There is some interest in the work of D. Howe and R. Meussner at the Naval Research Laboratory on the superconducting composite, V_3Ga in Cu. According to researcher Zhou Li, there are only three institutes in the world actively working on this system. These are the Chinese institute, NRL, and the National Research Institute for Metals in Japan. The Chinese investigators are anxious to hear of any recent NRL work.

BEIJING METALLURGICAL RESEARCH INSTITUTE

This institute was founded in 1960 and serves under the Beijing municipal government for the purpose of promoting the development of Beijing. The institute combines research, development, and production activities and is provided with a profit incentive. There are 1300 people, of whom 200 are engineers, 30 are technicians, and the others are administrators or workers. Four researchers have been accepted for study abroad; one is at Arizona State University, one at the Max Planck Institute in West Germany, and two are at Tohoku University in Japan.

The production side of the institute produces 800 to 1000 tons per year of a number of products, as follows:

- Superalloy castings,
- Magnetic materials,
- Low expansion alloys (Invar, Kovar),
- Stainless steel,
- Catalysts,
- Synthetic diamonds.

Many of these products are processed into pipe, strip, wire, or bars. The products vary among some 2000 specifications.

The research areas closely support the products lines. There are apparently many projects on soft and hard magnetic alloys, low expansion alloys, bimetallic sheet, constant modulus alloys (elinvar), cast turbine blades, high damping capacity alloys (copper-manganese and cast iron), and constant frequency alloys (reasonant frequency is constant with temperature).

The laboratory is well-equipped with the magnetic and elastic measurement apparatus necessary for work on magnetic materials. These materials have been under study for 20 years, since the institute was founded. During the past few years amorphous magnetic alloys have been studied. Efforts have been toward the production of high magnetic permeability and high saturation induction. Typical investigations have been on the effect of silicon concentration on crystallization temperature, glass temperature, saturation induction and saturation magnetostriction of Fe-Ni-Si-B alloys and the effect of annealing on the saturation magnetostriction constants in zero-magnetostrictive amorphous alloys. A staff member, Wu-Shing Chang, also attended the RQ-4 conference in Sendai.

SHANGHAI RESEARCH INSTITUTE FOR METALS

An outline of The Shanghai Research Institute of Metallurgy of the Academia Sinica was presented by Dr. Wu Tzu-liang, Deputy Director and a Ph.D. graduate of Carnegie Mellon University in 1948. The institute was established in 1928 and now employs over 1100 people, 650 of whom are scientists or technicians. The activities are divided among eight divisions, as follows:

- Large integrated circuits,
- Magnetic bubbles, superconductors, hydrogen storage as metal hydrides,
- Ion implantation, ion milling, electron beam lithography, laser annealing,
- Compound semiconductors, materials and devices,
- Fundamental research in semiconductor and metal physics,
- Corrosion and protection,
- Analytical service, and
- Electronic instruments.

The institute appears to be very active on research in the above listed areas, but most of the work is published in China. According to Dr. Wu the page charges to publish in such journals as *Journal of Applied Physics* are a formidable obstacle. Some assistance on this could be a most cost effective benefit for the United States.

On a tour of the laboratory, some interesting work on fatigue was first seen, although such work does not clearly fit into the list of divisions above unless it is classed as metal physics. In any case, Huang Yu-Pu described work in collaboration with Ke, C. L., Hsuch, C. C., and Yao, Y.L., on the mechanism of fatigue overload retardation, utilizing

observations with the interference microscope. SEN specimens of Ti-5Al-2.5 Sn were used. It was concluded that the diffusion model of fatigue overload retardation proposed earlier by Huang is valid. The retardation relates to recovery from lattice defects introduced during overloading. Huang stated that the work was presented in 1980 to ASTM in Philadelphia and has been accepted for publication.

The laboratory has a modern surface analysis system purchased from France, which includes scanning Auger, SIMS, and LEED. It is being used to study surfaces of GaAs for solar cell applications, among other uses.

There is an interesting home-designed 200 kV ion implantation facility built in 1967, the first in China. Experiments to improve surface hardness and wear resistance indicate that ion plantation is not universally advantageous. Dr. E. A. Wolicki of NRL visited this facility in 1979 and reported in some detail in the ONR Tokyo *Scientific Bulletin 4* (4), 13, (1979). I personally saw no sign of the new 600 kV ion accelerator which Dr. Wolicki reported was scheduled for 1981 completion.

The institute has a small but very active corrosion laboratory composed of one man and two women. The head is Wu Di-fan. Current studies are on stress corrosion cracking and hydrogen embrittlement, diffusion and permeability, and strain rate effects. Interest is in steel, aluminum alloys, and titanium alloys for engineering applications in China.

As one example of the work of the corrosion group, there are efforts to develop a slow strain rate method of determining the paramater K_{1scc} which is ordinarily obtained with the cantilever beam test of B.F. Brown. A preliminary paper has been completed entitled, "Slow Strain Rate Loading Fracture Mechanics Method for Stress Corrosion Testing." Basically, stress-strain curves are obtained using a precracked specimen in a selected environment such as water. At some point there is crack initiation as determined by an acoustic emission monitor. By conducting these tests at a variety of strain rates the investigators have developed curves of crack initiation stress intensity (K_{1N}) versus strain rate. Three zones on these curves have been identified:

- a zone of high strain rate where $K_{1N}=K_{1C}$ and there is no dependence of K_{1N} on strain rate or environment,
- an intermediate strain rate zone where K_{1N} is dependent on environment and strain rate (K_{1N} is lower with slower strain rate and increased aggressiveness of environment) and,
- a slow strain rate zone where K_{1N} is independent of strain rate and equal to K_{1scc}. The value of K_{1scc} of course depends on the alloy and the environment.

According to the investigators, tests conducted in the third strain rate zone where K_{1N} equal K_{1scc} produces K_{1scc} values equivalent to those obtained with the cantilever beam test.

The investigators are continuing to study the interplay of stress, strain rate and hydrogen diffusion and permeation on stress corrosion. Studies of the effects of plastic strain during the stress corrosion test are beginning. Preliminary studies involve the stress corrosion of steels in H_2S; a solution of 5 percent NaCl and 0.5 percent acetic acid saturated with H_2S is used (a standard NACE solution). Tests are at constant load using tensile bar specimens. The findings indicate that the entrance of hydrogen causes plastic deformation at lower than yield stress. Thus, apparently, hydrogen sulfide causes cracking below yield stress by supplying hydrogen, and the mobile dislocations then carry hydrogen to the crack tip.

Another investigation is concerned with high-strength steel wire for prestressed concrete to be used in seawater. Precracked specimens are tested in a lime-saturated solution. It is intended to investigate the effects on K_{Iscc} of chloride ion concentration, sulphate ion concentration, pH and potential. To date there has been difficulty because the transverse precracks in the 5 mm diameter cold drawn wires tend to propagate in oblique directions.

A visit to the electrochemical laboratory revealed the usual apparatus for monitoring potential dynamics. This group is interested in the corrosion of stainless steel in seawater, including pitting and crevice corrosion, and is engaged in some alloy development. Two alloys were cited which have shown no corrosion during eight years exposure to seawater. These are:

- 0.05C, 20Cr, 9Ni, 4Mo, 2Cu, 3Si, N
- 0.08C, 20Cr, 9Ni, 3Mo, 3Si, Cu.

Tests have been conducted both in 3.5 percent saltwater and in natural seawater, with similar results.

SHANGHAI INSTITUTE OF CERAMICS

My principal host at the Shanghai Institute of Ceramics of the Academia Sinica was Deputy Director, Dr. Yin Chih-Wen. Dr. Yin studied at the University of Illinois during 1948 through 1950. Dr. Yin noted that the director of the institute, Dr. Yen, studied at the University of Illinois at the same time. The concentration of top leaders in the various scientific institutes, who studied prior to the "liberation" in English-speaking countries, facilitates understanding and communication and is a tribute to the quality of this education, at least as it was 30 years ago.

The institute employs about 1000 people, about half of whom are scientific and technical. There are six research divisions and two service divisions, as follows:

- Synthetic single crystals - electrooptic and acoustooptic
- Synthetics - diamond, quartz, and mica
- Special glasses - optical fiber, amorphous semiconductors, photochromatic glasses, vicor glasses
- Electronic ceramics - piezoelectric ceramics for transducers, transparent ferroelectric ceramics
- High temperature structural ceramics - Si_3N_4, SiC, Beta alumina
- Inorganic coatings - infrared spectrum selective absorption coatings, protective coatings for metals, plasma spray
- Chemical analysis
- Instrumentation

There are also workshops and pilot plants in existence. The institute is in part a business venture and sells various products; for example, electrodes for pH meters are sold in the United States.

A tour of the laboratory began with the optical fiber laboratory. The laboratory is studying attenuation in glass fiber over 1.7 kilometers. The investigators measure numerical aperture, distribution of refractive index, and pulse response. There is a nanosecond pulse generator.

A second laboratory is called the laboratory for frequency doubling. This doubling through second harmonic generation involves the application of barium sodium niobate (Ba_2 Na Nb_5 O_{15}). There are applications as green laser sources. Specific applications are as follows:

- Satellite laser communication
- Underwater application
  laser communication
  TV and ocean optics
- Medical and biological applications
  opthalmological instruments
  irradiation effects
- Holography

There is a large crystal growing laboratory engaged in both research and production. Some crystals of interest are summarized in the table below:

	Lead Molybdate	Bi Germanate	Bi Germanate	Bi Silicate
Formula	Pb Mo O_4	$Bi_{12}Ge$ O_{20}	Bi_4 Ge_3 O_{12}	Bi_{12} Si O_{20}
Property	Acoustooptic	Piezoelectric	Scintillatant	Electrooptic
Use	Acoustooptic deflector	Acoustic surface	Computerized	Real time electro-optic
	Acoustooptic modulator	wave (delay line)	Tomography	Image modulator

Other ceramic materials being produced are lead-lanthanum-zirconate titanate and lead-barium-sodium niobate. Such materials are useful for stereoscopic television, and high energy transducer materials. The latter utilizes the characteristic of low loss at high electric field and high temperature.

A paper entitled "Some New Piezoelectric Niobate Ceramic Materials" by Guo, Y.Y., *et al.* was presented at the 10th International Congress on Acoustics in Australia, July 1980. This paper summarizes the development of the lead-barium-sodium niobate ceramics described above.

SHANGHAI IRON AND STEEL RESEARCH INSTITUTE

This institute is the local institute for the Shanghai Bureau of Metallurgical Industries. Work is done on metallic materials processes and equipment. Most of the work is on iron and steel. There are thirteen research departments performing research on alloy steel, corrosion, precision alloys, refractory metals, high temperature alloys and powder metallurgy.

The 700 research and technical people at the institute produce products as well as research results, as most of the research institutes do. Research funds are obtained from the profits of production as well as sponsors from local industries and governmental offices. Project selection is agreed on by the Bureau of Metallurgical Industries, the local

industries and by the institute itself. I was told that technical exchanges with scientists in foreign countries have increased greatly in the last few years.

On a tour of the laboratories I saw a variety of venerable, or home-built equipment, or both. However, there is an excellent new 200 kV Hitachi electron microscope with all the accoutrements and a rather complete laboratory for the study of corrosion.

Current projects are on the mechanisms relating to the mechanical properties and creep of alloys. Corrosion studies are related to pitting, crevice and stress corrosion in austenitic stainless steel, ultra-high strength steel and titanium alloys. Cantilever beam, tensile and electrochemical data are obtained to study effects of environment (chloride ion) and the effects of alloying elements. For example, the effects of Ni and Mo on the crevice corrosion of Ti and Ti alloys is a current project.

One development of particular interest is the electroplating of amorphous metal coatings which are said to be particularly corrosion resistant to hydrochloric acid. The alloy is of Cr-Ni-P-Fe. The exact composition is not known. To this date only a few microns in thickness can be successfully applied.

The laboratory is quite active in producing and experimenting with amorphous metals. I was given a demonstration of the production of foils by melt spinning. They are studying the effects of composition on magnetic properties at this time.

There is no laser or electron beam melting or welding work in progress.

GENERAL IMPRESSIONS

My impression is that China has enormous potential in science and engineering. The people have keen minds and work hard. The fact that China has such a large population almost assures a very high capability among those selected to pursue a scientific career.

I left China with a feeling of deep gratitude for the opportunity to make the visit and to become acquainted with so many fine, brilliant Chinese people.

ELECTRICAL ENGINEERING RESEARCH AT THE NATIONAL DEFENSE ACADEMY OF JAPAN

Leon H. Fisher

THE NATIONAL DEFENSE ACADEMY OF JAPAN

Military schools in Japan were closed by the occupying forces at the end of World War II. The National Defense Academy (NDA) is a post-World War II institution established in 1953, originally as the National Safety Academy. Its name was changed to its present one in 1954. NDA is an institution which provides four years of education and training as one source of officers for the Japanese Self-Defense Forces (Ground, Maritime, and Air). Upon graduation, the cadets are appointed to the rank of Master Sergeant or Chief Petty Officer First Class as Officer Candidates and are required to enter one of the three Officer Candidate Schools maintained by the three branches of the Self-Defense Force. At these schools, they are integrated with other Officer Candidates from the enlisted ranks and civilian universities and are commissioned as officers one year after graduation from NDA. Officers must be provided to lead the 180,000-strong Ground Self-Defense Force, the 42,000-strong Maritime Self-Defense Force and the 45,000-strong Air Self-Defense Force. NDA also offers graduate work. NDA is administered by the Ministry of Defense and not by the Ministry of Education, Science, and Culture (MOE) as are all other educational institutions in Japan. For this reason, all degrees granted by NDA are known as "equivalent" degrees, i.e., equivalent B.S.'s or equivalent M.S.'s. However, the education curriculum of NDA conforms to an ordinance established by MOE known as the University Chartering Standards. The president of NDA is appointed by the Prime Minister.

NDA is located near Yokosuka, which is south of Tokyo on the Miura Peninsula. It is situated on top of a plateau 85 meters above sea level and covers an area of 155 acres. It commands a view of the hills of the Boso Peninsula, Tokyo Bay, and (in clear weather) of Mt. Fuji. The location and ambience are indeed spectacular. There are 30 major buildings on the campus. The campus and buildings are very well maintained. This is in sharp contrast to almost all Japanese universities.

Admission to the undergraduate school is by examination (university entrance examinations are the bane of all Japanese high school students) and is open to all Japanese male citizens who are either, (1) between the ages of 18 and 21 and are high school graduates or have equivalent training or, (2) between the ages of 18 and 23 and are on active duty with the Self-Defense Forces. The entrance examination consists of a written examination, personal interview, and physical examination. Five hundred and thirty men are admitted to the undergraduate school each year, 300 for the Ground Force, 100 for the Maritime Force and 130 for the Air Force. Association with a particular branch of the Self-Defense Force is made at the end of the first year of study. About one candidate in ten is accepted.

On entering the academy, each cadet must take the following oath: "I do hereby swear that, with a full understanding of the honor and responsibility of the cadet of the National Defense Academy, I will obey the Constitution of Japan, laws and ordinances together with the regulations of the Academy, cultivate my character, respect the personality of others, train my body and mind, enrich my knowledge in every field and concentrate all my energy to work without any concern for, and participation in, any political activities." The cadets are admonished "to be gentle citizens with scientific

backgrounds" and "to be a gentleman first with a highly scientific background before being a militarist."

The graduate program is in science and engineering and is designed to train and educate officers who have graduated from NDA. Other officers as well as civilian officials working with the National Defense Agency who have bachelor degrees may also enter the graduate program. About 90 students are admitted to the graduate program each year and two years are required for the completion of the (equivalent) master's degree. Graduate training leading to the Ph.D. is also available, but the degree must be granted by a civilian university. Years ago, when Ph.D. work was first offered at NDA, as many as 20 officers enrolled in the program. Recently, the numbers have been decreasing and now most officers who wish to pursue the Ph.D. degree do so abroad.

NDA has the following departments:

- Aeronautical Engineering,
- Applied Physics,
- Chemistry,
- Civil Engineering,
- Electrical Engineering,
- Liberal Arts,
- Mathematics and Physics,
- Mechanical Engineering,
- Physical Education,
- Social Sciences,
- Ground Defense Science,
- Maritime Defense Science,
- Air Defense Science.

Those departments which carry out research receive funds for this purpose from the Ministry of Defense without any specification about what subjects will be pursued.

During the second year of undergraduate work, cadets are classified on the basis of their wishes and academic performance into groups majoring in:

- Aeronautical Engineering,
- Applied Chemistry,
- Applied Physics,
- Civil Engineering,
- Electrical Engineering,
- International Relations,
- Management Science,
- Mechanical Engineering.

All undergraduates must take general education courses in the humanities, social sciences, natural sciences, as well as in foreign languages and physical education. Academy graduates are qualified to enter graduate programs in civilian universities. The following table shows the number of cadets in each major for each of the three arms of the Self-Defense Forces. The numbers are for one entering class and should be multiplied by four to obtain the total number of majors at any one time. Eighty five percent of the majors are in engineering and fifteen percent are in the social sciences.

	Aerontl Engr	Appl Chem	Appl Phys	Civ Engr	Elec Engr	Int Rel	Mgmt Sci	Mech Engr
Ground Force	12	21	30	32	79	23	24	79
Maritime Force	15	5	10	0	30	5	5	30
Air Force	36	5	18	3	33	7	6	22

Two hours of basic training are given each week during the school term. In addition, cadets are required to undergo a six-week training course each year. Athletic and cultural clubs are available as extracurricular activities. Such clubs include flower arranging (ikebana) and the tea ceremony.

I visited the cadet dormitories and was very impressed with the arrangements for study.

THE NDA DEPARTMENT OF ELECTRICAL ENGINEERING

The Department of Electrical Engineering is at present one of the largest in the Academy in terms of number of faculty and staff (17 professors, 11 associate professors and eight lecturers) and one of the most active in research. The Department has already graduated 3000 cadets with (equivalent) B.S. degrees and 300 officers and officials with (equivalent) M.S. degrees. The remainder of this report touches on the work of a few faculty members in the department.

One group (koza) consisting of R. Fujimoto (Professor), S. Kashiwabara (Lecturer) and Dr. K. Watanabe is entitled, "Electrical Engineering Applications." Some of this group's activities are now briefly described.

- High pressure CO_2, rare-gas-monohalide excimers (KrF, XeF and ArF) and atomic fluorine pulsed lasers have been preionized with 6 μs pulses of 40 kV x rays. This procedure has been found to produce uniform preionization.

- An $H_2(D_2)/F_2$ chemical laser was initiated with a novel teflon surface ultraviolet flash. This work was reported in the May 1980 issue of the *Journal of Applied Physics* and in the November 1980 issue of the *Japanese Journal of Applied Physics*.

- Application of electron beams to surface processing of metals.

- Laser induced plasmas.

- Development of 1.3 μm laser devices for optical fiber studies.

- CW chemically pumped iodine laser.

- Pulse mode plasma recombination laser using metal vapors.

Professor Y. Murooka, my host during my visit to NDA, holds two doctoral degrees; a D. Engr. in electrical engineering from Tohoku University, and a Ph.D. from the University

of Liverpool obtained in 1968, also in electrical engineering. His work at Tohoku was on prebreakdown phenomena in liquids using a bubble chamber and at Liverpool he worked with Edels on arc recovery and electrical breakdown phenomena in gases at elevated electrode temperatures. Murooka has also made Lichtenberg figure observations of nanosecond surface discharge phenomena and has studied one to three meter long gap spark breakdown between rod electrodes in gases. His present interest is in identifying the nature of charge carriers when high voltages are applied to electrodes in cryogenic liquids using modified Schlieren techniques which he developed. He has recently (1980) published a paper (in Japanese) "Optical Study of Prebreakdown Phenomena in Liquefied Nitrogen," in which the relation between Schlieren photographs and current profiles were investigated. Murooka has published extensively and recently in the *Journal of Applied Physics* on Schlieren techniques as a tool for studying the development of prebreakdown currents in liquids. In such studies, the source of initial electrons is field emission from a sharp cathode. Murooka presented a paper on this material in July 1981 at the Seventh International Conference on Conduction and Breakdown in Dielectric Liquids which was held in West Berlin. (The interest in Japan in the properties of dielectric liquids is illustrated by the fact that Japan contributed 18 percent of the papers to this conference, more than any other country). Murooka has translated L. Brillouin's book on relativity, *Relativity Reexamined*, into Japanese. It has sold over 20,000 copies. Murooka has just been joined by K. Hidaka who recently received his Ph.D. in electrical engineering from the University of Tokyo on a method of measuring electric fields by a Pockels device with applications to observations of gaseous electronics phenomena.

Professor F. Okada is chairman of the department and works on solid state microwave devices. His laboratory contains many kinds of modern microwave measuring equipment including high-power devices. He presented a paper, "High-power Circulators for Industrial Processing Systems" at the 1981 International Magnetic Conference in Grenoble and another, "Nondestructive Measurement of Microwave Ferrite Magnetic Properties in A Ferrite Disk for High-power Circulator" at the Conference on Precision Electromagnetic Measurements held at Braunschweig in 1980. In 1978, he published two papers in the *IEEE Transactions on Microwave Theory and Techniques*, "YIG Resonator Circuit with Isolator Property and Its Application to a Gunn Diode Oscillator" and "Design of a High-power CW Y-Junction Waveguide Circulator."

Professor T. Saegusa is interested in analog and digital measurement of electric power, phase, and dielectric loss. He published two papers in the *IEEE Transactions on Instrumentation and Measurement*, "Digital Phase Meter Using Relative Counting A/D Conversion System" and "Wide Band tan δ Meter using Phase Comparison System" in 1978 and 1980 respectively. He has also published several papers, one in 1979 and the other in 1980, on using electrical methods for studying the deterioration of painted films on the bottom of ships.

Associate Professor H. Sato is working on three projects. One is on the application of lasers to medicine. Work is underway to analyze blood using an argon ion laser at 0.5017 μm. The reflectance of blood subject to magnetic fields of 3 kilogauss gives good information on whether the blood sample is malignant or benign. There are indications that this technique may lead to the early detection of gastric cancers. A second project is related to measuring the line shape parameters of CO_2 lasers. A third project relates to the shortening of mode-locked pulses from a 3.39 μm He-Ne laser by using an absorptive resonant medium inside the cavity. The titles of some publications give an idea of the kinds of work that have been carried out.

- Output Power and Frequency-pulling in a Partially Homogeneously Broadened, Saturated Single-mode Ring Laser: Analytical Formulas

- Photoelectric Evaluation of a Photovoltaic Detector for a Gaussian Incident Pulse

- Pulse Propagation in a High-gain Laser Amplifier: Pulse Waveform and Saturation

- Waveform Analysis of a Self-mode-locked Laser Pulse

- Pulse Propagation Method for Line-shape Parameter Analysis in a Slightly-saturated Laser Amplifier: Application to the Xenon 3.5 μm Line

- A Calibration Method of a Distorted Optical Short-pulse through a Detector

- Propagation of a Quasi-Gaussian Pulse in a Partially Homogeneously Broadened Gas Laser Amplifier: Effects of a Quasi-Gaussian Pulse on Line-shape Parameter Analysis

- Resonant-pulse Propagation Method for Line-shape Parameters Analysis

- An Application of $Pb(Zr,Ti)O_3$ Ceramics to Opto-Electronic Devices

- Reflection-type Electrically Controllable Diffraction Grating and Its Application to Intracavity Laser Modulation

Professor Y. Yasuoka works on metal oxide metal point contact diodes for detection of infrared radiation. These devices have a 10^{-14} second response time and are linear. An alcohol laser designed to operate at 118 μm will be used to study thin film MOM structure. Two papers published in 1980 on point contacts were entitled:

- Barrier Parameters of Tungsten-Nickel Point Contact Diodes

- Mechanism and Properties of Point Contact W-Ni Diode Detectors at 10.6 μm.

These papers appeared in the *Japanese Journal of Applied Physics*. In 1979 and 1980, the following papers,

- Film Thickness Dependence of Mobility in Deposited Tellurium Films,

- Tellurium Thin-film Field-effect Transistor Deposited on TGS Crystal,

appeared in the same journal. Yasuoka has spent time at the Department of Electrical Engineering and Computer Sciences at the University of California, Berkeley and has published several papers with T. K. Gustafson of that department.

It would be interesting to compare the research activities of our American military academies with that of NDA.

In the above, I have only mentioned one author per paper. All of these papers had multiple authors.

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PHYSICS AND ENGINEERING AT THE NATIONAL UNIVERSITY OF SINGAPORE

Leon H. Fisher

THE REPUBLIC OF SINGAPORE

Prior to World War II, Singapore had been administered at different times as a part of various British Crown Colonies, but in 1946 it became a Crown Colony on its own. Singapore became self-governing in 1959 as a member of the British Commonwealth of Nations. However, Singapore joined the Federation of Malaysia on its formation in 1963, but withdrew from the Federation in 1965. Since then, it has been an independent state, namely, the Republic of Singapore. In this article, the term Singapore will be used synonymously with the term Republic of Singapore.

Singapore is a thriving metropolis of about 2.4 million people. It is 130 kilometers north of the equator at the extremity of the Malay Peninsula. It has a land area of 616 square kilometers and consists of a main island constituting 92 percent of the total area, and of 62 small islands constituting eight percent of the total area. Urban Singapore has an area of about 130 square kilometers, but the most densely populated area, the Central Area, is less than nine square kilometers. The main island is connected by a short causeway to Malaysia over Johore Strait. Many people who work in Singapore commute daily from Malaysia.

UNIVERSITY EDUCATION IN SINGAPORE

The organization of university work in Singapore is intimately connected with the complicated history of Singapore, as well as with the fact that four official languages are recognized (English, Mandarin, Malay, and Tamil) and the fact that 98 percent of the population has the following ancestry: 76 percent Chinese, 15 percent Malay, and seven percent Indian (this includes those of Pakistani, Sri Lanki, and Bangladesh ancestry as well). English is the language most commonly used in business and in the civil service. Singapore has no compulsory education laws at any level. In Singapore, pre-university education lasts six years in elementary school, four years in middle school, and two years in high school. Students may elect any of the four official languages as the medium of instruction. Bilingualism is emphasized, but the second language need not be English. It may be one of the other three official languages or it may be French, Japanese, or German. For students who have had ten years in Chinese elementary and middle schools, high school training is extended to three years in order for such students to achieve competence in English. Undergraduate university training in Singapore usually lasts three years. There are exceptions. For example, the B.Sc. degree with honors in science requires a fourth year of study after the B.Sc. and the B.Engr. requires four years of study.

As of July 1980, there were two universities in Singapore both publicly supported. These were the University of Singapore, located on three campuses; Bukit Timah (90 acres) in urban Singapore, Kent Ridge (370 acres) in western Singapore, and the Medical School at Sepoy Lines (located on the grounds of the Singapore General Hospital); and Nanyang University located at Jurong (500 acres) in western Singapore. In addition to Bukit Timah serving as one of the University of Singapore campuses, it has also served, since 1978, as a Joint Campus of the two universities. This Joint Campus was set up to promote closer ties between the two universities, and to assist Nanyang University in its objective of becoming totally an English-medium institution. At the Joint Campus, students of Arts, Social Sciences, Science, Accountancy and Business Administration of the two Universities

studied together, were taught by the same instructors, and were examined by the same internal and external examiners.

These two institutions, the University of Singapore and Nanyang University, no longer exist and on their demise were immediately superseded by a single institution, the National University of Singapore (NUS), an amalgamation of the two previous universities, at which all instruction is in English. NUS took over all the campuses of the University of Singapore. Kent Ridge is already the main campus of NUS, and additional moves from the Bukit Timah campus to Kent Ridge are continuing. By 1985, the Bukit Timah campus and the Sepoy Lines campus will be given up and the entire university will be housed at Kent Ridge. At the time of the merger, Kent Ridge already housed a major part of the University of Singapore such as Engineering, Arts and Social Sciences, Biological Sciences, the Central Library, the University Computing Center, Administration, etc. Engineering has been occupying buildings and providing instruction at Kent Ridge since 1977. Kent Ridge was originally planned for a student population of 7500 and later the number was modified to 9000, the present size of the NUS student body. The physical capacity of the campus will be further expanded to accommodate about 13,000 students by 1985 and about 15,000 students by 1990. It is hoped that a Science City will eventually be developed near Kent Ridge.

The University of Singapore had the following history. The Straits Settlements and Federated Malay States Government Medical School was established in Singapore in 1905, and eventually was renamed the King Edward VII College of Medicine. This institution merged in 1949 with Raffles College, which was opened in 1929 to provide instruction in Arts and Science, to form the University of Malaya. In 1959, two autonomous divisions of equal status of the University of Malaya were established, one the already existing institution in Singapore, and was named the University of Malaya in Singapore and the other, the University of Malaya in Kuala Lumpur. The former institution became the University of Singapore in 1962. English had been the language of instruction at the University of Singapore and at all of its antecedents. However, graduate theses written in Chinese were accepted in a number of disciplines. At the time of the formation of NUS, the University of Singapore had about 6700 students. Enrollment at the University of Singapore had been limited by the government.

Nanyang University was set up as a private university by Chinese businessmen to provide education in Singapore for students who wanted to be educated using Mandarin as the medium of instruction, and began offering instruction in 1956. It gradually received government support, and became completely government supported in 1965. However, it was not until 1968 that degrees from Nanyang University were fully recognized by the Government of Singapore. Until about 1970, over 90 percent of the instruction was conducted in Mandarin but around 1970 the percentage changed to 50 percent Mandarin and 50 percent English. During the last three years of its existence, 80 percent of the instruction was conducted in English and 20 percent in Chinese. It had been felt that the standards at Nanyang University were not high. Very few employers wanted to hire Nanyang University graduates. Perhaps the reluctance to employ Nanyang University graduates was due to their poor ability to use English; perhaps there were some elements of discrimination involved. At any rate, fewer and fewer students chose to enroll at Nanyang University despite the fact that in an attempt to solve this problem, the Joint Campus of the University of Singapore and Nanyang University had been set up. Another factor in the declining enrollment at Nanyang University was a declining number of Chinese secondary schools in Singapore. At the time of the merger, Nanyang had an enrollment of about 1600. The campus of Nanyang University, with new buildings under construction, is to become the campus of the Nanyang Technological Institute (NTI). NTI is initially to be a

part of NUS and is to be a completely different type of institution from Nanyang University. NTI will be discussed later in this report.

All of the faculty and students at the University of Singapore and Nanyang University were transferred to NUS, where, as already stated, the instruction is completely in English. At the opening of NUS, as was also indicated earlier, there were about 9000 students, about 3900 were women. About 450 students were involved in postbaccalaureate work. Special attention is being given to those students from Nanyang University who are having difficulty in making the transition. Such students are being allowed to take examinations a second and even a third time.

Before the formation of the Republic of Singapore, about 25 percent of the enrollment at the University of Singapore consisted of regional students, not from Singapore. After the separation of Singapore from the Federation of Malaysia, the percentage of regional students fell to five percent. Singapore is anxious for regional students to attend NUS, and it is presently planned to eventually increase the percentage of such students attending the University to 20 percent. As one measure to bring this about, students from Malaysia seeking admission to NUS are being allowed to take an entrance examination conducted wholly in the Malay language with the examination being offered in Penang, Kuala Lumpur, as well as in Singapore. This is the Higher School Certificate Examination conducted by the Malaysian Examination Syndicate. The usual entrance examination is one of the Singapore-Cambridge General Certificates of Education which need not be taken in English. Entrance examinations may also be taken in Chinese. However, students taking entrance examinations not conducted in English must also pass a written English language proficiency test. Admission standards are higher for Malaysian students than for students from Singapore. The university is having difficulty in obtaining qualified Indonesian, Filipino, and Thai students. Such students often have difficulty, and students in the university are divided into English and non-English streams. These two streams may follow studies at different levels of difficulty. A number of Indonesian, and Indonesian-Chinese, send their children to secondary schools in Singapore. If such students do well in their studies, they are able to enter the university. Why the University of Singapore is anxious for such regional students to enroll is not clear since the number of available spaces at the university, by western standards, is miniscule for the population of Singapore. Perhaps there is a hope that a good number of such educated people would choose to stay in Singapore for a number of years, or perhaps even permanently. In fact, all students, both Singaporean and foreign, who attend NUS must be bonded to ensure that they work in Singapore, or for a Singaporean employer, for three years on completion of their courses if they pay only the normal tuition fees. The Government of Singapore subsidizes a student's education by $700 (U.S.) to $9,500 (U.S.) per annum, depending on the course of study.

NUS has eight Faculties:

-Accountancy and Business Administration,
-Architecture and Building,
-Arts and Social Sciences,
-Dentistry,
-Engineering,
-Law,
-Medicine, and
-Science.

One should mention the existence of two other government supported institutions of higher education, the Ngee Ann Technical College founded in 1963 and which has an enrollment of about 2,000, and the Singapore Polytechnic founded in 1954 with UNESCO funds and which has about 4000 full-time and about 3000 part-time students. These two schools are two or two and one-half year type institutions which offer diplomas, but no degrees. Ngee Ann Technical College, originally established as a private institution, provided instruction in Mandarin in the '60s but changed to English in the '70s. Ngee Ann was originally established as a private institution. Singapore Polytechnic has always provided instruction in English and has been publicly supported from the beginning. As will be discussed later, Singapore Polytechnic was very closely involved with the initiation of university-level engineering training in Singapore.

ENGINEERING AT NUS

Professional engineering education started in Singapore on the Singapore campus of the University of Malaya; this occurred in 1956. However, the department of engineering of the Singapore campus of the University of Malaya was transferred to Kuala Lumpur in 1958. Simultaneously with this transfer, a four year professional engineering diploma program was established at the Singapore Polytechnic. In 1964, this diploma course was superseded by the establishment of a four year Bachelor of Engineering program by which students at the Singapore Polytechnic could receive training at the Polytechnic, but receive their degrees from the University of Singapore. In 1969, a Faculty of Engineering was established at the University of Singapore and engineering students no longer enrolled at the Polytechnic, but enrolled directly in the University of Singapore. However, engineering instruction continued to be carried out on the campus of the Singapore Polytechnic (with University of Singapore faculty) until 1977, at which time it was moved to Kent Ridge, the site which was to eventually become the main campus of NUS. About 2000 engineering degree graduates have been trained by the Faculty of Engineering of the University of Singapore.

At present, there are about 1400 students in Engineering at NUS (Nanyang University did not offer engineering). NUS is continuing a plan of the University of Singapore for a large expansion in engineering enrollment, and is eventually planning to admit about 1000 engineering students each year. This is about a threefold expansion over the present admission number, and is to relieve the severe shortage of Singapore-trained engineers in Singapore. There is also an expressed desire to reduce the considerable number of expatriate engineers in Singapore on work permits. The government feels that its intention to develop Singapore into an advanced industrial society will lead to an increased demand for local engineers in both the public and the private sector. Many government officials of Singapore have been technically trained, and have a strong commitment to technology. This has led to the feeling that engineers make good administrators and managers. In the civil service, engineering graduates are among the most rapidly promoted. A survey has shown that over fifty percent of engineers in Singapore are in management positions. This emphasis on engineering and rapid expansion in engineering enrollments is not finding a parallel in nonscientific and nonengineering curricula in the university. It has also led to having a heavy program of management studies in the engineering curriculum. To allow this to occur, about two years ago it was decided to devote less time to physics and chemistry, and to restrict studies in these two subjects to only those topics which are considered "essential" for an engineer. Also about two years ago, the teaching of physics and chemistry to engineers was removed from the Faculty of Science and given to the Faculty of Engineering, a threat often made by engineering faculty in the United States but virtually never carried out. At the present time, all engineering students, except those in chemical engineering, only take one course involving physics (or chemistry), and it is given

in the first year and is called "Physics and Chemistry." Chemical engineering students take instead a course during the first year entitled "Chemistry and Physics." In both cases, these courses are one out of seven which the students must take during the first year.

There are five departments in the Faculty of Engineering. They are listed along with the number of faculty:

-Chemical Engineering (9),
-Civil Engineering (23),
-Electrical Engineering (27),
-Industrial and Systems Engineering (4), and
-Mechanical and Production Engineering (28).

At the present time, all engineering students take the same courses (with a few exceptions such as chemical engineering students taking "Chemistry with Physics" instead of "Physics with Chemistry".) However, when the expansion in engineering enrollment takes place, about 700 of the 1000 engineering students to be admitted annually will, after the completion of the first year of study, go to NTI to finish their studies in three additional years, after which they will receive their degrees from NUS. This four year course at NUS/NTI is designed for "practice-oriented engineers." The Faculty of Engineering of NUS will train the 300 remaining "academic-research" type of engineers. By 1990, NTI will become a fully independent technological university and will grant its own degrees. It is stated that NTI will be modelled after the Massachusetts Institute of Technology, an institution that hardly limits itself to "practical types."

The Faculty of Engineering also offers graduate work leading to master's and doctoral degrees.

The Faculty of Engineering of NUS has a joint program with Japan, and the Japanese are involved in setting up a computing school in NUS. Computing has up to now not been emphasized by NUS or its predecessors. University computing facilities were introduced into Singapore in 1968 when an IBM 1130 computer was donated by the Ford Foundation to strengthen teaching and research in engineering in Singapore. This computer was housed at the Singapore Polytechnic. At present, there is an HP 3000 system (with a CPU with main storage capacity of two million characters and 28 interactive terminals) at the University Computer Center (on the Kent Ridge campus) and an HP 1000 system on the Bukit Timah campus. The HP 1000 is optimized for scientific computations, and is linked to the HP 3000 so as to allow the full capabilities of the HP 3000 to be accessible to HP 1000 users. At the time of my visit, plans were underway for the installation of a new mainframe computer with a CPU with four million characters of main storage with 50 interactive terminals.

THE PHYSICS DEPARTMENT AT NUS

The Physics Department at NUS is housed in the Faculty of Science along with the following other departments:

-Anatomy,
-Biochemistry,
-Botany,
-Chemistry,
-Economics and Statistics,
-Mathematics,

-Microbiology,
-Pharmacy,
-Physiology, and
-Zoology.

There is immense expansion taking place in the physics department. At the time of my visit, the physics department occupied a huge building on the Bukit Timah campus. A new physics building was being constructed on the new campus at Kent Ridge. The move to Kent Ridge by the physics department occurred in the middle of 1981. The present faculty of 30 (28 men and two women) will be expanded to 50. All but two of the present faculty have doctoral degrees. I wonder if there is another academic institution in the world which is presently planning to expand its faculty in physics by 70 percent. Every six years, every university faculty member is given study leave. Usually, physicists choose the United States as the place for study (England is too expensive). The physics department is planning to introduce a plan whereby there will always be an outstanding visitor from abroad in residence. The term would be for one, two, or three years.

The student faculty ratio, at present, in physics is 16 to 1, but it is hoped to bring it down to 10 to 1. Physics is envious of the 4 to 1 student faculty ratio which obtains in the Faculty of Medicine. Research is beginning to be encouraged in the physics department, and it is hoped that it will become the expected norm. Up to now there have been no funds for research in physics, but small research grants are now available from the government. Nevertheless M.Sc. and Ph.D. degrees in physics are offered, but only an occasional degree is granted at the present time. There are no formal physics graduate courses.

The Faculty of Science admits about 1000 students each year. At the present time there are about 1300 students taking courses in the physics department; 600, 400, and 250-300 students are enrolled in first, second, and third year physics courses, respectively. (As previously mentioned, engineering students receive their instruction in physics in the Faculty of Engineering). After the first year, students may elect to study applied physics in their last two years. Usually, there are about 70 to 100 students in the fourth year leading to a B.Sc. with honors degree in physics. During the fourth year, only physics is studied. (Only one additional year beyond the B.Sc. with honors is generally required for obtaining the M.Sc. degree in physics.) Facilities are available for 80 or more such fourth year students but qualified candidates could not be found. External examiners are used throughout the university, and are selected from universities in the British Commonwealth and in the U.S. External honors degree examiners in physics come every two years. Third year and honors examinations in physics are sent abroad for evaluation every three years. The last two external examiners in physics were John B. Hasted of Birkbeck College, University of London, and Sir Ernest Titterton of the Australian National University (Titterton has been a frequent external examiner for Singapore University). Despite this external monitoring, the chairman of the physics department told me that it is very difficult to encourage creativity among students and that learning is mostly by rote. One third of the graduates in physics become school teachers and the rest go into industry. The pay structure for teachers in Singapore is being improved because education is felt to be important for economic development.

The chairman of the physics department is A. Rajaratnam. He received his doctoral degree working with W.R.S. Garton at University College, London, in the mid-50s. He measured the intensities and widths of absorption lines in cadmium for states which have sufficiently high energies for auto-ionization. I had met Rajaratnam at the International Conference on Ionized Gases in Venice in 1957. He is presently pursuing work relating to

the absorption of radiation by water vapor in the atmosphere. He takes advantage of the equivalent of the five cm of liquid water in the vertical atmosphere and the 150 cm equivalent of liquid water when observing the sun in the late afternoon. He has found a few hundred rotational absorption lines which had not been observed before, and has identified the transitions. The amount of water vapor in the absorption path is fairly constant, but the radiation intensity changes very rapidly. Therefore, short exposures of five minutes duration must be made. Intensity measurements have also been made but, as yet, oscillator strengths have not been obtained. There are five major water vapor absorption bands between 0.7 and 2 μm. Rajaratnam's work is being carried out between 0.7 and 2.4 μm with a relatively low resolution of 5.5 Å/mm and with a higher resolution of 1 Å/mm between 0.4 and 0.65 μm. The low resolution work is extending Howard's work at the Air Force Research Center Laboratory. Plans are underway to examine the absorption of water vapor in the 10 μm region and absorption due to the water dimer will be looked for.

Another faculty member that I had met previously is P. P. Ong. He was a student of J. B. Hasted (as noted, Hasted is the most recent external examiner in physics at NUS) on low energy ion-neutral cross section measurements of interest in aeronomy. At present, Ong is studying negative ions formed in a CO_2 discharge. Ions such as O^-, CO_3^- and CO^- forming a beam leaving a drift tube are cross-fired with laser radiation in order to study photodissociation or photodetachment of the ions.

The following other activities and/or equipment are to be found in the department:

- a plasma physics confinement experiment,
- CO_2 laser development is underway for correlation spectroscopy studies,
- an argon ion laser for carrying out Raman spectroscopy,
- optical polishing facilities for making Fabry Perots with zero expansion glass,
- a (D,T) neutron source using a 100 kV accelerator,
- a 2.5 MeV High Voltage van de Graaff accelerator,
- a 300 kV supply for nondestructive testing,
- a 60 kV X-ray source for crystallography, and
- vacuum evaporation facilities for making thin films.

The department has well-equipped machine shops and has its own liquid nitrogen plant.

One can say that the research activities in the department are centered around the fields of ionic physics, atmospheric physics, plasma physics, nuclear physics, atomic and molecular spectroscopy, irradiation techniques, solid state studies, solar radiation, remote sensing, nondestructive testing and high energy physics. One can obtain a more detailed picture of research activities from the following list of recent publications originating in the department.

- Y. J. Chong, "Transmission Characteristics of the Atmosphere," *Bulletin of the Institute of Physics*, Malaysia, *1*, pp. 182-184.

- C. K. Chew, D. Kiang, and K. K. Phua, "Particle Ratios of Jets and Quark Statistics," *Physical Review D*, Volume *21* p. 2525.

- C. K. Chew, H. B. Low, S. Y. Lo, and K. K. Phua, "Particle Ratios, Quarks and Chao-Yang Statistics," *Journal of Physics* G, *6*, p. 17.

- Y. J. Chong, A. C. Yeo, V. K. Vong, and B. C. Chew, "Unsupervised Classification of Landsat MSS Data," Proceedings of the First Asian Conference on Remote Sensing, pp. E-2, Japan-Asian Conference on Remote Sensing Secretariat.

- Y. J. Chong, A. C. Yeo, and T. Y. Liang, "Remote Sensing Activities in Singapore," Proceedings of the First Asian Conference on Remote Sensing, p. N-5, Japan-Asian Sensing Secretariat.

- P. P. Ong (with J. B. Hasted, D. Mathur, and M. H. Khatri), "Energy Distribution of Drifting Ions" (in Abstracts of Twelfth British National Atomic and Molecular Physics Conference, Oxford, 26-28 March 1980, p. T9.

- W. C. Kok, "Series Representation of the Percus-Yevick Pair Correlation Function g(r) of a Hard-sphere Fluid," *Physics Letters A, 78A*, p. 273.

- T. Y. Liang, "Computer Processing of Landsat Imagery of the Sea," M. Sc. thesis.

- B. T. G. Tan, "Developing Noise Criteria for Singapore," Proceedings of Seminar on Noise: Problems and Control, p. 48.

- B. T. G. Tan, "Hardware and Software Equivalence," *International Journal of Electronics, 47*, p. 621.

- K. T. Lua and A. Rajaratnam, "Energy Sum Rules Derived from the First Order Watson Equation for Assymetric Rotors," to be published in the *Journal of Molecular Spectroscopy*.

- A. Rajaratnam and K. T. Lua, "Telluric Spectra from 4647Å to 6036Å in a Humid Atmosphere," to be published in the *Journal of the Optical Society of America*.

- A. Rajaratnam and K. T. Lua, "Absorption of Solar Radiation by Atmospheric Minor Gases," Fourth Pacific Science Inter-Congress, 1-5 September 1981, Singapore.

Some of the other faculty members in the physics department besides Rajaratnam and Ong, along with the institutions at which they received the doctoral degree follows:

Associate Professors

A.C.Y. Joo, Ph.D. London,
L.Y. Kuo, Ph.D. Melbourne,
Y.C. Teck, D. Phil Sussex,

Senior Lecturers

C .C Kee, Ph.D. McGill,
C.M. Fatt, Ph.D. New South Wales,
S. Kisdnasamy, Ph.D. Durham,
K.C. Jin, Ph.D. Boston,
K.W. Choo, Ph.D. Cambridge,
N.S. Choon, Ph.D. McMasters,
P.P. Poo, Ph.D. London,
P.K. Khoo, Ph.D. Birmingham,
S.H. Kee, Ph.D. Notre Dame,
S.H. Kok, Ph.D. Columbia,
T.K. Lee, D.Phil. Oxford,
B.T.T. Gie, D. Phil. Oxford,
T.S. Mun, Ph.D. Indiana,
T.S. Hai, Ph.D. Stony Brook

Lecturers

R. Jones, Ph.D. Stevens Institute of Technology,
K.M. Hau, Ph.D. Canterbury,
S.E. Lian, Ph.D. Singapore, and
T.H. Chuan, Ph.D. McMasters.

THE ASIAN PHYSICAL SOCIETY

The Singapore physics community has been active in the Asian Physical Society. The Asian Physical Society was set up under the leadership of British Nobel Prize winner in physics, P.M.S. Blackett, with the aid of the Committee of Science and Technology in Developing Countries (COSTED) with the aid of United Nations Educational, Scientific, and Cultural Organization (UNESCO) funds. The Society's headquarters are at the Indian Institute of Technology, Madras (IIT, Madras) in Madras. Professor S. Radhakrishnas of that Institute is the secretary of the Society. Malaysia exerted pressure in trying to have the Society headquarters in Singapore. Japan participates in the activities of the Society, but Australia does not. Countries from the Middle East were invited to participate, but declined.

Three meetings of the Society have been held in India. About three years ago, a meeting was held in Penang, Malaysia. At this meeting, contributions from India dominated. Physicists from Malaysia, India, Indonesia, and Singapore attended. No one came from Hong Kong.

COSTED has sponsored the following four meetings (jointly with the institutions at which the meetings were held) in 1980/81:

- Scientific Instruments in Developing countries (held at IIT, Bangalore),
- Physics of Materials (IIT, Madras),
- Laboratory Curriculum Development (Khan Kaen University, Khan Kaen, Thailand), and
- Physics of Solid State Devices (Solid State Physics Laboratories, Ministry of Defense, New Delhi, India),

Asian societies of Mathematics, Biology, and Statistics have also been organized with the help of UNESCO funds.

ACKNOWLEDGEMENTS

I am indebted to Professor Rajaratnam for acting as my host during my visit to Singapore and to Mr. Chin Kwok Foo, Second Secretary, Embassy of Singapore, Tokyo for helpful discussions.

9TH INTERNATIONAL CONFERENCE ON ATOMIC SPECTROSCOPY AND XXII COLLOQUIUM SPECTROSCOPICUM INTERNATIONALE

John V. Gilfrich

The 9th International Conference on Atomic Spectroscopy and XXII Colloquium Spectroscopicum Internationale (9th ICAS/XXII CSI) was held 4-8 September 1981 at the Hotel New Otani and at Sophia University in Tokyo, Japan. Since the mid-1970s, these two international meetings have been held together, although they began as separate entities. CSI is the senior of the two, having started in 1950 in Strasbourg, France, and has been held at either one or two-year intervals since then.

In spite of the long history of these meetings one had never before been held in the Orient. The conference was organized by the Japan Society for Analytical Chemistry, celebrating its 30th anniversary, with the cooperation of the Spectroscopical Society of Japan, and was additionally sponsored by the Ministry of Education, Science and Culture of Japan, The Science Council of Japan, the International Union of Pure and Applied Chemistry, the Japan Society of Applied Physics and The Chemical Society of Japan. All of the people involved with the preparations for the meeting have every right to be proud of a job well-done. Some concern had been expressed at the previous conference in 1979 that foreign participation might be quite limited because of the distance most scientists would have to travel to get to Japan. Of the more than 700 participants, approximately one-third were from outside Japan, dispatching that worry to some considerable degree.

More than 450 papers were presented, dealing with every aspect of applied spectroscopy. This required that nine to eleven sessions be conducted simultaneously for all four days, except for the Opening Ceremony and the three Plenary Lectures. The instructions for speakers permitted any language for presentation as long as the abstracts and slides were in English. Remarkably, of the 50 or so papers attended by this reporter, only one was presented in a language other than English. While a few of the Japanese did not seem to be very facile (or comfortable) speaking English, their attempts were most valiant and certainly appreciated by those of us who did not understand their native language (with a few exceptions, all the non-Japanese participants).

The field of analytical spectroscopy is very large and varied. Each of the participants had his own area of interest and, with so many simultaneous sessions, could only attend the particular papers that most interested him or her. The sessions were kept on schedule so that it was possible to move from session to session and expect to hear the appropriate paper; physical distances from one session to another were sometimes significant but this presented only minor difficulties. Because of rather parochial interests in x-rays, this reporter experienced no problems; the x-ray sessions "X-Ray Analysis" and "Spectroscopy for Chemical State Analysis" were mostly held in the same room. For this same reason the only specific report which will be given here is limited to those sets of sessions. However, in order to illustrate the diversity of interests represented at the conference, the topics which were part of the formal scientific program are listed below:

- Plasma Emission Spectrometry (seven half-day sessions)
- D.C. Arc, Spark and other Emission Spectrometry (5)
- Hydride Generation Technique for Atomic Spectrometry (2)
- Furnace Atomic Absorption Spectrometry (6)
- Zeeman Atomic Absorption Spectrometry (1)
- Atomic Absorption Detection System for Separation Analysis (1)

- Atomic Fluorescence and Scattering Spectroscopy (2)
- Flame Atomic Absorption Spectrometry (2)
- Spectroscopy for Chemical State Analysis (4)
- Spectroscopy for Surface and Interface Analysis (8)
- Computers in Analytical Spectroscopy (4)
- Recent Developments in Laser Spectroscopy (1)
- Application to Life Science (3)
- Environmental and Geochemical Applications (3)
- X-Ray Analysis (5)
- UV-VIS Spectroscopy (3)
- IR and Raman Spectroscopy (3)
- Magnetic Resonance Spectroscopy (1)
- Mass Spectrometry (3)
- Photoacoustic Spectrometry (1)

In addition, there were two sessions of post-deadline papers and three poster sessions.

The Opening Ceremony, in a ballroom of the Hotel New Otani, was chaired by the Secretary General of the Organizing Committee, Professor Keiichiro Fuwa, University of Tokyo, and featured welcoming addresses by the Chairman of the Organizing Committee, Professor Hitoshi Kamada of Yamagata University, and the President of the Japan Society for Analytical Chemistry, Professor Giichi Muto of Saitama Institute of Technology. Speaking for the International Union of Pure and Applied Chemistry was Professor Jacques Robin of France, the Chairman of Commission V4. Professor Taitiro Fujinaga of the University of Kyoto, the ex-President of the Japan Society for Analytical Chemistry then inducted Dr. Velmer Fassel of the United States and Sir Alan Walsh of Australia as Honorary Members of the Society. Professor Muto presented the Medals and Sir Alan accepted for both of them.

The Opening was followed by two of the three Plenary Lectures: Professor Fassel spoke on "Inductively Coupled Plasma-Atomic Emission and Mass Spectroscopy (ICP-AES-MS): Present Status and Future Prospects," and Professor Gordon Kirkbright of the University of Manchester in the United Kingdom gave us "Some Perspectives in Analytical Spectroscopy." The third Plenary Lecture, "Combined XRF-XRD Improves Materials Characterizations," by L.S. Birks, recently retired from the Naval Research Laboratory in the United States, was presented at the beginning of the second day of the Conference.

The invited papers in the "Chemical State" and "X-ray" sessions dealt with such subjects as:

- "Chemical State Analysis by High-resolution X-ray Spectroscopy," (Y. Goshi, University of Tokyo);
- "Atomic Spectroscopy with Synchrotron Radiation," (B.F. Sonntag, University of Hamburg);
- "X-Ray Spectroscopic and Photoelectron Spectroscopic Investigations of Chemical Compounds," (A. Meisel, Karl-Marx University, Leipzig);
- "Chemical Analysis of Solid Surfaces by Means of Low-energy Electron-induced Soft X-Rays and Typical Examples," (M. Romand, *et al.*, Claude Bernard University, Lyon);
- "Studies of Atomic and Molecular Processes by Using Synchrototron Radiation in Japan," (T. Sasaki, National Laboratory for High Energy Physics, Tsukuba);

- "Geochemical Analysis by X-ray Fluorescence and Image Dissector Spectrometry in the Geological Survey of Sweden," (A. Danielsson, Geological Survey of Sweden);
- "Recent Trends in the Application of X-ray Analysis Instrumentation," (R. Jenkins, Philips, U.S.A.);
- "Preconcentration Methods for X-ray Spectrochemical Analysis of Water," (R. Van Grieken, University of Antwerp);

and finally, two papers from Austria, "X-ray Fluorescence Analysis with a Bragg-Polarized Primary Beam," and "X-ray Fluorescence Analysis in the Subnanogram Region Using Total Reflection of the Primary Beam," (H. Aiginger and P. Wobrauschek, Atominstitute of the Austrian University).

While a number of these invited papers were concerned primarily with experimental x-ray spectroscopy, the theoretical aspect was not overlooked. The presentations by Professors Sonntag, Meisel and Sasaki, in particular, can be cited as representing the forefront of theoretical atomic spectroscopy dealing with the breakdown of the independent particle approximation because of strong many-electron correlations, the interpretation of fine structure on the basis of one-electron transitions, and the ability to determine cross sections and their branching ratios.

The purpose of listing the invited papers in the above two areas is to illustrate the remarkable diversity of topics to which attention was paid by the Organizing Committee, just within the limited field which can be described as "X-Ray Spectroscopy." One of the "Chemical State" sessions did include some papers concerned with techniques other than x-ray (primarily Mossabauer), but since there was an "X-Ray Analysis" session simultaneously, few of us in the x-ray field found it possible to attend.

It would serve no purpose to list the titles and authors of the 35 or so submitted papers in the sessions dealing with x-ray techniques. Rather, it seems appropriate to attempt some general comments about the health of x-ray spectroscopy (and by inference, of atomic spectroscopy) as reflected by the papers, both submitted and invited, presented at this conference.

In the "Spectroscopy for Chemical State Analysis" sessions approximately three-quarters of the x-ray papers (invited and submitted) represented work done in Japan. The fact that the premier Japanese x-ray equipment manufacturer produces the only commercial double-crystal x-ray spectrometer (at least as far as this reporter is aware) may have some bearing on that fact. Of course, not all the work used such an instrument. Some papers discussed single-crystal instruments for the measurement of the fine structure of x-ray emission spectra, and there were many reports of the application of Extended X-Ray Absorption Fine Structure (EXAFS) to the chemical state problem. In the first invited paper on chemical state spectroscopy, Professor Goshi set the tone by discussing the difficulty of relating the experimental "finger-print" method to the theoretical analysis of chemical effects, and suggesting some directions in which future efforts should be expanded. Several of the papers over the two days of these sessions discussed the use of synchrotron radiation for such studies; for example, in Japan at the University of Tokyo and in Germany at the University of Hamburg. Some comments were also made about the Photon Factory shortly coming into operation at the Science City, Tsukuba.

The "X-Ray Analysis" sessions dealt with the full spectrum of x-ray fluorescence, some x-ray diffraction and one paper on Particle Induced X-ray Emission (PIXE). The solution of practical analytical problems, like the analysis of metals and ores in industrial process, of airborne particulates, environmental waters and soils, ancient pottery, and

geological and biological samples, were supplemented by papers describing new techniques for light element (long-wavelength) analysis using total reflection mirrors and layered microstructures as monochromators and the use of Bragg diffraction at 90° to produce high intensity polarized primary beams.

A couple of other sessions also dealt with x-ray techniques. One of the poster sessions was virtually all x-ray papers and one of the "Spectroscopy for Surface and Interface Analysis" sessions was subtitled "Analytical Electron Microscopy and XMA." Many of the papers dealt with the x-ray microanalysis area of this field. It would be presumptuous to suggest that a report of this nature could be considered more than the briefest summary of even the small part of this meeting being considered; rather it is intended to convey the character of the conference.

As was done for the XX CSI in Czechoslovakia in 1977, a series of postconference symposia were held after the conference in Tokyo to take advantage of the presence in Japan of many distinguished spectroscopists from abroad. These were held in:

- Kyoto, "Analytical Spectroscopy for Trade Characterization," September 11 and 12,

- Kurashiki City, "Recent Advances in ICP and AAS," September 14, and

- Kyushu, "Innovation in Spectro-Analytical Chemistry," September 16.

In addition, the 18th Annual Conference on X-Ray Chemical Analysis was held in Kyoto from September 13 to 15. Some of us from the x-ray community were fortunate enough to be invited to present lectures there. Readers who are familiar with the Denver X-Ray Conference held every year in the United States will understand when it is suggested that this annual Japanese x-ray meeting was very similar to the Denver Conference. While the invited papers were given in English by all the foreigners, all of the contributed papers were in Japanese. It was an interesting exercise for the imagination to attempt, with the aid of an English title and slides prepared mostly in English, to follow the progress of the talk. On several occasions it was possible to make oneself believe that he knew what was being said.

The general impression from these meetings is that x-ray spectroscopy is moving forward at a fairly rapid rate with progress to be expected in several areas: the use of the several techniques, which can be described in general as high resolution x-ray emission and EXAFS, are being applied more and more for the elucidation of the chemical state of the elements present in complex materials; developments in the dispersing devices available for soft (low energy, long wavelength) x-rays should improve our ability to measure such x-rays; and the application of synchrotron radiation to a wide variety of problems becomes more and more appealing as new facilites become available (the Photon Factory in Japan and the National Synchrotron Light Source in the United States may well have produced their first x-ray beams by the time this report is published).

It seems likely that if this report were written by a spectroscopist who practices his art in some region of the electromagnetic spectrum other than x-rays, many of the same comments would apply. The Plenary Lecture by Professor Fassel, for example, was replete with his enthusiasm for the visible and near-visible part of the spectrum in which ICP spectroscopy is useful. And just a glance at the 509 page abstract book gives one the feeling of very vigorous life in all areas of spectroscopy.

Finally, this report cannot be concluded without some reference to this reporter's observations on his first trip to Japan. First of all, the Japanese scientists as a group are the most hospitable people I ever met. Secondly, they are most devoted to their work. There was only time to visit a couple of laboratories but coupled with the general quality of the papers presented at the Conference, one is left with a most favorable impression.

The next conference, the XXIII CSI, is to be held in Amsterdam, The Netherlands, in 1983.

INFORMAL REPORT OF THE MEETING ON THE DESIGN OF MOLECULAR STRUCTURES

Haruo Kuroda

A meeting on the design of molecular structures, organized by Professor W. A. Little (Stanford University), was held at the Department of Physics, Stanford University, 17-18 August 1981.

This was part of a U.S.-Japan cooperative research program entitled "Development of the Design of Molecular Structure," which is sponsored by the National Science Foundation (NSF) of the United States and the Japan Society for Promotion of Sciences (JSPS). The research program started January 1, 1980 for a term of two years; the principal investigators being Professor W. A. Little (Department of Physics, Stanford University), and Professor H. Kuroda (Department of Chemistry, University of Tokyo).

The purpose of this cooperative research program is to investigate the basic principles which govern structures and properties of molecular solids and molecular aggregates, and to establish the basis of molecular engineering of materials of fundamental or technological interest. Special attention is directed to molecular systems such as organic metals and superconductors, artificial muscles, and electrode-active molecular systems.

Under this cooperative research program, experimental collaborations have been carried out between U.S. and Japanese investigators. Beside these activities, it was originally planned to have two meetings on related topics, once in Japan and once in the U.S. The first meeting was held last year at the Institute of Molecular Science, Okazaki, Japan, on 26-29 November [this *Bulletin*, 1 (1), 79 (1981)]. The meeting at Stanford University was the second meeting of this cooperative research program.

The meeting was opened by an address by Professor W. A. Little (Stanford University), who gave an overview of the cooperative research program and described future prospects of the development of the design of molecular structure. He described also the progress of the experiments done through the collaboration of U.S. and Japanese investigators. Professor H. Kuroda (University of Tokyo) presented a review on the charge-transfer interaction between donor and acceptor molecules. He discussed the role of various factors, including the intermolecular hydrogen bond, which determines the crystal structures and electronic states of solid charge-transfer complexes, taking up the results of the extensive studies carried out by his group.

Professor A. Heeger (University of Pennsylvania), reviewed recent studies on polyacetylene, in particular those related to solitons. Discussion ensued on the luminescence arising from the recombination of positively-charged and negatively-charged solitons.

Dr. R. Green (IBM, San Jose) gave an excellent review on the characteristic features of $(TMTSF)_2X$ crystals which are now known to be the first example of organic superconductors and the first example of an organic crystal which has a SDW insulating phase. Discussion followed on the problems related to the recently reported tunneling data of $(TMTSF)_2PF_6$ and $(TMTSF)_2ClO_4$. Professor H. Gutfreud (Hebrew University) discussed from a theoretical point of view how "molecular" character brings out unique features in the behaviors of organic conductors and organic superconductors. In particular, he took up the problem related to the T^2 law of resistivity and the role of the Umklapp process for understanding the SDW and superconducting phase of charge-transfer salts.

Dr. F. Wudl (Bell Telephone Laboratories, Murray Hill) reviewed his extensive work related to the design and synthesis of organic metals. He told about the syntheses of a variety of donor molecules containing sulfur. He also suggested several types of organic materials which are worth further investigation.

Dr. T. Nogami (Osaka University) told about the syntheses and properties of the crown-ether TCNQ complexes, and pointed out several unique aspects of the behavior of this group of materials. Professor I. Ikemoto (University of Tokyo) reported the results of x-ray photoelectron spectroscopic study of $(TMTSF)_2X$. He also reported on the temperature dependence of the reflectance spectrum of $(TMTSF)_2ClO_4$ over the temperature range of 30-300K. Professor H. Kobayashi reviewed his x-ray diffraction studies on the periodic modulation of conducting chains in low-dimensional conductors.

Dr. A. Diaz (IBM, San Jose) gave an interesting review on the recent progress in electrochemical synthesis. He presented results on the preparation of a polypyrolle film by electrochemical polymerization and on the modification of the electrical conductivity of a polypyrolle film by electrochemical doping of acceptor. The possibility of making a rechargeable battery using such a polymer film as electrodes was also discussed. Professor J. Tanaka (Nagoya University) reviewed his recent work on the structure and optical properties of cyanine dye crystals which are of great importance in connection with the sensitization of color film. Discussion followed on the origin of J-band.

In the afternoon of the second day, there was a special session entitled, "Microphysical Techniques." This session was held in view of the increasing importance of carrying out measurements of physical properties by using a small single crystal since it is often hard to obtain a large single crystal of a conducting or superconducing charge-transfer salt. The session was opened with the talk by Professor H. Kuroda (University of Tokyo) on the use of microspectrophotometry for the measurement of absorption and reflection spectra at low temperatures. Dr. R. Hollman (Stanford University) spoke on the design and construction of a microminiature refrigerator. Dr. R. Wolfe (Stanford University) showed a technique to perform scanning calorimetry on a single crystal of microscopic size and Mr. A. Aiello (Stanford University) spoke on a technique to measure the temperature dependence of elastic constants on a small single crystal, both by using an apparatus having a microscope optical system and a microminiature refrigerator system.

The final program of the meeting was the talk by Dr. K. Bechgaad (University of Copenhagen), who very clearly summarized the present status of the investigation concerned with the conducting and superconducting charge-transfer salts. He pointed out several problems which should be clarified in the future. Discussion ensued on the prospect of future development of the research on organic superconductors.

Professor W. A. Little (Stanford University) closed the meeting expressing his hope that the collaboration between U.S. and Japanese scientists in this research field would continue and be extended although the present cooperative research program will end this year.

The meeting was conducted in a relaxed and informal atmosphere and provided a good place for discussion and for the exchange of ideas. It was quite successful also as a place of making personal contacts and as a place to discuss future collaboration between scientists of the two countries.

Finally, I wish to gratefully acknowledge the assistance given by the Office of Naval Research, Far East, for the participation and attendance of Japanese scientists at this meeting.

APPENDIX

Mailing Addresses of the Scientists Mentioned in this Report

- Professor W. A. Little (U.S. principal investigator)	Department of Physics Stanford University Stanford, CA 94305
- Professor H. Kuroda (Japanese principal investigator)	Department of Chemistry Faculty of Science University of Tokyo 1-3, Hongo 7-chome Bunkyo-ku, Tokyo 113
- Professor A. J. Heeger	Department of Physics University of Pennsylvania Philadelphia, PA 19104
- Dr. R. L. Green	IBM Corporation Department K32 5600 Cottle Road San Jose, CA 95193
- Professor H. Gutfreund	The Racah Institute of Physics Hebrew University Jerusalem, Israel
- Dr. F. Wudl	Bell Laboratorie 600 Mountain Avenue Murray Hill, NJ 07974
- Dr. T. Nogami	Department of Applied Chemistry Osaka University Yamada-kami, Suita, Osaka 565
- Professor I. Ikemoto	Department of Chemistry Faculty of Science University of Tokyo 1-3, Hongo 7-chome Bunkyo-ku, Tokyo 113
- Professor H. Kobayashi	Department of Chemistry Faculty of Science Toho University Narashino, Chiba 274
- Dr. A. Diaz	IBM Research Laboratory 5600 Cottle Road San Jose, CA 95193

-	Professor J. Tanaka	Department of Chemistry Faculty of Science Nagoya University Furohcho, Chikusa, Nagova 464
-	Dr. R. Hollman Dr. R. Wolfe Mr. A. Aiello	Department of Physics Stanford University Stanford, CA 94305
-	Dr. K. Bechgaad	Department of General and Organic Chemistry University of Copenhagen Universitets parken 5 Copenhagen, Denmark DK 2100

PHYSIOLOGICAL SCIENCE IN JAPAN - SUMMER, 1981

Charles Edwards

INTRODUCTION

During the summer of 1981, I spent three months in Japan. One month was spent travelling and visiting a number of institutions and the other two months were spent doing research at two medical schools. There are about 78 medical schools and a large number of universities in Japan. Thus, the constraints of time and geography and my basic interests in membrane physiology limit my survey to a small, somewhat biased sample of these institutions.

Basic biomedical research seems to be well-supported today in Japan. The funding rate for grants is just under 20 percent. However, all departments receive some funds directly from the Ministry of Education and so there seems to be enough money to carry out some research without external grants. In addition, graduate students are funded directly by the government. Thus, grants cover only supplies and equipment, and so tend to be smaller than in the U.S. Finally, several departments doing work of possible clinical interest have financial support from some drug firms. It should be added that, in recent years, several large grants have been awarded each year to groups of departments collaborating on research in a single area; the focus is rather like National Institutes of Health (NIH) program project grants.

A typical physiology department has a professor, an associate professor and one to four junior people. There are usually two such departments at each institution and they share the instruction. In some institutions the staff shares the professor's research interests, while in others some may work independently. It should be noted that the fixed staffing, salary levels, and budget leave little room for negotiation when a candidate is offered a chairmanship.

In the Japanese cultural tradition, youth do not question their elders. This is, of course, not consistent with top quality science today. As I travelled, I attempted to assess how much this tradition affected present day graduate training. I found that the young people work hard and enthusiastically. I was unable to assess how freely they were able to challenge the senior faculty. One person told me that the students who were in the university in the early seventies, during the period of student unrest, were somewhat critical, while those who followed them are more passive. In addition, the extent of the questioning attitude of students and junior faculty depends very much on the attitude of the professor.

Despite this problem, there is much top quality research being done in Japan. There are a number of laboratories that are able to offer first class postdoctoral training. Currently there are few foreign trainees, for a variety of reasons. One is that only Japanese nationals can be employed by national universities; however, this rule may be changed in the near future and this change should help increase the number of foreigners doing research in Japan.

JUNTENDO UNIVERSITY

The chairman of one of the Departments of Physiology at Juntendo University in Tokyo is Akira Takeuchi. He and his colleague, Dr. K. Onodera, are continuing their

studies on the release of glutamate from the nerve muscle junction of crayfish. They have worked out a technique to demonstrate that electrical stimulation of the nerve increases the release of glutamate but has no effect on the release of aspartate and that the increase in release is related to the total amount of electrical charge produced in the muscle membrane by stimulation. The addition of the venom of the black widow spider causes the release of transmitter from the presynaptic nerve terminal and produces similar effects.

Dr. Noriko Takeuchi, also in the Physiology Department at Juntendo University, has been examining the effects of various ions and detergents on the spontaneous release of acetylcholine from the nerve terminal of the frog neuromuscular junction, with the goal of determining their mode of action.

TOKYO MEDICAL AND DENTAL UNIVERSITY

Nearby, at Tokyo Medical and Dental University, the only Professor of Physiology at the present time is Taro Furukawa. His main interest is the mechanisms underlying transmitter release at the synapse between the hair cell and the first order neuron in the ear of the goldfish. He has studied the release under a variety of conditions and is fitting a simple model to the results. In the same department, Dr. Shigeno has examined, with horseradish peroxidase, the distribution of pyramidal fibers in the central nervous system of the cat and monkey. In both animals, the descending fibers seem to distribute to several motor neuron pools.

The electrophysiological study of embryonic chick hearts is limited to preparations over two days old because of the fragility and small cell size of the tissue in younger animals. To overcome this difficulty, Dr. K. Kamino has used the changes in absorption of a potential sensitive merocyanine-oxazolone dye to monitor electrical activity. This technique has been developed over a period of years by Cohen and colleagues (including Kamino) at Yale University. Spontaneous rhythmic electrical activity is present at the seven-nine somite development stage, before the heartbeat which is known to start in the middle of stage nine. There is a large increase in the number of electrically active cells between late stage seven and stage nine. The shapes of the fluorescence signals suggest that the normal cardiac pacemaker and action potentials are first present during late stage eight. In experiments using five light monitors, the pacemaker regions have been localized first to the left atrial primordium and, subsequently, to the sinus primordium.

UNIVERSITY OF TOKYO

Dr. Jun Fukuda of the Department of Physiology of the University of Tokyo Faculty of Medicine, has been studying in tissue culture the properties of the nerve cells of the spinal ganglia and other ganglia of guinea pigs. The development of techniques to grow these cells in culture has required considerable effort. About half of the voltage-dependent sodium current in these cells is resistant to tetrodotoxin, and this ratio is constant over a period of 14 days in culture. Innoculation of the dorsal root ganglion cells with herpes simplex virus causes a loss of membrane excitability within 24 hours, possibly due to a decrease in the density of voltage dependent sodium channels. Staining with labelled antibody reveals that only 10-15 percent of the cells contain viral antigen after 24 to 48 hours. The shapes of the nerve cells are altered by the addition of colchicine or cytocholasin, which are known to affect the cytoskeleton. The changes in form occur without changes in properties of the resting cell membrane, but the rates of rise of the action potential are reduced. Colchicine affects the calcium current and not the sodium

current, while cytochalasin B affects the sodium current and not the calcium current.

BRAIN RESEARCH INSTITUTE

At the Brain Research Institute of the University of Tokyo, Dr. K. Takahashi is the head of a group interested in studying the early stages of development of the tunicate egg with electrophysiological techniques. The inside of the cell is perfused, so that the composition of the solution on both sides of the membrane may be controlled by the experimenter. The membrane of the unfertilized egg has a voltage-dependent sodium channel, whose selectivity is similar to that of similar channels in nerve and muscle. There is also a calcium channel, and the calcium current is reduced if the internal calcium level exceeds 10^{-6} M, as is also found with other cells. After fertilization in 1, 2 and 4 cell embryos, a long-lasting calcium spike is present. After three or more cell divisions, the presumptive ectodermal region shows a long-lasting calcium action potential, the presumptive neural blastomere shows a short-lasting calcium spike and the muscular blastomere has a sodium-calcium spike These differences may turn out to be important in the processes of differentiation. At the same institution, Dr. N. Yamashita is examining the effects of fertilization on the properties of the membrane of the mouse oocyte.

KINKI UNIVERSITY

At Kinki University, a relatively new private medical school in a suburb of Osaka, one of the physiology departments is headed by Shiko Chichibu. He worked at UCLA with Susumu Hagiwara in 1964. One of his interests is the functioning of various sensory hairs located on different parts of the body surface of the crayfish. Some are mechanoreceptors and the neural responses may be influenced by the velocity or the direction of the mechanical stimulus. These receptors are presumably involved in touch in some way.

There are other morphologically different sensory hairs on the antennae of crayfish, called aesthetasc hairs. They are thought to function as chemo or olfactory receptors. Chichibu has found calcium to be localized in the proximal portion of the hairs. Other work in his lab includes the study of how to apply chromaticity coordinate systems to microscopy, and an analysis of the electric field set up by the activity of the electric organ of a weak electric fish.

In the same department, Tetsuji Matsuura is examining the mechanisms underlying the receptor potential in the rods of the bullfrog retina. He uses the isolated retina, which can be mounted between two plates to measure the trans-retina potential, just as the frog skin can be mounted and studied. He also uses microelectrodes to measure the membrane potential charges of single rods. Papaverine, a phosphodiesterase inhibitor, has been found to delay dark adaptation in the absence of calcium; this makes it unlikely that the dark adaptation process after bleaching is related to the rate of restoration of cyclic GMP.

OSAKA CITY UNIVERSITY

At the medical school of Osaka City University, Professor S. Matsuura chairs one department of physiology. He is examining the effects of lidocaine on the frog spinal cord. This local anesthetic is known to block monosynaptic and polysynaptic reflexes. In low concentrations it seems to act principally on the postsynaptic membrane; in higher concentrations it may affect also the presynaptic nerve terminal and the generation of the action potential in the postsynaptic nerve. He is also continuing his studies of the

properties of the synapse between the hair cell and the first order neuron in the hearing organ of the goldfish. This work is being carried out in collaboration with Professor T. Furukawa, of the physiology department of Tokyo Medical and Dental University. With steady state stimulation, small decreases in sound intensity (1 or 2 dB) produce rather large transient decreases in the size of the postsynaptic potential.. These transients have been studied by the quantal analysis techniques that have been developed to study synaptic transmission at the neuromuscular junction. The transients seem to be due to a decrease in the number of quanta of transmitter available for release, while the probability of release is unaffected.

HIROSHIMA UNIVERSITY

MEDICAL SCHOOL

In the physiology department of the Medical School of Hiroshima University, Dr. I. Seyama is doing a structure-activity study of grayanotoxin and similar compounds. In nerves the toxin produces action potentials followed by a sustained depolarization. This is due to a specific increase in the permeability of the membrane to sodium. He has examined the actions of 34 analogues, and the action appears to depend on stereospecificity and the presence and location of 5 OH groups. It will be interesting to learn just how this toxin acts.

DENTAL SCHOOL

At the Dental School of Hiroshima University, the one physiology department is headed by Yoshinobu Kanno, who has spent several years in the laboratory of W. Loewenstein at the University of Miami and has long been interested in communication between epidermal cells in culture. If two cells are placed next to each other on a slide, the presence of electrical communication can be demonstrated within several hours. Kanno is presently examining the mode of action of tumor promoting agents, which are substances that greatly enhance tumorgenesis in cells previously initiated by exposure to low doses of a carcinogen. One compound, 12-0-tetradecanoylphorbol-13-acetate reduces cell communication in epidermal cells. Kanno is also working on coupling in acinar cells in the salivary glands. Dr. Y. Shiba in his department is investigating chemoreception in *Hydra*. The organism is usually stimulated by glutathione; Dr. Shiba finds that some but not all lectins produce similar effects.

SCIENCE FACULTY

In the Science Faculty of Hiroshima University, Professor Makoto Kobayashi is continuing his studies on the physiology of the cross-striated muscles of a Japanese mollusc. Octopamine and 5-hydroxytryptamine inhibit the muscles, apparently by hyperpolarization of the membrane due to an increase in chloride conductance. Acetylcholine may be the transmitter in the protector muscle and l-glutamate may be the transmitter in the retractor. Other work in his lab involves the transport of chloride by the intestine of the eel.

KAWASAKI MEDICAL SCHOOL

At the relatively new Kawasaki Medical School in Kurashiki, near Okayama, one professor of physiology is Dr. M. Matsumura. He has been investigating the mechanisms by

which injected strontium initiates contraction in crayfish muscle. In other experiments on glycerol-extracted muscle fibers, he has found that the first maximum in the diffraction pattern formed from laser light is most prominent in frog muscle fibers, is somewhat less prominent in mammalian fast muscle fibers and is absent in mammalian slow muscle fibers. The first maximum disappears, reversibly, when shortening is initiated by external calcium and ATP. His colleagues have investigated the properties of the slow muscle fibers in the muscles controlling eye movements.

Dr. H. Kita is studying the effects of tetanic stimulation, elevated osmotic pressure, and divalent cations on the spontaneous release of transmitter at the frog nerve muscle junction to learn more about the mechanisms controlling this release.

The other physiology professor at Kawasaki is Dr. H. Okada. In his laboratory, the results of experiments on the central control of defecation suggest a reflex control by the bladder, as well as by centers in the spinal cord, the pons, and in a more rostral part of the central nervous system. Stimulation of certain areas on the cortex has been shown to excite or inhibit the bladder emptying reflex initiated by distention.

NATIONAL CENTER FOR BIOLOGICAL SCIENCES

At Okazaki, near Nagoya, the construction of the National Center for Biological Sciences is nearly complete. To some extent the Center is modeled after NIH. One difference is that a number of the senior scientists will have appointments both at a university and at the Center, and so will be at the Center only part-time. The building for the National Institute for Physiological Sciences was occupied in spring 1981, and a number of laboratories were fully functioning when I visited in July. The present size of the staff is about half that originally planned, and it is expected that additional appointments will be made over the next few years.

The director of the Institute, Dr. Koji Uchizono, has been working on a sleep promoting substance (SPS). This material, which can be extracted from the brains of sleep deprived rats but is not present in normal rats, produces sleep when injected into the ventricles of rat brains. Similar results with other animals have been reported from other labs, but it is not clear whether the substances are the same or not.

Dr. Akira Watanabe is continuing his studies on changes in the optical properties of the giant axon of squid that accompany the action potential. Squid are available for this research for about half of each year. There should be some optical signal that accompanies the changes in protein configuration that underlie the opening of the voltage dependent channels responsible for the action potential. However, it is likely to be small; and this and its uncertain nature, make its detection difficult. To improve the signal to noise ratio, procedures to prolong the action potential are being investigated. Dr. F. Kuketa has found that perfused axons remain viable in the presence of solutions with osmotic pressures up to seven times normal provided the internal and external solution have the same osmotic pressure. Cooling the axons treated in this way greatly prolongs the action potential.

Some properties of the acetylcholine receptors on muscles in culture have been examined by Dr. H. Sugiyama. The receptors from cells grown from newborn rats or mice show two different isoelectric points when analyzed by isoelectric focusing. The two types seem to correspond to the two types of receptor, junctional, and extrajunctional, present in denervated muscle in mature animals. In contrast, chick muscles in culture show only one type of receptor. The intracellular receptor in rat or mouse muscle, which is thought to be

the precursor of the membrane receptor, has a single isoelectric point; and so it is thought that the two types of receptor may derive from a common precursor.

SHIGA UNIVERSITY OF MEDICAL SCIENCE

The Shiga University of Medical Science is quite new and lies in Ohtsu, near Lake Biwa, and just over Mt. Hiei from Kyoto. One physiology professor is Hiroshi Kitasato, whose interests include the mechanism of action of insulin on muscle. Insulin is known to hyperpolarize the membrane potential of muscle, and Dr. Kitasato finds that it shifts the relationship between sodium efflux and internal sodium concentration toward lower concentrations and decreases the Hill coefficient. He is now examining some properties of the sodium-potassium ATPase to learn more about the mechanism of action of insulin. In the same department, Koichi Murayama is studying the gating currents in perfused giant crayfish axons. He has measured the time course of inactivation during a square pulse (τ of several msec) and of recovery from inactivation during hyperpolarization (τ about 10 sec).

One of the physiology departments at the University of Kyoto is headed by Motoy Kuno, who returned to Japan last year. He had been in the physiology department of the University of North Carolina Medical School. Dr. Kuno has been investigating the properties of the membrane of the motor neuron in the spinal cord of the newborn rat. A voltage-dependent calcium conductance is present at birth and remains for two weeks, which is as long as he has been able to investigate with his present techniques. The role of this conductance is unclear at present. He is also examining the time course of the loss of excitability in cockroach axons after sectioning the axon from the cell body.

In the same department, Dr. Y. Okado is continuing his studies on the properties of the membranes of L-fibroblasts. The single cells are small for microelectrode studies; irradiation with x-rays causes cell fusion and the resultant larger cells are easier to study. Normal resting membrane potential is about -15 mV. Spontaneous hyperpolarizing oscillations are usually present with a frequency of about 5/min. The hyperpolarizing phase is thought to be due to an increase in potassium conductance caused by the entry of calcium, and the depolarizing phase is attributed to a decrease in internal calcium leading to a decrease in potassium conductance. This explanation is based on the effects of various blockers and inhibitors on the membrane potential.

KUMAMOTO UNIVERSITY

At Kumamoto University, near Fukuoka, one physiology department is headed by K. Nishi, who worked with C. Eyzaguirre at the University of Utah from 1969 to 1972. He and N. Akaike have studied the calcium current in nerve cell bodies in the snail, *Helix*. The cell bodies are opened and perfused with various solutions, so that the ionic environment on both sides of the membrane is controlled. The calcium channel is permeable also to barium and strontium, as is generally true of calcium channels. In addition, manganese and zinc are permanent, which has not been found to be the case in most other calcium channels. Propanol has been found to inhibit the voltage dependent calcium current in *Helix* neurons. The voltage dependent sodium channel in single rat heart cells has been studied with similar techniques. The selectivity of the channel appears to be the same as that of other sodium channels in squid nerve and in frog nerve and muscle.

KYUSHU UNIVERSITY

At Kyushu University in Fukuoka, one physiology department is headed by Y. Oomura. One of his interests concerns the role of the hypothalamus in feeding behavior. In the rat, there are neurons in the lateral hypothalamus which are sensitive to changes in glucose level; the frequency of action potentials is inversely related to glucose level. An increase in activity of these glucose sensitive neurons is thought to induce feeding. The inhibition produced by an increase of glucose concentration is due to a hyperpolarization probably produced by activation of the electrogenic sodium/potassium pump. In the ventral medial nucleus of the hypothalamus, the frequency of action potentials of certain glucose receptor neurons is increased as the glucose level is increased. This increase in activity is thought to underlie satiation following feeding. The effect appears to be due to the binding of the glucose to the cell membrane, rather than to entry, because it can be produced by phlorizin, a large molecule which binds to β-glucose and so whose structure is very similar to it. It is known that the blood level of free fatty acids increases during hunger, and the Kyushu group has found that this increases the activity of the glucose sensitive neurons in the feeding center and inhibits glucose receptor neurons in the satiety center. The group has also found several simple organic molecules which activate or inhibit these neurons. The possible eventual applications of these compounds to weight control is obvious. Oomura is also involved in experiments on the role of the central nervous system in feeding behaviour and sexual behavior in monkeys.

The department of pharmacology of Kyushu University, chaired by Professor Hirosi Kuriyama, is the largest department I visited and must be one of the largest in the world. There are about 25 staff and graduate students doing research, principally on various aspects of the physiology of smooth muscle. Preparations used include mesenteric, ear, basilar and cerebral arteries, and mesenteric veins from the guinea pig and other animals. Properties under study include;

- ionic basis of the resting potential and of the hyperpolarization induced by acetylcholine,
- role of the sodium/potassium pump,
- effects of catecholamines, adenosine triphosphate, histamine and vasopressin, and
- neuromuscular transmission and the effects of various drugs thereon.

The mechanism of action of calcium channel blockers, such as diltiazem, on excitation contraction coupling, and the roles of external and internal calcium are also being studied. Dr. Y. Ito is examining the electrical and mechanical properties of tracheal smooth muscle and has noticed that the responses to indomethacin resemble, in some ways, aspirin-induced asthma in man. Studies of the serum proteins of patients with myasthenia gravis have shown no relationship between the severity of the disease and the serum antibody titer measured against mouse acetylcholine receptor.

KURUME UNIVERSITY

At Kurume University, the two physiology professors, K. Koketsu and S. Nishi, spent a number of years at Loyola University in Chicago. Koketsu is continuing his studies on the sympathetic ganglion cells of the bullfrog. He has found serotonin to affect ganglionic transmission postsynaptically and cathecholamines to act presynaptically. With voltage clamp, a voltage dependent calcium channel is present if the sodium current is blocked by tetrodotoxin. Nishi has been studying the properties of the lateral horn cells in cat spinal cord slices. The slice is made with the spinal nerve and white ramus intact, so that it can

be shown that the cell being studied is a preganglionic sympathetic neuron. None of the various obvious possible transmitters tried so far, such as acetylcholine, glutamate, aspartate, glycine, noradrenaline, 5-hydroxytryptamine and GABA behaves as though it were the transmitter, and so the identity of the transmitter is still unknown. The ionic mechanisms of the effects of luteinizing hormone releasing hormone (LHRH) on synaptic transmission in the bullfrog sympathetic ganglion are being investigated. There appears to be a conductance increase to cations under some conditions, and a decrease in potassium conductance under other conditions.

MEETINGS

INTERNATIONAL PHARMACOLOGY CONGRESS

The International Pharmacology Congress held in Tokyo in July 1981 was accompanied by a number of smaller satellite meetings. These gatherings, held throughout Japan, provided an opportunity for small groups of scientists to meet and discuss a particular topic more intensively than is possible at a large meeting in a big city.

I attended part of a meeting on chromaffin granules held at Hakone, on the shores of the beautiful Lake Ashinoko. The opening speaker, H. Winkler of Innsbruck, reviewed the development of knowledge of the granules since they were first isolated in the 1950s. The list of substances in the granule is long and is still lengthening. The mechanisms by which catecholamines may be retained within the granules were reviewed and a model was proposed. The area of greatest controversy today concerns the exact mechanism of release of the catecholamines. P. Baker, of London, has examined the conditions for release in cells whose membranes have been made leaky by exposure to an electric field. Calcium, MgATP and the absence of small anions such as chloride (acetate or glutamate are all right) are the minimal requirements for release. Kidokoro, of San Diego, reported on his electro-physiological studies of stimulus-secretion coupling in isolated chromaffin cells. Acetylcholine induces depolarization and calcium entry and the depolarization opens voltage-dependent calcium channels giving additional calcium entry.

The papers presented at the meeting are to be published by Pergamon Press in 1981, under the editorship of F. Izumi of Fukuoka, who organized the meeting.

COMPARATIVE NEUROPHARMACOLOGY

A symposium on Comparative Neuropharmacology was held at Gifu. A lovely reception preceding the meeting was held on a boat on the Nagara River and featured cormorant fishing and a fabulous display of fireworks. The subject of the meeting was quite general, and so the range of work presented was quite broad. The meeting was opened by a review by G. Kerkut of Southampton of the types of isolated central nervous system preparations, both invertebrate and vertebrate, that have been used in pharmacological studies. The development of the vertebrate preparations has lagged behind the use of the invertebrate preparations, but the basic rules controlling drug actions seem to be similar. L. Prosser (Urbana) reviewed the general structural properties of the currently identified transmitters. He noted that most of the transmitters are either amino acids or closely related compounds. The functions and roles of purines in non-adrenergic non-cholinergic synapses in mammalian airways was reviewed by D. Satchell (Victoria). Comparative studies show differences in inhibitory mechanisms in guinea pig, rat, rabbit and monkey. J. Phillis (Saskatoon) discussed his work on the inhibitory effects of adenosine and related compounds on the central nervous system of the rat. K. Wachtler (Hanover)

discussed the evolution of the cholinergic system in the vertebrate telencephalon. Neuronal populations using ACh as a transmitter often show a characteristic distribution pattern. K. S. Rozsa (Tihany) has analysed the effects of several drugs on simple reflexes regulating the respiratory and cardio-venal systems in the snail. D. Sattelle (Cambridge) has used radioligand labelling, bungarotoxin binding, and electrophysiological techniques to learn about the cholinergic pharmacology of the cockroach nervous system. The properties of the octopamine receptors in the locust have been investigated by P. Evans (Cambridge). The d(-) isomer, the one which occurs naturally, is always the most potent, and the receptors are also activated by α-adrenergic agonists and formamidine pesticides. H. Takeuchi (Gifu) reviewed his recent work on a structure-function analysis of the effects of various amino acid derivatives on an identified neuron in the snail *Achatina*. The pharmacology of the central nervous system of *Limulus* is of interest because of the early appearance of the animal in evolution. R. Walker (Southampton) has found the pharmacology of ACh and GABA on the central neurons to be similar to that of insect and crustacean nervous systems.

The next session focussed on the actions of glutamate. A. Takeuchi (Tokyo) has used mass spectroscopy-gas chromatography techniques to demonstrate a parallelism between transmitter release and the release of l-glutamate at the crayfish neuromuscular junction. J. Dudel (Munich) has investigated the properties of the glutamate and quisqualate responses at the same junction with the technique of noise analysis. The mean open time of the quisqualate activated channel is longer than that of the glutamate activated channel, but the voltage sensitivity is less for the quisqualate response. Shinozaki (Tokyo) has found chlorisondamine (a nicotinic agonist) to be a channel blocker at the glutamate controlled channel. TI-233, a presumed calmodulin inhibitor, potentiates transmitter release and reduced the postsynaptic response. P. Usherwood (Nottingham) has used the patch clamp to examine the properties of the responses of single channels to glutamate on locust muscle. The data suggest that, once opened, the channels cannot close too quickly. Again, the mean open time induced by quisqualate is greater than for glutamate. J. Maruhashi (Fukuoka) reviewed his work on chemical modification of the glutamate receptor and its ion channels in a neuron in *Ochidium*. The data suggest that the presence of α-NH, α-OOH and ℓ-OOH groups are necessary for the response to ℓ-glutamate. A. Ishida (Okazaki) has found that d-aspartate potentiates the action of ℓ-glutamate on the horizontal cells in the goldfish retina; the action of ℓ-aspartate is not affected. The data suggest that d-aspartate may block an uptake system for ℓ-glutamate, and that ℓ-glutamate may be the neurotransmitter.

The actions of the pyrethroid insecticides may in part be due to the initiation of action potentials. L. Leak (Portsmouth) noted some similarities between these compounds and ACh and proposed a mechanism of action based on these similarities. Narahashi (Chicago) reported on his studies of the mode of action of pyrethoid insecticides and DDT on the squid giant axon. These compounds produce repetitive action potentials by modulating the closing of the voltage-dependent sodium channels. Ogata (Fukuoka) has found that substance P depolarizes cells in the guinea pig hypothalamus and decreases the membrane conductance. The effects are direct and not postsynaptic, as shown by intracellular recordings from cells in slices under conditions blocking synaptic transmission, and are blocked by baclofen. Kudo (Tokyo) has shown that the glutamate activated channel in the isolated frog spinal cord is permeable to calcium, magnesium, and strontium. Bennett (Nottingham) has examined the adrenergic induced release of thyrotrophin releasing hormone (TRH) and 5-hydroxytryptame (5-HT) from dermal glands in amphibian skin. The recovery of skin TRH and SHT levels following release seems to take place over a period of 50 or more days. Marsden (Nottingham) has found that 5HT, TRH and substance P may be stored in the same vesicles in rat spinal cord, especially around motor

nerve terminals and in the sympathetic lateral column.

The effects of chronic exposure to hashish on the social behaviour of adult mice were reported by Frischknecht (Zurich). Sexual behavior showed a pronounced decrease in mating tests, nestbuilding behavior was distinctly suppressed, and significant effects on gestation length and litter size were found. The currents carried by the voltage-dependent calcium channels in the membrane of the isolated internally perfused neurons of the snail were investigated by Akaike (Galveston and Kumamoto). The permeability sequence for various divalent cations is $Sr^{++}=Ba^{++} > Ca^{++} > Mn^{++} > Zn^{++} > Cd^{++}$, and the currents are all blocked by calcium channel blockers such as D-600 and verapramil applied either internally or externally. The pharmacology of the ionic channels in the membrane of rabbit skeletal muscle has been investigated by Wu (Chicago). The small effects of the sodium current in voltage clamp of several aromatic carboxylic acids which produce myotonia suggest that the effects of these compounds are likely due to actions other than those on the sodium current. The roles of cyclic nucleotides in synaptic transmission in rabbit sympathetic ganglia have been examined by Kobayashi (Tokyo). Both cyclic GMP and cyclic AMP have modulatory actions on the postganglionic responses, and the mechanisms of these actions have been investigated. The pharmacology of the gating currents, which are produced by the opening of the sodium channels, has been examined by Yeh (Chicago) in perfused squid axons. Three types of blocking actions have been found: closed channel blockers (diphenylhydantoin), open channel blockers (pancuronium) and mixed type blockers (local anesthetics).

The responses of several molluscan muscles to putative transmitters have been compared by M. Kobayashi (Hiroshima). Acetylcholine may be the excitatory transmitter in the protractor muscle, while ℓ-glutamate may be the transmitter in the retractor; both muscles are hyperpolarized by serotonin or octopamine as a consequence of an increase in chloride conductance. R. Hill (Rhode Island) has studied the properties of the electrogenic sodium pump in the ventricle of *Aplysia* and in muscles of *Buccon*. The pump rate is indirectly modulated by neurotransmitters which alter the intracellular sodium level. G. Stefano (New York) showed that as *Mytilus* ages, the number of stereospecific opiate binding sites in the visceral ganglion decreases. There is a concomitant reduction in the increase in dopamine produced by topically applied opiates. Makman (New York) has used several approaches to demonstrate the presence of dopamine receptors in *Octopus* brain and retina. In addition, elevated potassium releases labelled dopamine from the tissue. The release is inhibited by morphine, and the inhibition is blocked by naloxone. Cottrell (St. Andrews) has demonstrated the presence of a voltage sensitive response to serotonin released presynaptically in a gastropod nerve cell. Calcium ions are involved, but the mechanisms underlying the effect are still not clear. The effects of denervation on serotonin sensitivity in the gill of *Mytilis* have been examined by Catapone (New York). The increase in sensitivity following denervation is likely due in part to an increase in the number of serotonin receptors, and in part to changes in the uptake mechanisms for serotonin. Muneoka (Hiroshima) has examined the effect of some biogenic amines on the contraction of the body wall of and echiuroid. Twitches are elicited by acetylocholine and enhanced by serotonin and inhibited by noradrenaline. This is interesting phylogenetically because there is little evidence to date for the presence of noradrenaline in protostomes. Price (Florida) has examined the pharmacology of a small peptide found in *Helix* ganglia. The peptide is cardioexcitatory in *Helix* heart, but is different from a similar peptide previously described in the clam.

The proceedings are to be edited by G. Kerkut and will be published in a single issue of *Comparative Biochemistry and Physiology*.

A NOTE ON JAPANESE WOMEN IN SCIENCE

Francis A. Richards

A usual observation in Japan is that not too many women are active in the scientific world. Few women are employed in the laboratories as scientists, most do technician, clerical, or secretarial work. The ratio of women to men at the scientific meetings I have attended is usually small, and few papers are presented by women. A notable exception is my longtime friend and colleague, Dr. Katsuko Saruhashi, recently the director of the Geochemical Laboratory of the Meterological Research Institute, Japan Meteorological Agency, and now the first and only woman member of the Science Council of Japan. The Science Council is somewhat comparable to our National Academy of Science, reporting directly to the Prime Minister and advising the government on matters of science. The Japanese refer to it, in English, as the "parliament of science." Saruhashi was elected in December 1980, and is the only woman elected since the formation of the council in 1949. There are currently 210 members from all branches of science. Saruhashi first served on the 12th term of the council starting 20 January 1981.

Dr. Saruhashi is a marine chemist, geochemist, and chemical oceanographer whose research has centered on the role of carbon dioxide in the ocean and on a wide variety of questions about the geochemistry of radioactive nuclides, both natural and artificially produced. Her analyses of radioactive fallout resulting from U.S. and U.S.S.R. bomb testing were important in influencing Japan's opposition to the testing, and was probably instrumental in the negotiation of the limited test ban treaty signed in 1963. Much of her work has been in collaboration with Professor Yasuo Miyake, a world recognized authority on geochemistry, professor emeritus of Tokyo University of Education (now a basic unit of the new University of Tsukuba) and founder and first director of the Meteorological Research Institute.

Dr. Saruhashi did her undergraduate work at Toho University and was the first woman to get a Ph.D. in chemistry, in 1957, from Tokyo University. She started with the Meteorological Research Institute in 1943, shortly after its founding, at the research division of the Central Meteorological Observatory; her entire scientific career has been associated with the MRI, but she has traveled extensively both in Japan and abroad, and has been active in chemical, geochemical, and oceanographic circles in Japan. While at MRI she was an active member of the Geochemical Society of Japan, the Chemical Society of Japan, the Japanese Society of Analytical Chemists, and the Oceanographical Society of Japan. She served for four years (1975-1979) as the editor of the *Journal of the Oceanographical Society of Japan*, an internationally recognized and well-respected journal of results of scientific research. She has participated in many international congresses and symposia, including the 1973 Paris Symposium on Ecology of the International Atomic Energy Agency.

In 1979, she was appointed director of the Geochemical Laboratory of the MRI and became one of the two woman directors of government laboratories in Japan. The other is Dr. Fumiko Fukuoka, who was director from 1978 to 1980 of the National Cancer Center Research Institute of the Ministry of Health and Welfare.

THE SOCIETY OF JAPANESE WOMEN SCIENTISTS

The Society of Japanese Women Scientists was formed in 1958. Dr. Saruhashi was a charter member and is now Secretary General. The society promotes the scientific activities of women in Japan, has regional and national meetings, and sponsors visits and

lectures by women scientists, including Maria Goeppert Mayer, 1963 Nobel laureate in physics, Mrs. Linus Pauling, Dorothy Haegkin, 1964 Nobel laureate in chemistry, and other distinguished women from both the Japanese and the international community of science and engineering.

When the society celebrated its 20th anniversary, a special retrospective number of their news magazine was issued bearing a reproduction of a Polish coin commemorating Marie Curie on the cover. The issue carried special articles on the history of the society, on international relations, on the International Women's Year, and reports of the meetings of the society and plans for the next 20 years.

An important part of the anniversary issue is a membership list, with information on the academic degrees, dates of graduation, and places of employment of nearly 300 Japanese women scientists.

THE SARUHASHI PRIZE

The widespread respect and affection for Katsuko Saruhashi was demonstrated upon her retirement as Director of the Geochemical Laboratory. At that time her colleagues, both in Japan and abroad, collected donations of nearly Y5,000,000 (about $25,000) as a retirement gift, Typical of her dedication to science in general and especially to women in science, she has used the money to established the Saruhashi Prize to encourage young Japanese women in science. The present value of the award is around $1300 a year. The recipient is selected by a committee of 12. The first recipient of the prize is Dr. Tomoko Ohta, a geneticist in the National Institute of Genetics, a laboratory of the Ministry of Education. Dr. Ohta is a graduate of the University of Tokyo and holds a Ph.D. from the University of North Carolina.

Dr. Saruhashi has pointed out that only 3% of Japanese university professors are women, and only about 14% of their assistants are women. In national research institutes, only 1.1% of department heads (first class employees) are women, and only 23% of the assistants (fourth class employees) are women. She also points out there are very few facilities in Japan to make it possible for a mother to work (she herself has never married) and many well-educated and capable women have had to abandon careers in science to care for the home and children (*Asahi Evening News*, Tokyo, 4 November 1980). It is to be hoped that the activities of the Society of Japanese Women Scientists, the awarding of the Saruhashi Prize, and the activities of the Fusen Kaikan (The Women's Suffrage Center, 21-11 Yoyogi 2-chome, Shibuya-ku, Tokyo 151) will be successful in tapping this rich source of scientific talent.

INTERNATIONAL MEETINGS IN THE FAR EAST

1982-1986

Compiled by Seikoh Sakiyama

This list will be updated and augmented in future issues of the *Scientific Bulletin*. The assistance of Dr. T. D. Grace, Australian Embassy, Tokyo, and Dr. M. J. McNamara, New Zealand Embassy, Tokyo, in supplying a list of meetings in their countries is deeply appreciated. Similarly, the assistance of Dr. E. D. Rankin, American Embassy, Manila, Dr. J. H. Hubbell, NBS, Washington, Dr. F. A. Richards, ONR, London, in providing schedules of meetings is gratefully acknowledged. Readers are asked to notify us of upcoming international meetings in the Far East which have not yet been included in this report.

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Date	Title	Site	For information, contact
February 2-5	2nd World Conference on Chemical Research Applied to World Needs	Manila, Philippines	Mr. Gem Aluez International Rice Research Institute 605 Dona Narcisa Building Paseo de Roxas, Makati Metro Manila
February 8-10	9th Australian Institute of Nuclear Science and Engineering, Nuclear Physics Conference	Melbourne, Australia	Conference Secretary, AINSE Private Mail Bag, PO Sutherland, N.S.W. 2232
February 8-12	International Seminar on Control of Viral Diseases in Southern Asia, Western Pacific and Northern Australia	Canberra, Australia	Professor J.S. Mackenzie Dept. of Microbiology University of Western Australia The Queen Elizabeth II Medical Center Nedlands, W.A. 6009
February 15-19	7th Australian Electron Microscopy Conference	Canberra, Australia	Australian Academy of Science P.O. Box 783, Canberra City A.C.T. 2601
March 22-26	International Symposium on Hydrothermal Reactions	Yokohama, Japan	Prof. Shigeyuki Sohmiya Research Laboratory of Engineering Materials Tokyo Institute of Technology 4259, Nagatsuta-cho Midori-ku, Yokohama Kanagawa 227

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Date	Title	Site	For information, contact
April 14-16	International Society for Photogrammetry and Remote Sensing Symposium: Primary Data Requisition	Canberra, Australia	Australian Photogrammetric Society The Organizing Committee PO Box 14, Watson A.C.T. 2602
April	Second International Workshop on the Malacofauna of Hong Kong and South China	Hong Kong	Dr. B.S. Morton Department of Zoology The University of Hong Kong
April 26-29	A Pacific Regional Workshop on Assimilative Capacity of the Oceans for Man's Wastes	Taipei, Taiwan	Professor Jong-Ching Su SCOPE, Academia Sinica Taipei 115, Republic of China
May 7-15	General Meeting of the International Association of Geodesy	Tokyo, Japan	Prof. I. Nakagawa Geophysical Institute Faculty of Science Kyoto University Oiwake-cho, Kita-Shirakawa Sakyo-ku, Kyoto 606
May 10-14	Annual Scientific Meeting of the Australian Society of Microbiology	Hobart, Australia	The National Secretary Australian Society for Microbiology Inc. 191 Royal Parade Parkville, Vic 3052
May 10-15	General Meeting of the International Association of Geodesy	Tokyo, Japan	Assistant Prof. I.Nakagawa Geophysical Institute Faculty of Science Kyoto University Oiwake-cho, Kita-Shirakawa Sakyo-ku, Kyoto 606
May 11-13	Hydrology and Water Resources Conference	Melbourne, Australia	The Institution of Engineers, Australia 11 National Circuit Barton, A.C.T. 2600
May 11-14	International Cryogenics Engineering Conference	Kobe, Japan	Prof. H. Nagano The Institute for Solid State Physics University of Tokyo 7-22-1 Roppongi, Minato-ku Tokyo 106

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Date	Title	Site	For information, contact
May 12-14	Microelectronics Conference	Adelaide, Australia	The Institution of Engineers, Australia 11 National Circuit Barton, A.C.T. 2600
May 15-17	Conference on Atomic and Molecular Reactions and Structure	Adelaid, Australia	Professor I.E. McCarthy Flinders University Bedford Park, SA 5098
May 17-20	The 3rd World Conference on Lung Cancer	Tokyo, Japan	S.G. Prof. K. Suematsu The Secretariat of the 3rd World Conference on Lung Cancer National Cancer Center 5-1-1 Tsukiji, Chuo-ku Tokyo 104
May 23-28	16th International Congress of Dermatology (CID)	Tokyo, Japan	Japan Convention Service, Inc. Nippon Press Center 8F 2-2-1, Uchisaiwai-cho Chiyoda-ku, Tokyo 100
May 24-26	2nd InternationalMicroelectronic Conference	Tokyo, Japan	Dr. Hisao Hirabayashi I SHM Japan Office 5-635, Hanakoganei Kodaira, Tokyo 187
May 25-30	2nd International Symposium on Radiation Physics	Penang, Malaysia	Professor A.M. Gbose School of Physics University Sains Malaysia Minden, Penang
May (tentative)	35th Annual Metals Congress	Sydney, Australia	Australasian Institute of Metals P.O.Box 263, Bondi Beach N.S.W. 2026
May 30-June 4	International Symposium on the Properties and Applications of Metal Hydroid	Toba, Japan	Suda Laboratory Department of Chemical Engineering Kogakuin University 2665-1, Nakano-machi Hachioji, Tokyo 192
June 6-10	International Symposium on Chemical Kinetics Related to Atmospheric Chemistry	Tsukuba, Japan	Dr. Hajime Akimoto The National Institute for Environmental Studies 16-2, Yatabe-cho Ogawa Tsukuba-gun, Ibaraki 305

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Date	Title	Site	For information, contact
June 7-11	9th International Congress on Electrocardiology (23rd International Symposium on Vectorcardiography)	Tokyo, Japan	Tokyo University School of Medicine 7-3-1 Hongo, Bunkyo-ku Tokyo 113
June 7-11	4th International Symposium on the Genetics of Industrial Microorganisms	Kyoto, Japan	GIM Japan National Committee Microbiology Research Foundation 2-4-6 Yayoi, Bunkyo-ku Tokyo 113
June 27-July 2	5th International Conference on Geochronology, Cosmochronology, and Isotope Geology	Nikko, Japan	Geological Survey of Japan Agency of Industrial Science and Technology 1-1-3 Yatabe-Higashi Tsukuba-Gun, Ibaraki 305
July 5-10	VI International Symposium on Solute-Solute-Solvent Interactions	Osaka, Japan	Prof. H. Ohtaki Tokyo Institute of Technology at Nagatsuka Dept. of Electronic Chemistry Nagatsuta, Midori-ku Yokohama 227
July 10-16	The 5th International Congress of Plant Tissue	Yamanashi, Japan	Assistant Prof. A.Komamine Dept. of Botany Faculty of Science University of Tokyo 7-3-1, Hongo, Bunkyo-ku Tokyo 113
July 11-16	7th World Congress on Animal, Plant and Microbial Toxins	Brisbane, Australia	Dr. Ann M. Caneron 7th WCAPMT Zoology Department University of Queensland St. Lucia, Queensland 4067
August 15-21	International Biochemical Congress	Perth, Australia	Australian Academy of Science and International Union of Biochemistry P.O. Box 783, Canberra A.C.T. 2601
August 16-20	13th Australian Spectroscopy Conference	Melbourne, Australia	Australian Academy of Science PO Box 783, Canberra City A.C.T. 2601

Date	Title	Site	For information, contact
August 16-20	Fourth International Symposium on Antarctic Earth Sciences	Adelaide, Australia	Dr. R.L. Oliver Department of Geology University of Adelaide Adelaide, S.A. 5001
August 17-20	2nd International Kyoto Conference on New Aspects of Organic Chemistry	Kyoto, Japan	Prof. Z. Yoshida Dept.of Synthetic Chemistry University of Kyoto Yoshida-Hommachi Sakyo-ku, Kyoto 606
August 18-20	Annual Meeting of the Australian Society for Reproductive Biology	Sydney, Australia	Dr. R.H. Scaramuzzi CSIRO, Division of Animal Production PO Box 239, Blacktown N.S.W. 2148
August 22-26	The 7th Asia and Oceania Congress of Endocrinology	Tokyo, Japan	Prof. K. Shizume Dept. of Medicine 2 Tokyo Women's Medical College Kawadacho, Shinjuku-ku Tokyo 162
August 22-27	4th International Conference on Organic Synthesis (IUPAC)	Tokyo, Japan	Prof. T. Mukaiyama Dept. of Chemistry Faculty of Science University of Tokyo 7-3-1, Hongo, Bunkyo-ku Tokyo 113
August 23-27	The Royal Australian Chemical Institute 7th National Convention	Canberra, Australia	Executive Secretary, RACI HQ 191 Royal Parade Parkville, Vic. 3052
August 23-27	The 8th Congress of International Ergonomics Association	Tokyo, Japan	Masamitsu Oshima,Director The Medical Information System Development Center Landick Akasaka Bldg. 2-3-4, Akasaka, Minato-ku Tokyo 107
August 23-27	6th Australian Statistical Conference	Melbourne, Australia	Professor E.J. Williams Dept. of Statictics University of Melbourne Parkville, Vic 3052

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Date	Title	Site	For information, contact
August 23-27	5th Australian Institute of Physics Congress	Canberra, Australia	Vice-President Australian Institute of Physics Royal Military College Duntroon, A.C.T. 2600
August 24-26	Chemical Engineering Conference	Sydney, Australia	The Institute of Engineers, Australia 11 National Circuit, Barton, A.C.T. 2600
August 24-27	10th Australian Ceramic Conference	Melbourne, Australia	Mr. R.Bowman, CSIRO Division of Building Research PO Box 56, Highett Vic 3190
August 25-27	2nd Conference on Control Engineering	Newcastle, Australia	The Conference Manager The Institute of Engineers, Australia 11 National Circuit, Barton, A.C.T. 2600
August 25-30	The 7th Sagamore Conference on Charge, Spin and *Momentum Densities*	Nikko, Japan	Prof. S. Hosoya The Institute for Solid State Physics University of Tokyo 7-22-1, Roppongi Minato-ku, Tokyo 106
August 27-30	Second International Symposium on Molecular Beam Epitaxy and Related Clean Surface Techniques	Lake Kawaguchi, Japan	Prof. R. Ueda Department of Applied Physics School of Science and Engineering Waseda University 4-1, Ohkubo 3-chome Shinjuku-ku, Tokyo 160
August 29-September 4	The 5th International Congress of Pesticide Chemistry, IUPAC	Kyoto, Japan	Rikagaku Kenkyusho (The Institute of Physical and Chemical Research) 2-1 Hirosawa, Wako-shi Saitama 351
August (tentative)	1982 International Conference on Solid State Devices	Tokyo, Japan	The Japan Society of Applied Physics Kikai-Shinko-Kaikan 5-8, 3-chome, Shibakoen Minato-ku, Tokyo 105

1982, continued

Date	Title	Site	For information, contact
August (tentative)	4th International Conference in Australia on Finite Element Methods	Australia (undecided)	Professor L.K. Stevens Dept. of Civil Engineering University of Melbourne Parkville, Vic 3052
September 5-10	International Conference on Magnetism-1982 (ICM-1982)	Kyoto, Japan	Prof. J. Kanamori Faculty of Science Osaka University Toyonaka, Osaka 560
September 6-10	International Conference on Nuclear Physics in the Cyclotron Energy Region	Osaka, Japan	Prof. M. Kondo Research Center for Nuclear Physics Osaka University Yamada-kami, Suita-shi Osaka 565
September 13-16	6th International Symposium on Contamination Control	Tokyo, Japan	Japan Air Cleaning Association 6-7-5, Soto-Kanda Chiyoda-ku, Tokyo 101
September 13-16	The Sixth International Conference on Software Engineering	Tokyo, Japan	Information Processing Society of Japan Kikaishinko Building 3-5-8, Shiba-koen Minato-ku, Tokyo 105
October 4-6	3rd International Dental Congress on Modern Pain Control	Tokyo, Japan	Japan Convention Service, Inc. Nippon Press Center 8F 2-2-1, Uchisaiwai-cho Chiyoda-ku, Tokyo 100
October 24-29	Second International Conference on Stability of Ships and Ocean Vehicles	Tokyo, Japan	Prof. S. Motora The Society of Naval Architects of Japan 15-16, Toranomon 1-chome Minato-ku, Tokyo 105
November 6-9	Electric Energy Power Electronics Conference	Adelaide, Australia	The Conference Manager The Institute of Engineers, Australia 11 National Circuit Barton, A.C.T. 2600
November 17-19	3rd JIM (Japan Institute of Metals) International Symposium	Japan (undecided)	The Japan Institute of Metals Aza Aoba, Aramaki Sendai-shi, Miyagi 980

1982, continued

Date	Title	Site	For information, contact
November 26-December 2	The 7th International Conference on Vacuum Metallurgy	Tokyo, Japan	The Iron and Steel Institute of Japan Keidanren Kaikan 1-9-4, Ohtemachi Chiyoda-ku, Tokyo 100
undecided	International Conference on Mass Spectroscopy	Hawaii, U.S.A.	Prof. T. Tsuchiya Basic Science Lecture Room Chiba Institute of Technology 1-17-2, Tsudanuma Narashino, Chiba 275
undecided	International Rehabilitation Medicine Association Fourth World Congress	Sydney, Australia	Prof. G.G. Burniston Dept. of Rehabilitation Medicine Prince Henry Hospital Little Bay, N.S.W. 2036
undecided	Workshop on Marine Microbiology	Seoul, Korea	Korea Ocean Research and Development Institute P.O.Box 17, Yang-Jae Seoul

1983

Date	title	Site	For information, contact
February 1-11	15th Pacific Science Congress	Dunedin, New Zealand	University of Otago P.O. Box 6063 Dunedin, New Zealand
March (tentative)	Conference on Coastal Engineering	Queensland, Australia	Conference Manager The Institution of Engineers, Australia 11 National Circuit Barton, A.C.T. 2600
May (tentative)	36th Annual Metals Congress	Pt. Kembla, Australia	Australian Institute of Metals PO Box 1144, Wollongong N.S.W. 2500
May 16-20	5th National School and Conference on X-Ray Analysis	Melbourne, Australia	Dr. R. A. Coyle X-Ray Analytical Association, New South Wales Institution of Technology P.O. Box 90, Parkville Vic. 3052

1983, continued

Date	Title	Site	For information, contact
May 16-20 (tentative)	Annual Scientific Meeting of the Australian Society for Microbiology	Brisbane, Australia	The National Secretary Australian Society for Microbiology Inc. 191 Royal Parade Parkville, Vic 3052
August 1-7	International Association for Dental Research	Sydney, Australia	Mr. Scott Gotjamanos Dept. of Pathology Perth Medical Centre Verdon Street Nedlands, W.A. 6009
August 17-24	4th International Congress of Plant Pathology	Melbourne, Australia	Mr. B. Price Victorian Plant Research Institute Dept. of Agriculture Victoria, Swan Street Burnley, Vic. 3121
August 21-27	5th International Congress of Immunology	Kyoto, Japan	The Japanese Society for Immunology Institute of Virus Research Kyoto University Kawaracho, Shogoin Sakyo-ku, Kyoto 606
August 27	Symposium Commemorating the 100th Anniversary of the Mount Krakatau Eruption	Jakarta, Indonesia	Dr. Didin Sastrapradja Indonesian Institute of Sciences LIPI, JL Teuku Chik Ditiro 43 Jakarta
August 27-31	25th International Geographical Congress	Sydney, Australia	Australian Academy of Science P.O. Box 783 Canberra, A.C.T. 2601
August 26-September 2	18th International Ethological Conference	Brisbane, Australia	Professor E. McBride Dept. of Psychology University of Queensland St Lucia, Qld 4067
August 28-September	29th International Congress of Physiology	Sydney, Australia	Australian Academy of Science PO Box 783, Canberra A.C.T. 2601

1983, continued

Date	Title	Site	For information, contact
August 28-September 2	29th International Congress of Physiology	Sydney, Australia	Australian Academy of Science P.O.Box 783, Canberra A.C.T. 2601
August 28-September 3	The 3rd International Mycological Congress (IMC 3)	Tokyo, Japan	Prof. K. Tsubaki Institute of Biological Sciences The University of Tsukuba Sakura-mura, Ibaraki 305
August (tentative)	International Solar Energy Congress	Perth, Australia	Mr. P. Driver Honorary Secretary P.O. Box 123 Nedlands, W.A. 6009
August (tentative)	Computers in Engineering	Australia (undecided)	The Conference Manager The Institution of Engineers, Australia 11 National Circuit Barton, A.C.T. 2600
August (tentative)	Hydraulics and Fluid Mechanics Conference	Newcastle, Australia	The Conference Manager The Institution of Engineers, Australia 11 National Circuit Barton, A.C.T. 2600
October (tentative)	8th International Conference on Calcium Regulating Hormone	Kobe, Japan (tentative)	Prof. T. Fujita 3rd Division Dept. of Medicine School of Medicine Kobe University 7-13, Kusunoki-cho Ikuta-ku, Kobe 650
October 29-November 3	71st FDI Annual World Dental Congress (Federation Dentaire Internationale)	Tokyo, Japan	Japan Dental Association (Japanese Association for Dental Science) 4-1-20, Kudan-kita Chiyoda-ku, Tokyo 102
November (tentative)	Conference on Microprocessors	Australia (undecided)	The Conference Manager The Institute of Engineers, Australia 11 National Circuit Barton, A.C.T. 2600

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Date	Title	Site	For information, contact
November (tentative)	Metal Structures Conference	Brisbane, Australia	The Conference Manager The Institution of Engineers, Australia 11 National Circuit Barton, A.C.T. 2600
December (tentative)	12th International Laser Radar Conference	Melbourne, Australia	Dr. C. Platt, CSIRO Division of Atmospheric Physics PO Box 77, Mordiattoc Vic 3195
undecided	13th International Congress of Chemotherapy	Melbourne, Australia	Dr. B. Stratford St. Vincent's Hospital 59 Victoria Parade Fitzroy, Vic. 3065

1984

Date	Title	Site	For information, contact
May (tentative)	5th International Soils Expansion Conference	Adelaide, Australia	The Conference Manager The Institution of Engineers, Australia 11 National Circuit Barton, A.C.T. 2600
August 24-September 1	The 3rd International Congress on Cell Biology	Kyoto or Kobe, Japan	Japan Society for Cell Biology Shigei Medical Research Institute 2117 Yamada Okayama 701-02

1985

Date	Title	Site	For information, contact
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

1985, continued

Date	Title	Site	For information, contact
October 15-18	International Rubber Conference	Kyoto, Japan (tentative)	The Society of Rubber Industry, Japan Tobu Bldg., 1-5-26 Motoakasaka, Minato-ku Tokyo 107

1986

Date	Title	Site	For information, contact
(tentative)	International Microbiological Congress	Perth, Australia	Australian Academy of Science PO Box 783, Canberra A.C.T. 2601
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 Vic 3001

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NOTICE

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