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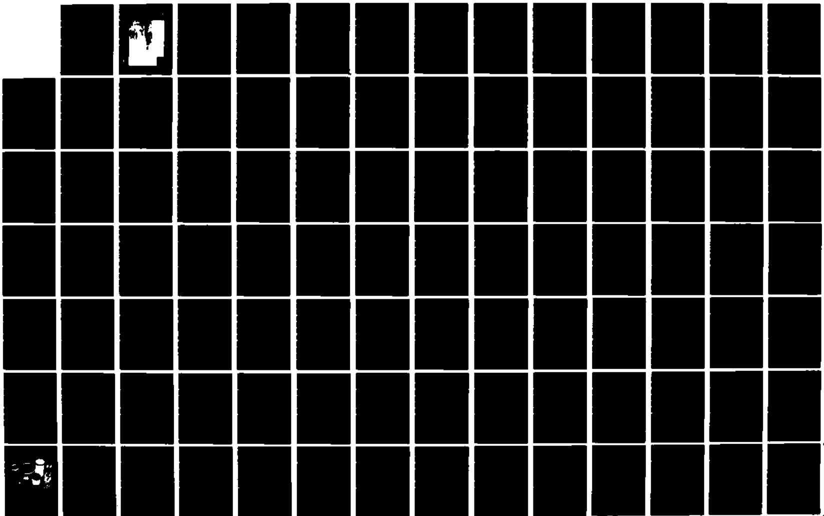

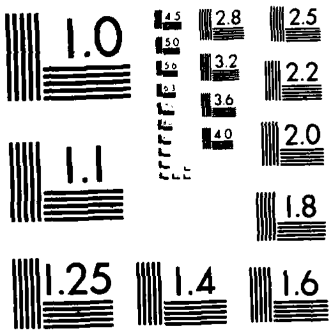

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This is a quarterly publication presenting articles covering recent developments in Far Eastern (particularly Japanese) scientific research. It is hoped that these reports (which do not constitute part of the scientific literature) will prove to be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

20. Abstract (continued)

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.

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CONTENTS

Cover: Chinese women on a tea farm of a commune near Hangzhou, in Zhejiang Province, People's Republic of China. The tea leaves are mostly gathered by the women, brought to a processing center for curing, then packaged. During the winter months, the women weave the baskets used in collecting the tea leaves. The baskets can also be sold in the free markets. Photograph by Mary Lou Moore.

OBSERVATIONS ON SCIENCE IN JAPAN

Rudolph J. Marcus

INTRODUCTION

This paper arises from my experiences in Japan where I spent two years as Director of the Office of Naval Research Scientific Liaison Office in Tokyo in 1979 and 1980. The Office of Naval Research has branch offices abroad which can serve as focal points for information exchange. Foreign scientists can find out from these offices about research in their specialty being done in the United States and we in turn can find out what science is being done over there. That information helps us to avoid duplication and also helps us in our own research planning.

After two years in Japan, any scientist is going to ask himself what makes the Japanese so effective at some things, what are the things that they are most effective at, and why they do things so differently from the way that we do them.

I should emphasize here that when I write about differences between ourselves and those from another nation, I am not making any value judgements. I personally believe that it is important to know what the differences are in people's habits, customs, and thought patterns, not necessarily for any imitation on our part, but mainly so that we can communicate better with them and that we can interpret better what some of their actions and responses might be and what the reason is for some of those actions and responses. Furthermore, I fully well realize that actions and characteristics of people span an entire spectrum in the United States as well as in Japan. Obviously, the spectral peaks are at different locations but the spectra overlap. That means that when I am generalizing, I am not speaking about all people in one country or the other, but I am taking about the location of the spectral peaks, or in other words, averages.

One of the things one needs to take into account in discussing Japan is the size of the country (Figure 1). Japan consists of a two-thousand-mile-long chain of islands, with much of the population concentrated in one megalopolis on the island of Honshu, stretching 30 miles from Tokyo almost to Hiroshima. The latitude of this chain corresponds roughly to the stretch between Los Angeles and Vancouver. The climate is hot and muggy during the summer, cold and dry during the winter. The total area of Japan is less than that of the state of Montana; the total population is about 117 million or half of that of the United States. However, some 75% of that area is either uninhabitable or nonarable, so that a population half the size of that of the United States is crowded into an area which is about 25% of the area of the state of Montana which gives you an idea of how closely packed together they live and work. The reason why such a large percentage of the country is nonarable is the very steeply mountainous volcanic character of the country.

There are some interesting economic figures (Table I) which compare Japan's productivity to that of other countries. These are put on the basis of gross national product (GNP) per km^2 of arable land. In these figures Japan obviously comes out way at the top; the next in line at about half of the value of Japan is West Germany. The United States, in these units, comes in at about one-twentieth of the productivity per km^2 of arable land as Japan does.

The dominating factor in the economy of Japan is its lack of indigenous natural resources; Japan imports almost all of its raw materials and more than 85% of its energy sources. Japan thus manufactures end items which are of higher value than the imports, and exports these end items. It is no wonder that Japan has totally embraced high technology industry.

AREAS OF EXCELLENCE

- Manufacturing

What is it that the Japanese do differently? Firstly, they are good at reliable manufacture at good prices. They are good in converting raw materials such as imported coal and iron ore into steel, much of which is exported. They do not hesitate to build more modern plants long before older plants have reached their service life, if economies in efficiency or manpower can be attained. Thus, they are well into their third generation of steel plants since the war whereas we still have some prewar steel plants. In heavy manufacture they are very good in large shipbuilding and in assembly line process where they can use a good deal of robotics, particularly in the automobile industry. They are also good at all kinds of high technology manufacturing, again much of which is automated or robotized.

There are at least two reasons why Japanese manufacture has good quality, it is reasonably priced, and delivers a good product. One of these has already been implied and that is automation in the manufacturing process. It is my understanding that, if you walk on the floor of a Japanese automobile assembly line, you will see hardly half a dozen people on the floor of the plant. Contrast this with the mass of humanity in the usual assembly plants in the United States. My own experience in buying an automobile in Japan and the experience of my friends indicates how automated this process is. The assembly line is computerized to provide for all models with all of the options in terms of color, upholstery, and equipment so that any order can be punched into the input unit of the computer. An additional wrinkle is that the computer controlling the assembly line is programmed to allow for automobile variations that are required by the laws of individual countries, and in our country, individual states. For example, one orders a car to be driven in California and not only does the computer-controlled assembly line place the steering wheel on the left-hand side rather than the right-hand side, but it also supplies the car with a catalytic converter. The same thing was experienced by one of my Finnish friends who ordered an automobile legal to drive in Finland.

Another characteristic of all Japanese manufacture is their very extensive and complete product testing. One thing which I have heard said about the Japanese character is that it is unable, unwilling, or inexperienced in dealing with the concepts of sampling statistics. Concepts such as 95% safe, or LD_{50} do not seem to convey the same meaning to the Japanese as they do to us. To them, a product is either 100% fit for consumption or use, or it is not, in which case it is not sold. This same diffidence in dealing with statistics carries over into their use of sampling for product testing. We are in the habit of taking every tenth or hundredth or thousandth product off the line and testing it, assuming thereafter that if every thousandth product tests out all right, then the assembly line must be operating well and all of the intermediate products are fit for sale. That kind of thing is not done in Japan, where every product coming off the line is tested. This kind of absolutism my seem strange to us, but it fits in well with the Japanese character. Furthermore, as we have seen, it provides a reliable product in the marketplace and has led to much of the success that the Japanese have experienced commercially. I might add that this kind of absolutism also carries over into other ways of looking at manufacturing or planning manufacture in Japan. For example, if a chip with 120 functions is designed and put into production in Japan, and one of the functions turns out upon product testing not to work as desired, any American designer or manufacturer would work very hard to adjust the one function, adjust the assembly line to produce that function slightly differently, and go on producing the chip. Not so in Japan. The entire assembly line would be dismantled, the entire design for the chip would be given up, and the entire chip and all 120 functions thereof would be redesigned from the ground on up.

- Research Planning and Funding

In reporting what the Japanese do differently, I first mentioned reliable manufacture at good price. A second item is that the Japanese do their industrial research planning and funding differently from the way in which we do it. In our country, and in much of the Western world, it is usual for one kind of individual, the basic researcher, to do the basic research and to publish his or her findings either in the open literature, as a company report, or as a patent. From that external or internal literature, the applied research community picks the new results which it needs, the fields which it considers to be promising, carries them through applied research, and then again publishes the results either in the open literature, as a company report, or as a patent. From this pool, the development community picks its promising projects and so on and so forth, each type of work being done by different kinds of scientists or engineers with its intermediate publication point. I might add that this also makes it easy to track the kinds and amount of basic research, applied research, development, etc., being done in our country. By contrast, the Japanese have one person or one team carrying through a particular item from basic research through applied research, development, prototyping, and even pilot plant. This seems to be almost as true in universities as it is in industry. It makes it very much harder to track the advances which they make because there are no intermediate publication points. They are limited in the amount of information which they can find in the intermediate publication pools. On the other hand, being associated with one particular item or development gives the Japanese research scientist and engineer a tremendous sense of pride and belonging which can be very motivational.

Since the Japanese research literature is voluminous, what does it consist of if there are fewer intermediate publication points between basic research and the final, manufactured product? What is presented at meetings of the Japanese Chemical Society or Physical Society? They do not appear to insist as much as we do, at least in chemical journals which I am familiar with, on publishing only original work. There are many progress reports as well as reports on setting up and testing methods of experimentation which may have been published elsewhere. This is related in part to Japanese feelings about originality, which are different from ours and which I will mention later, and in part to Japanese research funding practices, particularly in universities. Table II shows that industrial research funding is stronger in Japan than it is in the U.S. The Japanese do not have the array of funding agencies which we do such as the National Science Foundation (NSF), and the National Institutes of Health (NIH), etc. Rather, all of the money flows through government ministries, about half of it through the Ministry of Education. The fundamental research unit in a university is the "koza," or chair. It consists of one professor, an associate or assistant professor, one or two research assistants at the doctoral level, and two or three graduate students. With a minimal proposal each year, each koza is granted sufficient money to buy moderate supplies, but not much else. Travel money for international travel must be obtained separately, most frequently from foreign sources. Apparatus is often home-built; otherwise funding for apparatus also needs to be obtained separately.

Thus, much of a graduate student's time is spent in building and calibrating apparatus, much of it of the baling wire and sealing wax variety. The quality of the research results obtained in this manner, as well as the ingenuity and persistence shown in constructing apparatus, is truly remarkable. Exceptions to this rule are four national institutes which are showplaces and which have *all* the modern equipment one would like to see, two of them at Okazaki, just north of Kyoto. Another exception is the new University at Tsukuba, about 40 miles from Tokyo, where the government has founded a "science city" and to which it is relocating many national laboratories.

The ties between universities, industry, and government are very strong, although often informal. For example, many career government employees in technical fields are offered high-ranking industry positions after an early retirement from government service. Similarly, there seem to be frequent changes back and forth between positions in industry and in private universities by professors, deans, and directors of research. A very recent change permits national universities to participate in such exchanges.

Antimonopoly laws in the U.S. have required each competitor to carry on his own industrial research. Cooperation is not only limited, but actually forbidden by law. Things seem to be different in Japanese industrial research, where very often the government promotes the formation of consortia between the four or five leading companies in a particular field with respect to research and development. The patents developed in this manner go into a patent pool for all of the participating companies to use. This system has been widely used in Japan, particularly in the semiconductor and the computer industries. In this manner also, we find government support being given to industrial R&D outside of the usual project grant. Just think what government support, and government-encouraged cooperation, could have done for some of our own industry in times when company resources were not quite large enough for a really large-scale R&D project.

- *Subdisciplines*

Thirdly, what kinds of research are the Japanese good at? In chemistry, the Japanese seem to be particularly good at organic synthesis, particularly for polymers and pharmaceuticals. They are also very innovative in nonstoichiometric materials, such as those used for ceramics and for magnets. They are very active in the isolation and characterization of natural products. Obviously, they are also very good in the fields of integrated circuits and in robotics.

What is it in the Japanese culture that leads to specialization in a very few areas and in those areas in particular? One factor is the well-known Japanese respect for seniority, or the hierarchical structure of Japanese society. One of the most important books for my Japanese interpreter was a volume which listed all of the professors in the University of Tokyo in the order of their birthdays. This was obviously the order of their seniority, no matter how much they had published or what the quality of their publication was. With such respect for seniority, it is obvious that generations of graduate students follow those few of their elders who have been successful in one field or another. With such an attitude, it is natural that fields of research should be chosen in which many hands making minor changes in established experimental procedures, and many people making products slightly different from a parent product, are going to flourish. Organic synthesis, for example, particularly in natural products, is such a field in chemistry. The other fields which I mentioned, nonstoichiometric materials, integrated circuits, and robotics, are also of that kind of character.

This is coupled to a very subtle part of Japanese culture which is certainly open for detection but which is not often spoken about by the Japanese. A strong admiration for a few forms or subjects pervades Japanese tradition; perfection is sought by imitation rather than by innovation. I found the key to that in a book about sumie, the Japanese art of brush painting, whose introduction says about the Oriental artist that he or she "has little desire to depart from the main stream of tradition. Quality, not originality, is a mark of worth." Ringing changes on a well-established ground is admired, finding new grounds is not. I can hardly overemphasize the importance of this in Japanese tradition. This is the reason why one sees only a very limited number, as few as 30 or 40, subjects in Japanese art, and what may seem in our Western eyes to be a copy or almost a print, rather than an original, is to the Japanese an original of an approved subject which has been painted by many hundreds or thousands of artists over the years. Japanese themselves refer to this as a template mentality, one which prefers to follow a pattern rather than to break new ground. Please note that I am not saying that the Japanese are incapable of original thinking, or that a lot of original work is not being done there. What I am saying is that great departures from established patterns are not appreciated in Japanese culture. Dr. Kikuchi, director of the Sony Research Cente nd the man who pushed the Sony "Walkman" to development, says that in Japanese "le (manabu) comes from "imitate" (manebu).

It is much the same in science in Japan: quality is much adm , originality is not. It is said that Hideki Yukawa, who was one of the few indi Nobel Prize winners, was completely looked down upon by the Japanese establishr because of his originality until the moment when he won the Nobel Prize at which point he was suddenly respected.

Creativity is another example of the attributes, referred to at the end of this article, which reside in the individual in American civilization but in the group in Japanese civilization. Thus, in Japanese science and technology, a great group creativity may take the place of great individual creativity.

Another consideration in probing the Japanese research repertoire is the lack of Cartesian logic in Japanese philosophy or science. By Cartesian logic, I refer to the reductionist logic of René Descartes who recommended "to divide each problem I examine into as many parts as is feasible and as is requisite for its better solution." This kind of reductionist logic, which is the very basis and backbone of our scientific system, is not at all known or practiced in Japan, and those Westerners who come in practicing it are going to be met with a great deal of puzzlement. As nearly as I understand it, the Japanese way of solving problems, whether those of human relations, economics, or science, is to handle the problem as a whole, and not to subdivide it into any of its parts for easier understanding or easier handling. I asked more than once what happens if you do not understand or cannot handle a whole problem in its entirety. I was answered with a look of wonderment: "Of course then we just lay that particular problem aside and find a problem that is soluble by our methods."

With all of this emphasis on pattern, why are Japanese not known to be leaders in computerized clustering or pattern recognition? Their kind of pattern is a cultural and language characteristic, not something which is derived stochastically. Besides, computerized clustering falls under the general Japanese distrust of statistics which I mentioned earlier.

I have spoken about three kinds of things that the Japanese do differently. One was reliable manufacture at good prices; a second one is research funding; and the third one listed the kinds of scientific research that the Japanese are good at. I would now like to make some more general remarks about conditions in Japan which may contribute to our understanding, or misunderstanding, of what they are doing in science and technology.

RELATED FACTORS

- Educational System

First of all a comment about Japanese education. The Japanese educational system, like so many other things in Japan, is very highly structured. At its peak is the University of Tokyo Law School, from which most of the government administrators come. One of the strange things in Japan is to find mid-level or top-level administrators, even in the technical ministries such as the Ministry of Health, not being professionals in their own science, but being graduates of the University of Tokyo Law School. They explain very charmingly that, if they want expert advice they can always get that from advisors. The examinations which regulate a student's admission to various steps in this rigid educational structure, and which determine the quality of the school which the student may attend, are very much fact-centered, and do not encourage much original thinking.

- Politeness

Secondly, I comment about Japanese politeness. Almost every visitor to Japan mentions the formal system of interaction which he notices among Japanese and interprets by our Western standards as politeness. It is certainly true that any society which lives in such cramped conditions as those which I described at the beginning of this paper is going to have to develop a very elaborate system of social interaction. This system has been polished and purified for thousands of years and is in part a function of the hierarchical structure of Japanese society, or reinforces that hierarchical structure. This "politeness" leads to a good deal of indirection in one's dealings with Japanese. I always had a little translating device for my conversations with Japanese. When they said "yes," it translated to "maybe," when they said "maybe" it translated to "no," and "no" is a word which Japanese never use. Serious misinterpretations can occur if such a translational device is not used. I heard the story of the departure of one American negotiator after a two-day visit in Tokyo. His local American and Japanese hosts were walking back from the airplane when the Japanese said that a deal concluded during this American's short visit would certainly never meet with Japanese approval and would, therefore, fall through. He was asked: "Good heavens, why did you let our American friend depart with the thought that he had concluded a firm deal?" The Japanese shrugged his shoulders and said, "Well, it is such a long flight back to Washington, it would have been too painful to let him depart thinking he was not successful." This kind of attitude, interpreted by us as politeness, pervades many dealings with the Japanese. The current Prime Minister, Mr. Nakasone, said in one of his first statements after election that he would cease the usual Japanese practice of "polite evasion" in his international contacts. He did so on his first visit to the U.S., being praised for it in the American press and condemned for it in the Japanese press.

There is another side to this coin of politeness. The Japanese code of politeness is limited to a hierarchical structure where the people involved know the people on their own and adjacent levels of the structure. The moment they get into a situation where they are among strangers, they may or may not behave completely differently. Anybody who has walked into a Japanese subway station at rush hour will know what I mean. The amount of elbowing other people out of the way is quite remarkable for a supposedly polite society. It seems that when they are among strangers, Japanese as well as other nationals may well act by mob psychology, a situation in which all normal bets are off.

Another component of politeness is friendship. It is well-known that Japanese are not only polite to visitors, but are helpful and friendly. There are many times when we have been given help and guidance in the streets in Japan long before we even knew that we were lost. However, friendship is part of that hierarchical structure which I have been writing about, and it involves some of the most elaborate parts of Japanese politeness and ritual. For example, not only does a guest bring a gift, but also a host gives a gift to each guest, and there are strict rules about the kinds and costs of such reciprocal gifts. Occidentals are generally excused from following these rituals on the grounds that they cannot be expected to master them. (The same reasoning applies to language--Japanese people are always surprised by even the most rudimentary Japanese spoken by an Occidental.) With such strict codes, friendship is a lifetime investment in Japan, an investment not readily extended to non-Japanese. Thus, while non-Japanese residents in Japan may enjoy many productive and pleasant social and professional contacts in Japan, these contacts will seldom, if ever, ripen into friendships the way we know friendship in the West.

- Language

A third comment which I wish to make regards the Japanese language. The Japanese use the Chinese pictographs, rather than an alphabet, of which some 2000 or more are required to read a Japanese newspaper, more for college studies. In addition to that difference, we need to realize that any transliteration of these pictographs is extremely uncertain because all of the phonemes that have been developed for the Japanese language are rather constricted with respect to the richness of the pictographs. This means that anything expressed in phonetic form is going to be multivalued with respect to meaning. For example, in Table III all of the various Japanese characters which can be pronounced as "Seikoh" are written out. In the column in the right-hand side is a listing of the various English translations such as precision, success, political principle, steel manufacturing, Western suburb, inclination, fragrance, etc. The watch, of course, is named "precision" while a child might be named "happy boy," both pronounced the same way, but written completely differently.

In terms of the structure of the Japanese language, I should note some very severe differences from English. It is a language in which there are no articles for the nouns, neither definite nor indefinite; there is no difference between plural and singular; there is no difference of gender, he or she. This, perhaps, accounts for some of the familiar results when Japanese first try to speak English. On the one hand, one would say that this would make it a very simple language to learn.

On the other hand, there are certain built-in difficulties. One of them is the numbering system which differs with respect to the items being counted. In other words, one person is not the same "one" as one cat, and so on and so forth. I am reminded of the story of one of our scientists who was departing after a two-year tour in Japan and who was quite proud of his Japanese. On one of his last days in Tokyo he was in a department store elevator and said in Japanese, "Please leave me off at the seventh floor," and everybody in the elevator burst out laughing. Much to his embarrassment it turned out that what he had actually said was, "Please leave me off at the seventh teacup." Not that he did not know the difference between "floor" and "teacup;" it was the "seventh" which was different.

Another great difficulty for Westerners learning Japanese is the various levels of politeness which are built into the language. There are at least 36 of these. Together with the politeness there is a matter of involution. I personally quit Japanese lessons at the moment when we learned a rather popular phraseology which goes like, "Yes, there is no reason to believe that there will not be any bananas today." That kind of logic is hard to figure out even in English, but much more so in Japanese.

Another comment which I wish to make about the language is that all Japanese children seem to learn English at an early age in school. However, they learn it from people who themselves have never had any experience in speaking English. Therefore, while Japanese find it possible to read English, they have great difficulty at conversation. This has caused a flourishing trade in which all manner of English-speaking visitors are being asked to give English lessons that are really conversation lessons. Particularly in cities outside of Tokyo, where Western visitors are rare, young Japanese adults and children will come up quite frequently to you and ask whether they might practice their English on you for a short length of time. Dr. Kikuchi of Sony, whom I quoted earlier, presents an excellent summary of language differences in Table IV.

- Management

A last general comment that I wish to make is about the large amount that has been written lately about Japanese methods of running organizations and Japanese methods of decision-making. I am sure you have read in various places about this and I do not want to add to that except to recommend a book by a University of California at Los Angeles (UCLA) researcher named William Ouchi, *Theory Z*. While I am a chemist rather than a management consultant, I would say that my experience really bears out much that he writes about. One of the main features of Japanese society which Ouchi reports as being necessary for success is the great trust that exists between superiors and those who work for them. The trust extends both ways and, as Ouchi remarks, "unless that trust is present almost any scheme of decision-making is going to fail."

Dr. Yamamoto of the UCLA School of Neurosciences has published in this *Bulletin* [7 (2), 88 (1982)] a table which I found helpful in summarizing and relating some of the things I have been writing about. He contrasts a number of different characteristics of the American and Japanese civilizations. Obviously, one of the great inventions of Japanese industry which Ouchi describes, the so-called quality circles where five-ten workers discuss possible improvements in manufacturing processes, may not do as much good in this country as they do in Japan. In Japan they may be a principal mechanism for giving group sanction to departures from the template mentality.

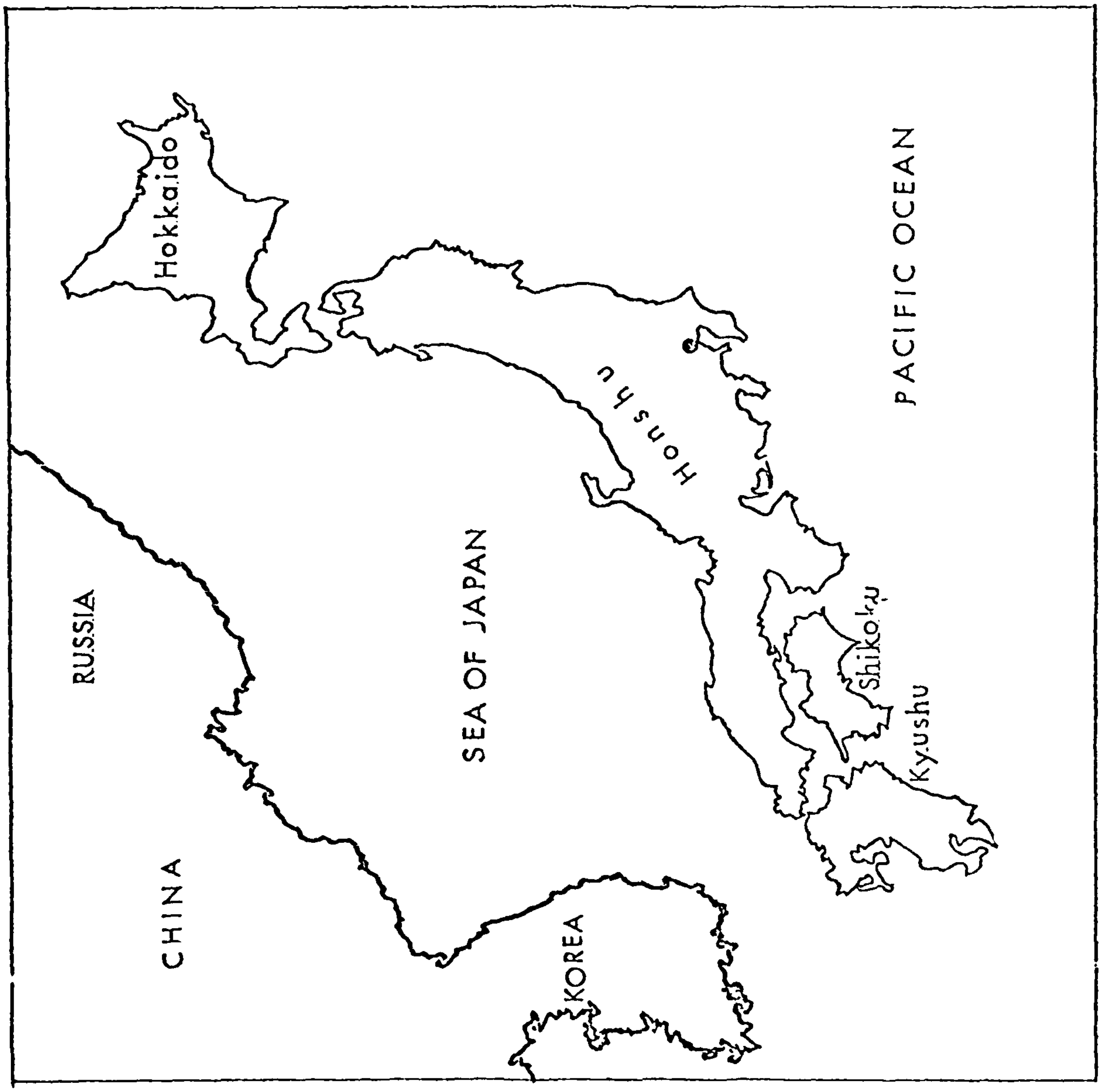
Hokkaido
Honshu
PACIFIC OCEAN
RUSSIA
SEA OF JAPAN
Shikoku
Kyushu
CHINA
KOREA

Figure 1.

Table I

RATIOS OF GROSS NATIONAL PRODUCT (GNP) TO INHABITABLE AREA

COUNTRY	$/KM^2 (In Thousands)
Japan	4867
W. Germany	2704
United Kingdom	938
France	676
U.S.A.	265

Source: S. Kodama, 1979 ACS-CSJ Meeting, Honolulu

Table II

RESEARCH PERFORMANCE

	Industrial	Academic
Japanese	60%	40%
U. S.	40%	60%

Table III

THE PHONEMES "SEIKOH"

精工	Precision
成功	Success
性交	Sexual Intercourse
政綱	Political Principle
製鋼	Steel Manufacturing
西郊	Western Suburb
性向	Inclination
清香	Fragrance
精巧	Elaborateness
西航	West Sailing
精鉱	Concentrate
生幸	Happy Boy

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Table IV

LANGUAGE CHARACTERISTICS

ENGLISH	JAPANESE
Digital expression	Analog expression
Logical orientation	Feeling orientation
Linear structures	Pattern structures
Quantitative	Qualitative
Science is ea: .er	Poetry is easier

Source: Makoto Kikuchi
Physics Today, September 1981

CURRENT COMPUTER-RELATED RESEARCH AND DEVELOPMENT EXPENDITURES OF THE JAPANESE GOVERNMENT

George E. Lindamood

The October-December 1982, issue (Volume 7, Number 4) of the *ONR Scientific Bulletin* contained an article by Barry Hilton of the U.S. Embassy, Tokyo, entitled "Government Subsidized Computer, Software and Integrated Circuit Research and Development by Japanese Private Companies," which presented figures on Japanese government subsidies for the five computer-related research and development programs now underway. Updated figures for the current Japanese Fiscal Year (which began March 1, 1983) have been obtained by the Embassy and are presented here, courtesy of Mr. Jack Osborn, Economic Attache for High Technology, in the format used in Hilton's article.

(Note: The approximate U.S. dollar equivalents given below are calculated at 220 yen = 1 dollar to be consistent with the figures presented in Hilton's article. However, the present exchange rate is approximately 240 yen = 1 dollar.)

SUPERCOMPUTER PROJECT

-English title — High Speed Computer System for Scientific and Technological Uses

-Budget

•	Total	23,000 million yen
	1981	30 " "
	1982	813 " "
	1983	1,568 " "
	1984-89	No information
•	Total	$104,545,000
	1981	136,000
	1982	3,695,000
	1983	7,127,000
	1984-89	No information

OPTOELECTRONICS PROJECT

-English title — Optical Measurement and Control System

-Budget

•	Total	18,000 million yen (projected)
	1979	51 " "
	1980	927 " "
	1981	2,418 " "
		(1,300 " " is for lab expenses)
	1982	3,238 " "
	1983	3,246 " "
	1984-86	No information overall; OEJRL expenses projected at about 6,000 million yen

•	Total	$81,818,000
	1979	232,000
	1980	4,214,000
	1981	10,995,000 (5,909,000 for OERJL)
	1982	14,718,000
	1983	14,755,000
	1984-86	No information; $27,273,000 for OERJL

NGI SEMICONDUCTOR PROJECT

-English title: "New Function Elements" Portion of the Next Generation Industries Basic Technologies Research and Development Program

-Budget

•	Total	25,0[illegible] million yen
	1981	673 " "
	1982	1,128 " "
	1983	1,450 " "
	1984-90	No information

•	Total	$113,636,000
	1981	3,059,000
	1982	5,127,000
	1983	6,591,000
	1984-90	No information

FOURTH GENERATION COMPUTERS PROJECT

-English title: Promotion and Development of Technology for Next Generation (Fourth Generation) Computers

-Budget: Millions of yen

Phase I (VLSI)	Private	MITI
Total	42,000	29,098
1976	4,500	3,500
1977	13,500	8,640
1978	13,500	10,052
1979	10,500	6,906

Phase II (Software and peripherals)	Private	MITI
Total	24,500	22,500
1979		1,700 (85% for software development)
1980		5,785 (85% " " ")
1981		6,200 (83% " " ")
1982		5,616 (88% " " ")
1983		2,865

Thousands of dollars

Phase I (VLSI)	Private	MITI
Total	190,909	132,263
1976	20,455	15,909
1977	61,364	39,273
1978	61,364	45,691
1979	47,727	31,391
Phase II (Software and peripherals)		
Total	111,363	102,272
1979		7,727
1980		26,295
1981		28,182
1982		25,527
1983		13,023

FIFTH GENERATION COMPUTER PROJECT

-English title: Research and Development Relating to Basic Technology for Electronic Computers (Fifth Generation Computers)

-Budget

• Total	No figure for the entire project has been announced. 10,000 million yen is projected for 1981-84.
1981	15 " "
1982	426 " "
1983	2,724 " "
1984-91	No information
• Total	$45,455,000 is projected for 1981-84.
1981	68,000
1982	1,936,000
1983	12,382,000
1984-91	No information

COMMENTS

Care should be used in the interpretation of these figures. They represent only direct cash outlay from MITI. They do not include indirect subsidization, which may take the form of partial absorption of overhead costs, salaries of "loaned" workers, and/or donated equipment, either from government agencies or from the private companies involved. They do not include funds for separate, but somewhat parallel, projects supported by NTT and (to a lesser extent) the various Japanese computer firms, which comprise a considerable, albeit somewhat delitescent, segment of the total Japanese computer R&D effort. Particularly notable in this regard is NTT's annual research expenditure of $300-350 million, nearly all of which is in the area of computers, telecommunications, and semiconductors.

UPDATE ON JAPAN'S FIFTH GENERATION COMPUTER SYSTEM PROJECT

George E. Lindamood

INTRODUCTION

Put very simply, the goal of the Japanese Fifth Generation Computer System (5G) project is not to build computers which are bigger, faster, more reliable, or cheaper, but computers which are "easy to use." The original idea for the project was conceived more than 10 years ago at the Electrotechnical Laboratory (ETL) of the Ministry of International Trade and Industry (MITI). Beginning in 1978, various representatives of Japanese academia, industry, and government participated in a three-year study to determine the scope of the 5G project and formulate a general approach. That study culminated in an international symposium in Tokyo in October 1981, at which time plans for the project were formally unveiled and reactions of international computer experts were elicited.

ICOT

The Institute for New Generation Computer Technology (ICOT) was established in April 1982, at the time of the beginning of the initial stage of the 5G project. The participants in ICOT are Fujitsu, Hitachi, NEC, Mitsubishi, Toshiba, Oki, Matsushita, Sharp, NTT, and ETL. Although ICOT is officially independent of MITI, all its funding for (at least) the initial three-year stage of the project comes through that Ministry. For Japanese Fiscal Year (JFY) 1982--April 1982 through March 1983--the budget was 426 million yen (which is about $1.8 million at current exchange rates). For the current JFY, 2.7 billion yen (about $11.4 million) has been allocated, which (based upon an initial projection of 10 billion yen for the initial stage) would leave nearly 7 billion yen (almost $29 million) for JFY 1984. However, because of severe budget deficits, the Ministry of Finance is expected to pressure MITI to cut government funding, possibly by seeking monetary support from the participating companies during the intermediate and final stages of the project.

ICOT's complement of about 40 researchers have been drawn from the participating companies. The five project leaders are from ETL and NTT (whose Electrical Communication Laboratories have a historical tie with ETL), so initial leadership cohesiveness has been assured. Beginning this JFY, the participating companies will undertake specific 5G R&D activities in their own facilities, albeit under ICOT coordination. Also, although Japanese national university professors are prohibited from direct participation in MITI projects because they are employees of the Ministry of Education, many prominent Japanese computer scientists participate in the various advisory committees and working groups associated with the 5G project, so that there is good technical interchange between ICOT and most university research groups.

GOALS

At the end of its first year of operation, ICOT published a revised *Outline of Research and Development Plans for Fifth Generation Computer Systems*. This document sets forth the latest articulation of project goals and plans for attaining them. At the broadest level, the goal identified is "provid[ing] for the conditions and information demands of the society in the 1990s." This is to be accomplished through the "utilization of more varied media, easy-to-use computers, higher software productivity, and application of information technology to those areas in which existing information technology has not been applied."

The basic approach continues unchanged from what it was when the 5G project was first proposed in 1978: "non-von Neumann computers." The current document puts it thus:

> In order to meet these needs, the design philosophy itself of the current computer technology should be studied and evaluated.... Conventional computers, following the von Neumann computer architecture, are now realized by the simplest hardware because the hardware was expensive and bulky when the first computers were invented. Most of the functions required are then realized by software in order to provide an efficient processing system. Therefore, the conventional computers have become numerical-processing oriented, stored-program sequential processing systems. High speed and large memory capacity have been pursued from the economic standpoint, producing the present enormously big computer systems.

In their public presentations on the 5G project, ICOT officials characterize von Neumann systems as having "very, very peculiar logic which has nothing to do with how people think." This, they claim, has led to increasing software complexity which is now approaching the crisis level. However, they say, the conditions which led to the von Neumann approach no longer exist:

- VLSIs have substantially reduced hardware costs, so computer systems can use as much hardware as required

- A new architecture for parallel processing is now required because device speed has approached the limit for sequential processing

- Parallel processing should be realized in order to utilize effective mass production of VLSIs

- The current computer technology lacks the basic functions for nonnumeric processing of speech, text, graphics and patterns, and for artificial intelligence field [sic] such as inference, association and learning

These are taken as the reasons for developing Fifth Generation "knowledge information processing systems which meet the needs anticipated in the 1990s" by employing the "latest research results in VLSI technology,...distributed processing, software engineering, knowledge engineering, artificial intelligence, and pattern information processing." To arrive at such systems, ICOT has identified four types of "required functions" and four associated "major research and development themes:"

- Problem solving and inference function

  This function is intended to enable the system to find solutions to problems by carrying on logical reasoning using data and knowledge stored in the system as well as information given to it from outside.

This capability covers deductive inference, inductive inference including guessing based on incomplete knowledge, and cooperative problem solving by mutual complementation of several bodies of knowledge. It is to be achieved through, (a) "an inference mechanism based on a distributed control architecture which is oriented to parallel processing instead of sequential processing," and (b) "basic software to manage and execute parallel inference."

- Knowledge base function

This function is aimed at providing systematic storage and retrieval of not only so-called data but also reasonable judgements and test results organized into a knowledge [sic]. Besides knowledge accumulation, it includes knowledge representation tailored to problem solving, knowledge acquisition and updating, and simultaneous utilization of distributed knowledge sources. It is to be achieved through, (a) "a knowledge base mechanism based on structured memory instead of one-dimensional memory," and (b) "basic software to manage knowledge bases for high-speed retrieval and relational storage of knowledge data."

- Intelligent interface function

This function is intended to enable computers to handle speech, graphics and images so that computers can interact with humans flexibly and smoothly. It might be regarded as giving computers the equivalents of human eyes, mouth, and ears, but its primary objective is to provide computers with a linguistic ability close to that of man. It is to be achieved through, (a) "an intelligent interface mechanism composed of a voice or signal processor and other devices," and (b) "basic software for natural language processing and graphics and image understanding to ensure flexible man-machine interaction."

- Intelligent programming function

This function is intended to enhance the intelligence of computers so that they can take over the burden of programming from humans. While its ultimate goal is to achieve an ability to automatically convert problems into efficient computer programs, it is aimed preliminarily at achieving a modular programming system and a program verification system and at establishing a specification description language. It is to be achieved through "basic software for automatic creation of optimum programs."

PLANS

The 5G project is planned to extend over a ten-year period, which has been divided into three stages called (logically enough) "the initial stage," "the intermediate stage," and "the final stage." In the initial stage, basic computer technology is to be developed; in the intermediate stage, subsystems (especially small-scale experimental systems) are to be developed; and a "total system" is to be developed in the final stage.

According to ICOT, "the emphasis ... in the initial stage is on accumulating the research achievements of the past in the field of knowledge information processing, and evaluating and restructuring them. In addition, candidates for each research subject have to be screened ...." Hardware and software modules are to be built and integrated into experimental systems. "The intermediate stage is mainly devoted to improving and extending the results of the initial stage and integrating them into (small- to medium-scale) inference and knowledge-base subsystems." This will be done by "establishing computational models as the basis for software and hardware as well as algorithms and basic architecture based on the evaluations of the initial stage." In the final stage, the software and hardware subsystems developed in the previous stage will first be reviewed and evaluated and then integrated into a total system. Emphasis will be given to "appropriate functions of both software and hardware systems, interfaces to maximize these functions, and the architecture for the total system."

There are also plans to develop applications systems in the intermediate and final stages. "To prove and assess the basic software system" model systems will be developed for VLSI CAD, machine translation, and consultation systems. The target for the machine translation system is "90 percent accuracy" for technical documents (only). ICOT officials stress that all systems developed will be only prototype or pilot models, not commercial products.

The current ICOT document notes that, "In Japan, little effort has been made in research on the key technologies, particularly software and basic theories. The research in this field should be promoted because it has a great influence on development of hardware technology, including computer architectures and VLSIs." The document frankly states that "We are obliged to move toward the target systems through <u>a lengthy process of trial and error, producing many original ideas along the way</u>." (Emphasis added.) The reason for breaking the project into three stages is to permit evaluation and revised planning in depth at the end of the initial and intermediate stages. In the words of one ICOT staffer, "Ten years in computer science is a long time."

CURRENT R&D ACTIVITIES

The *Outline of Research and Development Plans for Fifth Generation Computer Systems* recently published by ICOT presents the various research items planned for the initial stage of the project. The following is the description of these items as contained in that document.

R&D theme	Details
- Parallel Inference Machine (PIM)	The parallel inference machine, together with the knowledge base machine, forms the nucleus of the Fifth Generation Computer hardware. At the initial stage, an evaluation and study will be made on the basic inference module configuration composed of the following: A parallel-type inference basic mechanism to manage the parallel execution of inference operations.

R&D theme	Details
	A data flow mechanism to execute inference operations and rapidly determine solutions. An abstract data type mechanism to consolidate detailed inference operations into several groups and control them by group.
Modules for individual functional mechanisms for PIM	The parallel-type inference basic mechanism, data flow mechanism, and abstract data type mechanisms [each] individually consist of functional submodules. Initially, the prototypes of these submodules will be constructed. Then these prototype submodules will be combined to construct a prototype module for each of the three functional mechanisms.
Simulators for experimental operation	Prototype simulators for experimental operation will be built to simulate module configurations, using different numbers and combinations of submodules. They will also be used to determine the optimum configuration of the modules for three functional mechanisms and also of the inference basic module which these submodules will comprise.
Techniques for integration in VLSIs	Prototype software will be developed for evaluation and examination of the VLSI convertibility of the circuit composition of each submodule designed. It will be used for data gathering and evaluation for integration in VLSIs.
- Knowledge Base Machine (KBM)	The knowledge base machine, together with the parallel inference machine, forms the nucleus of the Fifth Generation Computer hardware. At the initial stage, an evaluative study will be made on the configuration of the basic knowledge base module composed of the following: A basic knowledge base mechanism to provide overall management of the execution of basic knowledge base operations. A parallel-type relation and knowledge operation mechanism to provide speedy knowledge accumulation, retrieval and updating, data conversion, etc. A relational data base mechanism to provide large-capacity knowledge accumulation, storage and management.

R&D theme	Details
Modules for individual functional mechanisms for KBM	The basic knowledge base mechanism, parallel-type relation and knowledge operation mechanism, and relational data base mechanism [each] individually consist of functional submodules. Prototypes of these submodules will be constructed at the initial stage. These prototype submodules will be subsequently combined to produce a prototype module for each of the three functional mechanisms.
Simulators for experimental operation	Prototype simulators for operation tests will be built to simulate module configurations using different numbers and combinations of submodules. They will also be used to determine the optimum configuration of the modules for three functional mechanisms and also of the basic knowledge base module which these submodules will comprise.
Techniques for integration in VLSIs	Prototype software will be developed for evaluation and examination of the VLSI convertibility of the circuit composition of each submodule designed. It will be used for data gathering and evaluation for integration in VLSIs.
- Basic software system	The basic software system forms the nucleus of the Fifth Generation Computer software, and is composed of the following four software modules for knowledge information processing: Problem solving and inference software module Knowledge base management software module Intelligent interface software module Intelligent programming software module An extended Fifth Generation kernel language needed for the intermediate stage will be developed by organizing the knowledge obtained through designing and breadboarding the basic software system. Furthermore, a prototype software system will be produced to test the correctness of specifications and validate their accuracy.
Problem solving and inference software module	The problem solving and inference software module has the capabilities of deductive inference including conjecture proposing based on incomplete knowledge, and inference by mutual complementation of knowledge.

R&D theme	Details
	The development of a prototype of basic software for parallel inference is planned for the initial stage for use in high-speed execution of deductive inference and basic software for problem solving to determine efficient solutions to problems.
Knowledge base management software module	The knowledge base management software module has the capabilities of knowledge accumulation, distributed-knowledge source utilization, and knowledge acquisition.
	The development of a prototype of a knowledge representation system is planned for the initial stage in order to define knowledge data representation methods. A large-scale relational data base management program is also planned to accumulate and manage a large volume of data represented as knowledge.
Intelligent interface software module	The intelligent interface software module is for flexible interaction between human and computer.
	The development of a prototype of a high-level parsing program is planned for the initial stage, and is aimed at achieving high-speed parsing and simplified algorithms for natural language understanding, which is critical to the man-machine interaction. Basic technologies for semantic analysis and a pilot model of a support dictionary system will also be developed.
Intelligent programming software module	The intelligent programming software module has the capability of automatic conversion of an input problem into an efficient computer program (a kernel language level).
	A program module management system with extraction capability of component modules, and verification facility of a program is planned to develop at the initial stage with the objectives to establish modular programming, which is basic to intelligent programming, extraction of the necessary program, and program verification prepared thereby.
- Sequential Inference Machines (SIM) Pilot models for software development	A pilot model (a prototype sequential inference machine) for efficient development of software for the Fifth Generation Computer Systems will be developed. This model will be developed by improving a selected language suitable for inference and by partly modifying the existing von Neumann type architecture.

The starting point of research in the initial stage of the 5G project is the "Version 0 Kernel Language," which is an extension of PROLOG. Specification of this new language was completed in 1982, and it will be used as the machine language for the Sequential Inference Machine and also for program description in software development. After experience is accumulated in developing and using Version 0 (which is intended for sequential processing), a "Version 1 Kernel Language" will be developed for parallel processing. The Parallel Inference Machine will be a high-level parallel processor to directly execute the Version 1 Kernel Language, while the Knowledge Base Machine will be designed for high-speed execution of "knowledge operations" (derived from the study on knowledge representation) and "relational data base operations."

PROJECT RESULTS

Officials of the (Japanese) Institute for New Generation Computer Technology (ICOT) have stated that "all research results from the Fifth Generation Computer System (5G) project are to be available to anybody who is interested." This will be done through a variety of means:

- ICOT will issue technical reports and other project-related publications as appropriate, in English and/or Japanese;

- ICOT will sponsor symposia related to the 5G project from time to time;

- project researchers will be encouraged to participate in international conferences, reporting their particular research results and describing project progress in general; and

- ICOT will publish a quarterly journal (albeit in Japanese).

All patents resulting from the 5G project will be property of the Japanese government and will be available for licensing to any party making application to a MITI subsidiary organization called the Industrial-technology Promotion Agency (Japanese: Sangyoo Gijutsu Shinko Kyookai).

The first issue of the *ICOT Journal* provides the following list of technical reports and papers which have been produced to date:

"Knowledge Expressions Which Form Basis of Intelligent Systems, and A Trend of Reasoning Methods," by Y. Furukawa and K. Fuchi. (In Japanese) *Nikkei Electronics*, No. 300, 168-181, (27 September 1982).

"The Predicate Logic Language PROLOG Which is Implemented with Reasoning Structure," by T. Yokoi and K. Fuchi. (In Japanese) *Nikkei Electronics*, No. 300, 267-286, (27 September 1982).

"A Report on the 1982 ACM Lisp and Fp Conference," by K. Taki, T. Chikayama, H. Yasukawa, and T. Ida. (In Japanese) 22nd Meeting of the Symbolic Processing Research Group, Japan Information Processing Society, (1982).

"Intelligent Access to Data Base," by Y. Furukawa. (In Japanese) *Information Processing 23*, (10), (1982).

"Problem Solution and Reasoning," by S. Kunito. (In Japanese) *Measurement and Control*, January 1983 (to appear).

"Expectations of Symbolic Processing Machine," by K. Fuchi. (In Japanese) *Information Processing, 23* (8), 706-711 (1982).

"A Trend of New Information Processing Technology and Its Use," by K. Fuchi. (In Japanese) 11th Meeting of the Computer Application Technology Study Group, Japan Information Processing Society, September 1982.

"The 5th Generation Computer," K. Fuchi. (In Japanese) *Administration and ADP, 15* (10), 2-5 (1982).

"Sequential Garbage Collection," by T. Kurokawa. (In Japanese) *Information Processing, 24* (4), (1983) (to appear).

"Structure of Reasoning Machine SIM-P and Its Language," by T. Chikayama and S. Takagi. (In Japanese) 24th Programming Symposium, Japan Information Processing Society, January 1983 (to appear).

"The Fifth Generation Computer Project Profile in Japan," by Y. Furukawa. (In Japanese) *Nihon Kikai Gakkaishi,* April or May 1983 (to appear).

"Toward a New Generation Computer Architecture," by S. Uchida. Chapter 19 in *VLSI Architecture,* Prentice-Hall (to appear). Also available as ICOT Technical Report TR/A-001, August 1982.

"PROLOG Interpreter Based on Concurrent Programming," by K. Furukawa, K. Nitta (ETL), and Y. Matsumoto (ETL). *Proc. 1st International Logic Programming Conf.*, Marseille, 38-44 (1982).

"Logic Programming--What Does It Bring to Software Engineering," by T. Kurokawa. *Proc. 1st International Logic Programming Conf.*, Marseille, 134-138 (1982).

"PROLOG Interpreter and its Parallel Extension," by Y. Matsumoto (ETL), K. Nitta (ETL), and K. Furukawa. *IBM Symposium on VLSI,* 57-72 (1982).

"Object Oriented Approach to the Input/Output in Logic Programming," by T. Kurokawa. *25th Nat. Meeting of Japan Info. Proc. Soc.,* (1982).

"PROLOG and Relational Data Bases for Fifth Generation Computer Systems," by S. Kunifuji and H. Yokota. ICOT Technical Report (to appear).

Earlier this year, ICOT began publication of its quarterly *ICOT Journal* (in Japanese). In addition to brief news items about happenings at ICOT (e.g., "a deeply impressive 'kick-off' party") and worldwide developments related to the 5G project (e.g., "U.K. R&D survey report"), the initial issue contained a four-page contributed article on "Artificial Intelligence and Computers" by Professor Kokichi Tanaka of Osaka University and a ten-page feature article "On the Start of the 5th Generation Computer R&D" by Professor Tohru Moto-oka of Tokyo University. The same Professor Moto-oka is also serving as editor-in-chief of Springer-Verlag's new quarterly (English-language) journal, *New Generation Computing,* the first issue of which appeared earlier this year, and North Holland Publishing Company (Amsterdam) is initiating an international "FGCS Reporting Service."

In June, ICOT sponsored a two-day symposium on its research activities. Although it was conducted entirely in Japanese, plans are now underway for another international conference in Tokyo in the fall of 1984, at which time ICOT expects to have sufficient research results to bear the scrutiny of the world's technical experts. The outcome of that conference is also likely to have a strong influence on the course of the 5G project during its second "intermediate" stage.

CONCLUSION

In a sense, the term "Fifth Generation" is misleading since it may suggest to many that fifth generation systems will bear the same relationship to fourth generation systems as the latter did to the third generation, the third to the second, etc. ICOT officials hasten to point out that such a conclusion is erroneous, that a "new generation" of systems are needed which are conceptually different--i.e., "non-von Neumann"--from those of previous generations. That is why the words "New Generation," rather than "Fifth Generation" appear in ICOT's name.

According to Japanese government sources, this project symbolizes a shift in MITI's policies to support more basic research and long-range innovative development. The reasons given for this are the following:

- Japanese computer manufacturers are now quite capable of holding their own with the rest of the world in the development and marketing of commercial computer and semiconductor products, so MITI support for these activities is no longer needed;

- Japanese computer and semiconductor technology has caught up with that of the rest of the world, so more basic R&D is now needed in Japan;

- R&D projects spanning a decade are very risky, so MITI sponsorship is needed to attract the participation of private firms; and

- it is Japan's turn to make basic scientific and technological contributions to the rest of the world since Japan has benefited from following the contributions of other nations in the past.

It is very easy to get lost in the technical details of the Fifth Generation Computer System project, if not in the emotion surrounding it internationally. Many Western technologists have been very skeptical about the prospects for success in the Japanese effort. Their mistake is in applying the wrong definition of "success." The Japanese 5G project will succeed--indeed, it has already succeeded--not just in a technological sense, but in a much broader, more lasting, and (hence) more significant way. It has focused Japanese attention and energies in new directions, engendering new organizational as well as technological innovations. ICOT official: "There is a tremendous advantage for the Japanese society [in this project]: even if it doesn't succeed, it will encourage people to go into basic research." It has spurred other nations to reassess and redirect their own research programs. "MITI expects that other nations will have similar projects and will welcome an exchange between these and the Japanese project." The result should be--will be--"positive sum," that is, beneficial to all. As the ICOT "Outline of R&D Plans" states: "We hope not only to conduct creative research in this field, but also to contribute thereby to the benefit of all mankind."

SOLID STATE PHYSICS IN THE PEOPLE'S REPUBLIC OF CHINA AFTER THE CULTURAL REVOLUTION

Arthur J. Freeman

SCIENTIFIC PROGRESS IN CHINA: AN OVERVIEW

China, since the "cultural revolution" has been treading a tortuous path back into the mainstream of modern civilization. In my two visits (April 1979 and November 1982) I found an intense desire of the Chinese people to be rid of the horrible consequences of the cultural revolution and to achieve, in the words of Vice Premier Fong Yi in March 1978, "a new stage of flourishing growth" in science and technology. "The dark clouds (of the cultural revolution) have been dispelled and the way has been cleared. A bright future lies ahead of us."

As it turns out, there was more than the usual official rhetoric behind Fong Yi's bold proclamations. Indeed, there have been significant changes (some would say a "renaissance") in science and technology in China since 1978. In sharp contrast to the attitudes of the cultural revolution, a new program of the "four modernizations" was proclaimed which called for modernization in the four areas seen as being weak-industry, agriculture, science and technology, and defense. As a result of these reforms, budgets for basic scientific research has been greatly increased, more than 100 professional, science-related societies have been revived or newly founded and a large-scale program has been launched which has allowed scientists rather than party cadres to head scientific institutes. Increasingly, the work of the research units has been focused onto China's developmental needs rather than to broad, politically motivated (and often fairly unrealistic) projects. There is a continuing effort to promote a general improvement in wages and working conditions of scientists. Many thousands of research scientists have been sent abroad for training (more than 10,000 Chinese were studying in Western countries in 1982 including about 6000 in the United States). The picture that emerges is that of a nation striving to provide a more rational structure with which to pursue and achieve rapid modernization with very limited resources.

There is little question but that the reforms instituted in the last few years have also significantly improved the status of China's 600,000 research specialists, many of whom suffered severe persecution during the "decade of destruction" (1966-1976) of the cultural revolution.

Without a doubt the cultural revolution had enormous consequences which has left a deep impression on all levels of life. Many people, especially scientists and intelluctuals, suffered severely. Quite a number died as a result of the torture they received in the course of "criticism." Intellectural life virtually ceased for about ten years. The decade of abuse not only severely damaged the university and scientific establishment, it devastated China's economy. Hence, China's efforts to raise itself from the low position to which Chinese science and technology had dropped by 1976 must be viewed from this perspective. Clearly, tremendous progress has been made since 1978, but it has not been easy to undo the damage that had been done by the "gang of four," to rebuild the educational and scientific establishment, and perhaps most difficult of all, to convince a nation of very poor people and, more importantly, of mostly poorly educated party officials that far from being "parasites," China's intellectuals and scientists represent a highly productive resource which is indispensable to the goals set out by the four modernizations. To understand these difficulties, it is important to know that with a population of over one billion people, China should have a quarter of the world's universities--which it clearly does not. Instead they have less than a handful of principal universities among the dozen "key point" or major universities. Thus, the pool of trained scientists and engineers is at least an order of magnitude less than what any of us would regard as appropriate.

My first visit in 1979 was during a time of optimism approaching on "euphoria." Fong Yi, in his report to the National Science Conference in 1978, outlined an eight-year plan for science which was highly optimistic about the future. Despite his admission that China lagged 15 to 20 years behind advanced world levels in many branches of science and technology, he told some 6000 delegates in Beijing's Great Hall of the People that it was his hope that by 1985 China would build new research facilities, expand research, rapidly increase the number of professional research workers, and in the process "approach or reach the advanced world levels of the 1970s in a number of important branches of science and technology." He further predicted that this in turn would make it possible for China to "catch up or surpass advanced world levels in all branches" by the year 2000.

While such general and grand designs are never, of course, taken literally, they serve to provide a direction for national goals. Fong Yi's outline of an eight-year plan for science categorized research needs in 27 "spheres," including oceanography, environmental protection, medicine, transportation, finance, and education. Significantly, he gave special prominence to the fields of:

- agriculture,
- energy,
- materials science,
- computer science,
- lasers,
- space science,
- high energy physics, and
- genetic engineering.

In addition, Fong Yi had identified 108 key projects for special attention in these key priority fields. It was described "as a grandiose bill of fare" which clearly stated not only perceived national priorities, but as is usual, also the special interests of individual scientists or groups of scientists.

It was quite clear during my first visit that the euphoria about the future was accompanied by a strong realization that some important political and administrative changes had first to be made to strengthen the scientific establishment. In consequence, the powerful State Scientific and Technological Committee was established under the State Council to coordinate China's national scientific activities. Significantly, the Chinese Academy of Sciences, which had lost most of its administrative authority during the cultural revolution, was also slowly restored to its place of influence and eminence, and since that time has resumed its responsibility for planning, directing, and supporting research. It is now clear that it plays a critical role in selecting and training China's most outstanding students for graduate studies in one of its research institutes of which there are now 117.

It may be informative at this point to give an overview of the present organization of the Academy of Sciences and its relationship with other scientific organizations under the auspices of the Scientific and Technical Committee of the State Council of the Chinese government. The organizational charts are given in Table I and II with English names of the various organizations that have been translated from the Chinese, and hence they may not be the same as the official Chinese translation. The names of the present directors of the scientific divisions are also given in Table II. The Academy is a mammoth organization which has 117 research institutes, eight factories, two universities, four regional scientific libraries, and one scientific and technical book publishing organization. It has 70,000 employees of which 60% are research scientists. The University of Science and Technology of China in the city of Hefei, Anhui Province, and the graduate school of the University of Science and Technology of China in Beijing, are directly under the control of the Academy, in contrast to all the other universities in China which are under the control of the Ministry of Education. This not only creates some friction between the Academy and the Ministry of Education, but also between the scientists in the whole scientific community because of the preferential treatment of their graduates in terms of employment given by the top research institutions of the academy.

In recent years, progress has been made to remove politics (which had dominated science as it did everything else during the cultural revolution) from the system, and control of research has generally been returned to the scientists. However, there are still complaints that in a number of institutes the directors of research have little real power because of the insistence of some party leaders for complete control. Increasingly, however, emphasis has been placed on expertness and abilities with professionals being judged solely on their performance. In a major move, ranks and titles have been reinstated and prizes and other incentives have been reintroduced. Last year, China established its own National Science Foundation which solicits and reviews proposals from individual scientists and awards grants. Extensive contacts with foreign scientists and institutions have been established, and in many instances these have been strongly encouraged into useful collaborations.

Unfortunately, China's economy in 1979 was also experiencing a short-lived period of euphoria--as was seen in the ambitious goals of the four modernizations. Quite soon however, many of these extravagant industrial schemes and highly ambitious and varied imports of foreign technology--which China was not able to pay for--had to be dropped. In consequence, a fundamental reassessment of economic goals and the realignment of developmental strategies took place from which science could not be excluded. Very soon science and scientists were "forced to retreat in the course of readjustment."

Readjustments have been taking place and scientists have been pressed in China, as in the U.S., to make a strong case that fundamental understanding is a prerequisite to technological development and that practical benefits come from research projects which may have had only intrinsic intellectual value initially. They have also had to make the case that without basic research it is impossible to attack practical problems creatively. Interestingly, however, it turned out that while U.S. scientists faced the constant challenge of convincing the Federal government of these facts, the Chinese scientists have been much more successful in overcoming resistance offered by their own leadership.

Many specialists tend to agree with the more modest goals currently encouraged in China. They are certainly sympathetic with Beijing's present view that in science "we should not try to do everything from scratch nor attempt to invent everything ourselves." Thus, for example, it is clearly recognized that China's 1978 goals in science and technology were too ambitious and, moreover, memorable in their overoptomistic assessment of their feasibility and for being divorced from China's immediate needs. Of some concern, however, is the possible effect of the retrenchment on China's newly established international relations in science such as its possible impact on Chinese participation in international conferences (which has only just begun in the last few years) and on efforts to reestablish and create new contacts with foreign scientists.

As stated more fully below, it was apparent to me during my visit in the fall of 1982, that the middle- and upper-level scientists which had returned from several years training in the United States had quickly gained special status. Further, a major effort has been made to equip their laboratories with modern equipment so that they could carry on first-rate research. China today recognizes the opportunities and the challenges inherent in having hundreds of these highly trained individuals at the research institutes and universities.

This is clearly a new phase of the scientific and technical developments in China since 1949. The Chinese divide the time from 1949 to 1979 into four periods. From 1949 to 1955, China could not obtain any scientific and technical equipment from Western countries and the Chinese had to develop all the equipment, apparatus, and some established technology by themselves. However, this is now seen to have turned out to have helped them establish the foundation for scientific and technical developments in the second period. Under the strong support of Chou En-lai, rapid scientific and technical advances were made during the period 1956-1967, at which time China developed nuclear power and aerospace technologies. The production of nuclear power and rockets was successfully accomplished even with the withdrawal of Russian technology. From 1967 to 1976, development and advancement of science and technology in China was completely stopped. During this period, scientists and engineers were labeled as "enemies of the people" and clearly had the lowest standing. As mentioned above, the vitality of the scientific and technical communities was restored after 1978.

The Chinese recognize, in this new period for Chinese science and technology, that quite a few problems still exist. The reorganization of the Chinese science and technology bureaucracy indicated in Tables I and II is in part a response to the reforms required as part of their modernization program. It further indicates that the Chinese are not only concerned with the future research directions and accomplishments, but also with the reforms required to achieve better working conditions both in the institutes of the Academy and the Chinese university system. The major problems that are widely recognized include:

- the lack of mobility of personnel between the university, research institutions, and industry,

- the aging of the teaching staffs (only 21% are younger than 55 years old, 43% are between 55 and 65 years of age, and 36% are older than 65, and

- the inflexibility of the social system in rewarding outstanding performers.

As part of the recognition of the reforms required to achieve better working conditions, Chinese scientists cite the inflexibility of their reward system, the inability to discharge incompetent researchers (they call this the "iron rice bowl" syndrome), the restriction imposed by the rule that moving from one city to another requires the approval of the Ministry of Internal Affairs (this means that the transfer of personnel is not completely determined by the scientific department, but also involves the political departments), and the low pay of scientific personnel relative to factory workers and farmers (especially now that the economic system is gradually being shifted toward limited free enterprise). Indeed, it is this gradual shift toward limited free enterprise which is most encouraging as indicating expected further changes in the social system as well, and perhaps a further easing up on the restrictions impeding the development of science and technology. Free enterprise, which is today only in its embryonic phase, signifies the most revolutionary change that has taken place in China since 1949--a change that may well propel China into a dominant world position by the middle of the twenty-first century.

VISITS TO RESEARCH INSTITUTES AND UNIVERSITIES IN CHINA

The advantage of the second trip to China included the opportunity to assess developments and changes which had occurred since my first visit in April of 1979. Specifically, I visited the Institute of Physics, Academia Sinica, Beijing; the Central Iron and Steel Research Institute, Beijing; the Physics Department at Nanjing University; the Physics Department, Fudan University, Shanghai; and the Shanghai Institute of Metallurgy. This gave me an opportunity to see at firsthand the operations of the Chinese condensed matter physics and materials science research establishment and how it functions in the three-tier system of university-academy-industry.

- Visit to the Institute of Physics, Academia Sinica, Beijing

The Institute of Physics of the Chinese Academy of Sciences (Academia Sinica) was established in 1950. Its predecessor was the former National Research Institute of Physics, Academia Sinica, and the Institute of Physics, National Academy of Beijing. In the early days the institute was known as the Institute of Applied Physics, Academia Sinica; its present name was adopted in October 1958. The sole function of this institute is to carry out research in basic condensed matter physics. The institute has recently been reorganized into 12 research departments, four technical service laboratories, a comprehensive machine shop, and a library. There has been a concerted effort to make the departments smaller. Whereas in the past, there were mostly 50 to 60 persons (but up to 100) per department, it has now been organized to have 20 scientists per department so that the leader can be familiar with the work in progress. In the past, it was thought that directors were too busy with administration. Under this reorganization, the leader of a department would correspond to a professor at a U.S. institution. The problem is that it is difficult to find so many qualified professors to supervise the research. Their major activities are concentrated in the area of:

- magnetism,
- laser spectroscopy,
- neutron scattering,
- surface physics,
- amorphous materials,
- liquid crystals,
- superconductivity,
- study of phase diagrams and phase transitions, and
- optical properties of crystalline solids.

Recently, they have been asked to modify their goals away from basic to more applied condensed matter physics. The institute under the direction of their young and able director, Dr. Kuan Wei-yen, recognizes the dangers inherent in such a shift. However, it is also generally felt that there is presently an insufficient basic applied interaction within the institute. Dr. Kuan is regarded by his colleagues as a very sound physicist and a leading authority in low temperature physics.

The budget of the institute is approximately 10 million yuan (over $5.0 million) which includes salary for their roughly 500 staff members and 350 supporting personnel, and about 3.5 million yuan for equipment. In addition, approximately $200,000-$300,000 in foreign currency is available to them for the purchase of foreign-made equipment.

Their need for foreign currency has led them to produce crystals such as $LiIO_3$ and GGG (GaGd garnet) for export, Fe_2O_3 recording powders (to Hong Kong for tapes) and most recently, sintered diamonds using high pressure facilities (5000 tons pressure). They are also engaged in developing A15 superconducting wires and ribbons (being produced in three working factories) such as Nb_3Si, Nb_3Sn, and N_3Ti. Their main market is inside China as they are not sure if their materials can compete abroad. The total output of each factory of superconducting wires is about one ton per year, mostly Nb_3Ti. They also produce some 20 or 30 kg of Nb_3Sn.

As far as condensed matter physics is concerned, this institute is perhaps the best equipped laboratory in China and will soon be ranked among the best laboratories in the world. Particularly impressive is the fact that approximately 100 of their researchers have studied or are studying abroad. To date there are more than 30 who have returned and are now the highly trained and important people at the Institute of Physics. It is clear that when all of them are back they will have a major impact on the research programs of the institute. (I was particularly pleased to see my former postdoctoral research associate, Wang Ding-sheng, who had spen 30 months with me (February 1979-September 1981) at Northwestern University, and some nine others who had also trained at Northwestern's Physics Department.)

In my visits to the research laboratories, I was struck by the enormous changes which had taken place in the previous three and one-half years. Whereas in 1979, I saw laboratories using equipment of 1950 vintage working on problems of importance 20 years earlier, I found in 1982 high quality research equipment and competent, well-trained scientists working on forefront problems. Aside from a small computer that was purchased used, all other equipment is bought new. For example, in the laboratory of Mr. Wang Cheng-heng, I saw a laboratory well-equipped to carry out XPS, UPS, Auger, and ELS studies. The equipment was imported from VG Scientific, Sussex, England, (a LEED attachment is on order). The spectrometer, rated at 10^{-10} Torr vacuum, was working at 10^{-9} Torr. This equipment cost $400,000 and will be run by an Apple II computer now installed and running off-line. A wide range of problems is being studied which extend from:

- Si on Fe_2O_3 (of interest for solar decomposition of H_2O),
- $SrTiO_3$,
- H storage in $LaNi_5$,
- mixed rare-earth Ni_5 compounds (for H storage),
- transport phenomena in In overlayers on Si (111),
- amorphous magnetic materials such as N atom implanted in FeCoB,
- properties of Sm_2Co_{17},
- to Josephson tunneling junctions (for studying the role of the distribution of O in the barrier region of Pb-PbO-Pb).

I was quite impressed with the fact that Mr. Wang has not been abroad. Apparently, he "studied the manual and talked to the engineer" from VG Scientific who installed the equipment. This department also owns a 1,000,000 yuan (over $500,000) molecular beam epitaxy (MBE) apparatus made by the Shenyang Scientific Instrument Factory in China. The machine has a quadrupole spectrometer, and an Auger electron gun, and RHEED as attachments. It is not yet of export quality since it operates at 10^{-8}-10^{-9} Torr. One novel feature is a quartz oscillator used as a thickness detector and apparently sensitive enough to detect a monolayer. Presently, they are studying surface reconstruction in GaS, the role of impurities in GaAs, and also metal-semiconducting interfaces.

In the Light Scattering Laboratory, I met with Mr. Zhang Peng-xiang who had studied with Kronmüller in Stuttgart. This is a well-equipped laboratory for carrying out Raman and Brillouin scattering studies of a wide variety of materials. They have argon and other lasers and an expensive Zeiss double-grating monochromator. Originally this laboratory had worked on FMR in garnets but now, for example, studies Raman scattering in GGG (where incidently, they have seen nearly all the 25 phonon modes in the system), and Raman and Brillouin scattering in $LiNbO_3$ samples supplied to them by a factory. Interestingly, they now cover a temperature range from helium to room temperature and in fields up to 17 K Gauss. They also study Brillouin scattering from METGLASS and have observed both bulk and surface magnons. In another setup they are studying magnetooptical Faraday and Kerr effects. (In the visible range, the magnetic field goes up to 20 K Gauss and in the infrared range up to 5 K Gauss. They find that adding In to $BCVIG_2[Bi_{3-x}Ca_{2x}(Fe_{2-y}In_y)Fe_{3-x}V_xI_{12}]$ enhances both phenomena. One area of interest to them is studying the influence of Faraday rotation on selection rules for phonons.

One new development since 1979 has been the establishment of a liquid helium workshop which produces 20 liters of liquid helium per hour. This permits up to eight experiments to be run per day. Of further interest is a new building for an ultralow temperature laboratory for experiments in very weak external fields.

The institute has built up a strong effort in the area of superconductivity. A group under the direction of Zheng Jia-ji (who spent two years at Northwestern University) is fabricating and studying tunnel junctions made up of low melting point materials particularly Tb and its alloys, V and its alloys, as well as V films. With good bake out they are able to operate at 5×10^{-10} Torr. Particularly interesting to them are $V/Al_2O_2/Al$ and Tb and In junctions. Two new magnetron sources for sputtering have been ordered from the Beijing Instrument Company to be delivered this year. Using a quartz oscillator, they have made a new film thickness counter which can control the tunnel junction film thickness more precisely (to 1 Å of Al_2O_3).

In a separate laboratory, Yang Pei-ran produces Josephson junctions by rf sputtering techniques. Work is in progress on studying the physical properties of Nb film microbridges (photoetched, micron-size Dayem bridges obtained by sputtering) and point contacts. They have obtained a field resolution of about 5×10^{-12} Torr. Since they were unable to purchase from the U.S. a SHE Corporation SQUID magnetometer, they had to develop one themselves. This work appears to be far from state-of-the-art, but they are narrowing the gap. In particular, they are expecting to receive a new Ti pump from a Chinese factory which will allow them to operate at 10^{-8} Torr.

Some excellent work is proceeding in the A15 Materials Laboratory run by Meng Ru-ling. For sample preparations, there is an arc melting furnace, a high frequency furnace with levitation melting and rapid solidification, and a 10^{-6} Torr vacuum rf and dc sputtering apparatus. They also have two expensive 750 kV Japanese electron microscopes in their department. By sputtering, they obtain a superconducting transition temperature for Nb_3Ge of nearly 23 K (an excellent result indeed). The sample is apparently bulk-like and includes a second phase identified as Nb_5Ge_3 which may be important for high T_C. They have also been studying superconductivity in both crystalline and amorphous phases of Mo_3Ge and Mo_3Si in order to understand the change of superconducting properties between the two.

The Mössbauer Effect Laboratory of Dai Shou-yu and Chen Guia-min (who spent a year and a half at Northwestern University) is a very well-equipped and well-functioning modern laboratory. They have two Mössbauer systems; one built in China and one purchased from Elscint with a Promeda data acquisition and processing capability. They have a microprocessor instead of a multichannel analyzer which gives them a leg up on most Mössbauer laboratories. In addition, their experiments are performed over a wide range of temperatures, from 4 K to 1000 K. At present, they are having a six T superconducting magnet built for them by an institute in Shanghai. Problems under study include hydrogen storage in $LaIn_5(Fe)$, surface and interface magnetism (αFe_2O_3) covered with CO or covered with AgI, and in cooperation with the amorphous magnetic materials group in the Department of Magnetism, they are studying hydrogen implanted in YFe_2 and YFe_n.

In the Department of Magnetism headed by Pan Xiao-shuo, a national facility is being established to measure magnetic moments and susceptibilities to an accuracy of 10^{-2} emu/g and 10^{-6} emu/g respectively by using a Japanese magnetic balance made by Shimazu (Model M8-9). They have a susceptibility apparatus supplied by the French Center of the National Research Council through the Sino-French Mutual Scientific Collaboration Program. This apparatus is useful for measurements in the temperature range from 4 K to 300 K.

- Visit to the Central Iron and Steel Research Institute (CISRI)

The Central Iron and Steel Research Institute is a comprehensive industrial and scientific research organization directly under the Ministry of Metallurgical Industry. The original name of this institute (established in 1952) was the Testing Institute of Iron and Steel and was changed in 1958 to Iron and Steel Research Institute. In 1979, the present name was approved by the Ministry of Metallurgical Industry. The Chinese are proud to point out that after some 30 years of development, the CISRI has become a research base for China's iron and steel industry.

The institute has over 3000 staff members of which about 1500 are engineers and technicians. There are all together some 20 research departments and subdivisions such as machine shops for both manufacturing and repair work, pilot plants for steelmaking, rolling, and tube manufacturing.

I visited mostly with the Department of Precision Metals; Mr. Ke Cheng is presently its Director. Their work seems to be at the forefront in the field of materials science involving Invar, rare-earth intermetallics, and amorphous magnetic materials as well as the more traditional soft magnetic materials, electrical steel sheet, elastic materials, and other "precision metals."

Their Powder Metallurgy Laboratory was particularly impressive. Most of their work centers on making superalloys for turbines. Using German equipment (by Leybold-Heraclus) costing $2.0 million they are able to produce 65 kg at a time. They have two cold isostatic presses designed and built at their institute. The first press, built in 1977 for research and production, operates as a cold press at a pressure of 3000 atm with dimensions 0.5 m x 1.5 m and as a hot press at 1500°C (at 1500 atm), handles a diameter of 2.5 m and a height of 7.5 cm. The second press built in 1982 has been cold press tested at a pressure of 3000 atm (diameter 7.5 cm and height of 1.8 cm). The hot press now being tested (0.69 m x 1.2 m) operates at 1500°C and pressure 1800 atm. The materials being produced are directly used for jet turbines.

I was also most impressed with their extensive work on $SmCo_5$ permanent magnetic materials. They claim that their SmCo alloys were as good as any made elsewhere, and that a California electronic company buys their products. Their major activity is to make new and different types of permanent magnetic materials for various applications. They were particularly proud of their ring oriented magnets [$SmCo(CoCuFe)_7$] which had a $(BH)_{max} = 22 \times 10^6$ and mesh metal made of $SmCo_5$ alloys which they claimed was the cheapest made anyplace. The people involved appeared to be very competent and proud of producing materials that are useful in various applications (including line printers, bonded materials for electronics, headphones, watches), and as devices for removal of nails from the stomach of oxen, and removal of impurities from people's eyes.

Finally, I was also struck by the fact that although it is an applied research institute, they are committed to expanding their efforts in basic research. In addition to studying defects in metals and determining formation energy of stacking faults, they are carrying out multiple scattering--Xα calculations using a program obtained from Keith Johnson at the Massachusetts Institute of Technology (M.I.T.). They are also doing some *ab initio* Hartree-Fock calculations with up to 22 atoms in a cluster.

- Visit to Physics Department, Nanjing University, Nanjing

Nanjing University is located in the center of the ancient city of Nanjing. As one of the (three) major universities in China, it includes faculties in both liberal arts and natural sciences. Its history dates from 1902 when it was founded as the Sanjiang Normal School. The university has 15 departments:

- Chinese,
- history,
- philosophy,
- economics,
- law,
- foreign languages,
- literature,
- astronomy,
- mathematics,
- physics,
- chemistry,
- computer science,
- geology,
- geography,
- meteorology, and
- biology.

Students work for B.A./B.S. degrees in 44 disciplines, for M.A./M.S. degrees in 53 disciplines, and for Ph.D. degrees in 24 disciplines. There are also nine research institutes and ten research groups at the university which has established academic relationships with more than ten well-known universities all over the world.

It is clearly a very energetic university with more departments and disciplines than any other in China. Each year it hosts about 3000 foreign visitors. The university has a long tradition of scholarship and is proud of producing scientists like the famous physicist, Madame C.S. Wu of Columbia University (formerly president of the American Physical Society).

My visit was, as in 1979, with the Physics Department of Nanjing University. The department lists itself as having ten professors, 33 associate professors, and 235 lecturers, five "other" teachers, and 47 assistants. Clearly, this large number of personnel is a remnant from the cultural revolution when the universities were turned into factories and untrained and unqualified people were placed into newly created jobs. The core group in solid state physics is, however, first-rate. While not up to the level of either Beijing or Fudan Universities (and certainly so far not as well-funded) they are making serious attempts to improve their research facilities. The main priority among these improvements is a proposed Center for Materials Analysis which will be established using $3.2 million out of the $7.0 million obtained from the World Bank by Nanjing University. Important facilities for the Center will include:

- a scanning electron microscope with a resolution of 60 Å.
- a transmission electron microscope with a resolution of 1.8 Å. [Presently they have an old transmission electron microscope (resolution 10 Å) for the study of crystal defects/dislocations. This TEM was imported from the United Kingdom more than 15 years ago.]
- a rotating anode 120 keV x-ray source for small angle scattering and x-ray tomography.
- Raman scattering equipment for low and high temperature studies. They would like, but cannot afford, a Brillouin scattering apparatus.
- a SQUID susceptometer operating with a 5 T superconducting magnet which they hope to obtain from the SHE Corporation. With this they plan to study weak magnetism and anisotropic magnetizations. They would like also to buy a SQUID-based magnetometer for geological uses to study paleomagnetism and continental drift, but it is not clear that an export license will be given by the U.S. Presently, they have a helium liquefier and a low temperature laboratory, but at a cost of 60 yuan per liter (about $30.00) the cost is very high (in general, helium gas is expensive in China costing some 200 yuan per m^3.
- facilities for chemical compositional analysis including a mass spectrograph and a chromograph. (The mass spectrograph will permit isotope analysis mainly for geological purposes.)
- optical analysis facilities including a fast Fourier transform IR spectrometer for atomic spectra and an ICPA which is an atomic spectrometer having an optical source excited by a plasma with photomultiplier detection (this permits highly sensitive, highly precise, and convenient measurements such as on inorganic materials) and an ultraviolet spectrometer and an absorbtion spectrometer (not described).
- electron spin resonance (ESR) equipment.

They claim to have enough trained people to handle all this equipment. This may be the case after a number of their scientists return from abroad. There is a new building being designed by architects which will have on its 13 floors a total of 12,000 square meters of space. Construction is expected to start in early '83 and it is hoped that the building will be completed in three years. In the meantime, they will modify some classrooms for use of the first equipment that arrives for the Center for Materials Analysis.

They have considerable strength in the area of magnetism both in experiment and in theory. Their work centers around investigations of rare-earth-transition metal alloys including the rare-earth Co magnets. Of particular interest to them is the effect of small additions of Fe and Sn on $SmCo_5$ and both x-ray and Mössbauer effect experiments are used to investigate the effects of additives. Their aim is to stablize the technology and improve the production of magnets in close cooperation with the Southwest Institute of Technology in Sichuan. The latter is the largest institute of magnetism employing about 1000 people. The institute is under the Ministry of Electronics.

Their investigations of single crystals of magnetic oxides show that small amounts of Ru can increase the anisotropy of hexagonal ferrites by as much as 20% at room temperature. The interest here is application to films. Also being studied are oxides of polycrystalline materials because of their possibility for new types of permanent magnets. The theoretical group has been calculating anisotropy (in the single ion approximation) and in general supporting the efforts of the experimentalists.

All in all, they have a rather strong theory effort centering on superconductivity (Professor Gong), superlattices (Professor Cai), Kondo problem (Associate Professor Lee), phenomenological theory of superconductivity (Associate Professor Xu), and the study of Josephson junctions (Mr. Ya).

A strong effort exists in the area of crystal physics under the direction of Professor Fong Duan. This group performs excellent work on understanding crystal growth, studying defects in ferroelectric domains, determining the influence of periodic laminar domain structures, and investigating the influence of dislocations on phase transitions. They hope to acquire a new electron microscope next year and are planning to have an MBE facility. Much of the credit for the intense activities is due to the leadership of Professor Fong who is also a leading authority on dislocation theory in China. Fong and associates have been able to grow lithium niobate single crystals with modulated impurity concentrations (pitch ~3.5 μ) in order to get the perfect phase matching for optical second harmonic generation.

- Visit to Physics Department, Fudan University, Shanghai

Fudan University is one of the two top universities in China. Originally founded in 1905, it was reorganized after 1952. As presently constituted, it has 16 departments:

- mathematics,
- physics,
- chemistry,
- biology,
- nuclear science,
- computer science,
- management science,
- electronic engineering,
- foreign languages and literature,
- Chinese language and literature,
- history,
- journalism,
- philosophy,
- economics,
- international politics, and
- world economy.

In addition, there are eight research institutes affiliated with the university departments:

- Institute of Mathematics,
- Institute of Genetics,
- Institute of Modern Physics,
- Institute of Electric Light Sources (working on the development of lamps through the gas discharge process),
- Institute of World Economy,
- Institute of Chinese Linguistics and Literature,
- Institute of Historical Geography, and now an
- Institute of Materials Science.

Thus, the university offers a varied curriculum which, for undergraduates, leads after four years to a B.S. or B.A. degree and for graduate students leads to M.S., M.A. degrees and a Ph.D. in certain fields (including solid state theory and experiment, and low energy nuclear physics). The professors and associate professors number approximately 400 and there are an additional 1900 "other faculty." In the fall of 1982, there were about 5600 undergraduates and about 400 graduate students plus some 210 visiting faculty members engaged in advanced study from other Chinese universities.

Finally, Fudan University has an active program for foreign students. This year there are 132 of which the largest number, some 36, are from the University of Leeds in England.

The Physics Department of Fudan University in Shanghai has achieved world recognition thanks to the intense efforts of Professor Xie Xide. She was trained in solid state theory by J.C. Slater at M.I.T. and received her Ph.D. in 1952 when I first met her. She is now President of Fudan University and a member of the Central Committee; this latter post, unfortunately, requires her to spend a lot of time in Beijing.

The last three years have seen great advances in the research capabilities of this department. A prime example among these is the Surface Physics Laboratory which was founded in 1978 and now consists of 26 people of whom 20 are experimentalists. The Surface Physics Laborary is one of eight laboratories which comprise the Modern Physics Institute of Fudan. The other laboratories are:

- vacuum physics,
- nuclear physics,
- semiconductor physics,
- laser physics,
- solid state optics,
- theoretical physics, and
- low temperature and superconductivity.

The Surface Laboratory is now handsomely equipped and contains two VG Scientific spectrometers. Their best one, costing $400,000, was installed in May of 1982 and operates at 10^{-10}-10^{-11} Torr which includes a microcomputer and peripherals this facility has acquired at an expenditure of $800,000. The second instrument is a multipurpose spectrometer for UPS, XPS, AES, LEED, and SIMS. The instrument has good sensitivity. Research has already started on a number of problems including:

- the Si-SiO_2 interface layer,
- the anodic passivated layer on $Cr_{18}Ni_9T_i$ stainless steel surfaces,
- laser desorption of surfaces in ultrahigh vacuum, etc.

They are also continuing studies relating to metal-semiconductor and insulator-emiconductor interfaces.

Excellent equipment is also available in the Vacuum Physics Laboratory of the Institute of Materials Science headed by Professor Hua, including a new scanning Auger microscope (model 590 from the Physical Electronic Company of Minnesota). While the instrument maintains a good vacuum, both the electronics and the computer (a PDP 11 interface) presented problems. (Apparently, the problem is that the service man who is based in Hong Kong, is not qualified to handle anything but the smallest problem.) There is an active research effort underway centering around Mr. Zhang Qiang-ji who spent three years with Professor Gomer at the University of Chicago.

Under Professor Xie Xide's direction, there is a strong group of theorists working in support of the experimentalists. This includes Jiang Ping (who spent some time in Trieste), Xu Zhi-zhong, Lu Fen, and two graduate students, Xu Yong-nian, and Fu Zhuo-wu. This group has done extensive work with semiempirical, self-consistent extended Hückel theory and tight binding calculations [on such systems as: the relaxation and reconstruction of semiconductor surfaces; chemisorptions such as H/Al(111), H/Ag(111); Ga, In, and Al on Si(111), Ge(111), GaAs(110), Cl on Si, Ge, GaAs; deep impurities levels of semiconductors; amorphous Si (with H and F), graphite intercalation compounds]. Mr. Xu will start a collaboration with my former visiting scholar Xu Jian-hua on silicide compounds using the LMTO method. Some of their projects include surface segregation studies on materials of interest for vacuum tubes for television using the appearance potential spectroscopy and Auger mapping, study of oxides and metallic connections (mostly Al alloys) since there is a small LSI effort (both production and study) taking place in Fudan, and study of Auger line shapes in rare-earth alloys. One of the really striking and new developments is the resonance photoelectron appearance potential spectroscopy (RPAPS) which was developed at Fudan. In this technique, both the sample and the target material are the same as the anode material of the x-ray source. This was but one example of the new developments that I have seen in my visit in China. It indicates that very soon the Chinese scientists will be making substantial contributions.

The one area where Fudan University is behind, as indeed is the case for all of China, is that of modern computer facilities. For the last four years, they only had available a homemade computer (FD 719). They are now putting on-line a general propose computer, the FD 753, which was designed by the faculty at Fudan University, but built by the Zhong Xing Radio Factory in Shanghai. This computer permits time sharing (64 users) with virtual memory--VMTSS, and uses a small computer built in China for diagnostics. Presently, the hardware has been installed and the VMTSS is being debugged. The computer has a central core of 128 K words (a word is 48 bits but with eight bits also available for checking). It has a speed of two MIPS and uses multimemory modules with two arithmetic units and three channel operations. The level of design appears up to those of high standards, but the Chinese readily admit that the problem is with the technology, "which is bad." (The CPU has 4000 printed words with some 80,000 chips in the circuit boards.) The real limitation on the operation of the computer is that presently they use a punch paper tape as a reader for the input. Soon they hope to attach floppy disks instead.

The physicists are especially aware of their intense need for upgrading the computing capabilities at the university. Restrictions on export of computers to China make it difficult for them to obtain machines that are newer than the IBM 370 class machines.

In general, the physicists are very eager to promote future research interactions for their faculty. To this end, they have established workshops in solid state theory and surface physics. National meetings will be held every other year. In addition, quite a few scientists have already been sent to work and study in the U.S., England, Germany, and Italy. In addition, they are actively seeking foreign scientists who will spend a minimum of three months at Fudan University for teaching and research.

- Visit to Shanghai Institute of Metallurgy, Shanghai

The original institute was founded in 1928, but was later split into two separate institutes--the Institute of Metallurgy and the Institute of Ceramics. Presently, the Institute of Metallurgy consists of 1100 people in 12 different departments of whom 400 are scientists, 300 are technicians, and about 300 are workers in their machine shop. By department, there is:

- LSI efforts consisting of 100 people,

- magnetic materials, especially magnetic bubbles for memory devices--approximate size, 50 persons,

- superconductors and low temperature (mostly He service) consisting of 30-40 persons,

- ion implantation and laser annealing--50 persons mostly on semiconductors and metals, and

- there are three new departments which were split from a large single department of 100 persons and are mostly concerned with materials for device applications like GaAs and InP,

- a service department of approximately 50 persons which contains a transmission electron microscope, x-ray diffraction, AES, SEM, (They consider this to be a bad system since the service persons are divorced from the researchers; a new plan is to allow the graduate students to use the instruments for their own experiments.)

- fundamental research--approximately 50 persons with Xie Ray-ming as its deputy director. This department is concerned with such problems as internal friction in metals and semiconductors, IR spectroscopy, epitaxial growth, interfaces and the study of their electronic properties, and defects in silicon and the metalization of semiconductor surfaces,

- metallurgy department--approximate size 70 persons concerned with corrosion and its protection, and

- there are two service departments: 80 persons are engaged in chemical analysis in the one service department, and 45 persons are engaged in making equipment in the electronics department.

I was mainly concerned with their fundamental research department because of an overlapping interest and because my former visiting scholar, Xu Jian-hua, is a member of this department. Mr. Xie Ray-ming and Mr. Lei Xiao-lin are the only persons with Xu who are concerned with theory. They have only a minicomputer at present, but they hope to soon be able to use a new Burroughs computer which is being purchased by the Shanghai Academy of Science.

Mr. Lei has worked during the last year on the electrical resistance of A15 superconductors and in rare-earth magnetic materials. This year he is investigating the coexistence of magnetism and superconductivity along with the possible coexistence of charge density waves and superconductivity.

Some of the equipment in the research laboratories is first-class. For example, they have a fast Fourier transform IR spectrometer (a Nicolet 7000) which was installed in January of 1982 at a cost of $220,000. They use a minicomputer, but hope to expand the memory. Most of their studies are on hydrogen in crystalline silicon and compare with the results obtained for the hydrogen line in amorphous silicon. They are presently deuterating a single crystal for determining the isotope effect using a vibrational model.

In the laboratory of Wang Nai-li, I found a really modern facility--namely a Riber Auger and scanning Auger facility. (This cost them "only $400,000" because it was purchased on the spot at an equipment exhibition with a 40% discount. Next year they hope to add ESCA and a computer.) This instrument has a CMA analyzer and is currently being used for in-depth profiles of GaAs/AlAs with LEED and SIMS and for studying the interface properties of Si/SiO_2 and Ni/Fe. They were quite proud of the fact that they had a homemade machine as early as 1978 which was the first Auger spectrometer in China. (This machine had its vacuum system made in a factory in Shanghai, but the rest of the machine was made in their electronics department.) It gave an operating pressure of 3×10^{-3} Torr.

They also have a scanning electron microscope which was made by the Scientific Instrument Factory in Beijing which belongs to the Academy of Science. It has a 200 A resolution with a 3×10^5 magnification, and is used for LSI work and for studying such problems as steps of aluminum on silicon and etch pit and dislocation studies.

The properties and characteristics of III-V semiconductors are investigated in the laboratory of Zhou Bing-lin. Here epitaxial layers of GaAs and InP are under study because of their interest in microwave devices and optical electronic devices, gun diodes, switch diodes, FET transistors, solar cells, and lasers. They are interested in preparing MOS and studying the role of surface states, understanding the Schottky barrier, and looking at the effect of deep impurity levels in GaAs and InP.

This institute is clearly making strenuous efforts to modernize. They have already sent 30 of their scientists abroad of whom ten have returned so far. Their plan is to send six or seven abroad each year for training. The problem that the institute faces is strong pressure on it to give up its fundamental research and to concentrate solely on device applications. It is not clear that they will succeed given the present environment.

FINAL COMMENTS

The legacy of the past still haunts China. Leaders are afraid to take the initiative because science had been so highly politicized and because the party line has frequently changed--sometimes virtually overnight. It is therefore not surprising that risk-taking, initiative, and personal responsibility, which are generally accepted as essential to innovation and creativity in science, are oftentimes lacking.

My trips gave me a much better insight into the operation of the Chinese research establishments. Clearly, the Academy of Science plays an essential role in the three-tier system of university-academy-industry. The main function of the university is to train scientific and technical workers with a minor role in research (except for the major universities). The research institutes and factories serve the purpose of giving students their practical experiences in a research/production environment. The Academy serves to create new knowledge, develop applications derived from that knowledge, and to transfer the knowledge to the university and the industrial research institute or factory. The major function of the industrial research laboratory is to improve product quality, to develop new manufacturing processes, and to develop new products. To the Chinese this seems to be a reasonable division of labor.

TABLE I

Scientific and Technical Committee of the State Council

(Chairman: Fong Yi)

- Regional scientific and technical research organizations
- Industrial technology
- National defense science and technology committee
    - rocketry
    - nuclear energy
    - aerospace
- Ministry of Education
- The Academy of Sciences

TABLE II

Chinese Academy of Science
(Presidium: Executive Chairpersons) (three)

President (one)
Vice Presidents (six)

Scientific Divisions

- Division of Technological Sciences, Director: Li Xun
  Deputy Directors: Wang Daheng, Zhang Guangdon, Chen Fangyun
- Division of Earth Sciences, Director: Tu Guangchi
  Deputy Directors: Cheng Yuqi, Ye Lianjun, Shi Yafeng
- Division of Biological Sciences, Director: Feng Depei
  Deputy Directors: Zhang Zhiyi, Cao Tienqiu, Xu Guanren
- Division of Chemistry, Director: Yan Dongsheng
  Deputy Directors: Zhang Quiglian, Chen Guanzong, Huang Yaozeng
- Division of Mathematics and Physics, Director: Ma Dayon
  Deputy Directors: Wu Wenjun, Wang Shouguan

Scientific and Technical Committees

- Environment science and technology
- Energy research and technology
- Agricultural research

Scientific Research Funding Committee

Funding unsolicited scientific proposals submitted from universities, research institutes and industries

Joint Management Divisions

- Operational management office
- Foreign affairs
- Education (The academy operates two full size universities)
- Science and technology import and export
- Long-range planning

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THE SIXTH INTERNATIONAL CONFERENCE ON RADIATION SHIELDING AND RELATED UNIVERSITY VISITS

A. Halim Kazi

INTRODUCTION

The Six International Conference on Radiation Shielding was held 16-20 May 1983 in Tokyo, Japan. This is the definitive international conference on radiation shielding and is held every five years. Attendance was about 200 with engineers and scientists from the Japanese nuclear power industry predominating. Topics covered a wide range including both theoretical and experimental shielding analysis for existing nuclear power plants and future fusion plants. Japan has a very broad and active nuclear power program. Japan has excellent computational capabilities, including three-dimensional analysis of complex structures.

The complete proceedings will be published. The author gave a paper entitled, "Neutron and Gamma Kerma and Spectrum Measurements to 1.6 km from a Fission Source." A companion paper entitled, "Comparison of Experiment and VCS Calculations for Transmission of Air-moderated Fission Radiation through a Shielded Structure," was given by Dr. A. E. Rainis. Both papers were well received.

Several papers of specific interest were:

- "Development of Neutron Shielding Material using LiF," by Keiji Kanda *et al.*

Several materials including cloth using LiF and ^{6}LiF have been developed which provide a thermal neutron shield while producing few secondary gammas. This is mainly useful for neutron capture therapy of cancers, but also has other applications. A lead cloth for gamma shielding is also available.

- "Radiation Streaming Studies at the Fusion Neutronics Source Facility," by T. Nakamura *et al.*

This work is interesting since it describes a 14-mm-diameter spherical NE 213 Scintillation Detector. Agreement between data obtained with this detector and with a more conventional 4.65 cm diameter detector is good. The small detector could be useful for in-phantom dosimetry. The small NE 213 scintillator is mounted on a small-size photomultiplier (Hamamatsu Photonics, R 647-01). The detector response seems to be limited to > 2.4 MeV. Whether it is an intrinsic limitation or only due to the use of a 14 MeV source is not clear.

- "A Benchmark Experiment for γ-Ray Skyshine," by Y. Yamaguchi *et al.*

Gamma ray measurements up to 300 m from a source were made using NaI and a high pressure argon-filled ionization chamber. The energy sensitivity of the latter is given.

- "Standardization of Moderating Type Neutron Detectors for the Usage of Neutron Spectroscopy," by T. Kosako, T. Nakamura, and S. Iwai.

This paper describes calibration and use of a Bonner sphere spectrometer. Agreement between measured and calculated response functions is very good. Comparison of measurements made with this and other spectrometer would be very valuable.

A MEETING AT THE JAPAN RADIOISOTOPE ASSOCIATION

On 17 May, a meeting was held at the Japan Radioisotope Association to discuss dosimetry relative to the Hiroshima-Nagasaki dose reevaluation effort. The Japanese scientists attending, in addition to the author, are listed in Appendix I. These scientists are the committee in charge of the Japanese evaluation of Hiroshima-Nagasaki and operate through the Ministry of Health and Welfare.

Dr. T. Maruyama presented a summary of his work involving dose determination from thermoluminescence of brick and tiles, and a paper entitled, "Potential Influence of the New Doses of A-Bomb after Reevaluation on Epidermiological Research," given at an International Atomic Energy Agency and the World Health Organization (IAEA-WHO) Symposium in Venice, Italy, April 1983. The latter paper summarizes the current status of the dose reevaluation effort.

A good informal technical discussion followed including subjects on:

- calibration experiments to determine the conversion factors of free-field dose to 60 cobalt activation in iron,
- shielding factors of Japanese houses,
- free-field to in-phantom dose factors for Japanese standard phantom.

UNIVERSITY VISITS

- A Meeting with University of Tokyo and Kyoto Scientists

On 19 May, a meeting was held with Japanese scientists principally from the Universities of Tokyo and Kyoto. The agenda is given in Appendix II. This group represents the Japanese capability in radiation dosimetry funded through the Ministry of Education. Professor Okano gave a presentation on a Helium-3 thermal neutron detector which is used to measure very low level radiations of the order of 1 microrem per hour on top of mountains about 3000 m high.

A number of experiments of mutual interest were discussed. Of key interest is intercalibration of the Bonner sphere spectrometers. Another key experiment is a skyshine measurement. Neutron skyshine from a nuclear facility is of great interest and in the past published Army Pulse Radiation Directorate (APRD) at the Army Aberdeen Proving Grounds, MD., data to 300 m range has been used in the validation of Japanese calculations [T. Nakamura and T. Kosako, *Nuclear Science and Engineering*, 77: 168-181 (1981)]. It would be valuable to repeat this analysis using the more recent APRD data to 1.6 km range.

It is interesting to note that the same general discrepancies exist between the APRD experimental data (including German and Canadian measurements) and Japanese calculations as between the measurements and U.S. calculations.

- A Visit to the Nuclear Engineering Research Laboratory, University of Tokyo

On 24 May, a visit was made to the Fast Neutron Source Reactor "YAYOI" at the University of Tokyo. Discussions were held with Professor Hiroaki Wakabayashi and his staff. He is the director of the reactor facility. The reactor is quite unique. The core consists of 28 kg of 93% enriched metallic uranium, and a thick depleted uranium blanket. This appears to be the only special nuclear material in Japan; the reactor is of interest to IAEA. The reactor is pulsed in a repetitive mode using dual oscillators. One of the oscillators is a machine gun which fires nylon bullets through an in-core glory hole which brings the reactor just above prompt critical. Power output is low and peak pulse temperatures are about 50°C. The facility also operates a LINAC and this machine can be operated in conjunction with the YAYOI.

The YAYOI fuel is showing some defects such as several small blisters on the fuel surface. Likely causes are a metallurgical defect or a local phase change--the alloy is in the alpha phase. This is of some concern and thought is being given to shutting down the reactor and recladding the elements to prevent fission product release. Whether this is necessary is not at all clear. It is probably more constructive to continue operation, but to watch it very carefully.

On 25 May, a visit was made to the Controlled Thermonuclear Reactor Blanket Engineering Research Facility of the University of Tokyo. Detailed discussions were held with Professor M. Nakazawa, the Director. This is an excellent facility with some very fine equipment: a Van de Graff accelerator with an on-line electron microscope, a dense focus plasma source, and a linear accelerator which can provide picosecond pulses. This is the same accelerator which can be operated with the YAYOI reactor. Japan has a very active fusion program. This facility does research to determine properties and radiation effects in potential fusion reactor blankets (or walls). The facility has considerable neutron spectrum measurement capability, including NE 213, Benjamin-type proton recoil counters, etc. Professor Nakazawa is interested in measuring radiation at a long distance from a source. This is to provide benchmark data for skyshine calculations for fusion and conventional nuclear reactors. Measurements have been made using YAYOI out to a range of 79 m.

APPENDIX I

JAPAN RADIOISOTOPE ASSOCIATION MEETING ATTENDEES

Eizo Tajima	Nuclear Safety Commission
Tadayoshi Doke	Waseda University
Kazuaki Katoh	KEK, National Laboratory for High Energy Physics
I. Hamada	The Japan Radioisotope Association
Yoshikazu Kumamoto	National Institute of Radiological Sciences
Takashi Maruyama	National Institute of Radiological Sciences
Tadaaki Hashizume	Azabu University
Senjun Taira	Ministry of Health and Welfare
Nobuo Oda	Tokyo Institute of Technology, Research Laboratory of Nuclear Reactors

Mail may be addressed to:

Japan Radioisotope Association
28-45, Hon Komagome 2-chome
Bunkyo-ku, Tokyo 113, Japan

APPENDIX II

INFORMAL MEETING ON NEUTRON DOSIMETRY IN RELATION TC THE A-BOMB DOSE REEVALUATION

Program

- Welcome Address, Sohei Kondo (Osaka University)
- "An Improved Type of Neutron Dosimeter," Masaharu Okano (Physics and Chemistry Institute)
- "Neutron Measurements to 1.5 km from a Fission Source," A. H. Kazi (Army Aberdeen Proving Ground, MD)
- Discussion

Japanese Participants

Professor S. Kondo	(Osaka University)
Professor K. Kanda	(Kyoto University)
Professor T. Nakamura	(Institute of Nuclear Study)
Professor M. Nakazawa	(University of Tokyo)
Professor T. Kosako	(University of Tokyo)
Dr. M. Okano	(Institute of Physical and Chemical Research)
Dr. M. Akiyama	(University of Tokyo)
Dr. H. Hashikura	(University of Tokyo)
Mr. J. Matsumoto	(University of Tokyo)
Dr. N. Sasamoto	[Japan Atomic Energy Research Institute (JAERI)]
Professor Okajima	(Nagasaki University)
Dr. T. Kobayashi	(Kyoto University)

Mail may be addressed to:

Institute of Nuclear Study
University of Tokyo
1-2, Midori-cho 3-chome
Tanashi, Tokyo 188, Japan

or

Institute of Atomic Energy
Kyoto University
Gokasho, Uji
Kyoto 611, Japan

THE NATIONAL INSTITUTE FOR ENVIRONMENTAL STUDIES

Sachio Yamamoto

INTRODUCTION

The National Institute for Environmental Studies (NIES) was established in 1974 under the Environmental Agency to "study the effects of human activities on the environment as well as the influence of environmental pollution on the health of man." The institute is located in Tsukuba Science Center and in Japan Fiscal Year (JFY) 1982 had 246 employees of whom 156 were researchers. A wide range of disciplines from mathematics and physics to medicine to sociology and economics are represented. The institute consists of ten divisions which are divided into 33 sections. The director is Dr. Jiro Kondo, formerly Dean of Engineering at Tokyo University.

This institute's total operating budget for JFY 1982 was $20.0 million ($1 = Y240); of this amount $5.25 million is for research and the remainder is for labor, overhead, and general expenses.

RESEARCH ACTIVITIES

There are two categories of research: special projects and continuing basic research. The former is of three-five year duration and comprises about 75% of the institute's research efforts. The current special projects are the following:

- study of the physics and chemistry of aerosols and aerosol formation,
- measurement of background levels of trace metals and organic pollutants,
- development of methods for remote sensing of pollutants and assessment of environmental pollution,
- study of pollutant perturbation and subsequent recovery of water ecosystems,
- study of the effect of gaseous pollutants on plants and animals,
- transport, mixing, and removal processes of atmospheric pollutants,
- study of the role of vegetation in the clean up of the atmosphere,
- development of methods of assessing the latent effects of heavy metals on health,
- microcosm studies of red tide blooms.

Research activities in each of the eight technical divisions are highlighted below (the other divisions are the Administration Division and the Engineering Division, which is a technical support group).

Environmental Information Division

This division plays the role of the environmental information center for Japan. The library and computing center are under this division.

Systems Analysis and Development Division

Research topics in this group include:

- development of environmental models,
- environmental assessments, i.e., what parameters should be used in making assessments,

- "bubble" concept in environmental control, i.e., controlling groups of emission sources rather than each individual source, and
- capacity of an environment to accommodate or accept pollution.

Chemistry and Physics Division

This division consists of four sections:

- Air Quality Measurement (five members),
- Water Quality Measurement (five members),
- Biochemical Analysis (five members), and
- Sediment and Soil Chemical Analysis (three members), and laboratory analysis and monitoring.

Dr. Yukihiro Nojiri, a recent graduate of Tokyo University, who did his thesis work on inductively coupled argon plasmas under Professor Keiichiro Fuwa, is continuing work in this area. The effort of the Water Quality Measurement Section is directed toward development of methods for analysis of pollutants in water and sediments. For trace metals they are strong on inductively coupled plasma (ICP) and surface ionization mass spectrometry. Among their research topics are:

- development of an electrochemical, continuous multielement monitoring system,
- application of field-emission ion sources for the analysis of nonvolatile organic pollutants, and
- development of measurement methods for monitoring background levels of trace metals and organics in the open ocean.

There is a project in background monitoring in which they are measuring trace metals and organics such as hexachlorobenzene, DDT, and polyaromatics (e.g., benzopyrene) in Lake Mashu in Hokkaido. This is a very clean lake and its transparency of 41.6 m is presumably the greatest of any lake in the world (Crater Lake is 39 m). Dr. Naoki Furuta succeeded in measuring, by laser-induced fluorescence spectrometry, a background level of 10 ppq (ten parts in 10^{15}) for benzopyrene. He thinks its the lowest level ever measured for a pollutant substance in an environmental sample. Dr. Kansaku Okamoto of the Biochemical Analysis Section directs the program for preparing certified reference materials.

Atmospheric Environment Division

Research projects include remote sensing of atmospheric pollutants by laser radar, wind tunnel and field studies of the atmospheric diffusion of pollutants, and wind tunnel studies of aerosols. In the Atmospheric Chemistry Section, Dr. Hajime Akimoto is studying gas phase kinetics with a very large smog chamber and Dr. Shiro Hatakeyama, the reactions of organic sulfur compounds such as $(CH_3)_2S_2$ in the atmosphere.

Water and Soil Environment Division

One project in this group is the study of eutrophication in Lake Kawaguchi-ura. A major program is the study of the red tide phenomena under the direction of Dr. Masataka Watanabe. The project includes the following topics:

- the mechanism of growth and accumulation of red tide flagellates,
- the effect of environmental factors, such as temperature, pH, salinity, nutrient levels, and trace metals on the growth of flagellates,

- the diel vertical migration of the flagellates. (They have observed that the organisms migrate at the rate of 1 m per hour, upward in the morning and downward at night,)
- mathematical modeling of transient phenomena,
- study of the relationship between the regular spacing of the red tide streaks on the sea surface and Langmuir circulation,
- direct NMR measurement of ^{31}P of the algae in the water. (With the highly concentrated pure culture, it is possible to make these measurements with a 400 MHz machine. Dr. Watanabe has been able to show that ^{31}P peaks for ATP and ADP can be distinguished. This means that one can simultaneously measure the different biochemical energy states directly.)

Basic Medical Sciences Division

This group is studying effects of pollutants on plants and animals, especially long-term effects of sublethal levels. An example of the effect of chemical stress is a study in which they exposed mice to O_3. They observed oxidized hydrocarbons in the exhaled air and the amount correlated with the degree of exposure.

Environmental Health Sciences Division

This division conducts epidemiological studies. They study people who live in regions where there might exist naturally high levels of particular pollutant material.

Environmental Biology Division

The effect of air pollutants on plants are studied in a controlled environment and exposed to pollutant gases. In another study they found that although the level of photochemical oxidants are lower in Tokyo now compared to a few years ago, plant damage in the outlying areas, such as Chiba Prefecture, is increasing. One reason might be that although the pollutant levels are now below the maximum allowable levels, they may be more widely distributed at a lower level.

FACILITIES

This institute has a number of special research facilities for studying the fate and effect of pollutant materials in the environment. Four are briefly described below.

- Facilities for Plant Experiments

There are two special facilities for plant experiments. One is a the "Phytotron," a 3,348 m^2 facility in which plants are raised in a controlled environment and exposed to controlled levels of pollutant gases. The effect on plants of long-term exposures to low levels of pollutants are being studied. The other is a natural environment simulator with which the effect on plants of changes in environmental conditions are being studied. It has the following features:

experimental chamber	18.5 m^3 (2.4 m x 2.4 m x 3.2 m)
wind velocity range	0.1 - 2.8 m/sec (10 stages)
temperature range	10 - 35°C (10 stages)
humidity range	30 - 80% (10 stages)
illumination range	0 - 60,000 lux
input gases	SO_2, NO_2, O_3, HC, CO_2

- Facilities for Animal Experiments

In the "Zootron," *in vivo* effects on animals of long-term exposures to low levels of air pollutants are being studied. In these facilities atmospheric pollutant gases as well as temperature, humidity, and ventilation are controlled. There are three exposure laboratories with eight chronic gas exposure chambers and laboratories for physiology and pathology, surgery, and autopsies. The animal rearing rooms have two levels, specific pathogen-free and conventional, and can simultaneously accommodate 6000 small to medium-sized animals.

- Facilities for Water Environment Experiments

The "Aquatron" consists of a building for hydrobiology and water quality experiments and another for hydraulic experiments. The former contains the following:

- microcosm and culturing tanks where temperature, lighting, and other parameters can be controlled to study behavior of microorganisms in water,

- a toxicity experiment facility to study the accumulation and effects of heavy metals and agricultural chemicals on aquatic organisms,

- artificial environment rooms for rearing standard experimental fish and indicator organisms, and

- aquatic microorganism laboratories with a germ-free room,
- an autoclave room,
- a sterilization room, and
- a culturing room.

In the hydraulics facility, simulation experiments relating physical factors such as precipitation, transport, and diffusion are being related to behavior of pollutants in flowing water.

- Photochemical Smog Chamber

The photochemical smog chamber was designed by Dr. Hajime Akimoto and is based on that developed at the University of California, Riverside. It consists of a reaction chamber (ca 6 m^3, temperature range 0-50°±1°C, vacuum 10^{-6} Torr), solar simulator, sample gas preparation equipment, and instruments for analysis. It has the following special features:

- the reaction chamber is made of stainless steel lined with Teflon and can be evacuated and baked to remove any reactants or products which may have accumulated on the chamber walls,

- parallel light beams from high-pressure xenon arc lamps with wavelength distributions and intensities near those of sunlight are used,

- a long-path Fourier transform infrared spectrometer is included in the chamber unit so that direct measurements of the concentrations of various reactants and products in the chamber is possible.

CONCLUSION

This institute is obviously intended to be a showcase laboratory. Its facilities and equipment are first-rate. Moreover, all the equipment is being used and the morale and enthusiasm of the workers appears to be very high. The laboratory seems to be well-funded. However, the period of growth in personnel and funds is over and because of the ceiling imposed on the number of government workers, there is very little new blood coming in and the staff, who for the most part are 35-45 years old, will all "grow old" together and most will be retiring in 15-25 years. This situation appears to be common in many government laboratories and may pose a problem in the future.

CHEMISTRY AND MARINE SCIENCES IN AUSTRALIA

Sachio Yamamoto

INTRODUCTION

With a population of 15 million people and an area almost equal to that of the United States, Australia is one of the most sparsely populated nations of the world. Yet Australian society is highly urbanized; about 60% of the population live in the major urban areas of the state and territorial capitals. The nation is rich in natural resources and is self-sufficient in many. Its agriculture is dominated by pastoral industries. Before World War II, the Australian economy was largely dependent on primary production. Now agriculture contributes 10% to total production while manufacturing and tertiary industries contribute 25% and 65%, respectively.

Scientific research and development in Australia differs from that of other industrialized Western nations and Japan in that it is mainly funded and performed by the government. In 1981-82, national and state governments provided 80% of R&D funds, 75% of which was spent in government laboratories and universities. One reason for this is that one-third of the nation's manufacturing industries is wholly owned by foreign companies, which prefer to import expertise and new developments and adapt them to Australian needs, rather than develop them domestically.

Chemical and oceanographic R&D are no exceptions and much of the R&D activities are centered in government research institutes and universities. The following is a discussion of research activities in chemistry and marine sciences in several government laboratories and universities in Australia.

CHEMISTRY

- Australian National University

The Australian National University (ANU) was established in 1946 by an Act of Parliament and is located in Canberra, the national capital. It is divided into two distinct parts: (1) the Faculties consisting of the Faculties of Arts, Economics, Law, Oriental Studies, and Science, and (2) the Institute of Advanced Studies consisting of the John Curtin School of Medical Research and the Research Schools of Biological Sciences, Chemistry, Earth Sciences, Pacific Studies, Physical Sciences, and Social Sciences.

Chemical research is conducted in the Department of Chemistry in the Faculty of Science and in the Research School of Chemistry. The Department of Chemistry is headed by Professor Ronald N. Norman and has research programs on laser spectroscopy, plant-growth regulators, antitumor drug synthesis, as well as on structures of macromolecules and proteins. The well-equipped Research School of Chemistry, which is located in a spacious laboratory building, is headed by Professor Lewis N. Mander and has 15 permanent academic staff members, 60 research fellows, and a general support staff of 100. Some areas of research emphasis include organometallic complexes (arene-ruthenium and arene-osmium chemistry, metal complexes of olefinic tertiary phosphines, and encapsulated metal ions), structures of metal sulfides and minerals, total synthesis of gibberellins, and soliton propagation.

- University of Sydney

Established in 1850, the University of Sydney is the oldest and largest university in Australia. About 17,800 students are enrolled of whom 3700 are graduate students. The School of Chemistry is in the Faculty of Science and is divided into the Departments of Inorganic, Physical, Organic, and Theoretical Chemistry. The chairman of the Physical Chemistry Department is Professor Walter J. Moore, the author of the well-known physical chemistry textbook. Moore and his associates are studying by proton NMR spectroscopy the conformation of myelin basic protein, which is important in the function of the nervous system. In the area of colloid and polymer chemistry, the emulsion polymerization of vinyl acetate is being studied by Dr. D. H. Napper. Research in the Inorganic Chemistry Department includes study of the crystal structure of the copper-containing protein plastocyanin, NMR studies of heme proteins, and electron transfer reactions of ruthenium amine complexes. In this department, Dr. J. M. Eckert has developed a method for determining iron, cobalt, nickel, copper, zinc, cadmium, and lead in water at the µg/l levels by coprecipitation with a molybdenum-pyrrolidine dithiocarbamate carrier complex. The precipitate is collected as a thin film on a membrane for subsequent analysis by x-ray fluorescence. Research projects in the Organic Chemistry Department include the chemotaxonomy of the Ructaceae and Proteoceae; and substitution and elimination reactions of aromatic, heteroaromatic, and aliphatic nitro compounds involving ANAr, SRN 1, and ERC 1 processes. In the Theoretical Chemistry Department, electrooptical properties of molecules in weak and strong electrical fields are being investigated.

- James Cook University

James Cook University of North Queensland was established in 1970. It was formerly affiliated with the University of Queensland as the University College of Townsville and opened in 1961. It has five faculties and 15 academic departments of which one is the Department of Chemistry and Biochemistry. In this department, Dr. Richard Keene is studying the mechanism of coordinated amine dehydrogenation using flash photolysis techniques and the excited luminescent states of polypyridyl complexes of ruthenium by time-resolved Raman spectroscopy. Metal-ion specific organic ligands are being synthesized and characterized by Dr. Leonard F. Lindoy. Those specific for transition metal ions such as nickel and copper are 14-17 membered macrocyclic ligands containing O_2N_2-donor sets. Research related to environmental problems is being conducted by Dr. Frank G. Thomas and by Dr. C. Burden-Jones and his associate Dr. G. R. W. Denton. Dr. Thomas, an electrochemist whose basic research interest is electrode interface chemistry, is measuring mercury in the underground waters of the Burdekin River to determine if there is any contribution from antifungicides used in sugar cane fields. Drs. Burden-Jones and Denton are monitoring heavy metal levels in organisms such as the black lip oyster, brown algae, and sharks and rays from the coastal waters of northeastern Australia.

- University of Adelaide

Established in 1874, the University of Adelaide is the third oldest university in Australia with an enrollment of 9000. Chemical research is centered in the Faculty of Science in the Departments of Inorganic and Physical Chemistry, Organic Chemistry, and Biochemistry. The Inorganic and Physical Chemistry Department is headed by Professor M. I. Bruce whose research involves the synthesis of mixed metal clusters such as $Ru_3CoAu(CO)_{13}(PPh_3)$. Such clusters have utility in the synthesis of heterobimetallic metallites for surface catalysis. Dr. W. Maher is studying organometallic compounds in marine biota and sediments and has developed methods for the determination of arsenic and tin in marine samples by generation of arsine and stannane. Other research topics include:

- NMR studies of fast exchange and ligand substitution processes in transition, lanthanide, and actinide metal ions (Dr. S. F. Lincoln).

- Application of pulse radiolysis to study mechanisms of inorganic reactions such as those of halogen radical anions and the thallium (II) ion (Dr. G. S. Laurence).

Research programs in the Organic Chemistry Department include:

- Synthesis of heterocyclic compounds active in the central nervous system (Dr. A. D. Ward).

- Structure analysis and synthesis of natural products, in particular, terpenoid compounds (Dr. R. A. Massy-Westropp).

- Chemistry of cyclooctatetraene and some of its derivatives (Dr. G. E. Gream).

A novel feature of the chemistry facilities is the freshmen laboratory. It is equipped with a number of television monitors with headsets. If a student is having difficulties, he calls the laboratory monitor and explains his problem. The monitor then selects the appropriate videotape and plays it for the student who can watch it from his laboratory bench.

- La Trobe University

La Trobe University is located on the outskirts of Melbourne in the community of Bundoora. It was established in 1966 and has an enrollment of 9000 including 750 graduate students. The university consists of eight schools:

- Agriculture,
- Behavioral Sciences,
- Biological Sciences,
- Economics,
- Education,
- Humanities,
- Physical Sciences, and
- Social Sciences.

The three Departments of Chemistry (Physical, Organic, and Inorganic and Analytical) are in the School of Physical Sciences. Each department has eight staff members.

The Physical Chemistry Department is headed by Professor J. D. Morrison whose primary research interest is in mass spectrometry. The department, in particular, and the university, in general, are especially strong and active in photoelectron spectroscopy. There is a Research Center for Electron Spectroscopy and its current chairman is Dr. G. Nyberg. He is studying hydrogenation-dehydrogenation mechanisms of organic molecules adsorbed on surfaces of metals such as Ni and Pd by this method. Dr. B. Peel is applying photoelectron spectroscopy to the study of molecules which have only a transitory existence after their production in the gas phase.

- Catalysis and Surface Science Laboratory, Commonwealth Scientific and Industrial Research Organization (CSIRO)

The organization of CSIRO was described by Dr. Michael J. Koczak in an earlier issue of the *Scientific Bulletin* [*8* (1), 1 (1983)]. The Catalysis and Surface Science Laboratory is one of two laboratories of the Division of Materials Research of CSIRO. This well-equipped laboratory has a staff of 60 and is located on the campus of the University of Melbourne. The laboratory chief is Dr. John. R. Anderson. Research is concentrated on the development of catalysts for the processing of liquid and gaseous fuels. The areas of research are shown in Figure 1 within the overall framework of natural energy resources, refining and reforming processes, and liquid fuel and chemical feedstocks.

Work on supported metal catalysts includes detailed study of the properties of Pt, Ir, and Rh on titanium dioxides (rutile and anastase). Application of zeolite catalysts for the production of liquid fuels and chemical feedstock from sources other than crude oil are being studied. These applications include use in the Fischer-Tropsch processing of synthetic fuels and conversion of methanol to light olefins.

This laboratory has excellent equipment and expertise for characterizing catalysts with the following systems:

- X-ray diffraction and electron microscopy. Their Siemens D500 x-ray diffractrometer has been fitted with a monochrometer which makes it possible to to have only copper $K\alpha_1$ radiation incident on the specimen. Their electron microscope, a JEM 100 CX, has an attachment so that samples can be transferred to and from a treatment furnace without exposure to air.

- Nuclear magnetic resonance. The NMR has a small reactor attachment so that NMR spectra can be obtained during a normal catalytic reaction at elevated temperatures. ZSM zeolite synthesis can be followed by means of high resolution ^{29}Si NMR.

- X-ray photoelectron spectroscopy (XPS, ESCA). This method has been applied to the surface analysis of supported metal catalysts such as Pt and Rh on TiO_2 and Nb_2O_5 and to the determination of Si/Al surface ratios of ZSM-5 zeolites.

- Scanning Auger microscopy. The scanning Auger facility has a six-channel multiplexer which can automatically switch the analyser pass energy among six different elements for purposes of monitoring the separate elemental concentrations during a continuous milling away of the surface by ion bombardment so as to obtain elemental depth profiles.

MARINE SCIENCE

- Australian Institute of Marine Sciences (AIMS)

AIMS was established in 1972 by the Commonwealth Government and has the following functions:

- to carry out research in the marine sciences,
- to arrange for carrying out research in marine science by any other institutions or persons,
- to cooperate with other institutions and persons in carrying out research in marine science,
- to provide any other institutions and persons with facilities for carrying out research in marine science,

- to collect and disseminate information relating to marine science and to publish reports, periodicals, and other papers relating to marine sciences.

Although the institute is very much smaller than CSIRO, its status is equivalent in that both organizations report directly to the Minister for Science and Technology. The institute's laboratory facility was completed in 1976 and is located on 470 acres in a beautiful setting on Cape Ferguson about 26 miles south of the city of Townsville in North Queensland. The main laboratory covers about 10,000 m^2. The site has dock facilities for the institute's three vessels: the R.V. *Lady Basten,* 24.4 m, seven scientists; R.V. *Harry Messel,* 21 m, six scientists; and R.V. *Sirius,* 14.5 m, four-six scientists.

AIMS has a scientific staff of about 60 and their research efforts are directed primarily to the study of the physical, chemical, and biological processes affecting the Great Barrier Reef, the Coral Sea, and the coast and adjacent waters of North Queensland. In the area of chemistry, Dr. Kevin Boto is studying nutrient uptake and detoxification at the root-soil interface of mangroves. Dr. Frank T. Gillan has developed HPLC methods for the analysis of microbial carotenoids and neutral lipids. These methods are applied to the study of the microbial ecology of marine sediments. Field studies of primary production and calcification by coral reefs are being conducted by Dr. David J. Barnes who has developed an automated system for measuring titration alkalinity.

The institute has a program for visiting investigators who are either invited or have made other arrangements for support. Information about this program, as well as AIMS in general, can be obtained from:

Dr. John S. Bunt
Australian Institute of Marine Science
Private Mail Bag No. 3
Mail Sorting Office
Townsville, Queensland 4810
Australia

- Division of Oceanography, CSIRO

This Division was originally part of the Division of Fisheries and Oceanography. The two were reorganized into separate divisions in 1980. The Division is in the process of moving from its facilities in Cronulla, south of Sydney, to Hobart in Tasmania. The Division is headed by Dr. A. D. McEwan and has a staff of about 40 scientists. It consists of the Physical Oceanography Section headed by Dr. G. R. Cresswell and the Ocean Characterization Section headed by Dr. M. Tomczak. The physical oceanography programs include development of a three-dimensional circulation model of the Gulf of Carpentaria and measurement of ocean currents and eddies off the east coast of Australia with satellite tracked buoys. In the area of marine chemistry, Dr. D. J. Mackey is characterizing metal-organic complexes in seawater. A sample is passed through a "Sepak" column and then eluted with methanol. The eluate is separated by HPLC and subsequently analyzed by atomic fluorescence spectrometry. Dr. G. Gardner Sandars has a program measuring and predicting trace metal speciation.

The Division has under charter its own research vessel, the R.V. *Sprightly,* a converted U.S. ocean going tug. A new research vessel similar to a U.S. AGOR is being constructed.

- Other Institutions

University of Melbourne

There are two members of the chemistry staff at the University of Melbourne who have active programs in marine chemistry. Professor R. B. Johns and his staff are examining food chain structure and geochemical characteristics of seagrass communities using techniques which include biochemical analysis of the digestion of seagrasses, microscopic and macroscopic examination of gut content, stable carbon isotope determinations and analysis of various lipid classes present in the seagrass and associated organisms for use as chemical markers. Dr. David Smith is measuring polyaromatic hydrocarbons in sediments and soft tissue of clams from the Great Barrier Reef area as well as trace metals and ^{210}Po in phytoplankton and other marine organisms.

University of Sydney

There is at this university a Marine Studies Center. A number of the participants are on the staff of the Royal Australian Research Laboratory. The research programs are all in the area of physical oceanography and include study of the distribution of microbubbles in coastal waters, sea surface temperature studies using satellite information, and the study of the coastal currents of Australia.

James Cook University

The Sir George Fisher Center for Tropical Marine Studies was established at this university in 1981 with Dr. J. T. Baker as its director. At present, it is staffed with eight scientists and its area of research emphasis is marine microbiology.

CONCLUSION

The caliber of Australian science is very high. The laboratories have excellent facilities and equipment and are staffed by highly competent scientists. Yet, in some universities morale seemed low. The universities went through a period of great expansion in the sixties and are now faced with low growth or, in some cases, declining enrollment and a lack of funds. In many instances, the fine facilities and equipment are underused. A more fundamental difficulty may be that Australia simply does not have the population base to support and sustain a broad range of scientific research.

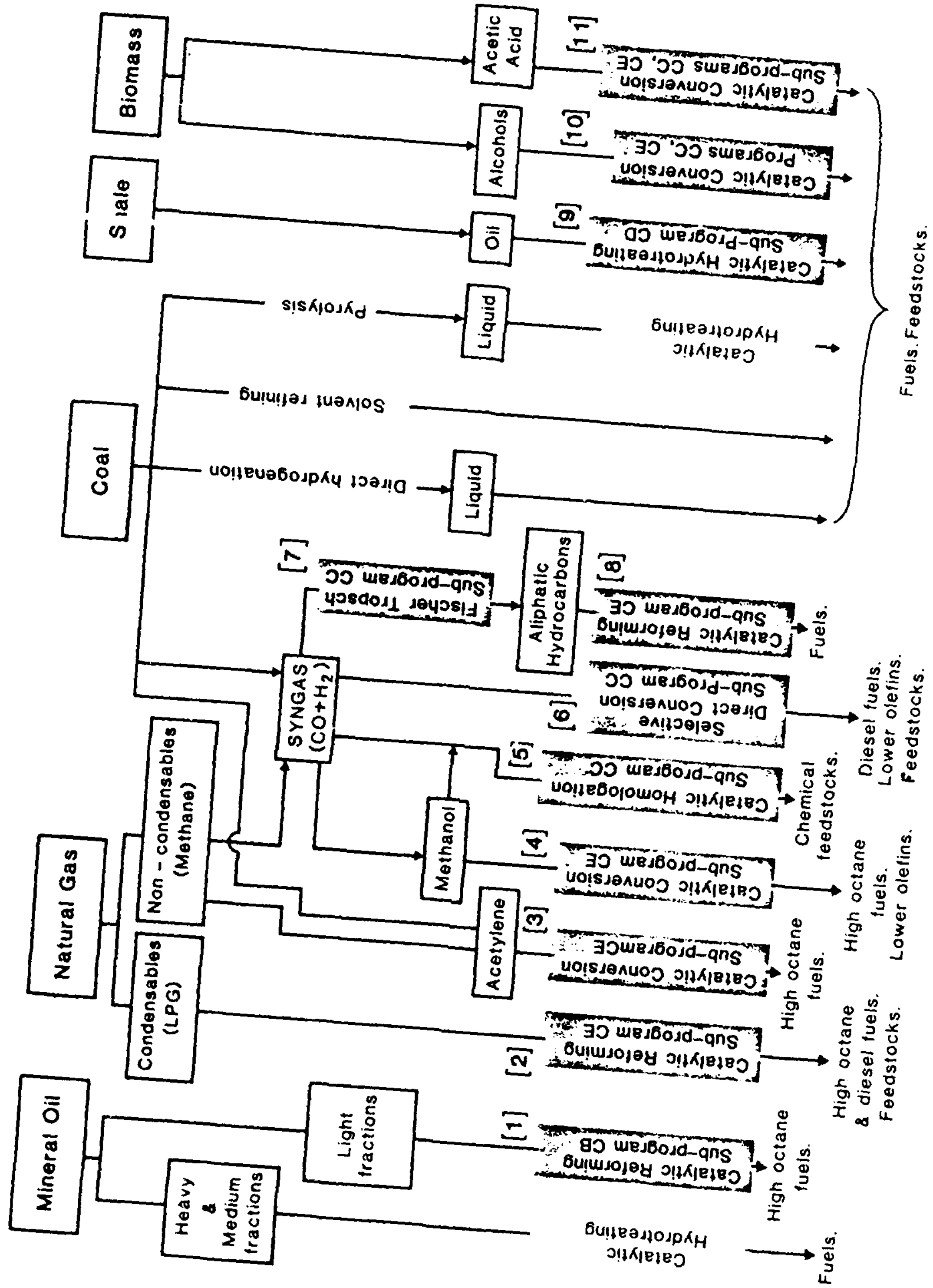

Figure 1. Diagrammatic representation of the areas (shaded) of research of the Catalysis and Surface Science Laboratory of CSIRO within the overall framework of natural energy resources, refining and reforming processes, and liquid fuel and chemical feedstocks.

METALS INDUSTRY IN KOREA

Michael J. Koczak

OVERVIEW

The Korean economic recovery has been quite remarkable during the last twenty years. The economy has maintained a growth rate of 8.8% and the per capita GNP for 1980 was U.S. $1503 *vs.* $87 in 1962. In addition, the export sector has changed with manufactured goods accounting for a major portion of the export market. Table I provides a summary of the major economic indexes of Korea's machine industry since 1973, indicating production activity with 1975 as a base year. Of particular note is the developing steel industry and the increased production of pig iron, steel ingots, semifinished steel products, bar, rods, and plates. In addition, the nonferrous industries has demonstrated growth particularly in electrolytic copper and zinc ingots. The Korean steel industry and shipbuilding industry has demonstrated parallel growth and competiveness on the world market based upon recently modernized plant and low labor costs. A steelworker's salary in Korea would be $6 per month, in Japan $12 per hour, and in the United States in excess of $20 per hour, a factory worker in the People's Republic of China makes $0.30 per hour. As a result, the steel products from Korea are sold to the United States and Japan at very competitive prices. Steel imports to Japan are increasing while Japan's steel production is stabilizing or decreasing.

The manufacturing of finished steel products and electronic equipment has increased as shown in Table II. The Korean manufacturing industry has grown quite competitive based upon low labor costs coupled with a growing number of competent engineers and modernized facilities. The glowing development of the competitive Korean industries must also be considered and tempered by several negative factors: the dependence on imported raw materials and energy resources, a recent stagnating world economy, and loan-related debt burdens. Nevertheless, the growth of the Korean secondary and tertiary manufacturing has been impressive considering the increased competiveness of the world's markets.

The industrial visits in Korea included a range of companies: a powder metallurgy part manufacturer, the Korean Powder Metallurgy Company, Ltd., the Kukje Special Metal Company, an automotive and industrial parts producer, the Korea Tungsten Mining Company, Ltd., and an integrated producer of tungsten products including tungsten powders and cemented tungsten carbides. In addition, large manufacturing facilities included: the Pohang Iron and Steel Company (POSCO), a modern integrated steel facility producing 8.5 million tons of crude steel annually; the Hyundai Motor Company, which produces 100,000 automobiles annually and the Korea Heavy Industries and Construction Company, Ltd., an integrated manufacturing facility primarily owned by the Korea Development Bank, the Korea Electric Power Corporation and the Korea Exchange Bank. The facilities included small to large manufacturing complexes and served to provide a many faceted view of Korean industry.

POHANG IRON AND STEEL COMPANY, LTD. (POSCO)

The Pohang Iron and Steel Company (POSCO) is an excellent example of an efficient production facility. From the raw materials loading docks to final finishing mills, the operation of POSCO has grown and flourished in an industrial climate where U.S., Japanese, and European steel facilities are facing economic hardships. The reasons for the development are apparent based upon modern facilities, qualified engineers, a relative low wage scale and access to inexpensive raw materials, i.e., iron ore and coal. The imports of iron ore are primarily from Australia (40%) with Brazil, India, and Peru contributing approximately 20% each. Australia contributes about 60% of the coal and limestone is obtained domestically. POSCO in an effort to secure a reliable supply of iron ore and coal has invested in coal mines in Australia, Canada, and the United States. The development of the production facility is shown in Table III. A second facility is planned in Gwangyang with a construction period from July 1985 to March 1988. The initial production capacity to include continuous casting capability, will be 2.7 million tons per year with further expansion anticipated.

From a research viewpoint, recent efforts at POSCO have been directed at the enlargement of their research and development staff. To this end, the figures in Table IV were cited to justify the enlargement of the research group. Steel production and the total number of staff at POSCO in 1981 and 1982 as well as comparable figures for Nippon Steel, Nippon Kokan (NKK) and Kawasaki Steel, e.g., Japan's largest three steel producers, are shown. The research staff is divided by the total staff number as well as total steel production in order to assess the fractional contributions of research effort per 10,000 tons of steel produced as well as per cent of total staff effort. Nippon Steel and NKK have 4% of their staff involved in research. Nippon Steel also had the largest research contribution per 10,000 tons per year. Clearly, the production figures may not directly correlate with research staffs, nevertheless, a comparison with European and North American steel companies would present an interesting comparison for the same time period.

Current research efforts at POSCO are divided into application (55%), basic studies (10%), product developments, e.g., API X70 steel (25%) and experimental methods (10%). Efforts are underway to reduce the oxide contents and improve the consistency. In addition, studies are underway on API K55 and API J55 pipeline steels and high strength low alloy (HSLA) steels with Nb and V additions.

The continuous casting production facility can produce slabs of thickness of 208 mm and width ranging from 930 to 1800 mm. The slab production facility in their No. 1 plant is 600,000 tons per year and the bloom production is 270,000 tons per year. The maximum casting speed is 1.8 m/sec for 220 mm thick slabs and 2.0 m/sec for 200 mm slabs. Efforts have been underway to improve mold powders and reduce scrap rates. The continuous casting scrap rates have been reduced from 3% at start up to a level of 0.2% currently. The host for my visit at POSCO was Dr. Y. K. Shin who received his Ph.D. at the University of Sheffield under Professor Davies. His research efforts involve the effects of Mn and S on the solidification cracking in continuously cast steels as well as model prediction of crack formation.

In late 1982, the Korean government revised a plan to make the Korean steel industry more competitive. The actions included: the construction of a second integrated steel mill of POSCO at Gwangyang Bay with an investment of 1.6 trillion won, U.S.$ 2.5 billion ($1=650W) with an projected annual production of 2.7 million tons per year. In addition, the current POSCO plant in Pohang shall increase its capacity from 8.5 million tons per year to 9.6 million tons of crude steel with an investment of 210 billion won ($320.0 million at $1=650 won). Also the encouragement of the importion of coking coal and other raw materials is planned. In order to maintain and balance the expansion of POSCO, electric furnace steel plants with an annual capacity of 4 million tons will be maintained at their current levels until 1986. Also, the expansion of cold rolled and galvanized plate facilities and steel pipe plant and tin plate expansion will be discouraged until 1986.

From these actions, it appears that the POSCO plant success in Pohang will be expanded and a continuous cast facility shall be developed in Gwanyang Bay with strong financial support and at the expense of other steel production facilities, i.e., electric furnace, tin plate, and steel pipe expansion. It is hoped that the success story of POSCO at the Pohang site can be repeated at Gwanyang Bay.

KOREA TUNGSTEN MINING COMPANY

Tungsten is one of the four naturally abundant resources of Korea, and the Korea Tungsten Mining Company is an integrated mining and manufacturing company for the production of tungsten powders and parts. Their main products involve tungsten powders and cemented carbide products. The powder products include tungsten metal powder in size ranges from 0.7 to 11.0 μ, ammonium paratungstate (APT), synthetic and natural scheelite (75% WO_3, 25% CaO) for tungsten alloys, high speed steels and tungsten carbide powder, with a size range from 0.80 to 12.0 μ. The tungsten carbide products involve a range of cutting and mining tools which contain TiC/Al_2O_3 or TiC/TiN coatings. The tool life of the coated carbide cutting tools is claimed to be 2-5 times greater than a conventional cemented carbide tool.

Byproducts of the tungsten and tungsten carbide powder production include gold, silver bismuth metals produced from the refining process, and bismuth nitrate produced from the hydrolysis reaction. Additional byproducts from precipitation, thermite calcination, or reduction reactions include molybdenum oxide, ferromolybdenum, ferrotungsten, natural and synthetic scheelite, ammonium paratungstate, and tungstic oxide.

The production facilities of Korea Tungsten was established in 1952 and the integrated manufacturing facility in Daegu for tungsten and tungsten carbide began production in 1974 and 1977, respectively. The operation involves carburizing steps for tungsten, tantalum, and titanium followed by the addition of cobalt powders. The subsequent process steps include blending, milling, vacuum drying, compaction, and sintering. The production facility is well-equipped with modern operational equipment.

Dr. C. K. Chun, Director of the Research and Development Center, indicated that 4000 tons per year of WO_3, Wolfranite are mined producing 600 tons per year of tungsten powder and 400 tons per year of tungsten carbide powders. The tungsten powder exports go to carbide manufacturing companies including, Sandvik, Mitsubishi Metal, Sumitomo Electric, Kennametal as well as domestic Korean powder companies. Specific research areas involves production of carbides with a uniform carbide size distribution, examination of toughness and hardness variations in cemented carbides, and growth studies in WC powders.

KOREA HEAVY INDUSTRIES AND CONSTRUCTION COMPANY, LTD. (KHIC)

The Korea Heavy Industries and Construction Company, Ltd. (KHIC) is the largest integrated manufacturing company in Korea with activities in six areas:

- power generation equipment and construction (thermal, hydraulic, and nuclear),
- power plant maintenance and service,
- integrated manufacturing systems,
- plant engineering and construction,
- heavy construction equipment,
- castings and forgings.

KHIC has two facilities (Table V) at Gun-po and Chang-won which were established in 1970 and 1976, respectively. Some facilities at the Chang-won location are currently being installed and tested, while others are fully operational. The past and current projects of KHIC involve areas of conventional power plants, i.e., steam, turbine nuclear power plants, cement chemical and petrochemical plants. The ownership of KHIC is held primarily by the Korea Development Bank, (KDB), the Korea Electric Power Company (KEPCO) and the Korea Exchange Bank.

The Chang-won facility involves a major foundry shop, a forge shop, for production of power generation equipment, iron and steelmaking equipment, propeller shafts for shipbuilding and for industrial machinery and equipment. The facilities during any visit appeared to be underutilized; an expected result of the stagnant world economy. Additional facilities in Chang-won involve heavy machine shops, a heavy fabrication shop as well as a boiler shop. They also have major nondestructive testing and analysis facilities for hydrostatic and pneumatic evaluation of pressure vessels.

The efforts at KHIC appear primarily in the manufacturing sector with limited research and development efforts. At this point in time, the major facilities of KHIC are quite modern and with an upturn in the world economy, KHIC would be in a good position to take on additional projects particularly in the area of heavy equipment, and turnkey production of plants.

HYUNDAI MOTORS

The Korean economy is linked to the growth and future development of the automobile. Since the industry within a developed country combines various industries including steel, chemical, rubber, machinery, electronics and is also linked to national defense; as a basic industry, it can directly or indirectly employ 10 to 20% of the work force and also provide 5 to 10% in the gross national product of developed countries. In addition, several small businesses contribute to the automotive industry through parts suppliers. Apart from the United States, Europe, and Japan, the developing countries, i.e., Korea, Taiwan, Mexico, and Brazil are all forging an automotive industry. The production figures for the Korean automotive industry are impressive in terms of its growth, but also in the greater growth of the associated parts industry (Table VI).

With regard to motor vehicles exports, (Table VII) the major markets include South America, Europe, Africa, the Middle East, and India. In terms of motor vehicle parts, 27% of the export market is North America, with the Middle East and Asia having a share of 26 and 22% respectively. The steel and the automotive industry have had parallel growth. The major companies involved with automotive production are Hyundai Motors, and the Saehan Motor Company while the Kia Industrial Company and Asia Motors are involved in truck and bus production respectively. Future plans involve a joint venture with Mitsubishi for the production of a front wheel drive, 1000-1500 cc engine car with mileage of 39 miles per gallon with a planned production rate of 300,000 units per year. Although the production of automobiles may not at this time represent a significant threat to the automobile market of Japan and the United States, the plans and expansion of the industry should be of particular interest in the competitive world market.

The ferrous parts production are produced at Hyundai while nonferrous parts are obtained from suppliers. Specifically, Hyundai produces the cast iron engine castings, transmissions, pistons, and crank shafts. The foundry and forging shop has an annual capacity of 100,000 gasoline engines and 24,000 diesel engines. The research and development department is primarily involved in material specifications, as well as a limited number of research topics, e.g., improvement of fatigue resistance of crank shafts, formability and weldability of high strength low alloy steels. The improvement in productivity, process control and weight savings are also areas of concern. The production facility of Hyundai Motor Company is a clean, efficient, well-run operation. The annual production has increased and with a joint program for production with Mitsubishi, Hyundai Motors market share shall expand further.

TABLE I

During	Paper and paper products				Industrial chemicals						
	News-print paper	Vellum paper	Kraft paper	Paper board	Sculphuric acid	Soda ash	Ammonia	Urea fertilizers	Fused phosphate	Complex fertilizers	Insecticides
	M/T				M/T						
1977	199,879	117,598	159,043	204,250	1,033,637	170,467	882,157	1,125,636	111,125	1,138,150	94,130
1978	230,784	153,989	174,089	260,980	1,461,399	176,090	1,091,133	1,185,969	123,808	1,658,002	80,261
1979	179,695	169,243	205,906	291,284	1,644,797	203,792	1,168,641	1,165,612	125,467	1,696,365	79,217
1980	214,764	223,739	207,272	297,823	1,683,322	221,920	1,031,473	972,876	120,901	1,438,528	72,288
1981	236,402	221,263	192,149	333,432	1,294,345	202,063	908,422	1,070,089	93,596	1,210,516	51,757
7	18,991	19,258	13,319	28,793	103,405	19,728	70,991	93,074	4,485	78,906	4,667
8	20,572	15,927	14,960	28,598	106,470	13,223	73,094	83,130	–	121,438	5,201
9	17,936	16,047	13,685	25,539	87,243	13,027	70,542	85,235	9,216	63,582	91
10	19,292	18,497	16,784	28,711	85,814	17,371	55,168	73,700	15,676	71,848	35
11	17,593	19,315	17,005	26,258	62,509	16,166	28,683	26,017	10,955	77,822	236
12	18,926	18,612	17,877	26,146	93,279	15,612	53,233	49,010	5,608	80,806	701
1	17,465	16,352	12,583	24,965	128,004	16,400	76,281	87,120	4,037	91,592	101
1982. 2	18,524	17,074	14,004	27,572	122,536	14,800	63,984	71,489	819	118,985	152
3	19,073	16,672	14,875	29,131	149,929	12,070	58,937	80,360	1,039	155,845	6,178
4p)	17,028	20,276	16,547	27,484	154,054	10,860	51,129	59,900	3,583	152,770	11,498

During	Rubber products			Pot., china and earthen-ware	Glass and glass products		Other non-metallic mineral products				
	Rubber shoes	Rubber boots	Sporting footwear	Ceramic sanitary	Plate glass	Medicine glass carboys	Brick	Portland cement	roofing tile of asbestos cement	Pig iron	Steel ingot (incl. alloy steelingot)
	1,000 pairs			1,000 each	1,000 case	1,000 each.	1,000 each	1,000 M/T	1,000 m²	M/T	
1977	20,009	35,812	127,104	686,067	2,436	793,044	147,697	14,196	60,993	2,425,410	2,736,669
1978	18,646	37,155	140,261	974,933	3,335	894,624	190,031	15,133	38,166	2,741,147	3,138,497
1979	19,899	38,784	138,855	1,062,264	3,497	1,049,366	176,098	16,413	38,875	5,062,549	5,199,930
1980	11,107	27,964	157,996	1,305,463	3,088	1,048,490	117,185	15,631	23,878	5,577,361	5,790,163
1981	8,615	18,298	181,141	1,576,884	3,874	1,159,483	94,808	15,617	26,187	7,928,331	5,890,943
7	857	1,627	14,263	155,024	272	91,269	11,533	1,119	1,300	723,190	521,337
8	778	1,475	13,394	101,404	360	102,962	11,215	1,515	2,449	706,158	434,649
9	663	1,402	12,717	105,875	501	105,089	9,726	1,411	2,811	675,760	459,538
10	691	1,525	15,098	126,468	353	106,914	11,239	1,504	3,339	714,925	500,904
11	637	1,403	14,718	116,007	389	103,571	8,621	1,292	2,538	698,101	476,888
12	803	1,555	15,078	128,374	382	103,297	5,015	1,368	1,924	719,126	486,298
1	640	1,291	13,144	103,757	424	100,739	1,905	1,201	1,851	720,919	477,013
	745	1,172	12,749	88,417	367	81,833	1,503	903	1,780	657,857	435,457
3	765	1,515	14,147	104,307	382	90,128	7,151	1,441	2,111	723,242	488,942
4	500	1,525	15,585	102,322	355	87,052	12,565	1,620	2,310	694,302	465,700

During	Machinery				Electrical machinery apparatus appliances and supplies						
	Looms	Motor pumps	Sewing machines	Electric motors	Trans-formers	Radio receivers	Television receivers	Telephones	Electric refrigerators	Electric fans	Filament bulbs
	each			HP	1,000 KVA	1,000 each	each				1,000 each
1977	9,773	239,426	551,860	1,225,800	4,976	6,404	2,990,141	707,282	388,432	1,181,880	104,646
1978	7,873	404,939	496,442	1,979,944	10,318	4,768	4,826,477	813,273	1,052,771	1,940,113	101,069
1979	10,498	449,986	443,751	2,506,088	13,465	4,772	5,867,321	1,019,830	1,445,150	2,708,250	66,977
1980	4,081	361,541	362,313	1,242,981	17,290	4,143	6,819,002	919,342	652,418	1,534,376	41,552
1981	4,368	502,346	337,003	1,352,523	8,137	5,126	7,696,813	1,216,136	932,278	830,682	44,684
7	449	48,149	26,847	119,259	670	492	714,698	83,959	126,182	84,374	3,398
8	360	41,759	28,524	115,612	1,102	406	647,577	141,638	63,170	3,655	3,077
9	420	43,568	27,477	128,757	558	503	680,382	93,456	65,604	420	3,144
10	311	54,812	27,861	163,171	1,272	460	653,532	95,025	49,453	6,840	3,174
11	364	45,150	26,389	117,446	743	461	600,598	144,123	41,404	22,130	3,208
12	543	34,230	24,939	140,155	1,082	560	546,250	172,310	47,001	45,709	4,709
1	284	20,349	19,704	131,644	822	350	450,061	171,731	41,798	71,656	3,079
1982. 2	401	34,601	17,752	123,771	1,190	403	498,427	170,890	73,324	123,841	3,646
3	269	44,297	17,996	131.64	890	441	541,397	129,579	84,114	174,470	3,435
4p)	414	48,646	16,014	101,728	749	409	492,600	188,909	115,726	208,867	3,783

TABLE II

Source: Bureau of Statistics, Economic Planning Board

Polyvinyl chlorides	Paint (oil and water)	Laundry soap	Household synthetic detergent	Tooth paste	Gasoline	Naphtha	Distillate fuel oil (diesel oil)	Residual fuel oil (heavy)	Bunker C oil	Automobile tire	During
	Other chemical products				Petroleum refineries						
	kl	M T			1,000kl					1,000 each	
115 959	45 601	117 842	47 923	6 240	1,114	3 146	4 808	860	11 848	4 768	
130 952	67 474	116 147	64 358	7 515	1,270	3 296	5,476	934	12 731	6 905	
191 760	68 441	131 878	69 621	8 351	1,385	3,570	6 050	1 169	13 320	10 025	1979
231 502	65 508	132 024	63 593	6 865	1,126	3 805	6 073	778	13 653	12 328	1980
287,253	69,145	163 181	57,928	9 266	983	3,906	6 228	618	13 154	9 102	1981
24 087	6 691	12 358	4,040	802	71	264	395	39	949	786	J
21 657	6 300	13 703	3,992	700	76	285	544	52	1 000	841	A
22 916	6 122	13 872	4 008	785	90	307	445	41	987	772	S
25 846	6 183	15 875	4 435	874	88	301	513	61	984	703	O
24 875	5 669	18 590	5 111	908	75	351	599	43	1 105	795	N
23 8[illegible]9	5,045	14 315	4 027	870	104	360	389	58	1,155	697	D
26,216	4,651	13,573	4 962	701	46	218	53[illegible]	49	1 114	589	J 1982
25,328	5 495	14 900	5 301	729	62	246	442	38	977	600	F
27,734	6,377	13 276	6 067	645	72	200	529	41	905	614	M
26 526	5.377	19,148	5.322	841	61	203	477	49	918	525	Ap

Semi-finished steel products	Steel bars	Wire rods	Heavy and medium plates	Pipes and tubes of steel	Electrolytic copper ingots	Zinc ingots	Bare copper wire	Welding rods	Lathes	Power tillers	During
	Iron and steel basic				Non ferrous metal basic			Febricated metal products	Machinery		
	M/T				M/T			M/T	each	HP	
4 528 331	191 662	240 984	502 227	668 280	42,880	32 756	42,659	42 181	4 262	412 691	1977
5 184 491	271 015	299 300	820 510	946 094	52 442	58 970	71 546	54 026	5 793	430 092	1978
7 631	359 275	424 975	1,439,155	1 089 994	63 082	83 014	66 136	54 708	6 260	547 936	1979
8 608 881	298 169	552 954	1,483 904	1 099 418	72 931	79 150	48 597	51 678	3 181	539 242	1980
12,983,771	390,882	591,565	1,765,349	1,415,271	107,984	83,915	64,533	71,212	3,211	662 100	1981
1 030 460	38 589	45 436	166 094	122 603	9 812	5,841	5 976	6 467	267	61 056	J
1 191 476	32 797	51 217	168 10[illegible]	126 792	[illegible]	[illegible]	6 063	6 815	281	48 558	A
1 114 898	29 134	48 063	120 858	135,545	4 533	7,571	5 608	6 236	317	50 580	S
1 149 060	32 209	32 338	163 563	131 730	8,352	7 883	4 806	6 238	266	48 798	O
1 168 053	36 287	52 244	139 561	123,644	10,184	7,868	5 828	6 671	237	53 591	N
1 230 908	34 630	51 336	164,758	121,662	10,778	8,211	5 335	6 869	216	29 176	D
1 169,682	27 001	57 458	148 513	104,262	8 606	8,177	6 439	6 297	271	45 169	J 1982
1 104 048	36 850	50 522	148,952	113,697	9 619	7,568	5.505	6 087	295	44 579	F
1,221,675	37,370	53,577	163,084	115,601	8,246	7,639	7,099	6,555	312	51,392	M
1,180 012	36,672	56,297	155,978	155,098	10,935	7 683	5 357	6,257	332	60 125	Ap

Flourescent bulbs	Steel cargo ships	Bus	Passenger cars	Trucks	Cycle bodies	Frames for spectacles	Wrist watches	Metal ribs	Dolls	Wigs	During
	Transport equipment					Scientific and measuring equip		Other manufacturing			
000 each	G T	each				1,000 each		1,000 each			
21 296	428 869	5,530	44 029	36 227	672,113	12 138	5 073	13,654	11 041	18 446	1977
19 144	458 997	7 304	92,331	58,326	980 389	11,596	7,172	12,256	2,999	17 128	1978
25 146	437 955	12 063	112 400	78 589	868 936	12,574	7 903	10 898	2,069	12 255	1979
24 881	784 338	11 854	57 037	52 169	754 266	14 749	7 902	8 107	3,861	11 831	1980
25 187	1,354,458	11,387	72,132	46,733	773,249	13,430	8,043	5,261	882	11,289	1981
1 935	108 939	858	6 270	3,461	64,756	959	810	497	38	1 064	J
1 980	127 570	994	5,991	3,612	58,590	969	678	476	27	853	A
1 849	111 254	893	5,932	3,512	54,488	954	722	425	55	763	S
2 453	141 595	656	5 811	4,141	53 907	1 060	707	376	24	915	O
2 400	131 180	597	5 118	4,234	64,757	1,020	600	387	35	902	N
2 407	132 139	718	6 602	4,156	63,428	1,095	645	392	59	1 038	D
2 [illegible]63	102 761	721	4 114	3,409	61 242	954	499	339	33	892	J 1982
2 [illegible]	140 378	883	4 483	3,248	62,197	1,061	485	434	29	876	F
1 785	143 686	992	5,817	3 830	55,322	1,139	572	424	21	904	M
2 020	136 091	992	8,785	3,598	55,580	1,290	514	431	23	1,026	Ap

TABLE III

HISTORY AND SCOPE OF POSCO

April 1, 1968	Pohang Iron and Steel Company was incorporated
July 3, 1973	Dedication of 1.03 million ton capacity facility (1st stage)
May 31, 1976	Dedication of 2.6 million ton capacity facility (2nd stage)
December 8, 1978	Dedication of 5.5 million ton capacity facility (3rd stage)
July 8, 1980	Construction of Tonoma Coal Mine (located in the United States)
February 18, 1981	Dedication of 8.5 million ton capacity facility (4th stage)
November 4, 1981	Selection of Gwangyang as the site for the new steel works facility with an initial production capacity of 2.7 million tons
October 15, 1982	Agreements signed with Mannesman Demag Company of West Germany to assist in construction of wire rod mills at Gwangyang site

TABLE IV(+)

A COMPARISON OF RESEARCH STAFFS OF JAPANESE AND KOREAN STEEL COMPANIES

	POSCO (1981)	POSCO (1982)	NIPPON STEEL	NKK	KAWASAKI STEEL
Total Staff	15,375	14,800	64,590	23,700	28,500
Research Staff	123	222	2,519	948	855
% Staff in Research	0.8	1.5	3.9	4.0	3.0
Total Steel Production ($X 10^6$ MT/yr)	8.78	8.54	48.4	21.1	20.4
Research Staff / Annual Steel Production	0.14	0.26	0.52	0.45	0.42

(+)Data provided through the courtesy of POSCO

TABLE V

SUMMARY OF KHIC FACILITIES

CHANG-WON PLANT

Location:	Guygok-dong, Changwon, Kyungsangnam-do (near the port of Masan)
Total Area:	5,270,000 m^2
Floor Area:	535,000 m^2
Main Facilities:	Machine Shop Heavy Machine Shop Heavy Fabrication Shop Boiler Shop Steel Foundry Forge Shop Heavy Construction Machinery Shop Training Center Laboratory

GUN-PO PLANT

Location:	Dangjung-ri, Gunpo-eup, Siheung-gun, Kyunggi-do (30 km south of Seoul)
Total Area:	264,000 m^2
Floor Area:	124,000 m^2
Main Facilities:	Heavy Machine Shop General Machine Shop Fabrication Shop Foundry Shop Forge Shop Heavy Construction Equipment Workshop Laborarory Training Center Utility Buildings

TABLE VI

TOTAL KOREAN MOTOR VEHICLE PRODUCTION (+)

YEAR	CARS	TRUCKS	BUSES	TOTAL	MOTOR CYCLES
1970	14,487	10,529	3,803	28,819	12,254
1971	12,428	7,511	3,063	23,002	12,317
1972	9,525	6,542	2,581	18,648	9,012
1973	12,751	10,069	3,494	26,314	13,857
1974	9,230	19,179	3,947	32,356	11,495
1975	18,498	14,973	3,808	37,279	13,012
1976	26,701	19,376	3,468	49,545	16,798
1977	43,981	35,776	5,453	85,210	32,629
1978	86,823	64,856	7,279	158,958	70,654
1979	113,564	78,576	12,307	204,447	100,496
1980	57,225	53,857	12,053	123,135	110,773
1981	68,760	50,966	13,358	133,084	123,503

GROWTH OF KOREAN AUTO PARTS EXPORTS

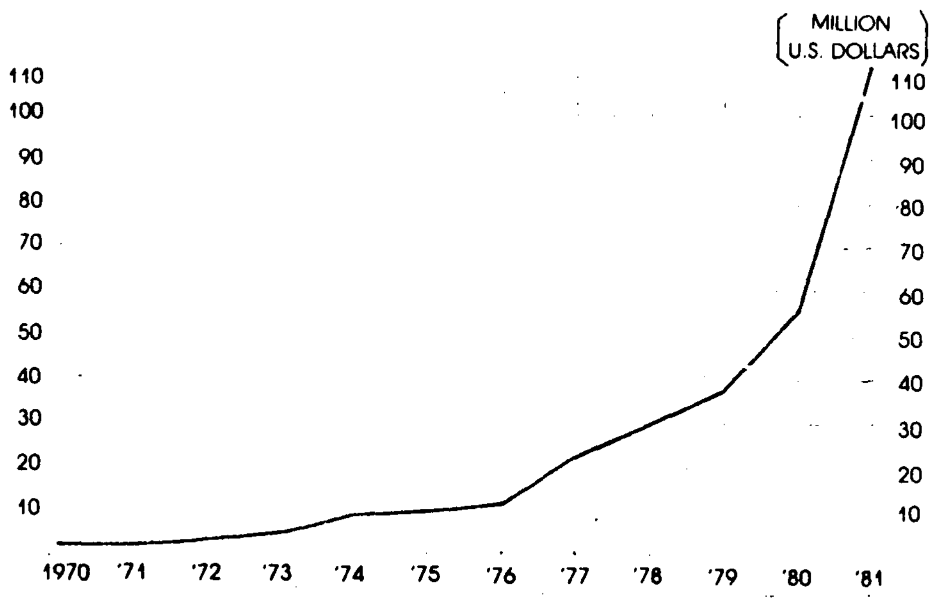

TABLE VII

EXPORT PRODUCTION OF KOREAN MOTOR VEHICLES (+)

YEAR	CARS	BUSES	TRUCKS	TOTAL	MOTOR-CYCLE
1975	—	—	31	31	—
1976	558	36	649	1,243	64
1977	5,075	6	4,055	9,136	2,058
1978	16,371	67	9,899	26,337	5,500
1979	18,702	75	12,709	31,486	—
1980	14,655	243	10,355	25,253	1,681
1981	17,221	395	8,768	26,384	2,417

EXPORTS BY ORIGIN

YEAR	ASIA	MIDDLE EAST ASIA	NORTH AMERICA	SOUTH AMERICA	EUROPE	AFRICA	OCEANIA	TOTAL
1975	—	31	—	—	—	—	—	31
1976	232	466	—	235	25	285	—	1,243
1977	119	1,747	1	5,584	211	1,429	45	9,136
1978	1,748	5,827	1	8,384	5,412	4,875	90	26,337
1979	829	6,960	—	8,047	9,610	5,988	52	31,486
1980	1,703	5,531	—	9,932	5,644	2,408	35	25,253
1981	2,926	3,290	6	7,890	7,391	4,699	182	26,384

(+) Courtesy of Korean Auto Industries Association

NAGOYA NEW CERAMICS FAIR '83

Michael J. Koczak

INTRODUCTION

At the Aichi Trade Center in Nagoya, Japan, with the support of the Ministry of International Trade and Industry (MITI), the Science and Technology Agency, the Japan Fine Ceramics Association and the Agency for of Industrial Science and Technology, the '83 New Ceramics Fair was held on 20-24 March 1983. The Nagoya area in central Japan is seeking to attract research institutes and industrial groups in order to create a center for fine ceramic industrial and research activity. As part of this nurturing effort, the New Ceramics Fair in Nagoya attracted 70 companies which displayed an assorted variety of products and services. The spectrum of applications included automotive, electronic, refractory, medical, and domestic products. A listing of the companies is provided in Table I and shows the range of interests from electronic component manufacturers, system manufacturers, equipment suppliers, to chemical and metallurgical companies.

A ceramics association has been founded to promote the development of the Japanese ceramics industry. Specific areas of application include the nuclear industry, electronics, transportation, superprecision machining and optical systems. Traditional ceramics can be considered as products that have been fabricated utilizing natural silica or clays coupled with pouring or lathe molding processes and kiln operations. The generation of materials termed "new ceramics" involves production of high quality synthetic powders combined with injection or pressure molding operations and controlled consolidation and firing processes; the application in electronics, precision machining and structural components typically has a high value added factor. The utilization of ceramic components can be subdivided in terms of equipment for different industries as well as function. The major industries involve electronic nuclear, machine components, metal processing, hydraulic equipment, industrial machines utilizing wear-resistant components and precision instruments.

The estimated market in ceramics in Japan is estimated to be 3 trillion yen ($12.5 billion) in the 1990s. The sale of fine ceramics in the electronic area was 350 billion yen in 1981 and estimated to exceed 1,000 billion yen in 1985. A summary of the Japanese and the world market for high technology ceramics is shown in Table II.

GOALS, APPLICATIONS, AND FUNCTIONS

In a systematic division of ceramic materials, the role and applications of these materials have been divided into various subgroups based on physical, thermal, or electromagnetic functions. The role of ceramic materials have been classified into functions and are detailed below:

- Thermal and Mechanical Functions

  Thermal Functions

  - thermal insulation,
  - heat conduction

  Mechanical Properties

- hardness,
- strength,
- dimensional stability,
- lubricity

- Special Multifunction Properties

Electromagnetic Properties

- conductivity,
- piezoelectric,
- magnetic,
- dielectric, etc.

Optical Functions

- light collection,
- fluorescence,
- polarization,
- reflection

Nuclear Fusion and Fission Functions

Living Body Functions

- biocompatibility,
- adsorption,
- catalytic
- corrosion resistance

These functions and the ceramics related to the specific application are summarized in Table III and Figure 1. As demonstrated, the role of these materials is manifold. Of particular interest to the Japanese economic system, they represent materials which have low energy requirements for the production of high value added components.

With regard to the fine ceramic's research program goals, i.e., the MITI program, specific mechanical and physical property requirements have been announced. In the area of strength, corrosion resistance, and precision, abrasion resistant materials, the following targets have been defined:

High Strength Ceramics

Following exposure at 1200°C for 1000 hours, the material should have a strength in excess of 30 kgf/mm^2 with a Weibull coefficient of greater than 20; and a creep strength of greater than 10 kgf/mm^2.

High Corrosion Resistant Material

Following exposure in excess of 1300°C for 1000 hours, the material should have a tensile strength of 20 kgf/mm^2 with a Weibull distribution of greater than 20 and a weight increase of less than 1 mg/cm^2.

High Precision, Abrasion Resistant Material

Following exposure at 800°C for 1000 hours the material should have a tensile strength in excess of 50 kgf/mm^2 and a Weibull coefficient in excess of 22.

At normal temperatures, the specific abrasion loss should be less than 8-10 mm^3/kg-mm with a surface smoothness of less than 2 mm.

The fair included 70 companies which represented powder producers, electronic components, communication, medical and home appliances, and transportation manufacturers. In support of this manufacturing and marketing promotion effort, the required equipment producers for the ceramic industry were also represented. The roles of special function ceramics, i.e., thermistors, ferrites, varistors, sensors, and optical fibers were demonstrated. In addition, structural ceramics were displayed, e.g., Hitachi, Kyocera, Showa Denka for use in the application of SiC and Si_3N_4 for automotive and turbine systems. Several areas of the ceramics market have clearly matured and the Japanese contribution represents a dominant market force, e.g., IC packages, ferrites, piezoelectrics, capacitors. The major participants in component manufacturers include Kyoto Ceramics, TDK Electronics, Murata, NGK Sparkplug, Toshiba Ceramics, Narumi China, Taiyo Yuden, Hitachi Metals, Tohoku Metals, and Sumitomo Special Metals. The area of structural ceramics for high performance turbine and diesel engine application is currently a "high stakes derby" between Japan, the United States, and West Germany. The manufacturers involved in the structural ceramics efforts for turbine applications include Kyoto Ceramics, Toshiba, NGK, Asahi Glass, IHI, Kawasaki Heavy Industries, Mitsubishi Heavy Industries, Hitachi and Ikegawa Electric. Figure 2 show a range of SiC components by Hitachi which are pertinent to high performance application. The relevance of ceramics for high temperature, high pressure ball valves has a particularly appropriate application and utilized different ceramics for varying temperatures, i.e., Al_2O_3, 250°C; Si_3N_4, 300°C and SiC 800°C. In addition, household items and machinery items were demonstrated, i.e., knives, precision measuring devices etc., and show a range of new ceramic applications.

SUMMARY

The new ceramics fair in Nagoya may represent a self-fulfilling prophecy by pooling the necessary components of a materials area into a critical nucleus and urging joint cooperation and communication of products and processes. The diversity and promotion of products of the 70 exhibitors was particularly impressive, since the materials and services ranged from starting powders, to molding, processing, consolidation and finishing equipment. In addition, the exhibit demonstrated several ceramic products which have matured and currently have large market shares, i.e., electronics, ferrites. Several areas of application are emerging in structural ceramics and include wear-resistant high temperature valves, precision measurement equipment, ceramic vacuum pumps, diamond finishing tools as well as the traditional structural refractory applications.

A Japanese publication, *The Third Material New Ceramics-Its Overview and Problems* is available from:

Oversea Courier Service
2-9 Shibaura, Minato-ku, Tokyo, Japan 108
Tel: 03-453-8311

Price: 1800 yen

It reviews the ceramics efforts in Japan as well as providing for a listing of comparies and patents in this area. A second publication, partially in English, *Ceramic Science and Technology at the Present and in the Future,* edited by S. Somiya, contain 11 papers in English and 17 in Japanese with English abstracts, reviews ceramic applications in electronic and structural materials. This book is available from:

Yono Shobo Ltd.
Kimurashoji Building, 6F
3-2, Kanda Ogawa-machi
Chiyoda-ku, Tokyo 101, Japan

Price: 8800 yen

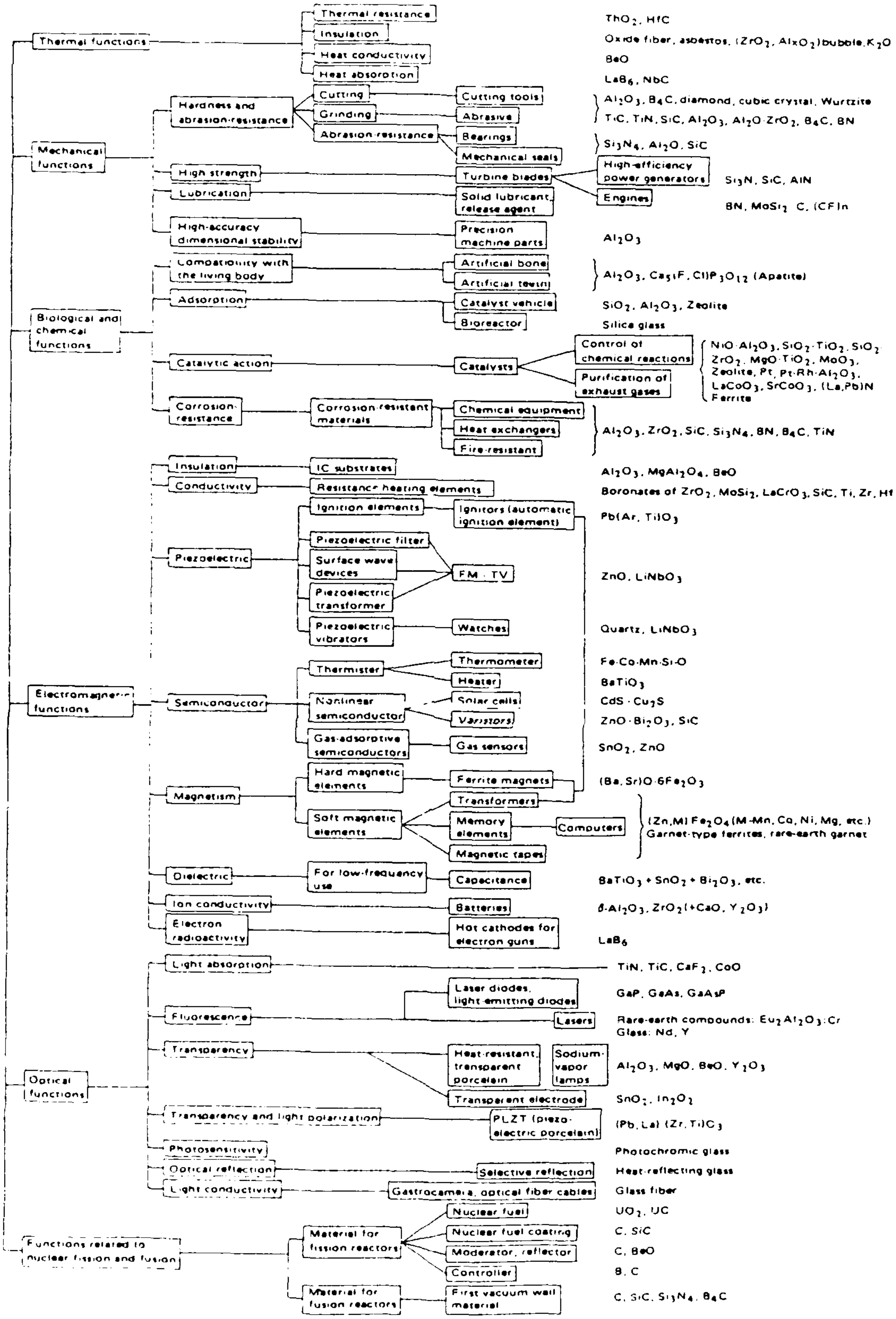

Figure 1. Application for New Ceramics,+ (+) *Technocrat*, 15, 13 (1982).

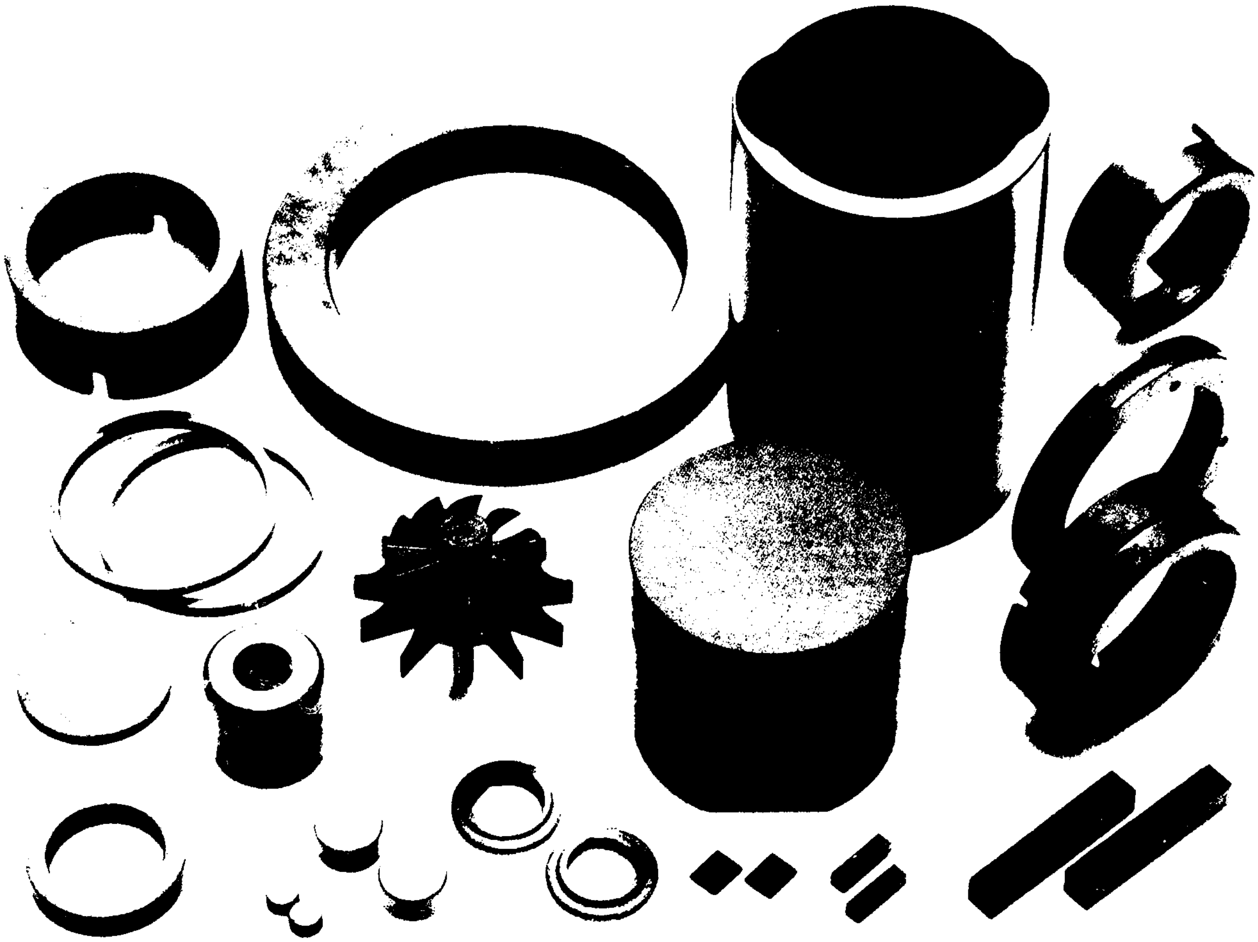

Figure 2. Applications of Silicon Carbide Ceramics, Hitachi Chemical Co.

TABLE I

COMPANIES REPRESENTED AT NEW CERAMICS EXHIBITION

Kyocera Corporation
Sumitomo Electric Industries, Ltd.
Sumitomo Corporation
Kyoritsu Ceramic Materials Company, Ltd.
Ishizuka Glass Company, Ltd.
Nippon Light Metal Company, Ltd.
Nissho Iwai Corporation
Narumi China Corporation
Mitsubishi Mining and Cement Company, Ltd.
Nikko Manufacturing Company, Ltd.
Tokyo Yogyo Company, Ltd.
Nippon Carbide Industries Company, Ltd.
The Carborundum Company
Akita Scientific Research Company, Ltd.
Shin Nisso Kako Company, Ltd.
Rinnai Corporation
Tateho Chemical Industries Company, Ltd.
Murato Manufacturing Company, Ltd.
Shin-Etsu Chemical Company, Ltd.
Showa Denko Company, Ltd.
Nihon Sogyo Company, Ltd.
Misawa Homes Company, Ltd.
NGK Spark Plug Company, Ltd.
Mitsubishi Electric Corporation
Nippon Electric Company, Ltd.
Toshiba Corporation
Fujitsu Limited
Toyoda Machine Works, Ltd.
NGK Insulators, Ltd.
Chugai Engineering Company, Ltd.
Z. Kuroda and Company, Ltd.
Aisin Seiki Company, Ltd.
The Nihon Kogyo Shimbun
Takasago Industry Company, Ltd.
Toray Industries, Inc.
Ibiden Company, Ltd.
Sumitomo Chemical Company, Ltd.
KemaNord Industrial Chemicals, Sweden
Nippon Kogaku Company, Ltd.
Aichi Prefectural Ceramic Industrial Association
Fujikin International, Inc.
Nippon Denko Company, Ltd.
Nippon Kagaku Togyo Company, Ltd.
Fuji Electrochemical Company, Ltd.
Ozawa Seisakusho Company, Ltd.
Osaka Yogyo Company, Ltd.
Y.S. Porcelaintubes Manufacturing Company
Maruto Instrument Company, Ltd.
Tokai Carbon Company, Ltd.
Toda Refractory Ceramics Company, Ltd.
Electrochemical Industries Company, Ltd.
Nakazumi Earth Crystals Corporation
Aichi Electric Trading Company, Ltd.
Showa Aluminum Industries Company, Ltd.
Toyo Soda Manufacturing Company, Ltd.
The First Business Company, Ltd.
Hitachi Limited
Kobe Steel Limited
Sony Corporation
Toyota Motor Corporation
Nippon Denso Company, Ltd.
Matsushita Electric Industrial Company, Ltd.
Toyoda Tsusho Company, Ltd.
Iwatani and Company, Ltd.
Noritake Company, Ltd.
Natural Juicer Company, Ltd.
Shimazu Corporation
Nippon Carbon Company, Ltd.
Brother Industries, Ltd.
Nippon Kouatsu Electric Company, Ltd.

TABLE II

1980 MARKET FOR HIGH TECHNOLOGY CERAMICS+

	Japan	World
Powders	130	250
Electronic Applications e.g., piezoelectrics, substrates	1290	2200
Ferrites	330	480
Cutting Materials	125	1025
Structural Ceramics	120	250
Translucent Materials	20	45
Totals	$2065	4250

(+)in millions of dollars

Adapted from *New Ceramics Market in Japan*
Yano Research Ltd., Information Researchers, Inc.
Tokyo, Japan

TABLE III

APPLICATION AREAS OF CERAMICS

ELECTRONIC MATERIALS

- Integrated Circuit Substrates and Packages
- Condensers
- Sensors
- Fiber Optics
- Piezoelectric Materials
- Insulators

MECHANICAL AND MACHINE APPLICATIONS

- Mechanical Seals
- Valves
- Cutting Tools
- Precision Measuring Equipment
- Wear-Resistant Guides

AUTOMOTIVE AND TRANSPORTATION

- Exhaust Catalysts
- Bumper, Brake Linings
- Rotor and Startor Blades
- Fibers and Whiskers for Structural Applications
- Diesel Pistons and Cylinders
- Heat Exchangers
- Superchargers
- Ignition Plugs

MEDICAL

- Artificial Teeth and Bones
- Heart Valves
- Bone Screws
- Artificial Lungs

ATOMIC POWER

- Nuclear Fuel
- Moderators
- Shielding Material
- Valves and Sliding Joints

DOMESTIC APPLICATIONS

Scissors, Knives
Cooking Utensils
Tape Rollers
Sports Equipment

INDUSTRIAL MACHINES

Crushers, Mills
Liners
High Temperature Nozzles
Wear Resistent Surfaces
Precision Instruments

THE 1983 ANNUAL MEETING OF THE JAPANESE CERAMIC SOCIETY
AND VISITS TO JAPANESE UNIVERSITIES AND INDUSTRIES
RELATED TO CERAMICS RESEARCH

Michael J. Koczak and Minoru Tomozawa

INTRODUCTION

The annual meeting was held in Tokyo on May 16 (Monday) - May 18 (Wednesday), 1983. The authors are familiar with the annual meeting of the American Ceramic Society, therefore, in this report, the annual meeting of the two corresponding societies will be compared. The registration fee of the annual meeting of the Japanese Ceramic Society was quite inexpensive, 1,000 yen ($4.00) for a member. For an additional 3,000 yen one gets a copy of the voluminous (550 pages) book which contains extensive abstracts of all the papers to be presented at the meeting. All the abstracts are in Japanese but titles, authors, and their affiliations are written in English. Each abstract is two-pages long and usually contains two to three figures with English captions.

Technical sessions were held on all three days, except Monday afternoon when presentations of special lectures, business meetings, and an award ceremony was conducted. There were several concurrent sessions although not as many as in the annual meeting of the American Ceramic Society. One of the difficulties many of us experience at a large meeting such as the annual meeting of a society was missing interesting papers because of the conflicting concurrent sessions. At this meeting, however, thanks to the extended abstracts, one could get the necessary information even if one missed a presentation.

One is pleasantly surprised at the low cost of registration ($4.00 in comparison to $80.00 at the American Ceramic Society) and the book of abstracts. The cost of the abstract was probably reduced by the extensive advertising. The low registration cost was also due to the extensive use of volunteers. The meeting was essentially run by committee members who are usually prominent members of the society, rather than by paid staff. An individual was assigned to each session and was expected to "run" and coordinate the meeting.

The audience in the Japanese Ceramic Society appeared much more serious than their counterparts in the United States, spending more time inside the session rooms rather than conversing in the hall. Many people were furiously taking notes. Typically, the sessions are continuous with no coffee breaks, however, with a changing of session chairman. As a result, the majority of the audience are in place for three hours at various levels of attention. On the other hand, the discussion period was rather dull. This was partly due to the short time allocated for presentation (ten minutes including discussion in most cases; 15 minutes in special session), but was largely due to the Japanese character. They are polite and do not make critical comments. Therefore, when the Japanese feel, "Your analysis is all wet since you did not take this factor into account," the normal remark is to say, "Would you please comment on the possible effect of this factor?" Or, more likely, nothing is said. This is somewhat disappointing to the speaker. One author (MT) presented experimental results on the stress-enhanced diffusion of water into SiO_2 glass. When a part of this result was presented at a NATO meeting earlier this year, there were so many comments and questions that the session chairman had to intervene to stop the discussion. But at this Japanese meeting, even though the room was jampacked, there was only one polite question from the session chairman.

The information to be learned from the conference can be considerable since the extended two-page abstracts serve not only to provide a theme, but a discussion of the results. Specifically, tables, graphs, photomicrograph,and processing schemes are detailed. One author (MJK), although speaking some Japanese, and understanding much less, had difficulty in the oral presentations, nevertheless, with knowledge of the general topical area, i.e., ceramic powder processing, one can learn a great deal since the tables and photomicrographs use similar units, e.g., MPa, g/cm^3, and many of the visuals are entirely in English so that a sense of the research can be obtained. The loss of information is clearly in the interpretation and the discussion where subtleties are discussed and weaknesses are bared. Nevertheless, the presentations in Japanese at the Japanese technical meetings provide the most current open research disclosures. Also, more information is provided at the sessions than is naturally available in the abstract so that attendence and participation at these conferences serves as an effective means of information dissemination.

TECHNICAL SESSION

Program topics and the number of papers were as follows:

Basic science	70
Cement	15
Glass and enamel	46
Electronics material	39
High temperature, structural material	17
Raw material	11
Whiteware	9

Special sessions

Strength and fracture of ceramics	22
Processing of ceramics	9
Ceramic synthesis from gas phase, liquid phase	38

In addition, several special lectures were given on topics of general interest. These special lectures were given by invited speakers who are experts in related fields. For example, one of the special lectures was on, "The Impact of Microcomputer Technology and Application," by Dr. Koji Yada of the Electrotechnical Laboratory. It is not possible to describe all the subjects discussed in the technical sessions in this space, but, in general, most research work was of high quality. Perhaps the quality of the presented papers is related to the extended abstracts required for acceptance. When only a short, i.e., 50 word, abstract is required, several disappointingly low quality papers can be included.

The sessions involved with production of ceramic powders enumerated several approaches; i.e., evaporation and decomposition of solutions, vapor phase deposition, chemical vapor deposition, chemical reduction techniques, r.f. plasma techniques, plasma CVD techniques, hydrolysis of organic metallic compounds, hydrothermal as well as alkoxide techniques. The materials prepared via these approaches are detailed below:

Ceramic	Process	Research Group
Si_3N_4	r.f. plasma	Asahi Chemical Company
Diamonds	r.f. plasma CVD	National Institute of Research in Inorganic Materials

Carbon film	Plasma deposition	Sumitomo Electric Company
$NdSiO_2$	Plasma CVD	University of Tokyo
$BaFeI_2OI_9$	Hydrolysis of organo-metallic compounds	Nagoya University
$NiFe_2O_4$	Acetylacetonates	Nagoya University
$MgOAl_2O_3$	Alkoxide processing	NGK Insulators
ZnO	Organometallics	Ikutoku University
WO_3, $BaWo_4$	Alkoxide	Seikei University
Te Oxides	Alkoxide	Seikei University
$NiFe_2O_4$	Acetylacetonates	Nagoya University
$MgOAl_2O_3$	Alkoxide processing	NGK Insulators
ZnO	Organometallics	Ikutoku University
WO_3, $BaWo_4$	Alkoxide	Seikei University
Te Oxides	Alkoxide	Seikei University
Perovskite	Alkoxide	Seikei University
Titanates	Alkoxide	Seikei University
Oxide glass	Sol-gel process	Mie University
Mullite	Hydrothermal	Tokyo Institute of Technology
TiO_2, HfO_2	Hydrothermal	Tokyo Institute of Technology
$NiFe_2O_4$,$ZnFe_2O_4$	Fused salts	Keio University
$SrCaBI_2$,	Solid solutions	Kanagawa University
BSO	Single crystal	Osaka Industrial Research Institute
Sillenite	Unidirectional solidification	Kyoto University

The summary demonstrates a variety of techniques utilized for the production of fine ceramic powders. In several of the research papers, the talks simply identified the process technique and documented the phases present with little or no discussion of mechanical or electrical properties. The more interesting research involved studies of the orientation relationship between substrate and the deposited films in ZnO and Y_2O_3 films by researchers at Nagaoka University. Also studies at Tokyo Institute of Technology by Dr. Takase and Dr. Nakamura which described the production of β-Al_2O_3 films from $AlCl_3$ with "appreciable" orientation was significant.

In the area of structural ceramics and ceramic composites, there is considerable interest. The papers presented in the conference were primarily from universities, government research laboratories, and limited participation from industrial concerns. The MITI-sponsored fine ceramics program efforts were not openly described and considered in this conference. However, there were limited industrial presentations from Hitachi and Toshiba in the areas of silicon carbide and silicon nitride. Papers involving structural ceramics of particular interest are provided below:

Organization	Title
- Yamanashi University; National Institute Research in Inorganic Material Tsukuba University	Synthesis of ZrO_2 dispersed ceramics by FZ method
- Nagoya Institute of Technology	Sintering of C_2O_3-ZrO_2

- Hitachi Research Laboratory, Hitachi, Ltd.	Hot corrosion resistance of stabilized ZrO_2+ Na_2SO_4-NaCl molten salt
- Chubu Institute of Technology University of Tokyo	Machinable ceramics of potassium titanate fiber-glass system
- Government Industrial Research Institute, Kyushu Fukuoka Industiral Research Institute	Mechanical properties of Ti (CN) - TiB materials
- Research Laboratory of Engineering Materials; Tokyo Insitute of Technology	Rapid quenching of $ZrSiO_4$-Al_2O_3 melt with Xe-Arc image furnace
- Kawasaki Refractory Company, Ltd.; Institute of Scientific and Industrial Research Osaka University	Preparation and properties of SiC-AlN solid solutions with Wurtzite structure
- National Institute for Research in Inorganic Materials; Max-Planck Institut für Metallforschung	Thermal expansion coefficient of α-sialon ceramics
- Toshiba Research and Development Center	High tem erature creep of nonoxide ceramics
- Toshiba Research and Development Center	Synthesis of silicon nitride powder from silica reduction
- Toshiba Research and Development Center	Densification of Si_3N_4 ceramics by HIP
- Government Industrial Research Institute, Nagoya; Aichi Institute of Technology	Joining of silicon nitride ceramics
- Government Industrial Research Institute, Nagoya	Electro-discharge machining of SiC
- Government Industrial Research Institute, Osaka	Electrical discharge machining of Si_3N_4-SiC whisker ceramic composite
- Kagawa Prefectural Industrial Technology Center; Japan Grain Institute Ltd.	Grinding of new ceramics using vitrified bonded diamond grinding wheel
- Electrotechnical Laboratory	Ceramics cutting by CO_2 laser
- Kyoto Institute of Technology	Bending strength and toughness of AlN-ZrO_2 composites
- National Institute for Research in Inorganic Materials, Tokyo Soda Company	Strength distribution of sintered ß-sialon ceramics

- The Research Institute for Iron, Steel and Other Metals; Tokyo University	Preparation and mechanical properties of Al_2O_3-based composites
- Government Industrial Research Institute, Nagoya	Fatigue failure of Si_3N_4
- Research Laboratory Asahi Glass Company, Ltd.	High temperature tensile stress rupture and low cycle fatigue testing of sintered Si_3N_4
- Government Industrial Research Institute, Nagoya	High temperature strength of high performance ceramics
- Niigata Engineering Company, Ltd. Government Industrial Research Institute, Nagoya	Anisotropics of fracture toughness in high performance ceramics

The titles above indicate the varied systems and applications involved in the studies. Of specific interest are the reported structural properties of he high performance ceramics. Researchers at Tohoku University have examined Al_2O_3-SiC composites and hardness, and indentation fracture toughness with varying levels of SiC additions to 30 mole % SiC. Highest values of K_{IC} were reported at 1600°C at SiC levels of 10 mole %. Dr. Bando, Dr. Ito, and Dr. Tomozawa studied the blunting of crack tips in silica glasses utilizing high resolution electron microscopy. The blunting process is attributed to the dissolution and reprecipitation at the crack tip of $Si(OH)_4$ which increases the radius of curvature at the crack tip and thereby lowering the stress concentration. Mechanical property studies of $TiN-TiB_2$ composite materials were conducted at the Government Industrial Research Institute (GIRI) at Kyushu by Dr. Watanabe and co-workers; the studies involved the relations between sintering temperature Ti(CN) grain size and sintered strength,the range of sintering temperature were from 1700 to 1950°C, with grain size ranging from 1 to 5 μ, the range of volume fractions were from 30 to 60% TiB_2. Additional composite ceramic mechanical property studies were carried out at the Kyoto Institute of Technology by Dr. Nishida *et al.*, examining the bending strength of $AlN-ZrO_2$ systems with additions of ZrO_2 ranging from 10 to 70 mole %. The highest values of hardness was achieved at 33 mole % with strength levels of 450 MPa and K_{IC} values of 2.7 MPa/m^3. A study at Tokyo Institute of Technology involved the fracture toughness of high pressure sintered alumina-zirconia and aluminia-diamond composites. Utilizing microhardness indentation techniques, he highness values of fracture toughness were achieved wi*h 10 v/o addition of zirconia to alumina. The values of Kc for alumina diamond systems appeared to increase with increasing additions of diamond up to levels of 15 v/o.

Studies of monolithic ceramics included fatigue studies of hot pressed silicon nitride by Dr. Yamauchi *et al.* at GIRI Nagoya. Utilizing four point bending in tension-tension and tension-compression S-N curves were obtained, (Figure 1). High temperature low cycle fatigue and tensile stress rupture were evaluated in the temperature range from 1000°C to 1200°C by Dr. Fujita and coworkers at Asahi Glass Company. Degradation of fatigue and stress rupture properties were significant above 1000°C, (Figure 2). Failure initiation is associated with internal voids. Additional torsional strength tests as a function of temperature on pressureless sintered silicon nitride with additives of MgO and Al_2O_3 have been undertaken at the National Aerospace Laboratory. Density levels ranged from 3.10 to 3.15 g/cm^3. The torsional studies show good correlation with tension mechanical property data, (Figure 3), and degradation of strength at temperature in excess of 900°C. The torsional test data provided higher apparent strength vis-à-vis tensile property values. A statistical stren th evaluation as a function of temperature for hot pressed silicon nitride and silicon carbide in the temperature range from 25°C to 1600°C were conducted by Dr. Shoji *et al.*, at GIRI, Nagoya. Bend strengths of silicon nitride decreased at temperature in excess of 800°C, while silicon carbide strength was maintained to temperatures up to 1600°C, (Figure 4). The failure probability of silicon nitride and silicon carbide at various temperatures with silicon carbide distributions of greater scatter and higher strength at temperature in excess of 1200°C. Studies on fracture mechanics and crack propagation in silicon nitride utilized double cantilever beam and chevron notch techniques. K_{IC} measurements by NGK Insulators compared values utilizing notched beam and chevron test with various widths, (Figures 5 and 6). In summary, the dissemination of information which is one of the most important functions of the society, was done efficiently enhanced greatly by the book of the extended abstracts.

FUNDING OF CERAMICS RESEARCH IN JAPAN

In a conversation with Professor Mitsue Koizumi, Director of the Institute of Scientific and Industrial Research, Osaka University, who is the representative of a large-scale national research project, "Investigation of Functional Ceramics," he described how a research project was initiated. Functional ceramics is being funded by the Ministry of Education for a three-year period starting in 1982. Since this project may be a topic of interest to readers of this report, it will be briefly outlined below. [M. Koizumi, *Bulletin* of the Ceramic Society of Japan (Seramikkusu) *17*, No. 12, p. 1026].

- Entire Planning, Fund Distribution, and Report Preparation

  Representative: Professor Mitsue Koizumi

- Processing and Function Evaluation of Surface Active Ceramics

  Representative: Professor Akio Kato

  Synthesis of ultrafine ceramics particles and property control
  Property evaluation of ceramics powder
  Preparation of polycrystalline thin film material and property evaluation

- Processing and Function Evaluation of Reactive Ceramics

  Representative: Professor Shichio Kawai

  Synthesis of ceramic catalysts, catalyst carriers, and property evaluation
  Synthesis of electron-sensitive ceramics and function evaluation

- Processing and Function Evaluation of Heat Pressure-Sensitive Ceramics

  Representative: Professor Shoichi Kume

  Search of heat-sensitive ceramics and their evaluation
  Search of pressure sensitive ceramics and their evaluation

- Processing and Function Evaluation of Light-Sensitive Ceramics

  Representative: Professor Naohiro Soga

    Preparation of raw material of light transmitting ceramics and structure analysis
    Preparation of active ion-added ceramics and function evaluation
    Synthesis of light exchange elements and function evaluation

The first year budget of this project is $1.0 million. This sum does not include personnel costs nor tuition of graduate students. It is expected that this project will make a major impact on ceramics research. This project is one of eight major projects initiated by the Ministry of Education.

MINORU TOMOZAWA'S VISITS TO JAPANESE UNIVERSITIES AND INDUSTRIES

After attending the 1983 annual meeting of the Japanese Ceramic Society in May 1983, I had an opportunity to visit various universities and industries in Japan. The arrangements for the visits was made by Professor Masasuke Takata of Nagaoka Technological University.

UNIVERSITY VISITS

- Tokyo University

Department of Industrial Chemistry,
Yanagida Laboratory

This is the most prestigious university in Japan. Professor Hiroaki Yanagida is the head of the group working on new ceramics. In his group, Associate Professor Dr. Kunihito Komoto, research associate Mr. Masaru Miyayama, one technician, one secretary, nine graduate students (six M.S., three Ph.D.'s), six undergraduate students, two foreign researchers (from China and Korea), and four industry researchers are working on a variety of new ceramics. Topics include electric and dielectric properties, fracture-microstructure relations, phase transformation, gas sensors, PTC, nonoxide ceramics and cement hydration.

At present, new ceramics (or fine ceramics) is a popular topic in Japan. In various ways, Dr. Yanagida is the representative of Japanese new ceramics research activities. On the day of my visit, for example, he was giving an interview to a British embassy official in charge of science and technology on Japanese ceramics research activities. Dr. Yanagida's research laboratory is well-equipped and most students are bright and hard-working.

- Tokyo Institute of Technology at Natsuka

Laboratory for Hydrothermal Synthesis in the Research Laboratory of Engineering Materials,
Somiya Laboratory

The main campus of the Tokyo Institute of Technology is in Tokyo. Because of the congestion of the city, the Research Laboratory of Engineering Materials, which is affiliated with the university, moved to its present site which is in the suburbs of

Yokohama. The Research Laboratory consists of several smaller laboratories, one of which is Professor Somiya's hydrothermal laboratory.

Professor Somiya is a well-known ceramic scientist in the United States as well as in Japan, having organized several international conferences on ceramics (e.g., the International Symposium on Factors in Densification and Sintering of Oxide and Nonoxide Ceramics, 1978; the International Symposium on Ceramic Components for Engines, 1983, etc.). Together with Associate Professor Yoshimura, a research associate, and several graduate students, Dr. Somiya runs a huge hydrothermal facility. This group is extremely active in research, well-equipped, but understaffed.

At present, the popular catch phrase among Japanese politicians is "Gyosei-Kaikaku," (administration reform) which is roughly equivalent to President Reagan's policy of less government influence in private enterprise. Since most of the presitigious universities in Japan are national universities, this policy puts a squeeze on the personnel costs at these universities which results in understaffing.

- Kyoto University

Institute for Chemical Research,
Sakka Laboratory

This laboratory was headed by Professor Megumi Toshiro who retired a few years ago. Professor Sumio Sakka succeeded Professor Toshiro, and is from Mie University where he has been a professor for the past ten years. This laboratory has traditionally been the leading research laboratory on glass and has published numerous important papers on glasses. With the addition of Dr. Sakka, this tradition of excellence will undoubtedly be continued. Dr. Sakka, together with Associate Professor Tadashi Kokubo; research associates, Dr. Setsuro Ito, Dr. Toshio Maki, and several graduate students is conducting research on bioceramics, glass and ceramics fibers from the sol-gel process, directionally solidified electrooptic glass-ceramics, alkaline-resistant glasses and the structure of glasses.

Professor Sakka, together with Professor Naohiro Soga of Kyoto University, is going to host the 1986 International Conference on Physics of Noncrystalline Solids in Kyoto, Japan.

- Nagaoka Technological University

This is one of the few, new national universities. Some years ago, several five-year technical colleges (10th-14th grade) which train practical engineers were formed. To accommodate some of the graduates of these colleges who wish to continue their education, two technological universities were founded. One is in Toyohashi and the other is in Nagaoka. The graduates of the five-year technical colleges are admitted to these universities as juniors and get their master's degrees in four years. This is a unique university and it emphasizes practical education. Students receive training, for an extended period of time, by working in industry (similar to a coop program in the United States). Most of the traditional Japanese national universities have a tendency to shy away from the close university-industry cooperation, but the technological university does not. Consequently, graduates of these technological universities are in great demand by industry.

Nagaoka Technological University is in the suburbs of Nagaoka City. The university has a spacious campus by Japanese standards, a good environment, and good facilities. Various expensive analytical pieces of equipment such as x-ray units with rotary anodes, and electron optic facilities are constantly maintained by specialists. The policy of "Gyosei-Kaikaku" (administration reform) appears to have bypassed this university.

Here I talked with Professor Yokota, Matsushita, and Komatsu who are working with amorphous material, both oxides and metallic glasses; Professors Okamoto and Takata, who are working on magnetic materials and various ceramic sensors; Professor Kamata, who is working on ceramic thin films prepared by low temperature CVD of organometallic compounds.

- Meisei University

Traditionally in Japan, government-run national universities have enjoyed a better reputation compared with private universities. However, this situation is gradually changing and private universities are becoming increasingly popular. The tough competition of entrance examinations at various levels of public schools is causing this trend. The competition used to exist only at the time of entering a university. In order to get into a good university, however, one has to attend a good high school and the competition has become very keen at the high school entry level. Now there is competition even at the kindergarten level. Most private educational institutions have classes that range from kindergarten through to a full university, and since students in these schools can be advanced without suffering from the entrance examination competition, private institutions are becoming popular.

Meisei University is a comparatively new, private university located in the suburbs of Tokyo and is a part of Meisei Institute which encompasses classes from kindergarten through to graduate school. I visited the science and engineering school of the university. Among senior faculty members of the school, there were many prominent scientists and engineers who had retired from prestigious national universities. Among the young and active faculty members, I met Professor T. Ishii, who is studying the fatigue of metals and Professor H. Kanno who is investigating amorphous materials.

One of the unique features of this university is its collection of numerous rare books including William Shakespeare's first folio, books by Nicolaus Copernicus, Galileo Galilei, and some laboratory notebooks of Marie S. Curie.

Overall, Japanese universities are well-equipped, but lack flexibility in personnel matters such as in hiring, promoting, and transferring.

INDUSTRIAL VISITS

- Semiconductor and Integrated Circuit Division, Musashi Works, Hitachi Corporation

This is Hitachi's development and manufacturing center for LSI and VLSI. A large number of people constantly visit this plant, both from other parts of Japan and abroad because of the tremendous future prospect of this scientific and technological area. All personnel have to go through elaborate cleaning steps before entering into the semiconductor processing area because of the requirement of a dust-free environment. Consequently, visitors are allowed only into limited areas. Numerous pieces of expensive state-of-the-art equipment, both internally developed and purchased from [illegible] companies, including those in the United States, impress visitors. The most [illegible]

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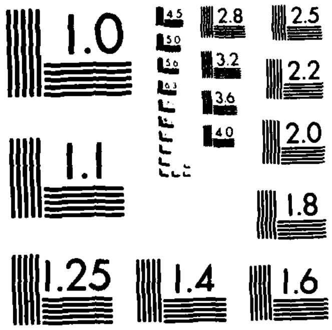


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

machine was what was claimed to be the world's fastest wire-bonding machine, which automatically makes the electrical connections between chips and terminals.

Through discussions with engineers at Hitachi Musashi, I learned that there are many areas where glass and ceramic engineers can make contributions to microelectronics development.

People in these plants work extremely hard, even by Japanese standards. Most engineers here start their working day at 7:30 a.m. and rarely leave the plant before 9:00 p.m. Perhaps this is a temporary phenomenon, but this shows their competitiveness and sense of urgency. Their main competitor is the Nippon Electric Company (NEC). Because of fierce competition inside the country, it may be easy for Japanese companies to take on foreign competitors.

- Central Glass Company

This is the third largest plate glass manufacturer in Japan. They are keenly aware that a steady growth in sales is not to be expected in the future because of the rather mature nature of the plate glass industry. Thus, they are very much interested in developing new areas of ceramics products such as manufacturing sensors. As a first step, they are educating engineers by sending them to various universities both in Japan and abroad. Management is very much interested in learning about current and future ceramic research directions.

- Nippon Sheet Glass Company, Central Research Laboratory

The Nippon Sheet Glass Company is the second largest plate glass manufacturer in Japan. But its Central Research Laboratory, headed by Dr. Nobuo Araki, is more famous for its new product, the Selfoc lens, a self-focusing glass rod and fiber with a parabolic refractive index profile produced by ion-exchange. The original intended applications was an optical wave guide for telephone communication, but it turned out to have a larger loss than SiO_2 glass made by CVD. Application has been found instead in xerographic machines and its use is primarily responsible for the smaller copying machine which is dominating the market now. Selfoc is one of the few instances where an intensive research effort has led to a profitable product. It is anticipated that Selfoc will be widely used in the next generation of public communication systems, i.e., facsimile communication.

A new product is being developed at Nippon Sheet Glass Company, and this is a planai microlens, formed on plate glass by the ion-migration method. This is expected to be used in many optoelelctronic applications.

Dr. Ichiro Kitano of the laboratory is organizing an international conference on optics called the "Fourth Topical Meeting on Gradient-index Optical Imaging Systems" on 4-5 July 1983 at Kobe, Japan.

- Hitachi Research Laboratory, Hitachi Corporation

This is one of the seven research and development laboratories of the Hitachi Corporation and employs approximately 1200 people. The laboratory covers the areas of energy, electronics, and materials. Thus, approximately one-third of the effort at this laboratory is directed toward the development of new metals, ceramics, and polymers. The materials and technologies they are working on are:

- Materials

  Fine ceramics
  Materials for computer and semiconductor applications
  Materials for displays and printers
  Optical materials
  Insulating materials
  Heat resistant, high strength materials
  Corrosion and radiation resistant materials
  Superconductors

- Technology

  Thin film trechnology
  Molding and casting
  Chemical and physical analysis
  Materials reliability
  Nondestructive diagnosis
  Welding and joining

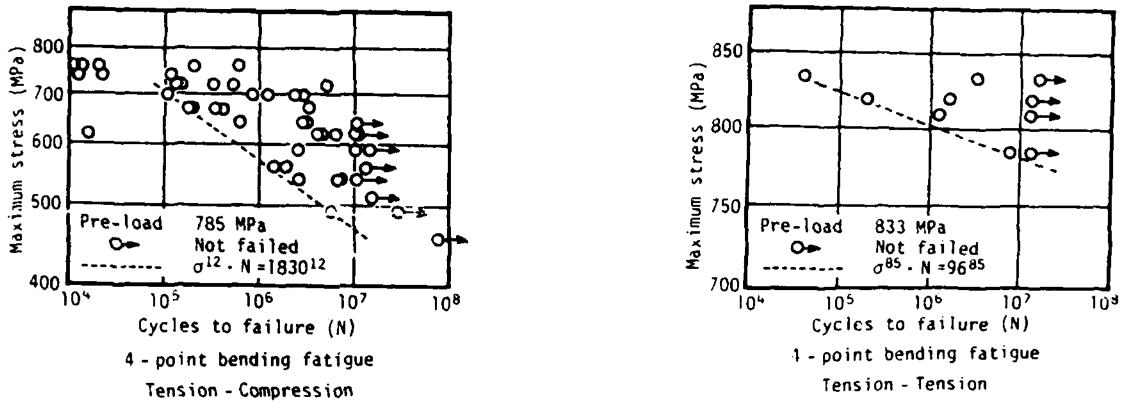
One of the recent developments made by Hitachi in the ceramics field is SiC doped with BeO. The product has high thermal conductivity, high electrical resistivity, and is well-suited as an insulating substrate for semiconductors. At present, this laboratory is probably the leading research and development center in new ceramics in Japan.

In recent years, numerous discussions have occurred as to why the Japanese are so successful. Various reasons have been sought such as Japanese government subsidization of industries, etc. This may be partly true, but none, I believe, is the major reason.

For the past 100 years, the most popular slogan in Japan has been "Oitsuke-Oikose" (catch up-pass them). This originates from the realization that the Western world is ahead and Japan is behind in industrialization. In order to catch up and pass the competitor, one has to learn rapaciously from those who are ahead and try harder than them. This is the driving force and the method by which Japanese industries are achieving their phenomenal success.

ACKNOWLEDGEMENTS

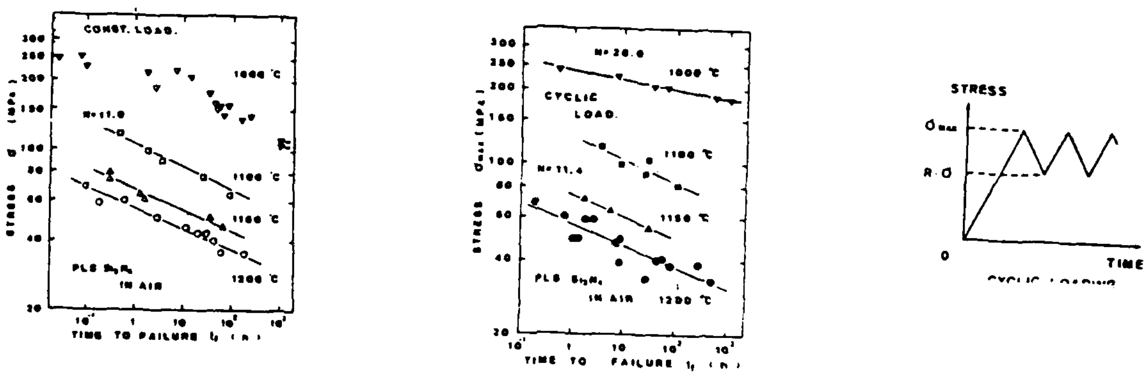
I would like to thank Professor Masasuke Takata of the Nagaoka Technological University who organized my visit as well as numerous other people who extended their hospitality to me.



(a)

(b)

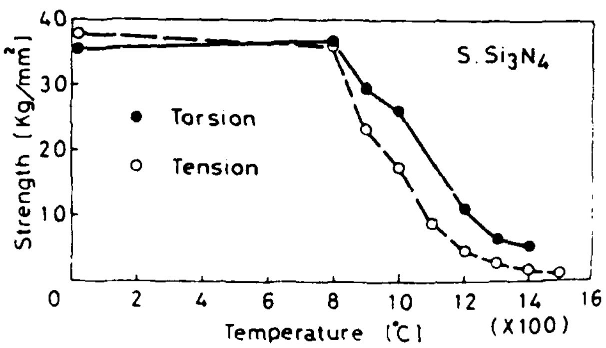
Figure 1. Four Point Bending Results of Hot Pressed Silicon Nitride (a) Tension-Compression (b) Tension-Tension



(a)

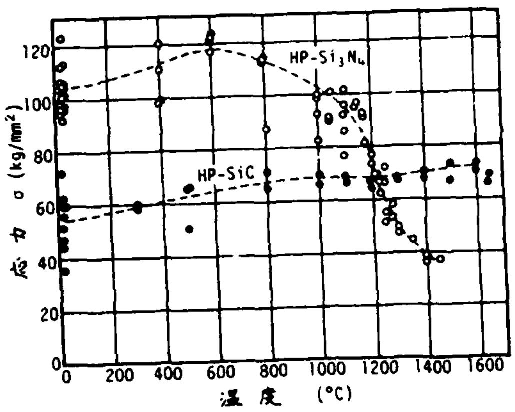
(b)

Figure 2. High Temperature Tensile (a) and Low Cycle Fatigue Results (b) on Sintered Silicon Nitride

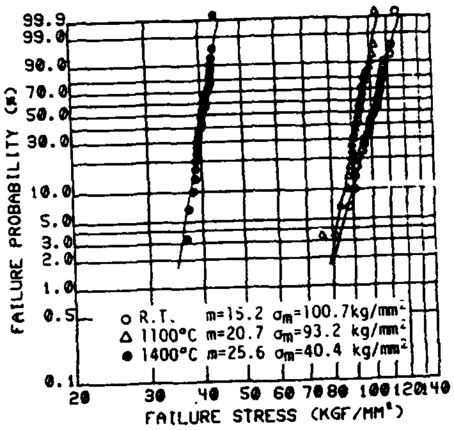


(c)

Figure 3. Comparison of Tension and Torsional Strength of Sintered Silicon Nitride



(a)



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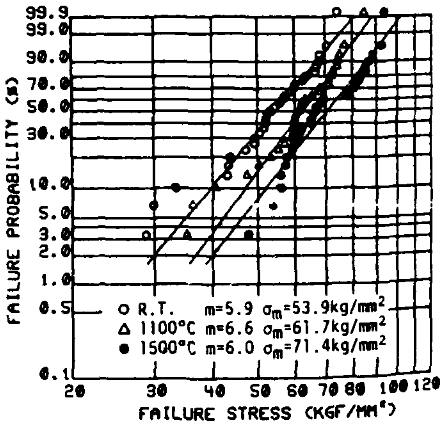

(c)

Figure 4. (a) Strength of Hot-pressed Silicon Carbide and Silicon Nitride from 25°C to 1600°C
(b) Failure Probability of Silicon Nitride, and
(c) Failure Probability of Silicon Carbide

$$K_{IC} = \frac{P_{max}}{B\sqrt{W}}(3.08+5.00\alpha_0+8.33\alpha_0^2)\left(\frac{S_1-S_2}{W}\right)\left[1+0.007\left(\frac{S_1 \cdot S_2}{W}\right)^{1/2}\right]\left[\frac{\alpha_1-\alpha_0}{1-\alpha_0}\right]$$

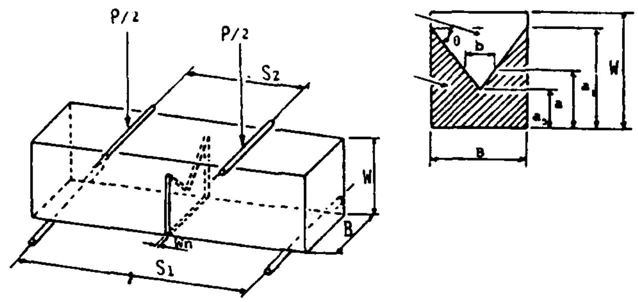

Figure 5. Specimen Design for K_{IC} Testing

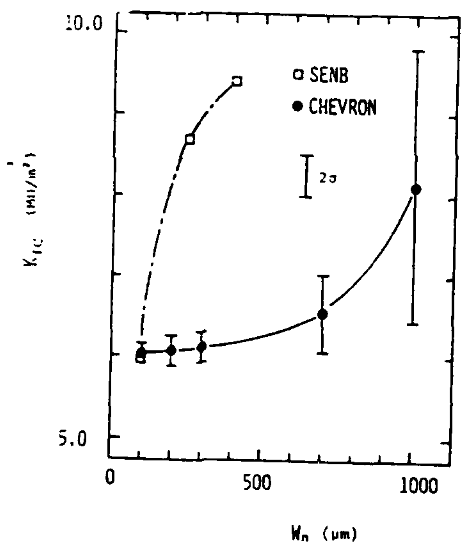

Figure 6. Variation of K_{IC} between SENB and Chevron Specimens

INTERNATIONAL CONFERENCE ON METAL SCIENCES

Ronald W. Armstrong

INTRODUCTION

The International Conference on Metal Sciences, ICMS-83: Deformation--All Aspects, was held from 17 through 19 March 1983 at Ranchi, India. The program included four sessions on deformation mechanisms and the following individual sessions:

- strain ageing,
- thermomechanical processing,
- superplastic forming,
- metal forming,
- deformation of ceramics and composites, and
- surface friction and wear studies.

The conference was organized by the Research and Development Center for Iron and Steel (RDCIS) of the Steel Authority of India, Ltd., (SAIL), Ranchi, and the Metal Sciences Division of the Indian Institute of Metals. Previous conferences in the biannual series were organized in Banaras, 1977; Bombay, and Bangalore, 1981. S. Samarapungavan, chairman of SAIL, headed a national steering committee comprising representatives from 15 metals-related centers of research. N. S. Datar, Director of RDCIS, was president of the organizing committee; V. Ramaswamy, project coordinator at RDCIS, was convener of the program.

At the opening session, A. K. Seal, Principal of Bengal Engineering College and Chairman, Metal Sciences Division of the Indian Institute of Metals, welcomed the 200 participants (about half had written papers for the conference). The inaugural address was given by S. Vardarajan, Secretary of the Government Department of Science and Technology.

V. S. Arunachalam, Scientific Adviser for the Ministry of Defense, gave the keynote address. Dr. Arunachalam was at the Bhabha Atomic Research Center (BARC), Bombay, the National Aeronautical Laboratory (NAL), Bangalore, and the Defense Metallurgical Research Laboratory (DMRL), Hyderabad, before being chosen as the first metallurgist to be appointed to his present post. To illustrate the challenging research projects being undertaken at the DMRL, Dr. Arunachalam described his involvement in work with N. Ramakrishnan and T. Balakrishna Bhat, analyzing pressure sintering by computer simulation. Figure 1 is a graphical representation of their finite element description of the sintering process. The work relates, for example, to the DMRL interest in hot isostatic pressing for gas turbine components.

TECHNICAL SESSIONS

The technical sessions began with invited lectures:

Names	Title
- R. W. Armstrong ONR, London	Grain size effects and their importance to polycrystal deformation behavior

- R. Raj — Deformation processing maps
  Cornell University, Ithaca, NY

- K. Lucke — Deformation textures
  Institut für Allgemeine
  Metallkunde und Metallphysik, Aachen
  West Germany

- P. G. McCormick — Dynamic strain ageing
  University of Western Australia
  Nedlands, Australia

- J. L. Strudel Ecole — Catastrophe theory for dynamic strain ageing
  Nationale Supérieure des Mines de
  Paris, Centre des Matériaux
  Evry, France

- V. Vitek — Dislocation core effects in plastic deformation
  University of Pennsylvania
  Philadelphia, PA

- V. Ramachandran — Plastic deformation near absolute zero
  NAL
  Bangalore, India

- K. A. Padmanabhan — Origins and applications of superplasticity
  Indian Institute of Technology (ITT)
  Madras, India

- A. K. Ghosh — Recent advances in metal forming technology
  Rockwell International Science Center
  California

- D. H. Sastry — Impression creep behavior of metals at high temperatures
  Indian Institute of Science (IIS)
  Bangalore, India

- N. Balasubramanian — Deformation of composites
  Asbestos Cement, Ltd.
  Bangalore, India

Dr. Armstrong pointed out that 50% of the 550-MPa yield stress achieved in the Product Development unit of RDCIS, SAIL, for microalloyed high strength SAIL-MA joist material was due to the grain size term in the Hall-Petch relation [see J. Gurland, "Yield, Flow and Fracture in Polycrystals," the Office of Naval Research, London, *European Scientific Notes* 36-11:301-302 (1982)]. The material, microalloyed with 0.03 weight percent Nb, has a 7-micron grain size with precipitation of fine Nb carbonitrides within the grains of the hot-rolled product. About 30,000 tons of the steel have been produced for use in bridges, transmission towers, pipelines, storage tanks, and offshore oil drilling platforms. S. Sen (RDCIS Subcenter, Durgapur) and R. Priestner (Manchester University, U.K.) described the "Effect of Strain-induced γ-α Transformation on Grain Refinement of Micro-alloyed Steels," including a 0.06 weight percent niobium steel and a 0.17 weight percent vanadium steel.

R. Raj presented his application of a strain criterion to strain rate versus temperature-determined deformation processing maps so as to define the useful working ranges for rolling and other metal forming operations. K. P. Rao and H. M. Roshan (IIT Madras), S. M. Doraivelu [Wright-Patterson Air Force Materials Laboratory (WPAFML), Ohio], and Y.V.R.K. Prasad (IIS), reported the "Development of a Processing Map for Al-4Mg Alloy." In follow up papers, A. P. Singh (RDCIS) and K. A. Padmanabhan described the strain characteristics of materials in axi-symmetric upsetting and rolling operations; K. K. Ray and A. K. Mallik (IIT Bombay) presented measurements of the "Stress Rate Sensitivity and Stress Relaxation Techniques," for obtaining basic information on metal forming operations and the kinetics of deformation processing.

S. K. Ray, K. G. Samuel, and P. Rodriquez [Reactor Research Center, (IRRC), Kalpakkam] described the temperature and strain rate dependences of the tensile work hardening rates for two grades of type 316 austenitic stainless steel of interest for sodium-cooled fast breeder reactor applications. "An Experimental Study of Warm Rolling of Type 316 Austenitic Stainless Steel," by S. Venkadesan (RRC), and K. A. Padmanabhan, showed that the ductility of the material could be improved for this use. S. L. Mannan and P. Rodriquez (1983) have reported the effect of grain size on the creep rate of type 316 stainless steel at 873 and 973°K. In related work, K.B.S. Rao, M. Valsam, R. Randhya, S. K. Ray, and P. Rodriquez reported on the "Deformation Behavior of AISI 304 Stainless Steel in High Strain Fatigue," and K. Bhanu Sankara Rao, V. Seetharaman, S. L. Mannan, and P. Rodriguez (1983) reported the "Effect of Long-term Exposure at Elevated Temperatures on the Structure and Properties of a Nimonic PE 16 Superalloy," of recent interest as a candidate material for the core components of sodium-cooled fast breeder reactors.

Superalloy materials themselves are of great interest at the DMRL for gas turbine applications, as evidenced by the paper, "Hot Deformation Studies on a High Strength Wrought Nickel-base Superalloy EI-929," by K. K. Sharma and S. N. Tewari. The creep properties are slightly better than those for Nimonic 105 when compared on a Larson-Miller basis. A. M. Sriramamurty, D. Banerjee, and S. N. Tewari (1982) have reported detailed electron microscope results on the crystallography of the orientation relationship between the (γ/γ')-α directionally solidified eutectic superalloy system.

K. Lucke gave a comprehensive description of:

- methods for determining deformation textures in metals and alloys,
- the dependence of various deformation textures obtained for face-centered-cubic and body-centered-cubic materials on the temperature and amount of deformation, and
- theoretical approaches to understanding or predicting the experimental results.

Particular attention was given to the intricacies associated with the method of orientation distribution functions (ODF) in accounting for multiplicity effects in pole figure results. An assessment of the effect of stacking fault energy on texture results showed that the copper texture is intermediate between that of aluminum and alpha brass. S. Mishra (RDCIS), followed with an ODF description of "The Origin of the Surface Texture in Hot-rolled Low-carbon Steels." For hot rolling steel conditions where appreciable shear deformation occurs at the sheet surface, Mishra obtained a mixed $\{110\}\langle 001\rangle$ and $\{4\ 4\ 11\}\langle 11\ 11\ 8\rangle$ texture as theoretically predicted by Dillamore. A Humboldt Fellow at Aachen, Dr. Mishra has reported with C. Därmann and K. Lucke (1983) on the recrystallization texture of another SAIL product, "SAILDRAW BORON," with improved deep drawing properties over aluminum-killed steels.

K. Rao, H. M. Roshan, S. M. Doraivelu, and Y. Prasad reported on "Strengthening in High Temperature Forged 2618 (RR58) Aluminum Alloy," of interest for aircraft compressor blades, fins, and engine forgings. Y. Prasad, who has won the prestigious National Metallurgist's Award this year, is on leave from WPAFML. In related papers, N. Gope, S. Sharma, and P. K. Chakravarty (Tata Iron and Steel Company, Ltd., Jamshedpur) and R. Singh and R. Kumar (National Metallurgical Laboratory, Jamshedpur) described the creep rupture properties of ferritic and low alloy Cr-Mo-V creep-resistant materials for thermal power generation applications. The creep properties of ferritic/ pearlitic, bainitic, and martensitic microstructures with varying carbide morphologies were compared.

P. G. McCormick gave a complete description of modern experimental results obtained on a number of alloy systems exhibiting serrated plastic flow due to dynamic strain ageing. Elegant results were presented on the three categories of serrated stress-strain curves now distinguished according to their Lüders band characteristics, including the occurrence of serrations for flow within a propagating band, the increase in strain occurring with an increase in distance of band propagation, and the nature of band initiation. McCormick presented strain versus strain rate results obtained at various temperatures, strain measurements as a function of gauge length, and bandwidth measurements as a function of strain and sample size. Sufficient strains are achieved in torsion to allow the beginning and end of serrated flow to be measured. McCormick discussed theoretical aspects of the Cottrell model for dislocations dragging their solute, the static strain ageing of dislocations while heldup at local obstacles, and the Kocks proposal of solute diffusing along forest dislocation cores to interfere with contacting gliding dislocations. McCormick concluded that vacancies affect dynamic strain ageing. J. L. Strudel argued for the advantage of using a creep machine to study the effects. No load drops are observed in creep testing, but otherwise the same three types of behavior are exhibited. His description of the deformation behavior on the basis of catastrophe theory seemed to allow a proper perspective on the combined influences of the solute dragging force, lattice friction and solid solution effects, and concentration of diffusing solute atoms. This behavior is important for stainless steel material applications in the fast breeder reactor. S. L. Mannan, K. G. Samuel, and P. Rodriquez (1982) have reported that dynamic strain ageing occurs in the Hall-Petch term for the elevated temperature deformation of type 316 stainless steel. Of course, serrated plastic flow can occur under conditions of effective low temperatures and high strain rates not associated with diffusion processes. V. Ramachandran described this behavior mostly associated with deformation twinning and plastic instability at high applied stresses.

V. Vitek discussed why the intrinsic structure at a dislocation core is important to the deformation properties of materials. Whereas R. Armstrong emphasized the dependence of material properties on the cumulative interactions of dislocations, Vitek drew attention to the role "core spreading has in determining the basic character of slip and cross-slip processes in body-centered-cubic (bcc), hexagonal-close-packed (hcp), and face-centered-cubic (fcc) structures. The experiment that determines whether core spreading is important in a particular case is measurement of the orientation dependence of the resolved shear stress for slip--which seems to become more complicated the more carefully it is investigated. Vitek asserted that the splitting of partial dislocations in the fcc case was a special case of the more general consideration of core spreading which occurs for bcc structures; the hcp case is intermediate. The influence of normal stresses on "pure slip" is understandable in terms of core spreading. Its effect on slip in the superalloy $L1_2$ structures is being investigated.

K. A. Padmanabhan gave an overview of superplasticity research and applications. He has co-authored the book, *Superplasticity* with G. J. Davies (University of Sheffield), which is in the Materials Research and Engineering series edited by B. Ilschner (Springer-Verlag, 1980). Padmanabhan presented results for the aluminum-copper eutectic system and for zinc-22% aluminum alloy. He credited the plastics industries for the basic idea that materials could be drawn to very large strains without necking at energy efficient low loads with low cost equipment. Complex shapes also can be produced with essentially no leftover scrap. Commercial applications in the U.K. and U.S. have included the manufacturing of gas turbine disks. In a follow up paper, G.S. Murty and H.S. Anand (IIT Kanpur), and B.P. Kashyap (University of California, Davis) described the internal stress method of assessing superplastic deformation for lead-tin eutectic alloy. Stress relaxation tests provided a valuable tool for interpreting the material behavior. Padmanabhan worried that such tests showed the stress exponent in the constitutive relation contained a temperature dependence, and that this result called into question the appropriateness of the analysis.

A. K. Ghosh described the combination of superplastic forming and diffusion bonding (SPF/DB) of sheet metal components to produce an expanded "sandwich" composite structure for aerospace applications. He showed a Rockwell film of the processing steps. Achievement of the proper strain rate with argon gas pressure was an important element in the procedure. Aluminum and titanium materials were being thoroughly investigated; for example, the conditions for superplastically forming aluminum 7475 alloys were established, but the material was found to be too strong during forming to justify the cost of tooling for production. Forming within the die was a subject of strong research interest, including strain rate considerations and finite element analyses for thinning problems. In a related paper, K. Bose, A. Dutta, and N. C. Birla (DMRL) discussed "Development of SPF/DB Technique for a Titanium Alloy (Dish) Component." They used Ti-6Al-4V alloy and Ti-6.6Al-2.9Mo-1.7Zr-0.23Si alloy (called Soviet VT-9 alloy) which is used for blades and discs in advanced MIG aircraft. A maximum elongation of 406% was achieved for a 4.7-micron grain size Ti-6Al-4V alloy at 1200°K with an initial strain rate of 0.002 (1/s). R. Sundaresan and A.C. Raghuram (NAL), presented "Densification of Ti-6Al-4V Powder Under Hot Isostatic Pressing." Powders were produced at NAL by a rotating electrode process and by a rotating rod process developed there. Temperatures from 800 to 1050°C and pressures to 1 kbar were achieved. Excellent micrographs of the densification process were presented; they showed the extensive plastic deformation of small particles in interstices.

Other papers in the conference were,

Name	Title
- A.I. Wilson Hille Engineering Company Sheffield, U.K.	High reduction mill
- A.K. Sengupta RDCIS and University of Cambridge	Simulative studies of deformation behavior of long rod projectiles under high and hypervelocity normal and oblique impact
- K.H. Häusler Mannesmann Federal Republic of Germany	Manufacture of seamless steel tube by the hot pilger process

- W. Randerath Mannesmann Federal Republic of Germany	Longitudinally welded large-diameter pipe made by the U-O-E process
- F.E. Dolzhenkov and Y.I. Krivonosov RDCIS Soviet Coordination	Combined deformation of heterogeneous metals
- A.M. Sriramamurthy and S.N. Tewari DMRL	Mechanical properties of a (γ/γ')-α (Ni-Mo-Al) *in situ* composite
- K.M. Jasim and E.S. Dwarakadasa University of Technology Baghdad, Iraq	Wear in aluminum-silicon alloys der dry sliding conditions
- D.K. Goel, R.K. Pandey, and A.N. Kumar IIT Delhi	Deformation and fracture behavi f a graphite epoxy composite
- R. Ramesh, K. Ravikumar IIS	Wear of EN31 steel
- J. Bhattacharya, B.N. Ghose, and S.K. Banerjee NML	Differential deformation during roll bonding of stainless steel to aluminum sheet.

A further report on visits to the Reactor Research Center, Kalpakkam; Defense Metallurgical Research Laboratory, Hyderabad; National Aeronautical Laboratory and Indian Institute of Science, Bangalore; and Indian Institute of Technology, Madras, will be given in a forthcoming issue of the ONR Far East *Scientific Bulletin*.

REFERENCES

- "Effect of Grain Size on Creep Rate in Type 316 Stainless Steel at 873 and 987°K." Mannan, S.L. and P. Rodriquez. *Metal Science, 17* (in press) (1983).

- "The Influence of Grain Size on Elevated Temperature Deformation Behavior of a Type 316 Stainless Steel." Mannan, S.L., K.G. Samuel and P. Rodriquez. *International Conference on Strength of Metals and Alloys*, ed., R.C. Gifkins, *2* pp 637-642, (Melbourne, 1982).

- "Orientation Distribution Function Analysis of the Recrystallization Texture in a Boron-Treated Deep-Drawing Steel." S. Mishra, C. Darmann, and K. Lucke. *Metallurgical Transactions, 14A* pp 11-15, (1983).

- "Effect of Long-term Exposure at Elevated Temperature on the Structure and Properties of a Nimonic PE 16 Superalloy." Rao, K. Bhanu Sankara, V. Seetharaman, S.L. Mannan, and P. Rodriquez. *Materials Science and Engineering, 41* (in press) (1983).

- "International Structure in DS (γ/γ')-α Eutectic Superalloy." A.M. Sriramamurty, D. Banerjee and S.N. Tewari. *Acta Metallurgica, 30* pp 1234-1242 (1982).

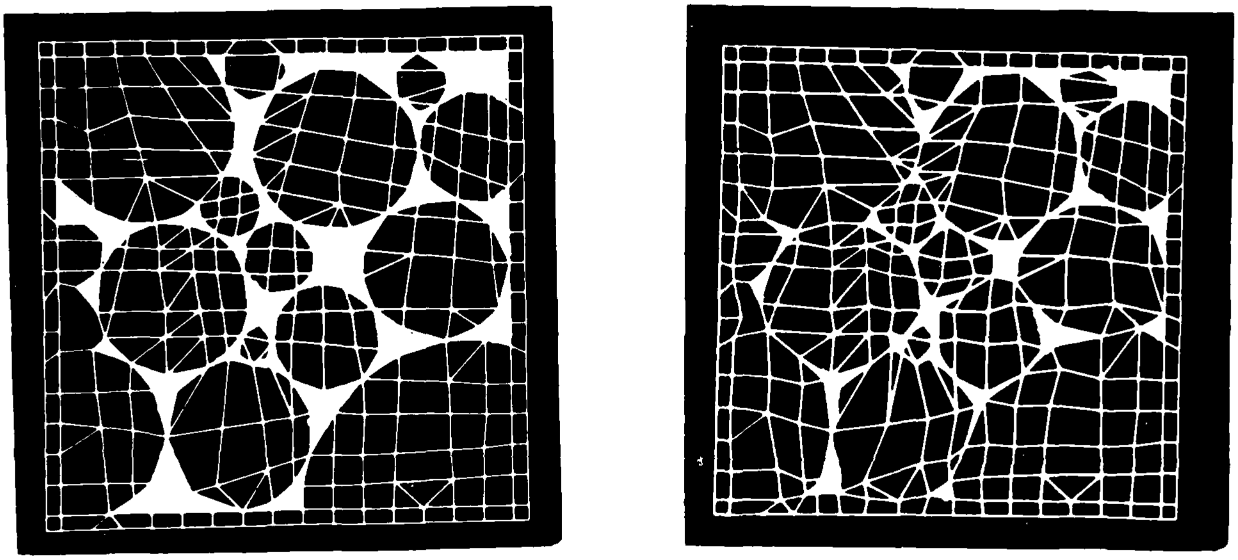

Figure 1. Finite elements model description of sintering in hot isostatic pressing; N. Ramakrishnan and T. Balakrishna Bhat (Defense Metallurgical Research Laboratory, Hyderabad-500258, India) and V.S. Arunachalam (Scientific Adviser to the Minister for Defense, South Block, New Delhi, 110011, India)

INTERNATIONAL MEETINGS IN THE FAR EAST

1983-198

Compiled by Seikoh Sakiyama

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

1983

Date	Title	Site	For information, contact
October 2-5	The 3rd International Display Research Conference	Kobe, Japan	Japan Convention Services, Inc. Nippon Press Center, 8F 2-1, Uchisaiwai-cho 2-chome, Chiyoda-ku Tokyo 100
October 3-6	International Symposium on Interferons	Kyoto, Japan	Japan Convention Services Inc., Osaka Branch Ikari Building 3-1-59, Fukushima Fukushima-ku, Osaka 553
October 10-13	International Radar Symposium, India '83	Bangalore, India	Mr. N. L. Krishman Bharat Electronics, Ltd. 29 Race Course Road Bangalore, 560001
October 16-24	The 8th International Conference on Calcium Regulating Hormones	Kobe, Japan	Professor T. Fujita 3rd Division Department of Medicine School of Medicine Kobe University 7-13, Kusunoki-cho Ikuta-ku, Kobe 650
October 17-20	International Symposium on Ceramic Components for Engines	Hakone, Japan	Professor Shigeyuki Somiya Research Laboratory of Engineering Materials Tokyo Institute of Technology 4259 Nagatsuda, Midori Yokohama, Kanagawa 227

Date	Title	Site	For information, contact
October 17-21	1983 (98th) IEC (International Electrotechnical Commission) General Meeting in Tokyo	Tokyo, Japan	Japan Standards Association 4-1-24, Akasaka Minato-ku, Tokyo 107
October 18-23	International Telecommunications Energy Conference (INTELEC '83)	Tokyo, Japan	Professor Koosuke Harada Department of Electrical Engineering Kyushu University 6-10-1, Hakozaki Higashi-ku, Fukuoka 812
October 23-28	1983 Tokyo International Gas Turbine Congress	Tokyo, Japan	The Organizing Committee of 1983 Tokyo International Gas Turbine Congress Sansei International, Inc. Showa Building, 1-7-5 Akasaka, Minato-ku, Tokyo 107
October 24-28	The 28th Annual Scientific Meeting of the Royal College of Pathologists of Australia	Melbourne, Australia	The Secretariat, The Royal College of Pathologists of Australia 82 Windmill Street Sydney, N.S.W. 2000
November 7-11	Japanese National Committee of CIGRE Study Committee 34, 35	Tokyo, Japan	CIGRE The Institute of Electrical Engineers of Japan Shin Yurakucho Building 1-12-1, Yuraku-cho Chiyoda-ku, Tokyo 100
November 7-11	International Congress on Heat Treatment of Materials, (3rd)	Shanghai, People's Republic of China	Heat Treatment Institution of CMES P.O. Box 907 Beijing, People's Republic of China
November 14-15	The 4th Mathematical Programming Symposium, Japan	Kobe, Japan	Professor R. Manabe Department of Management Science Kobe University of Commerce 4-3-3, Seiryodai Tarumi-ku, Kobe 655

Date	Title	Site	For information, contact
November 14-20	The 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 15-17	The 4th Congress of the International Society for Artificial Organs-ISAO'83	Kyoto, Japan	The Secretariat, ISAO'83 Intergroup Akasaka-Yamakatsu Building 8-5-32, Akasaka Minato-ku, Tokyo 107
November (tentative)	Conference on Micro-processors	Australia (undecided)	The Conference Manager The Institute of Engineers, Australia 11 National Circuit Barton, A.C.T. 2600
November (tentative)	Metal Structures Conference	Brisbane, Australia	The Conference Manager The Institution of Engineers, Australia 11 National Circuit Barton, A.C.T. 2600
November 28-December 3	International Wheat Genetics Symposium, (6th)	Kyoto, Japan	Dr. S. Sakamoto Faculty of Agriculture Kyoto University Mozume Muko, Kyoto 617
November 29 December 2	The Third Congress of the Federation of Asian and Oceanian Biochemists	Bangkok, Thailand	Dr. Montri Chulavatnatol Department of Biochemistry Mahido University Rama 6 Road Bangkok 10400
November 30-December 2	Symposium on Prediction in Water Quality (SPWQ)	Canberra, Australia	SPWQ P.O. Box 783 Canberra, A.C.T. 2601
December 4-10	International Council on Alcohol and Addictions. 2nd Pan Pacific Conference on Drugs and Alcholism: Drugs and Psychotropic Substances	Hong Kong	Miss Winnifred Mary Ng Hong Kong Council of Social Service Duke of Windsor Social Service Building 15 Hennessy Road Hong Kong

Date	Title	Site	For information, contact
December 6-10	The 2nd International Conference on Chemistry and World Food Supplies	Manila, Philippines	International Rice Research Institute Massachusetts Ave., NW Washington, D.C. 20036
December 11-21	International Congress of Genetics	New Delhi, India	P.O. Box 2841 New Delhi 110060
December (tentative)	The 12th International Laser Radar Conference	Melbourne, Australia	Dr. C. Platt, CSIRO Division of Atmospheric Physics P.O. Box 77 Mordiattoc, Victoria 3195
December (tentative)	Applied Mechanics Conference	Australia (undecided)	The Conference Manager The Institution of Engineers, Australia 11 National Circuit Barton, A.C.T. 2600
December (tentative)	Annual Meeting of the Australian Society for Immunology	Perth, Australia	Executive Officer Australian Society for Immunology P.O. Box 206 Nedlands, W.A. 6009
December (tentative)	The 39th Annual Session of the Sri Lanka Association for the Advancement of Science	Colombo, Sri Lanka	Dr. T. Gunawardhane Sri Lanka Association for the Advancement of Science 120/10 Wijerama Mawatha Colombo 7, Sri Lanka
December (tentative)	International Federation for the Theory of Machines and Mechanisms. 6th World Congress	New Delhi, India	Professor J. S. Rao Indian Institute of Technology New Delhi 110016
December (tentative)	Groundwater '83	Sydney, Australia	Dr. W. Williamson Ibis House 201/211 Miller Street P.O. Box 952 North Sydney, N.S.W. 2060
Undecided	The 13th International Congress of Chemotherapy	Melbourne, Australia	Dr. B. Stratford St. Vincent's Hospital 59 Victoria Parade Fitzroy, Victoria 3065

1984

Date	Title	Site	For information, contact
February 12-16	The 14th Australian Polymer Symposium	Ballarat, Australia	Dr. G.B. Guise P.O. Box 224 Belmont, Victoria 3216
February (tentative)	International Conference on Mesoscale Meteorology	Australia, (undecided)	Royal Meteorological Society Australian Branch P.O. Box 654 Melbourne, Victoria 3001
April 3-5	Tele Conference (tentative name)	Tokyo, Japan	Data Communications Department Kokusai Denshin Denwa Company, Ltd. 2-3-2, Nishi-Shinjuku Shinjuku-ku, Tokyo 160
March (tantative)	Geology, Mineral and Energy Resources of Southeast Asia (GEUSEA V)	Kuala Lumpur, Malaysia	Dr. T.T. Khoo Department of Geology University of Malaya Kuala Lumpur 22-11
May (tentative)	The 5th International Soils Expansion Conference	Adelaide, Australia	The Conference Manager The Institution of Engineers, Australia 11 National Circuit Barton, A.C.T. 2600
June (tentative)	The 4th Congress on World Computing Services Industry	Tokyo, Japan	Japan Software Industry Association Kikai Shinko Kaikan 3-5-8, Shiba-koen Minato-ku, Tokyo 105
July 11-14	The 4th International Drying Symposium	Kyoto, Japan	Dr. Ryozo Kiriei Chemical Engineering Association 4-6-19, Kobinata Bunkyo-ku, Tokyo 112
July 25-28	The 10th International Symposium on Nonlinear Acoustics	Kobe, Japan	Dr. Akira Nakamura, Chairman, The Institute of Scientific and Industrial Research Osaka University 8-1, Mihogaoka, Ibaraki Osaka 567

Date	Title	Site	For information, contact
July 26-30	The 10th International Congress of Biometeo-logy	Tokyo, Japan	Dr. Hiroshi Inaba Juntendo Medical School 2-1-1 Hongo Bunkyo-ku, Tokyo 113
August 19-24	The 13th Congress of the International Commission for Optics	Sapporo, Japan	Dr. Mumpei Tsujiuchi Faculty of Engineering Tokyo Institute of Tech-nology 4259, Nagatsuda-cho Midori-ku, Yokohama Kanagawa 227
August 24-30	The 5th International Congress on Mathematical Education	Adelaide, Australia	Dr. John Mack Department of Mathematics University of Sydney N.S.W. 2006
August 26-31	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
August 26-September 1	International Conference on the Photochemical Combustion and Storage of Solar Energy	Osaka, Japan	The Society of Kinki Chemical Industry 1-8-4, Utsubo-hommachi Nishi-ku, Osaka 550
August 27-September 1	The 9th International Conference on Raman Spectroscopy	Tokyo, Japan	Professor M. Tasumi Department of Chemistry Faculty of Science University of Tokyo 7-3-1, Hongo Bunkyo-ku, Tokyo 113
September 1-7	The 6th International Congress of Virology	Sendai, Japan	Professor T. Ebina Department of Bacteriol-ogy, Medical School Tohoku University 2-1, Seiryo-cho Sendai, Miyagi 980
September 2-7	International Symposium on Snow and Ice Proc-esses at the Earth's Surface	Sapporo, Japan	The Institute of Low Temperature Science Hokkaido University 8-chome, Kita 19-Jyo Kita-ku, Sapporo 060

Date	Title	Site	For information, contact
September 2-8	The XIIth International Biometric Conference	Tokyo, Japan	Dr. T. Okuno Department of Mathematical Engineering and Instrumentation Physics Faculty of Engineering Tokyo University 7-3-1, Hongo Bunkyo-ku, Tokyo 113
September 3-7	The 1st International Conference on Technology of Plasticity	Tokyo, Japan	Japan Society for Technology Plasticity Torikatsu Building, 3F 5-2-5, Roppongi Minato-ku, Tokyo 106
September 10-15	The VII International Symposium on Organosilicon Chemistry	Kyoto, Japan	Dr. Makoto Kumata Faculty of Engineering Kyoto University Yoshida-Honcho Sakyo-ku, Kyoto 606
September 11-14	The 10th International Conference of IMEKO TC-3 (International Measurement Confederation)	Kobe, Japan	Professor T. Ono Department of Mechanical Engineering College of Technology University of Osaka 4-804, Ume-machi, Mozu Sakai, Osaka 591
September (tentative)	Shiga Conference '84 on Conservation Management of World Lake Environment	Shiga, Japan	Department of Civil Life and Environment Shiga Prefectural Government 4-1-1, Kyo-machi Otsu, Shiga 520
October 1-7	Pacific Region Wood Anatomy Conference	Tsukuba, Japan	P.O. Box 16 Tsukuba Agricultural and Forestry Research Institutes Ibaraki 305
October 7-12	The XVIIth International Congress of Internal Medicine	Kyoto, Japan	The Japan Society of Internal Medicine Hongo Daiichi Building, 8F 3-34-3, Hongo Bunkyo-ku, Tokyo 113

1984, continued

Date	Title	Site	For information, contact
October 16-18	1984 International Symposium on Electromagnetic Compatibility (EMC)	Tokyo, Japan	Professor T. Takagi Department of Electrical Communications Faculty of Engineering Tohoku University Sendai, Miyagi 980
October (tentative)	The 3rd Asian Pacific Regional Astronomy Meeting of IAU	Tokyo, Japan	Professor T. Kogure Department of Astronomy, Faculty of Science University of Kyoto Sakyo-ku, Kyoto 606
November 12-15	The Second International Conference on Electrostatic Precipitation	Kyoto, Japan	Professor Senichi Masuda Chairman, The Institute of Electrostatics Japan Sharumu 80 Building, 4 F 4-1-3, Hongo, Bunkyo-ku Tokyo 113
November 22-23	Technology: Past, Present, and Future	Melbourne, Australia	Executive Officer Australian Academy of Technological Sciences Clunies Ross House 191 Royal Parade Parkville, Victoria 3052

1985

Date	Title	Site	For information, contact
February 11-14	International Symposium on Characterization and Analysis of Polymers	Melbourne, Australia	Polymer 85 Royal Australian Chemical Institute 191 Royal Parade Parkville, Victoria 3052
March (tentative)	Annual National Conference of the Institution of Engineers, Australia	Melbourne, Australia	LtCol. J.A. McDonald Secretary, Victoria Division Institute of Engineers, Australia National Science Center 191 Royal Parade Parkville, Victoria 3052

1985, continued

Date	Title	Site	For information, contact
May 20-24	The 3rd Conference on Steel Development	Melbourne, Australia	Australian Institute of Steel Construction P.O. Box 434 Milsons Point, N.S.W. 2061
August (tentative)	Coastal Engineering Conference	Melbourne, Australia	The Conference Manager The Institution of Engineers, Australia 11 National Circuit Barton, A.C.T. 2600
August (tentative)	International Association Hydraulic Resources Conference	Melbourne, Australia	The Conference Manager The Institution of Engineers, Australia 11 National Circuit Barton, A.C.T. 2600
September (tentative)	The 11th International Teletraffic Congress ITC-11	Kyoto, Japan	ITC-11 Committee Musashino Electrical Communication Laboratory 3-9-11, Midorimachi Musashino, Tokyo 180
October 15-18	International Rubber Conference	Kyoto, Japan (tentative)	The Society of Rubber Industry, Japan Tobu Building 1-5-26, Motoakasaka Minato-ku, Tokyo 107

1986

Date	Title	Site	For information, contact
May 11-17	Congress of the International Society of Haematology and the International Society of Blood Transfusions	Sydney, Australia	Dr. I. Cooper, President Haematology Society of Australia Cancer Institute 481 Little Londsdale Street Melbourne, Victoria 3001
September 21-25	The World Congress of Chemical Engineering	Tokyo, Japan	Society of Chemical Engineers Japan Kyoritsu Kaikan 4-6-19, Honhinata Bunkyo-ku, Tokyo 112

1986, continued

Date	Title	Site	For information, contact
Undecided	International Microbiological Congress	Perth, Australia	Australian Academy of Science P.O. Box 783 Canberra, A.C.T. 2601
Undecided	International Institute of Welding Annual Assembly 1986	Tokyo, Japan	Japan Welding Society 1-11, Sakuma-cho, Kanda Chiyoda-ku, Tokyo 101

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