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Science & Technology

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SCIENCE & TECHNOLOGY

JAPAN

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CERAMICS GAS TURBINE ENGINE TO BE TEST DEMONSTRATED BY TOYOTA

43067406P Tokyo CERAMICS in Japanese Jan 88 p 68

[Text] Toyota will test a ceramic gas turbine engine on their new luxury passenger car, "SOALA [phonetic]," in the summer of 1988. New features include:

--burns fuel at 1,400 degrees C

--30 percent better fuel consumption than gasoline

--2 shaft gas turbine engine

--ceramic materials are used for both the turbine and the duct which distributes burning gas evenly around the turbine

--290 HP (improved from 150 HP)

/06662

Laboratory Research Development Updated

Supersonic Wind Tunnel Test

43062010a Tokyo KOGIKEN NYUSU in Japanese Sep 87 pp 4-5

[Article by Takeshi Onuki, New Aircraft Research Group]

[Text] Looking into the future, Group 9 of the new Aircraft Research Group is conducting an aerodynamic study of a new type of aircraft. it is continuing research into the high aspect ratio swept forward wing.

The idea of delaying the resistance divergence at supersonic speeds by inclining the wing to the front or rear can be applied to the sweptback wing as well as the sweptforward wing, and the sweptforward wing is not a particularly new idea. It is said that the characteristics of the sweptforward wing are superior to those of the sweptback wing. For example, the induced drag of the sweptforward wing is small if compared aerodynamically to that of the sweptback wing. The tip stall that an aircraft must avoid is likely to occur in the sweptback wing; by contrast, the sweptforward wing has a tendency to cause root stall. Not many sweptforward wing aircraft have been developed. The reason for this is that there was a problem of aerodynamic divergence in that the angle of incidence of the tip is increased if the sweptforward wing is bent by the dynamic lift, and twist is added. However, with the development of composite material technology in recent years, the increase in weight can be held down and suppression of the divergence has become possible. For these reasons, research into the sweptforward wing has become active again.

We conducted a basic test by inclining a model wing back and forth to make clear the basic aerodynamic characteristics of the membrane filter. Part of the results of this test will be presented here.

The test was conducted at the 2M x 2M supersonic windtunnel of this laboratory. The model is a half-cut one having a chord component section that can be inclined back and forth. The tip is made to be faired to keep a constant aspect ratio of 9.5 in various configurations. Figure 1 shows the relationship between the resistance divergence mach number and the lift coefficient of the sweptforward wing (sweepforward angle 15°, FSW), sweptback wing (sweepback angle 15°, ASW), and the trapezoid wing (sweepback angle 0°, NSW). The resistance divergence mach number at the

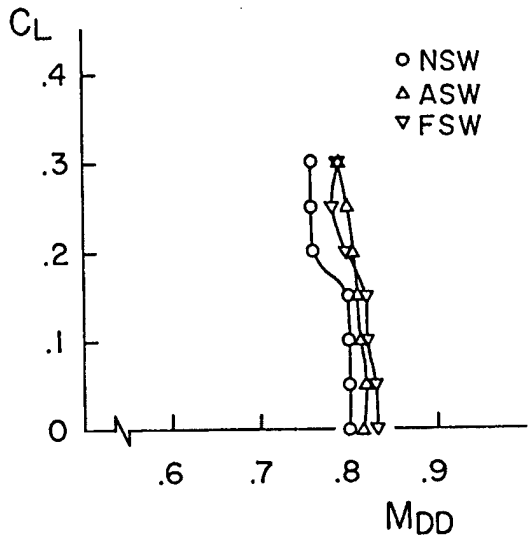

Figure 1. Resistance Divergence Mach Number

time of zero dynamic lift for the sweptforward wing, sweptback wing, and the trapezoid wing is 0.83, 0.815, and 0.80, respectively. The mach number of the sweptforward wing is the largest. Figure 2 shows the equal pressure lines on the top faces of the sweptforward wing and sweptback wing when the mach number is 0.83 and the angle of incidence is 0°. For reference, Figure 2 also shows the same for the trapezoid wing when the mach number is 0.82 and the angle of incidence is 0°. The inclination of the shock wave against the main stream in this case is smallest for the sweptforward wing. Figure 3 shows the ratio of the pressure immediately before the shock wave against the total pressure of the vertical flow to the shock wave in the direction of the wing span. This figure shows the substantial strength of the shock wave, that is, the extent of the wave making resistance. If the ratios of the sweptforward wing and sweptback wing are compared, it can be seen that that of the sweptforward wing is smaller. Further, it can be seen that it does not form a distant shock wave in the inner wing of the sweptforward wing, and the resistance divergence is caused by the shock wave on the outer wing.

It is planned to explore the possibilities of the sweptforward wing by comparing the sweptback wing and the practical sweptforward wing that is to be designed based on the results of this basic test.

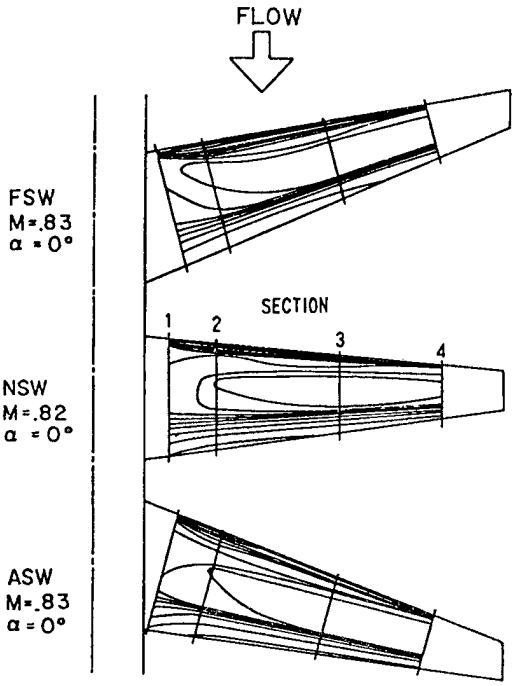

Figure 2. Equal Pressure Line on Top Side of Wing

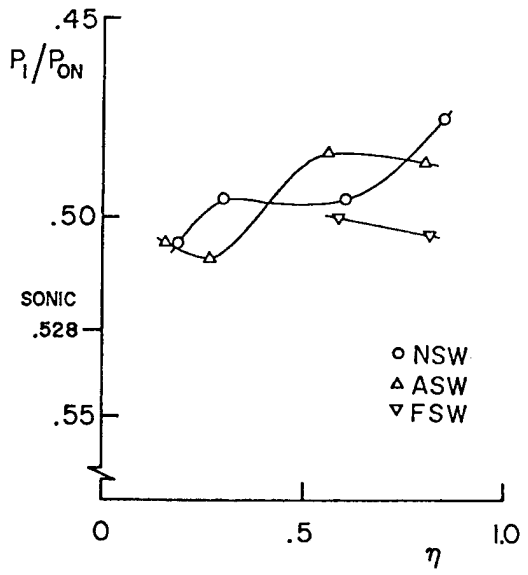

Figure 3. Strength of Shock Wave

Subsystem for Structural R&D

43062010a Tokyo KOGIKEN NYUSU in Japanese Sep 87 pp 5-7

[Article by the individual in charge of NS Structural R&D Subsystem]

[Text] As previously reported (KOGIKEN NYUSU No 331), the numerical simulation (NS) system has been in operation at this laboratory since February 1987, and a structural R&D subsystem (SRS) has been introduced as a part of the NS system to efficiently advance numerical simulation in the aerospace structure fields. The SRS has a fixed disk page printer of SGB, a 2/3D graphic display, an XY plotter, and TSS terminal equipment. It uses the medium general-purpose ACOLS 61010 as the main memory with a capacity of 16MB. In addition, the SRS is high-speed coupled to the main NS system and is also coupled with the PC 9801 system personal computers in the structure-related research rooms in the NA Laboratory operated by the LAN or by the lines.

In Japan's aerospace field, large-scale self-sustained technology development projects such as the STOL and H-II are underway and concept studies for the development of a space shuttle are being advanced. These are giving a new stimulus to the computational structural mechanics (CSM), which are presently suspended in Japan. Structural numerical simulation is a comprehensive technology that forms the nucleus of computation engineering, called CAE, which is a combination of the CSM based on the matrix law and graphic and image processing technology. The following trends have gained worldwide attention over the last several years.

(a) Computation modeling of objects by using a high-degree automatic input cord in combination with the CAD technology.

(b) Challenge to nonlinear and nonstationary phenomena by large models premised on the use of supercomputers.

(c) High-quality post processing including animation processing by adopting image processing technology.

The idea of using (a) and (c) combined with (b) should motivate numerical simulation engineers to carry out technical parametric design studies. These engineers have been dissatisfied with the old mesh generator that has only limited automatic functions for its complicated procedures and with the graphic processing of monochrome drawing.

When introducing the NS system, this laboratory, taking these circumstances into consideration, introduced the SRS system mainly for the purpose of processing the structural analysis section by the main system, making the high-speed large-capacity vector processor the core while at the same time automatically performing the high-degree before-and-after processings not suited to the main system. Therefore, the SRS system is equipped with the preprocessor capacity of the solid modeler and surface modeler and a post-processor that can process animations and images. At the same time, it is essential to conduct high-speed information exchanges with the main system

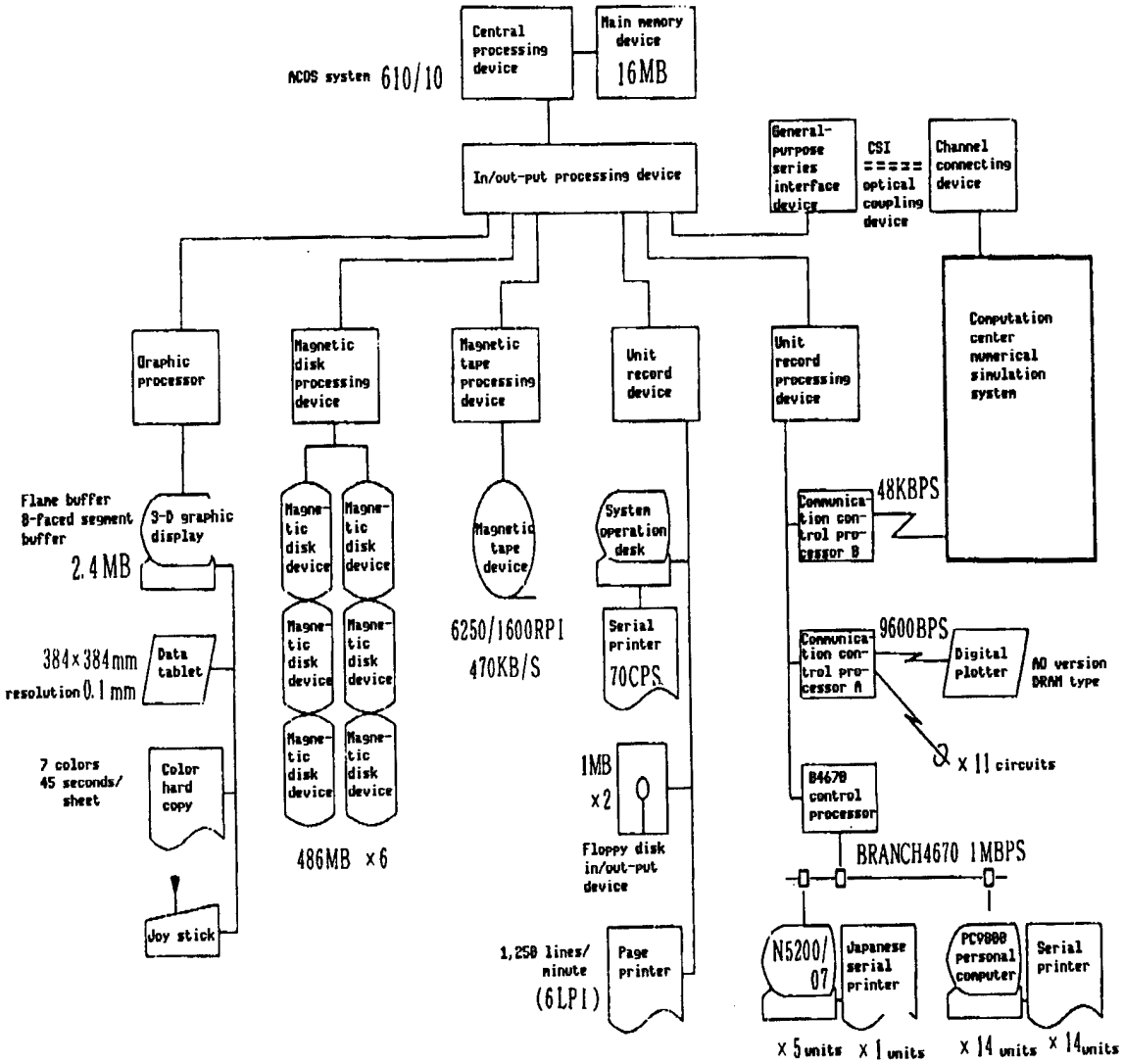

Figure 1. Block Diagram of Subsystem for Structural R&D

and it also provides system support for the terminal equipment possessed in research rooms by having the equipment perform the simple GD function. The use of this system will be enhanced in the future and its effectiveness will be verified by trying to apply it to the H-II project and the development of the ATP blade. Figure 2 [omitted] shows the vibration mode during the opening of the head of the fairing of a large rocket equivalent to the H-II. It is also important to accumulate the CSN technology required for the space shuttle project.

In conclusion, I would like to express my appreciation to the staffs of the Mathematical Analysis Section and the Body First Section who gave us their understanding and cooperation in introducing the SRS system.

20155/9365

VARIOUS AEROSPACE NEWS UPDATED

Aircraft Industry Looks Ahead

43062026 Tokyo AEROSPACE JAPAN in Japanese Nov 87 p 29

[Article: "Society of Japanese Aerospace Companies, Inc. Investigates 'Long Term Outlook'" in column: "The Aircraft Industry"]

[Text] On 28 September the Society of Japanese Aerospace Companies, Inc. held the first meeting of the "Kokuki Kogyo Choki Tenbo Chosa Iinkai" [Committee to Examine the Long-Term Outlook for the Aircraft Industry] and, in addition to electing Tokyo University Professor Emeritus Hiroshi Nakaguchi as committee chairman, deliberated on such matters as the basic policy for the study which is to be conducted.

The Society has conducted a few studies in the past on the aircraft industry's long-term vision, long-term plan and long-term outlook, and its previous research report of FY83 discharged a role as basic material for the present Kokuki Kogyo Shinkoho [Aircraft Industry Promotion Act] and establishment of the new system of assistance. The Society presents an outline concerning such matters as the significance of this time's long-term view as follows.

1) Recently there has been conspicuous progress in aircraft technology and industry in advanced countries; moreover developing nations too are concentrating their efforts on the fostering of aircraft industry as a national policy, and are catching up rapidly. It will be difficult from now on to maintain our ranking in the world, and develop it, unless Japan, too, attempts development of the aircraft industry without delay.

2) It is considered that the aircraft industry should bear part of the burden in the conversion of Japan's industrial structure. Under this kind of perception, it is necessary to conduct a long-term view of the proper form of Japan's aircraft industry. Based on this opinion, the Society has established a committee in order to accurately grasp the present state and trend of the Japanese aircraft industry and those of major foreign powers, to investigate and discuss what the future development of Japan's aircraft industry should be, and to make proposals which will establish a direction for the aircraft industry.

3) The committee started out with approximately 40 members: in addition to a representative of each firm which is a member of the Society, it is made up of persons of learning and experience, financial institutions and the like, and MITI-related persons as observers. Furthermore, it has been arranged to establish a research subcommittee as a subordinate organization, and to have it carry out such work as collection, analysis and discussion of material and creation of reports. Somewhat over 30 persons have been decided on for this subcommittee too, with Professor (Megumi) Sunakawa of Tokyo University's Faculty of Engineering as chairman.

4) The items to be researched and discussed will be structured as (1) trends in the environment surrounding the aircraft industry, (2) trends in the world aircraft industry, (3) future outlook and tasks for Japan's aircraft industry and (4) conclusion.

5) The tentative target date for the term of the investigation is the end of FY87, but an extension of a few months is also possible.

Planned Satellite Launchings

43062026 Tokyo AEROSPACE JAPAN in Japanese Nov 87 p 30

[Article: "Planning Targets for Satellite Launchings" in column: "Space Development"]

[Text] The Science and Technology Agency has arranged the planning targets for space development; an outline follows:

1. The 15th science satellite (ASTRO-D) will be launched in FY92 by means of an M-3S II rocket.

2. The 1-D marine observation satellite (MOS-1b) [as published] will be launched in FY89 by means of an H-1 rocket.

3. The launching of the earth resources satellite (ERS-1) will be changed from FY90 to FY91.

4. The (ADEOS) will be launched by means of an H-II rocket in FY93.

5. The number 5 geostationary meteorological satellite (GMS-5) will be launched by means of an H-II rocket in FY93.

6. The first International Microgravity Laboratory (IML-1) will be put into operation in FY90, and equipment for experiments will be loaded on board.

7. The first launching of an experiment-module for installation on a space station (JEM) will be changed from FY94 to FY95.

8. The number 1 test-model of the H-II rocket will be launched in

FY91 carrying a payload used to verify its performance. Furthermore, the number 2 test-model will be launched in FY92 carrying the technology-testing satellite VI (ETS-VI).

9. An experimental data-relay and tracking satellite (EDRTS) will be launched by means of an H-II rocket in FY94.

Development of Space Technology

43062026 Tokyo AEROSPACE JAPAN in Japanese Nov 87 p 30

[Article: "Ministry of Transport's Development of Space Technology" in column: "Space Development"]

[Text] On 18 September the Council for Transport Technics made an interim report on "The Ideal Way to Develop Space Technology in the Ministry of Transport." The Ministry of Transport held that in regard to space development it is necessary to make clear the guiding principles of development concerning (1) development of new satellite systems, (2) use of space platforms and space stations and (3) coming to grips with transport activities in space, and examined the ideal way to do it. Among these, the interim report this time stated a necessity for combining satellite systems; the essential points are as follows:

1) Development of satellites which combine multipurpose functions has become possible because of recent development of such technologies as space technology, electronics, communications technology and rocket technology. Furthermore, because of common use of the satellite bus and so on, combining of satellite functions not only has an economic advantage over launching separately rockets which correspond to each objective, importance must be attached to it also from the viewpoint of efficient use of geostationary satellite orbit positions.

2) The needs of many transport-related fields for use of satellites are in the process of maturing, and there are also encouraging factors in the trend of development of technology in response to this, so it is thought that development of a transport-related, multipurpose satellite system is fully worthy of study. Since this multipurpose satellite system is a Japanese venture, it is thought that development will require at least about 10 years; but when one considers the increase in the need to use satellites both in Japan and abroad, it is necessary to study that integration with the era of launching weather satellites, which is assumed to begin around 1995, as the target.

Novespace Agency in Japan

43062026 Tokyo AEROSPACE JAPAN in Japanese Nov 87 p 30

[Article: "Novespace Establishes Agency in Japan" in column "Space Development"]

[Text] France's Novespace Corporation has concluded an agency contract with Japan Eurotech, and agreement has been reached on promoting transfer of technology between Japan and France. Taking this opportunity, Novespace President Jean-Pierre Fouquet came to Japan, and held a press conference and a seminar on 7 October.

Novespace is a public enterprise which was established by France's National Space Development Center (CNES) with capital participation by the Agency for Application of Technology (NVAR) and eight French banks; its prime object is to cause the CNES's leading-edge space technology to be transferred and applied to the public welfare. The technologies to be transferred are such things as the optics, electronics, new materials, machines, process technology, computer software, and management systems which have accumulated in space development; and it is considered possible to transfer them to diverse fields.

Moreover, it is said that Japan Eurotech, which has become the agent, will not stop at a one-sided introduction of technology from France, but plans, conversely, to go on introducing the excellent technology and products of Japanese enterprises to French space-related enterprises via Novespace.

Three-hundredth Rocket Launched

43062026 Tokyo AEROSPACE JAPAN in Japanese Nov 87 p 30

[Article: "Three Hundredth Rocket Launched at Kagoshima" in column "Space Development"]

[Text] At 11 am on 9 September the Ministry of Education's Institute of Space Science launched the 47th MT-135 weather observation rocket from the Kagoshima Space Observatory at Uramachi in Kagoshima prefecture, and succeeded in making observations at an altitude of 60 kilometers by means of observation devices loaded therein. Furthermore, the 48th rocket of the same model was launched at 1 pm on the same day, and was the 300th rocket launched from the Kagoshima Observatory.

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Revised Launching Date Announced

43062047 Tokyo AEROSPACE JAPAN in Japanese Nov 87 p 29

[Summary] The Science & Technology Agency announced the following changes to Japanese launch schedules:

1. ASTRO-D launched by H-II in FY 1992.
2. MOS-1b by H-I in FY 1989.
3. ERS-1 in FY 1991.
4. ADEOS by H-II in FY 1993.
5. GMS-5 by H-II in FY 1993.
6. Engineering test device will be placed on the IML-1 in FY 1990.
7. JEM will be launched with the space-station in FY 1995.
8. H-II No. 1 payload capability test in FY 1991.
   Test No. 2 with ES-VI in FY 1992.
9. EDRTS by H-II FY 1994.

/09599

Biosensor for Cell Detector System Developed

43066606 Tokyo BIO INDUSTRY in Japanese Jun 87 pp 13-19

[Article by Tadashi Matsunaga, assistant professor of Engineering at Tokyo University of Agriculture and Technology: "Use of Cell Cortices--Development of Biosensors"; first paragraph is editorial introduction]

[Text] Cell cortices of microorganisms, animals, and plants are covered with cell walls and cell membranes, and have a complex structure. I describe the use of biosensors employing cell cortices made by combining electrode reaction on cells with differential elements such as antibody, porin, and cell wall of these cell cortices. In addition, I explain the measurement of phosphoric acid compounds, and the discrimination of cells, antigens, and antibodies as examples to which cell discriminating sensors are applied.

1. Preface

Up to now, various sensors have been devised by regarding the enzyme, antibody, antigen, organelle, microorganism, and animal and plant cells as differential elements, and it has been shown that these biosensors can be applied to the instrumentation of various chemical substances extending from low molecules such as glucose to high polymer molecules such as protein. Up to now, of the biosensors, the microbial sensor and the animal and plant sensor were based on a principle in which the oxygen forming electrode activators are measured by using the electrode, and the respiratory and metabolic reactions of cells.

By the way, cell cortices of microorganisms, animals, and plants are covered with cell walls and cell membranes, and have a complex structure. In addition, the structure varies according to the type of cells. For example, there is a great difference between the structure of cell cortices of gram-positive bacteria and gram-negative bacteria. As shown in Figure 1, biodifferential elements which selectively discriminate the sugar antigen, porin, and membrane-bound protein, exist locally in cell cortices of microorganisms. Differential elements of these cell cortices can each selectively discriminate the antibody, ion, and sugar.

The author, et al., have demonstrated that electric signals can be obtained directly from cells by clarifying an electron transfer reaction between

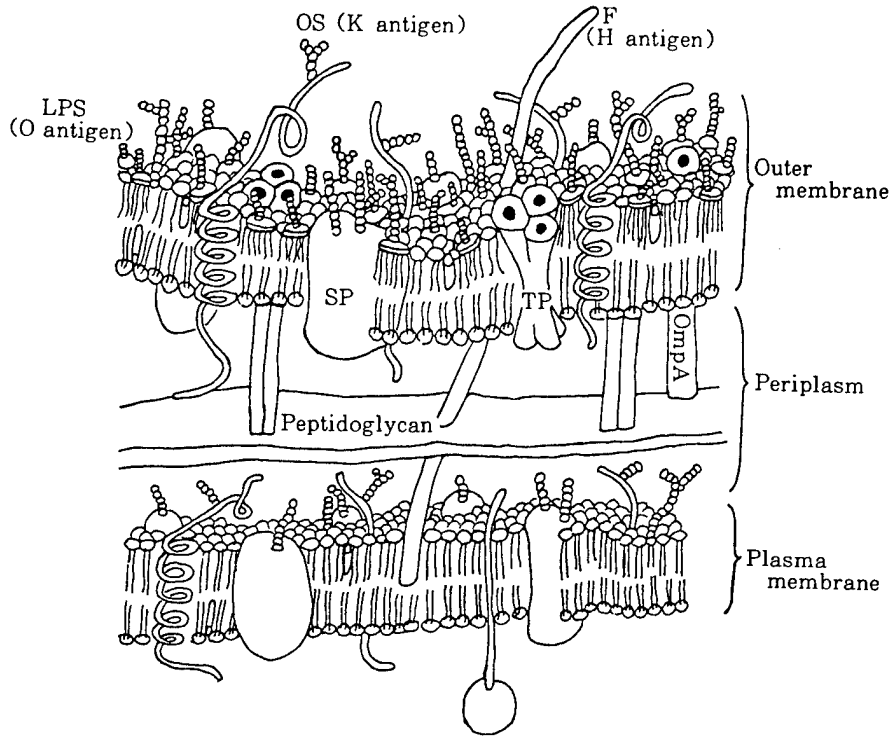

Figure 1. Typical Drawing of Cell Cortices of Gram-Negative Bacteria
F: flagellum; LPS: lipopolysaccharide; OmpA: adventital protein A; OS: oligosaccharide; SP: spherical protein (enzyme binding protein, etc.); TP: porin (OmpC, F, PhoE), as a trimer.

cells and electrode. So, we have developed biosensors using cell cortices by combining the electrode reaction of cells with differential elements such as porin, antibody, and the cell wall of cell cortices, and have applied these biosensors to the discrimination of cells, the detection of antigens and antibodies, and the measurement of phosphoric acid compounds.

2. Electrode Reaction of Cells

The electrode reaction of cells was studied by using the platinum, gold, HPG (high purity graphite), and BPG (basal plane pyrolytic graphite) electrodes.

A cell detecting system consisting of potentiostat, function generator, and X-Y recorder was made by using these electrodes as active electrodes for detecting cells, a platinum wire as a counter electrode, and an SCE (saturation calomel electrode) as a reference electrode and by putting them into the H-type cell as a reaction cell.

As a result, the background current value was large in all the platinum, gold, and HPG electrodes, and the peak current was not seen clearly therein, but as shown in Figure 2, the current caused by direct reaction between cells and the BPG electrode was clearly achieved in the BPG

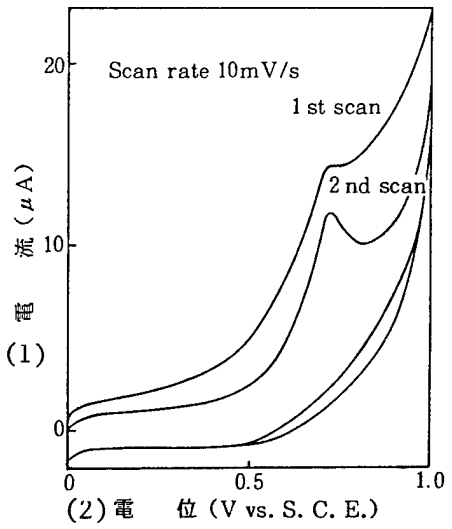

Figure 2. Cyclic Voltammogram of Gram-Negative Bacteria
A cyclic voltametry for Escherichia coli (1 x 10^8 cells) was carried out in 0.1 M phosphoric acid buffer solution at a scanning speed of 10 mV/sec.

Key: (1) Current (μA)
(2) Potential (volt vs. SCE)

electrode. In addition it is clear that the substance which carries the electron transfer reactions between cells and electrodes is an intracellular coenzyme A (CoA).

Also, as a result of applying 4.4'-bipyridyl modified-BPG electrode to an electron transfer reaction between cells and electrodes, the peak current obtained from yeast, Saccharomyces cerevisiae was increased about 1.5 to 2 times. This fact has clarified that the 4.4'-bipyridyl promotes the electron transfer reaction. In addition, as a result of investigating a relation between peak current value and the number of cells by using a BPG electrode, it has been shown that the relation is linear in an interval between 10^6 to 10^9 cells $m\ell^{-2}$, and it is possible to detect cells by using this method.

This electrode could be applied to detect other microorganisms, B-cell, T-cell, macrophage, and cancer cells, as well as yeast. In addition, electron reactions of suspension components could be removed by using a system which directly installs somata adsorbed and immobilized on a membrane filter, on an electrode. Also, high detecting accuracy and reproductivity could be obtained, because it has become possible to detect cells, even if the number of necessary somata is small.

3. Cell Discriminating Sensor

3.1 Discrimination Between Gram-Positive and Gram-Negative Bacteria

Most of the gram-negative bacteria in enteric bacteria are pathogenic, and it is medically important to make a discrimination between gram-positive and gram-negative bacteria among enteric bacteria. So the development of a new sensor has eagerly been sought, because conventional methods are complex and take a long time. The new sensor must be able simply and promptly to make such discriminations and to measure the number of bacteria. Accordingly, such a discrimination was tried by using a cell detecting system based on voltametry using the previously mentioned BPG electrode. Figure 3 shows an outline drawing of the system.

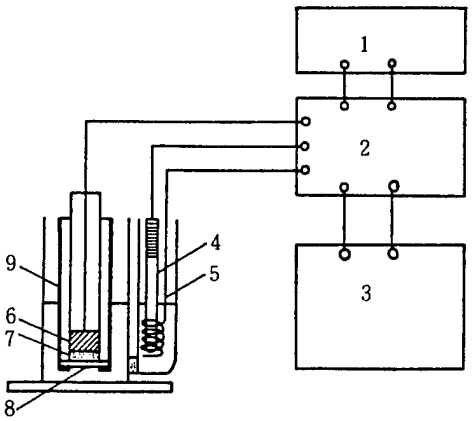

Figure 3. Cell Discriminating Electrode System

Key:

1. Function generator
2. Potentiostat
3. X-Y recorder
4. Reference electrode (SCE)
5. Counter electrode (platinum wire)
6. Active electrode (BPG)
7. Cell
8. Membrane filter
9. Holder

The following gram-positive and gram-negative bacteria were aerobically cultivated at a temperature of 37°C for 18 hours in a Rogosa agar medium. The gram-positive bacteria are the Lactobacillus acidophilus, L. fermentum, L. casei, Staphylococcus aureus, Sta. epidermidis, Streptococcus sanguis, Str. equinus, and Str. mitis. The gram-negative bacteria are the Escherichia coli, Salmonella typhimurium, and Proteus vulgaris. After cultivation, the respective colonies were gathered and immobilized on a membrane filter. The peak potential and peak current of the primary and secondary waves were measured by immobilizing bacteria on a membrane filter, by directly installing the membrane filter on the surface of the BPG electrode, by using a platinum wire as a counter electrode and SCE as a reference electrode, and by carrying out a cyclic voltametry in 0.1M phosphoric acid buffer solution (pH 7.0) within a range of 1 to 1.0 volt (vs. SCE).

As a result of carrying out a cyclic voltametry for a gram-positive bacterium, L. acidophilus and a gram-negative bacteria, E. coli, oxidized waves could be obtained from the former bacterium at 0.68 volt (vs. SCE) and from the latter at 0.72 volt (vs. SCE), respectively, but no reduced wave could be detected. The peak current value of primary waves of a cyclic voltammogram was 0.21 μA per 10^8 cells in the case of the E. coli. From the above results, it could be estimated that the peak current value and the peak potential of gram-negative bacteria were higher than those of gram-positive bacteria.

Also, making a comparison between the peak current value of secondary and primary waves, the former was more than 80 percent of the latter in the case of the E. coli, while the former was less than 50 percent of the latter in the case of the L. acidophilus. The peak current could be seen in other gram-positive bacteria within a range of 0.64 to 0.68 volt (vs. SCE), and the proportion of the peak current value of the secondary waves to the primary waves was 27 to 47 percent. In the same way, that could be seen in other gram-negative bacteria within a range of 0.70 to 0.78 volt (vs. SCE), and the proportion of peak current value was 80 to 91 percent.

The above results are shown in Table 1.

Table 1. Peak Potential and Peak Current Value of Primary and Secondary Waves of Various Enteric Bacteria

Strain	Peak potential(V vs the SCE)	Peak current (μA/10^8cells)		B/A (%)
		Scan 1 (A)	Scan 2 (B)	
Gram-stain positive				
Lactobacillus fermentum	0.66 ± 0.02	0.27	0.12	44
Lactobacillus acidophilus	0.66 ± 0.02	0.21	0.08	38
Lactobacillus casei	0.66 ± 0.01	0.21	0.08	38
Streptococcus equinus	0.66 ± 0.01	0.19	0.04	47
Streptococcus mitis	0.65 ± 0.01	0.27	0.09	33
Streptococcus salivarius	0.66 ± 0.01	0.42	0.15	36
Streptococcus sanguis	0.68 ± 0.01	0.45	0.12	27
Staphylococcus aureus	0.67 ± 0.01	0.33	0.13	38
Staphylococcus epidermidis	0.68 ± 0.01	0.47	0.19	40
Gram-stain negative				
Escherichia coli	0.71 ± 0.01	1.25	0.99	80
Proteus vulgaris	0.72 ± 0.02	0.81	0.74	91

From the above results, it has been clarified that a discrimination between gram-positive and gram-negative bacteria in enteric bacteria can be made in a short time by electrochemically measuring the peak potential and the proportion of the peak current value of secondary waves to that of primary waves.

3.2 Discrimination of Animal Cells

(1) Discrimination of lymphocytic cells

It is well known that there is a correlation between disease change and quantity of T-lymphocytes, B-lymphocytes, and basophils which control immune responses. But discriminations between cells have been made, and the number of these cells has been measured by using rosette formation reactions because it is difficult to make these discriminations based on shape. This method requires skilled techniques, because it is accompanied by intricate operations. For this reason, the development of a new sensor is desired, one which is able promptly to measure the number of cells of T-lymphocytes, B-lymphocytes, and basophils in blood.

Accordingly, the basophils, T-lymphocytes, and B-lymphocytes were detected and discriminated by using cyclic voltametry.

Basophil, RBL-1 cells were cultivated at a temperature of 37°C. using 5 percent Co_2 and a culture medium having 90 percent MEM-Earle and 10 percent FBS (fetal bovine serum). Cultivated cells were adsorbed and immobilized directly on a membrane filter, and then installed directly on the surface of a BPG electrode. A cyclic voltametry for the cells was carried out in phosphoric acid buffering physiological saline (pH 7.0) by using active electrodes of platinum wire as a counter electrode and SCE as a reference electrode. Leukocytes such as mouse-T and B-lymphocyte were subjected to the same experiment.

As a result of carrying out a cyclic voltametry for basophil suspension, a peculiar peak current was achieved in the vicinity of 0.34 to 0.35 volt (vs. SCE). Also the only peak potential of 0.64 to 0.65 volt (vs. SCE) was got in the T- and B-lymphocytes. It was confirmed that there was a correlation between intracellular CoA and the peak current value at 0.64 to 0.70 volt (vs. SCE) obtained from various leukocytes, and it was estimated that the CoA was a medium caused by an electron transfer reaction between electrode and cells in this potential.

Also, the peak potential of serotonin which is one of the basic granule components is 0.27 volt (vs. SCE), which was almost equal to that obtained from supernatants of cells treated with ultrasonic waves. From this result, it was believed that the peak potential of 0.34 to 0.35 volt (vs. SCE) obtained from basophils had changed in appearance, because serotonin was confirmed within the granules of phospholipid membranes and the cytoplasmic membranes of these basophils. Actually, taking only the basic granules out of the cells, the peak potential was measured at 0.30 volt (vs. SCE).

Also, it was confirmed that the relation between the number of cells and the peak current value was linear within a range of 0.4 to 10^5 to 3 x 10^5 cells.

From these results, it was shown that discriminations between cells by electrodes can be done by using the difference among intracellular

electrode activators as well as by using CoA in cell walls. In other words, it has been clarified that it is possible to discriminate basophils from other leukocytes by using the difference between peak potentials, and the number of cells can be measured by using the peak current value.

(2) Discrimination of cancer cells

Mouse ascitic cystohepatic cancer cells were also subjected to the same experiment as the above one.

The peak potential was 0.65 to 0.67 volt (vs. SCE) in mouse ascitic cystohepatic cancer cells. This value has clarified that there is a tendency for the peak potential of cancer cells to be slightly higher than that of other, normal cells. Also, CoA could be inferred to be an electrode activator in cancer cells.

In addition, the investigation of the relation between the number of mouse ascitic cystohepatic cancer cells and peak current value showed it was linear within a range of 0.8×10^5 to 3×10^5 cells.

3.3 Cell Discrimination Using an Antibody Modified With Dopamine

As mentioned up to now, it has been shown that it is possible to discriminate cells of microorganisms and of some animals from those of others by using electrodes. In addition, a cell discrimination was made by using an antibody modified with dopamine to make discriminations at the level of species or lower.

It has become possible to measure the number of antibodies by using electrodes, because the peak potential value could be seen in the vicinity of 0.15 to 0.27 volt (vs. SCE) in the antibody modified with dopamine, an electrode activator. So after adding 10^9 cells such as Escherichia coli, lactic acid bacteria, and yeast to 1 mℓ of serum solution modified with dopamine, the peak current value of supernatants was measured (Table 2).

Table 2. Peak Current Values Obtained From Supernants of Serums (Anti-Escherichia coli K-58 Serum) Modified With Dopamine After Addition of Bacteria

Strain	Peak current (μA)
Escherichia coli	
IID - 561	0.5
K - 12	2.3
Lactobacillus acidophilus	2.5
Saccharomyces cerevisiae	2.3

Cell numbers : 1.0×10^9 cells

As a result, it was confirmed that the peak current value of the only cell (Escherichia coli IID 561) holding the K-58 antigen was decreased by about 2 μA, and this cell could be selectively discriminated even at the level of

genus or species from others not holding the K-58 antigen. In addition, an investigation of the detection limit of cells confirmed that the reduction of the peak current value was proportional to the logarithm of the cell concentration, and was linear within a range of 10^7 to 10^9 cells per mℓ.

This fact indicates that the instrumentation work can be carried out at a high sensitivity which is 1,000 times that for the case of no use of any modified antibody. It was surmised that this was because the antibody modified with dopamine showed an antigen-antibody reaction on cells having the K-58 antigen, and the dopamine combined with the antibody was removed together with these cells from solution.

From this result, it has been confirmed that cell discriminations can be made selectively at a high sensitivity by combining antibodies modified with dopamine with each other.

4. Antibody Sensor Using Sugar Antigens of Cell Cortices

4.1 Escherichia Coli Antibody Sensor

Before diagnosing patients for microbism, it is important to measure the very small number of antibodies existing in serums. So the measurement of Escherichia coli antibodies was studied by using sugar antigens of Escherichia coli and by directly measuring the change as an electric signal generated in cells for the case when Escherichia coli shows an antigen-antibody reaction.

After adding the anti-Escherichia coli K-58 serum to the suspension of Escherichia coli, a cyclic voltametry was carried out by adsorbing and immobilizing somata on a membrane filter.

When serums containing K-58 antibodies were added to the Escherichia coli IID 561 strains holding K-58 antigens, the peak current value was decreased by about 40 percent i.e., from 1.00 to 0.65 μA, but when those were added to the Escherichia coli C 600 strains not holding any K-58 antigens, no decrease at all could be seen in the peak current value. Therefore, it has been shown that this reaction is selective. Also, when other serums were added to such Escherichia coli IID 561 strains, the peak current value was almost 1.00 μA, and no decrease could be seen in this peak current value. In addition, as shown in Table 3, various antibodies exist in the Escherichia coli IID 561 strains, but when K-58 antigens are present, a decrease in the peak current value could be seen.

From this result, it has been shown clearly that the decrease of the peak current value shows the selectivity corresponding to an antigen-antibody reaction. The occurrence of such antigen-antibody reactions will cause the change of cell walls and will readily elute CoA. For this reason the decrease of the peak potential and the peak current value was inferred. Also, it has been shown that the relation between the decrease of the peak current value and the concentration of antibodies is proportional and the number of antibodies contained in serums can be estimated from the decrease of the peak current value.

Table 3. Peak Current Values Obtained From Escherichia coli IID-561 in Case of Addition of Various Antibodies

Antibody	Peak current (μA)
None	1.00
Anti - *Escherichia coli* (K60, K61 K62, K63 K73)	0.96
K51, K90	1.04
(K58, K51 K90)	0.57
Anti - *Streptococcus* group D	1.14

Strain ; *E. coli* IID 561
Cell numbers : 1.0×10^8 cells

These results have suggested that it is possible to simply detect specific antibodies contained in serums of the high sensitivity within a short time by using the electrode reaction of cells having antigens of cell cortices.

4.2 Allergy Sensor

It is believed that immediate allergies such as allergic rhinitis and asthma are caused by mainly IgE (immunoglobulin E) antibodies produced in vivo against allergens. For this reason, in clinical medicine, it is important to detect and quantify IgE contained in blood in order to diagnose patients for allergies.

The concentration of IgE contained in blood is very low, and at present, the RIST (radioimmunosorbent test) and double antibody technique, are most frequently used to measure this concentration. However, a new sensor which can measure it simply has been required, because all the methods require radioactive elements, and their operations are complex.

Accordingly, the detection of IgE contained in blood was studied by using a sensor employing basophils having IgE receptors in differential elements of cell cortices. Figure 4 shows the principle of an allergy sensor. The RBL (rat basophilic leukemia)-1 was used as a basophil having IgE receptors.

A peculiar peak current could be seen in the vicinity of 0.34 to 0.35 volt and 0.68 to 0.70 volt (vs. SCE) in a cyclic voltammogram obtained from RBL-1 cells. On the contrary, the peak potential obtained from these RBL-1 cells combined with IgE was decreased to 0.31 to 0.34 volt , and the peak current value was also decreased by about 30 percent. It is believed that this is because the combination of IgE antibodies with IgE receptors on cytoplasmic membranes has changed the structure of these cytoplastic membranes and has changed the permeability of the cytoplastic membranes of basic granules.

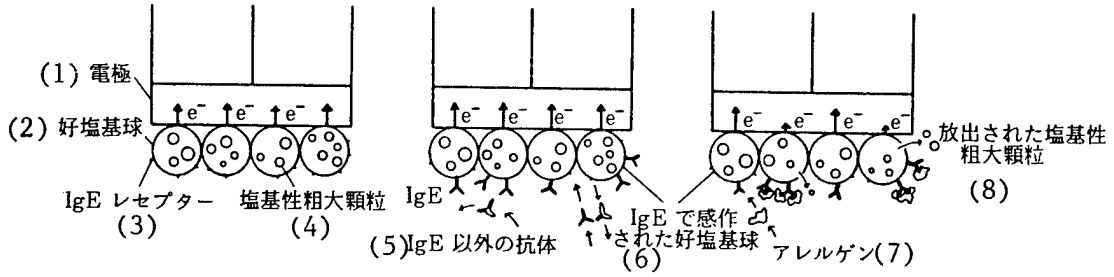

Figure 4. Conceptual Drawing of IgE and Allergen Based on Biosensors Using Basophils Having IgE Receptors

Key:

1. Electrode
2. Basophil
3. IgE receptor
4. Basic coarse granule
5. Antibody other than IgE
6. Basophil sensitized with IgE
7. Allergen
8. Discharged basic coarse granules

In addition, when DNP (deoxyribonucleo-protein) antigens reacted on IgE sensitized cells, the peak current value was 0.20 μA per 10^5 cells, which was decreased by about 50 percent against cells which have not acted on any substances.

The above results have made it clear that IgE contained in blood can be detected by using electrode reactions of basophils having IgE receptors, and antigens (allergens) corresponding to the IgE can be detected with the reduction of the peak potential and peak current value.

5. Phosphoric Acid Composed Sensor Using Porin of Cell Cortices

Porin in a porous protein exist in the outer membranes of gram-negative bacteria, and is concerned with the permeation of low molecular substances. The permeation of substances due to porin is selective, and is controlled by two factors, molecular weight and electric charge.

At least six kinds of porins, OmpC, OmpF, PhoE, ProteinK, Protein2, and NmpC exist in Escherichia coli. Of the six porins, the OmpC and OmpF have the cation selective permeability. Also, the PhoE has a molecular weight of about 37,000, exists as a trimer, and has the phosphate anion and phosphoric acid compound selective permeability.

Author, et al., have made an electrode modified with phospholipid double membranes containing PhoE porin for the purpose of manufacturing phosphate anion and phosphoric acid compound biosensors with high sensitivity.

As a result of carrying out a cyclic voltametry for FMN (flavin mononucleotide) by using a BPG electrode modified with lipid membranes containing PhoE porin, the reduction peak was observed at -0.48 volt and -0.56 volt (vs. SCE) and the oxidation peak was observed at -0.52 volt (vs. SCE). But, neither reduction peak nor oxidation peak could be seen in

electrodes modified with lipid membranes containing no porin. Also, as a result of carrying out a cell cortices for riboflavin which is a compound made by removing a phosphate radical from FMN, neither reduction peak nor oxidation peak intrinsic to riboflavin could be seen in both electrodes regardless of the existence or absence of PhoE porin in membranes.

Of the anions, the PhoE porin selectively permeates the only compounds having a phosphate anion. That is, it has been clarified that phosphoric acid compounds can be selectively detected with lipid membranes containing a porin.

6. Conclusion

I have mainly described biosensors using cell cortices, cell discrimination, detection of antigens and antibodies, and measurement of phosphoric acid compounds.

Research on biosensors using cell cortices has taken its first step, at last. It is believed that if the structure of cell cortices of microorganisms, animals, and plants is clarified and the antigen and antibody reactions and the selective permeation of substances due to these cell cortices are clarified in the future, their applications will spread increasingly. Also, these methods of directly converting cell responses into electric signals will probably be useful to explain the mechanism of immune responses and allergies.

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PRACTICAL ULTRA-LOW HEAD HYDROELECTRIC POWER GENERATION

Tokyo TSUSAN JANARU in Japanese Aug 87 p 73

[Article: "Development of Practical Ultra-Low Head Hydroelectric Power Generating Technique"]

[Text] The effective use of hydroelectric energy, which is noncontaminant and produced solely domestically, is in growing social demand. Few of the economically advantageous high- and medium-head sites, once central to hydropower generation, now remain to be developed. Low-head sites with heads of less than 20 m, once deemed to be disadvantageous, are, thus, becoming central to hydropower development in Japan and other advanced industrial nations. Lately, many valve-type water wheels and generators having horizontal shaft axial flow runners with movable vanes are being used for these sites.

At these low-head sites, however, the power plant output is relatively small and the generating cost is rather high. To further their development, therefore, it is important to cut not only the cost of generating equipment but the cost of the entire power plant including its civil engineering cost. Because of this, the Electric Power Development Co. and the Fuji Electric Co., Ltd., are conducting jointly the Development of Practical Ultra-low Head Hydroelectric Power Generating Technique with a view to making practical use of the straight-flow water wheel and generator which can be used for a more ultra-low head zone (heads: 2-3 m) than the head zone for which the valve-type water wheel is designed. This makes the whole power plant compact and may well reduce the construction cost drastically. The straight-flow water wheel and generator characteristically has the generator rotor provided in a ring around the water wheel runner and has movable runner vanes (Figure 1). This development is being conducted as a 3-year project from FY 1985 with a grant-in-aid from the New Practical Power Generating Techniques Development Fund.

The details of this research and development are as follows:

(1) Research and development of the basic structure of the straight-flow water wheel and generator

The key points of the development are the structure of the generator rotor, the structure of the rotor support bearings, and the drive mechanism for the runner vanes of a water wheel and generator having three runner vanes suitable for ultra-low heads.

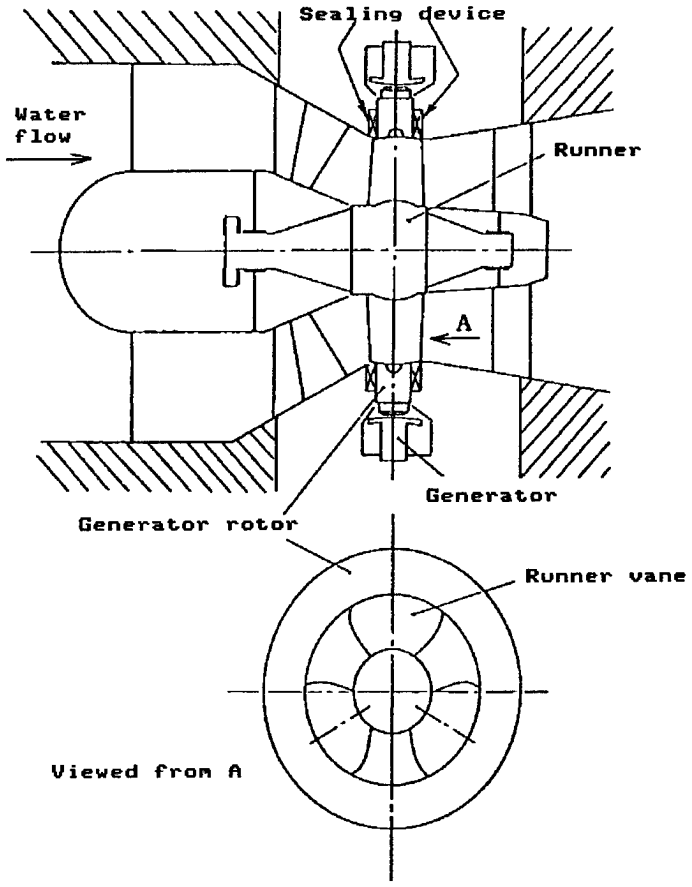

Figure 1. Conceptual Diagram of Straight-Flow Water Wheel and Generator

(2) Research and development concerning the sealing device

A super-size, high-peripheral-speed sealing device will be developed for provision in the generator rotor center peculiar to this water wheel and generator. This development consists of a basic test to select a sealing material and performance confirming tests using a sealing device model with the same structure as the real machine.

(3) Performance confirming tests by model water wheel

A model water wheel is manufactured and various tests including an efficiency test are conducted with it to confirm the performance of the water wheel as to the water wheel shape obtained by research and development.

This research and development, based on the technique of the valve-type water wheel and generator that have already become practical, takes full advantage of the design, manufacture, installation and maintenance accumulated by the two companies with abundant experiences in this area.

The results of this research will not only render possible the extensive development of ultra-low head hydropower sites, which thus far have never been objects of development, but can also be applied to the water wheel and generator for tidal power generation now in the limelight as a large-scale project of the future.

20108/9365
CSO: 43062569

Compound Semiconductor Superlattice Technology Developed

43063816 Tokyo DENSHI ZAIRYO in Japanese Sep 87 pp 6-7

[Article by Editorial Staff: "Development of Manufacturing Technology for Production of Compound Semiconductor Superlattices Using MOVPE"]

[Text] Matsushita Develops Technology Concerning II-VI Group Compound

Matsushita Electric Industrial Co., Ltd.'s Semiconductor Research Center has developed a technology for manufacturing superlattices of group II-VI compound semiconductors by using MOVPE (metal organic vapor phase epitaxy). superlattice refers to a substance made by multilayeredly and mutually laminating ultrathin films with a thickness of less than 100 Å. This technology is characterized by the fact that the pressure is reduced by using methyl-based organic metal as a raw (source) material and the MOVPE is obtained at a temperature (550°C) which is higher than a conventional one (up to 350°C)

A superlattice layer, consisting of 100 ZnSe/ZnS layers, has been formed of III-V group GaAs compound semiconductors using this technology. In addition, the company made a loaded-type optical waveguide using the technology, and succeeded in conducting an experiment on the visible light guide waves of superlattice three-dimensional optical waveguides for the first time by irradiating He-Ne(6,328 Å) laser light from the cleavage end face to the loaded-type optical waveguide. The loaded-type optical waveguide is constructed so that thin films with small refractive indexes can be formed in the shape of a stripe through an optical waveguide on the upper portion of the optical waveguide layers, and waveguide light can be shut under these striped thin films (SiO_2 films in this technology). The above success means that the company will be able to manufacture optical waveguides necessary for OEICs (optoelectronic integrated circuits) by using II-VI group compound semiconductors in the future. Also, the OEIC has come into the limelight as a future technology. The company thinks it will be possible to develop various optical devices of II-VI group compound semiconductors, such as low-loss optical waveguides of short wave semiconductor lasers, based on AlGaAs/GaAs formed on GaAs substrates, etc.

The company has some comments on the developmental background of the technology which will be presented below. III-V group compound semiconductor devices based on GaAs, InP (indium phosphorus), etc., have

rapidly been put to practical use together with the development of epitaxial technologies for compound semiconductors. On the other hand, ti is generally said that II-VI group compound semiconductors based on ZnSe (zinc selenide), ZnS (zinc sulfide), etc., are materials effective for short-wave optical devices, such as the blue semiconductor laser (LD: laser diode), blue LED (light emitting diode), etc., since these II-VI group compound semiconductors have a very wide and direct transition-type band gap and a large nonlinear optical effect, and III-V group compound semiconductors cannot realize the highly-efficient blue semiconductor laser, blue LED, etc. Therefore, the recent development of epitaxial growth technologies for II-VI group compound semiconductors has been carried out enthusiastically by fully utilizing epitaxial technologies accumulated from technologies for III-V group compound semiconductors. III-V group compound semiconductors, which are presently being put to practical use, have a structure in which different materials are laminated. This structure is called a "Hetero Junction Structure." Guide wave light can be shut in specific locations of light and carriers indispensable for electronic and optical devices using the hetero junction structure. However, unlike III-V group compound semiconductors based on AlGaAs/GaAs, practical II-VI group compound semiconductors, used for blue optical devices, etc., have few combinations of different materials which can be used to match lattices. In addition, a problem exists with technology mentioned above in that different substrates must be used to unmatch lattices, because it is difficult to inexpensively obtain good-quality substrates for II-VI group compound semiconductors. Therefore, this technology has not yet been completely established as a technology for forming epitaxial thin films.

We have noted the validity of using technologies for forming SLS (superlattice strain) layers having ultrathin film multilayer structures as a means of freely controlling band gaps and other physical constants in order to obtain a favorable hetero junction structure which can realize blue optical devices, etc.

We will now introduce features of a new technology for forming II-VI group compound semiconductor superlattices. Features of this technology are as follows: 1) an MOVPE unit developed independently by the company is used for the technology; 2) this MOVPE unit employs a load lock system; 3) methyl based-organic metals (for example, dimethyl zinc, dimethyl selenium, etc.) are used as source materials; 4) the growth temperature is 550°C, which is higher than conventional ones (less than 400°C); and 5) the epitaxial growth can be promoted at a pressure reduction of 100 Torr. The load lock system refers to a complete sealing system, and is devised so that a crystal growth chamber does not come into contact with the outside air, even when the crystal growth chamber is taken in and out of crystal growth substrate units. Due to the above features, it has become possible to form high-crystal-forming semiconductor superlattices consisting of 100 layers of ZnSe (50 Å)/ZnS (50 Å).

GaAs is used as a crystal growth substrate for ZnSe and ZnS, dimethyl zinc or dimethyl selenium is used as a source material for ZnSe, and dimethyl zinc, dimethyl sulfur, or hydrogen sulfide is used as a source material for

ZnS. These substances are used to restrain unnecessary reactions generated from gas mixtures caused by crystal growth at reduced pressure. Also, organic metals based on methyl and hydrogen selenide were conventionally used for general use. The growth temperature for the conventional method was less than 400°C, but that for the above-mentioned new method is considerably higher, being 550°C. The use of such high temperatures will bring about epitaxial thin films with sufficiently high crystallization when viewed from the standpoint of photo luminescence.

Next we will introduce the constitution and features of a superlattice three-dimensional optical waveguide manufactured on an experimental basis. Figure 1 shows results of investigating the behavior of the constituent elements, Zn, Se, and S, by means of a SIMS (secondary ion mass spectrum) analyzing method. It can be appreciated that both Se and S show a periodic change, the film thickness estimated from the growth rate accords well with a SIMS profile period, and superlattices with high-controllability are formed by the pressure-reduction MOVPE. Also, judging from the fact that the satellite reflection peak can be seen as ±1 and ±2 on the X-ray locking curves according to the X-ray diffraction and, as shown in Figure 2, the film thickness dependency of a peak emitted from the photo luminescence accords well with a calculated curve, it can be clearly seen that this SLS has a favorable ultrathin film multilayer structure with a quantum size effect.

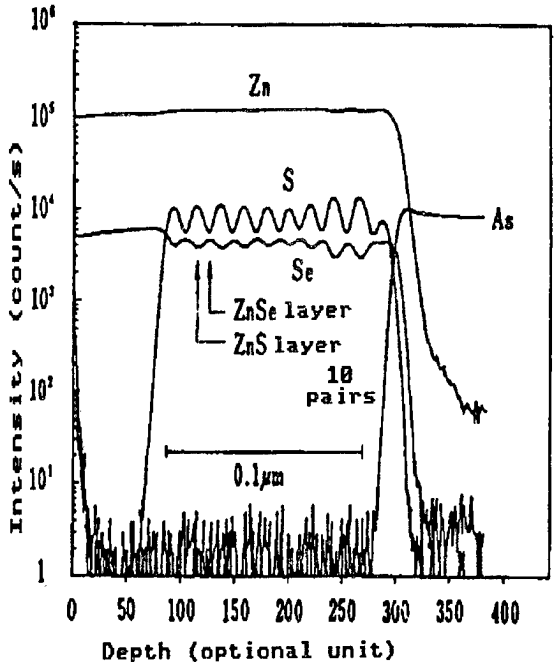

Figure 1. Depth Profiles of Elements

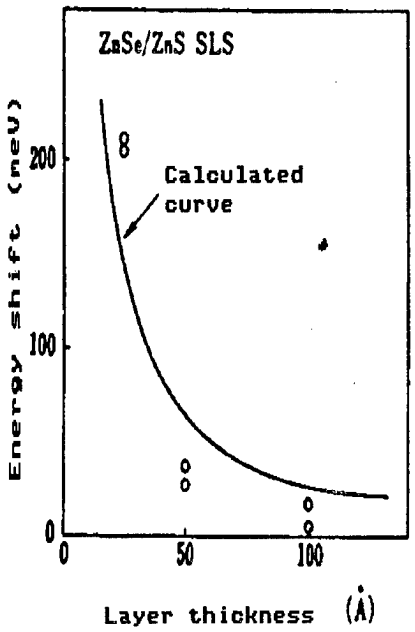

Figure 2. Energy Shift of Light Emitting Peak

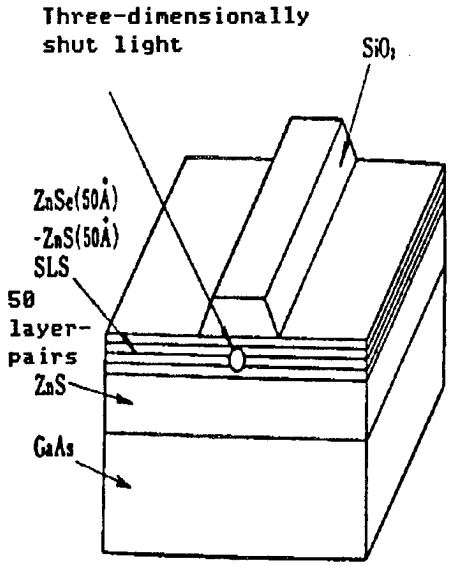

Figure 3. Element Structural Drawing

Figure 3 shows the outline drawing of the superlattice three-dimensional optical waveguide. The chip measures 300 μm x 3 mm, and the stripe width is 10 μm. The SLS layer is formed with 50 pairs of ZnSe (50 Å)/ZnS (50 Å), and the total thickness is 0.5 μm. It has a loaded-type structure in which stripes of 20 μm in width are formed after SiO_2 films, 0.25 μm thick, are

deposited. Ne-Ne (6,328 Å) laser light was irradiated from a cleavage end face to this waveguide.

The waveguide was made so that the stripe length would be 1 to 5 mm. Photo 1 [omitted] shows a near-field pattern of an ejected light. It can be seen that the He-Ne laser light is shut three-dimensionally.

This is the first time that visible light guide waves have been confirmed in the superlattice optical waveguide of II-VI group compound semiconductors. As a result of actually investigating the three-dimensionally graphed data, transmission characteristics of the guided light were slightly attenuated, but the minimum propagation loss was less than 1 cm^{-1}. The company expects that optimizing the epitaxial growth and structure will enable the superlattice optical waveguide to be sufficiently used as an optical waveguide.

The SLS is also highly deserving of use as a superlattice buffer layer. As shown in Photo 2 [omitted], the optical and crystal structural predominances of the ZnSe layers on the superlattice buffer have been demonstrated through a comparison between the case in which a superlattice buffer is developed on a ZnS layer and a ZnSe layer is developed, in turn, on this buffer, and that when a ZnSe layer is developed directly on a ZnS layer. This means that the crystallizability of ZnSe epitaxial layers has been increased by using the SLS as a buffer layer. This usage is an extremely promising means of forming the hetero junction of II-VI /group compound semiconductors. It seems that the SLS application range will be increased in II-VI group compound semiconductor devices.

Finally, we mention a view of future development. The company has already and enthusiastically carried out research involving a technology for developing GaAs on Si, because this technology is important in combining III-V devices with Si devices. The superlattice manufacturing technology is very important for combining II-VI devices with III-V devices.

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Nuclear Development News Updated

Reactor Life Prolongation Research

43062507a Tokyo GENSHIRYOKU SANGYO SHIMBUN in Japanese 6 Aug 87 p 1

[Text] **Establishment of a Comprehensive Evaluation Method--Planning of Long-Term Irradiating Test Cooperating With JAERI**

The Central Research Institute of Electric Power Industry (CRIEPI) initiated a full-scale development of technology aimed at prolonging the life of the light water reactor [LWR] starting this current fiscal year. The project scheduled to be continued over 10 years from the current fiscal year to FY 1996 will carry out an irradiation experiment on the test materials using the amount of neutrons equivalent to that in the case of using the reactor for 50 years, and will also deal with the development of comprehensive evaluation techniques for prolonging reactor life.

If the residual life of the equipment in the atomic power generating stations can be evaluated for safe usage for a longer period of time, not only the cost can be reduced but also the advantages would be great for this country where available construction sites are limited.

With this in mind, CRIEPI started development focused on the technology for prolonging life of the vapor generator and the structures difficult to exchange within the reactor and are important among the light water reactor equipment, from the viewpoint of prolonging the reactor life.

More specifically, it was to grapple with research such as on the evaluation of neutron irradiation effect on the structures in the reactor, evaluation and measure for long-term soundness of vapor generator, and comprehensive evaluation techniques on enforcement of reactor life.

Of these, with respect to the neutron irradiation effect on the structures within the reactor, an experiment corresponding to the actual operating conditions will be carried out in 1988 by the use of the materials test reactor (JMTR) under joint research with Japan Atomic Energy Research Institute. In addition, a project of estimating the residual life and application of the substitutive materials in the actual reactor will be evaluated, by actual irradiation of the reactor with the amount of neutrons

equivalent to 50 years' use of reactor, extending over 7 years from FY 1990 to FY 1996.

Moreover, regarding the soundness of the vapor generator, preventive maintenance measures by means of an optimum water quality control and structural design are also scheduled to be established.

Symposium on Nuclear Fusion

43062507a Tokyo GENSHIRYOKU SANGYO SHIMBUN in Japanese 6 Aug 87 p 2

[Text] **JAERI and Academicians Gather for Discussion Concerning Future Projects**

The Liaison Committee on Nuclear Fusion Research of the Science Council of Japan held a "Symposium on the Future Projects of Nuclear Fusion" on 30 and 31 July 1987 at the auditorium of the Council in Roppongi, Tokyo. It is the first attempt in the country that the researchers of the Tokamak type [reactor] of the Japan Atomic Energy Research Institute [JAERI] as the center and the helical type [reactor of the universities] gathered together under one roof to hold discussions and exchange ideas. During the symposium, a lively exchange of opinions took place regarding such items as the future tasks of nuclear fusion research and as to the way international cooperation should be.

On the first day of the symposium, papers were presented on the topic of the "Next Stage Large-Scale Plasma Projects at Universities."

Among these papers, Professor Atsuo Iiyoshi of Kyoto University, who discussed about the large helical facilities, emphasized the necessity of carrying out physical and engineering research on the core plasma due to generation of a currentless plasma as a main object of the next-stage facilities, and a complementary research on the Tokamak type reactor from the viewpoint of toroidal plasma.

As research tasks for the above purpose, he pointed out an α-particle simulation experiment by such as the use of high energy particles, and realization of high β plasmas.

On the second day, Tanetsugu Yoshikawa of JAERI presented a lecture on the large-scale next-stage project for nuclear fusion research of the Tokamak type reactor.

He mentioned an improvement of the reactor engineering technology as well as achievement of auto-ignition conditions as the main objects of FER, and indicated a goal which was "aimed at auto-ignition using D and T, and a longer combustion time of about 800 seconds."

On the other hand, as to the reactor engineering technology, he revealed his view that the "tritium recovery, safety, and power generation technology will be the future tasks." In addition, after stating that there are difficult areas for the Atomic Energy Research Institute to

pursue alone in the future nuclear fusion research, he requested the cooperation of universities, such as in the field of reactor engineering and tritium handling.

Yasuji Kamimae of the Futuristic Engineering Research Laboratory commented subsequently that "technology in the peripheral fields should also be developed in parallel with the development for the experimental facilities," and presented also an opinion about international cooperation that "a proposal should be made to establish in this country a design center for the Eta Project which is the international cooperation among the United States, the USSR, European countries, and Japan that succeeds the INTOR Project."

In addition, comments, such as the "need for promoting the assessment of biological and environmental influence of tritium, and the strong magnetic field related to nuclear fusion," "the need for systematizing the researchers and facilities that are now scattered around the respective universities in the country," and "necessity to strengthen the PR activities for the citizens of the nation regarding nuclear fusion," were presented one after another.

Finally, to summarize the symposium, Kenzo Yamamoto, standing consultant, Atomic Energy Industry Council, JAERI stated that "a sufficient amount of accumulated data should be prepared before starting construction of a large-scale helical facility" as well as that "significance of research and field of research for the existing small-scale facilities should also be examined in parallel to those of the large-scale facilities."

Decommissioning Measure for Reactors

43062507a Tokyo GENSHIRYOKU SANGYO SHIMBUN in Japanese 20 Aug 87 p 5

[Text] Fujita Industrial Co. (headquartered in Tokyo, Kazuaki Fujita, president) announced recently that the company started a design and test for a composite material for low radioactivation concrete. The aim is for the prevention of exposure to induced radioactivity during decommissioning of reactors and reduction in radioactive wastes. The company has been proceeding on the investigation of raw materials under subsidiary funds for promoting development of technology for reduction of exposure to atomic energy facilities of the Science and Technology Agency. With a prospective aim at this time, the company has initiated a design and trial manufacture of a new type concrete based on the data accumulated thus far.

Structures around a reactor have radioactivity (induced radioactivity) due to irradiation of neutrons generated in the reactor, and are considered to be the cause of exposure to radiation by the workers when disassembling an atomic power generating station.

Because of this, development of structures which are not easily radioactivated even under the irradiation of neutron rays, easy to construct, and disassemble, etc., is being hoped for.

In response to this, Fujita Industrial Co. started investigation of raw materials for low-radioactive concrete, aimed at prevention of radiation exposure to workers, and reducing the amount of radioactive wastes.

The company selected about 300 kinds of materials, including gravel and sand collected from all over the country, cement, admixture that has been used as material for conventional concrete, and new materials, such as the long fiber reinforcing materials like carbon and silicon carbide, various kinds of fine ceramic structural material, and the carbon-based and titanium-based engineering plastics. Activation tests were rendered to these materials in the reactor to measure mainly the activated amount through a trace of elements contained in them.

Utilizing the result of the test, Fujita Industrial Co. is aiming to design and trial manufacture new concrete by excluding raw materials (elements which generate induced radioactivity with long half-life) that are easily activated, and by combining various kinds of raw materials that can produce high strength.

The company plans to use the low activation concrete not only for atomic energy generating stations but also for the surroundings of nuclear fusion facilities and in the surroundings of the equipment for accelerators.

Construction of SOR Facility

43062507a Tokyo GENSHIRYOKU SANGYO SHIMBUN in Japanese 20 Aug 87 p 5

[Text] Soltec Corp., which has been engaged in the development of utilization technology of synchrotron radiation (SOR), recently started construction work of Tsukuba Research Laboratory in the Northern Tsukuba Industrial Complex in Ibaraki Prefecture.

Soltec was established in June 1986 under the auspices of the Basic Technology Research Promotion Center and 13 related enterprises for the purpose of development of a small SOR source (electron storage ring) for industrial use. During the coming 10 years the company is to develop technology for utilization of SOR by expending a total of ¥14.3 million for research funding.

SOR is an electromagnetic radiation which is emitted in a narrow region around a tangential direction of an orbit of an electron which is accelerated close to the light velocity when the orbit is bent sharply under the influence of magnetic force. Of the various electromagnetic radiation, soft X-rays (X-rays in the wavelength region from several Å to several hundred Å) are especially strong and possess a high degree of parallelism. They are expected to be applicable to various fields, such as hyperfine processing, analysis and evaluation of materials, medical diagnosis, photochemical reactions, and basic physical research.

With the development of the SOR utilization techniques as the object, Tsukuba Research Laboratory of Soltec will carry out 1) R&D on high brightness light sources that are stable, 2) R&D on port techniques for

stably taking out SOR with uniform intensity over a wide area of irradiation, and 3) R&D on application techniques of SOR for spectroscopic research, hyperfine processing, etc.

Moreover, the research laboratory consists of a research building, a testing building, and a machinery building. It is scheduled to be completed in September 1988.

Atomic Ship 'Mutsu'

43062507a Tokyo GENSHIRYOKU SANGYO SHIMBUN in Japanese 27 Aug 87 p 1

[Text] A meeting was held on 24 August 1987 at a hotel in Aomori City among Mitsubayashi, director of the Science and Technology Agency (STA); Ihara, chairman of the board, Japan Atomic Energy Research Institute (JAERI); Kitamura, governor of Aomori Prefecture; Suigiyama, mayor of Mutsu City; and Vemura, chairman of Aomori Prefecture Fishermen's Association, to confer about the warm mode preliminary inspection and the unloading of extremely low activity wastes, at Ominato harbor, Mutsu City, Aomori Prefecture, where the atomic ship "Mutsu" is currently moored. The local three parties informed in writing that they were ready to accept the plan of STA and JAERI. In response to this decision JAERI submitted an application for alteration in the installation of the atomic reactor on the following day, the 25th, and it is scheduled to start preliminary inspection, etc., of the reactor in October.

At the five-party conference, the three local parties advised in a jointly signed letter that they were basically ready to accept the plans submitted to them last month for the deliberation by STA and JAERI that 1) a warm mode preliminary inspection in which the soundness of equipment will be confirmed by elevating the pressure and the temperature of the primary cooling water for the reactor by the use of the existing electrical heaters, and 2) the unloading of the extremely low activity radioactive liquid and solid wastes stored within the ship.

In the letter of agreement, strict observance was expressly sought on the "Agreement concerning the construction of a new mooring port for the atomic ship 'Mutsu,' and the entry to Ominato harbor, etc.," which was agreed upon in August 1982 among the five parties, to allow "Mutsu," at that time undergoing repairs for shielding at Sasebo harbor, Nagasaki Prefecture, to reenter Ominato harbor, as well as on the environmental protection agreement. In addition, it was desired also that "the new experimental plan be implemented accordingly in completing the experimental nautical voyage by FY 1990."

In response to this proposal by the five-party conference, JAERI submitted on 25 August 1987, an application for alteration of the installation of the reactor which includes the elevation of temperature and pressure of the primary cooling water for the reactor to the rated temperature and pressure (about 273°C and about 110 atm) by means of heaters, while keeping the reactor in a shutdown state. At the same time, it started the unloading of

general wastes, such as lumber, work garments, and gloves that were used in the shielding repairs.

According to future plans, after unloading the general wastes, and subsequent to unloading the extremely low activity wastes, dismantling of the crane at the pier, etc., a preliminary inspection in the warm mode will be conducted for 3 months starting in October.

The warm-mode preliminary inspection will serve as a preliminary test for the reactor functional test that is to be given after bringing the ship to the new mother port (mooring harbor) at Sekinehama, Mutsu City, during the current fiscal year. The inspection is aimed at confirming the soundness of the cooling system, the pressurizer, etc. However, due to the tight schedule up until the test voyage, it is necessary to prepare for the preliminary work as much as possible at Ominato harbor where the ship is currently anchored.

After navigating the ship to Sekinehama harbor, there are scheduled functional tests in the cool mode and the warm mode and an inspection of the reactor vessel with the lid open to be given in FY 1988, an inspection of the vessel in dock in FY 1989, a test voyage in FY 1990, and its retirement at Sekinehama in FY 1991.

Plutonium Recycling Evaluation

43062507a Tokyo GENSHIRYOKU SANGYO SHIMBUN in Japanese 27 Aug 87 p 1

[Text The Science and Technology Agency [STA] recently compiled a report entitled "Survey of Fundamental Problems Concerning Practicability of Plutonium Utilization" in which the agency evaluated the comprehensive economy of plutonium recycling based on the analysis of import premium. According to the report, it was clearly revealed that the plutonium recycling is not only competitive with the once-through cycle but also it is quite conceivable that it can surpass the once-through cycle after the year 2000. The survey was conducted by Nomura General Research Laboratory under a contract with STA.

The import premium is the result of the market factor which indicates the rise of price and the security factor, and is an idea of converting the probability of an occurrence of the uranium supply description onto the unit price.

This study analyzes what the effects of the five developments--the domestic enrichment uranium, stockpile of uranium, utilization of recovered reprocessed uranium, utilization of uranium in sea water, and diversification of supply source of natural uranium--have on the risk reduction for dependency on the overseas sources of the uranium fuel in this country.

First, concerning the stockpiling of uranium, the import premium was $13 to $20/lb U_3O_8 in 1985 which meant that the necessity of its stockpile was not too high. However, by about the year 2000 it will be somewhere in the

$30/lb range so that uranium stockpiling would be a policy which has sufficient economic advantage.

Further, as to the value of utilizing the reprocessed recovered uranium, it is necessary to consider not only the saving of uranium itself but also the portion of the import premium that corresponds to the effect of reduction in the amount of imported uranium.

Based on the evaluation of the import premium at about $30/lb, U_3O_8 for uranium around the year 2000, it reports that the economic value of the utilization of the reprocessed recovered uranium is about twice as much as that of the conventional effect of economizing uranium.

As for the recovery and utilization of uranium in sea water, if the uranium price around the year 2000 is assumed to be about $40/lb U_3O_8, the developmental target will be $70 to $77/lb U_3O_8 which will be difficult to achieve in reality. However, after the year 2000, it is quite possible for the market price of uranium to exceed $60/lb and the import premium become fully in the range from $30 to over $50/lb, so that the target developmental cost will possibly be reaching around $100/lb U_3O_8. Because of this, the report considers that promoting the utilization of sea water uranium will be a rational developmental policy as seen from an economic viewpoint.

On the other hand, concerning domestic enrichment of uranium, even if the price of domestic SWU is higher than the international price by $15 to $50, it will be economically reasonable. However, for this, it must include the investment portion for R&D.

Regarding the economy of plutonium recycling, it has been said that the higher processing cost of plutonium recycling compared with the once-through cycle sharply detract the economy of the plutonium cycle. According to the estimate published by OECD NEA in 1985, it is said that the reprocessing cost will not be equivalent to that of the once-through cycles unless the cost is reduced to $500/kg HM. According to the survey, however, by considering the premium of saving on uranium and SWU, it will be able to compete economically with the once-through cycle even if the cost is about $550/kg HM.

Moreover, the report estimates that after the year 2000 the comprehensive economy of the plutonium cycle will have a possibility of exceeding the once-through cycle due to the possibility of an increased security price of uranium saving and a lowered cost of reprocessing.

New Reactor at Fukushima

43062507a Tokyo GENSHIRYOKU SANGYO SHIMBUN in Japanese 27 Aug 87 p 1

[Text] Tokyo Electric Power Co. finished the final inspection of the No 4 power generation unit of the Fukushima Second Power Generating Station which had been undergoing trial operation, and began operating on 25 August.

With this, all four of the power generating units, with a total output of 4.4 million kw, as initially planned were completed at the Fukushima Second Power Generating Station. The total output of 10.196 million kw from the 11 units of the atomic power generating facilities of Tokyo Electric Power Co. reached about 26 percent of the company's total power generating facilities.

The No 4 unit has the same design as the No 3 unit, and adopts a "100 percent turbine bypass system" which directly leads the entire amount of steam generated by the reactor to a condenser by bypassing the turbine. With this arrangement, the output can be reduced without shutting down the reactor, and power transmission can be resumed as soon as the power system is restored.

In addition, this unit employs a "new type of 8 x 8 fuel." Through an improvement of the transient characteristic of the reactor the thermal margin of the fuel and the operational margin of the reactor can be increased and the reliability of the plant can be improved.

Furthermore, addition and automation of various kinds of mechanisms for supporting the operation of the plant have also been proceeding.

Incidentally, the developmental plans for No 4 unit were approved by the 75th meeting of the Committee for Deliberating Adjustment of Electric Power in July 1978. Construction was started in December 1980, critical condition achieved for the first time in October of last year, and trial operation has been in progress since December of the same year.

The cost of the construction of the unit was about ¥292 billion. Based on the "New Development for Wide Area of Operation" which was agreed upon with Tohoku Electric Power Co. in 1980, as in the case of the No 3 unit, one-fourth of the power generated by the No 4 unit will hereafter be transferred to Tohoku Electric Power Co.

Nuclear Fuel Cycle Discussed

43062507a Tokyo GENSHIRYOKU SANGYO SHIMBUN in Japanese 27 Aug 87 p 6

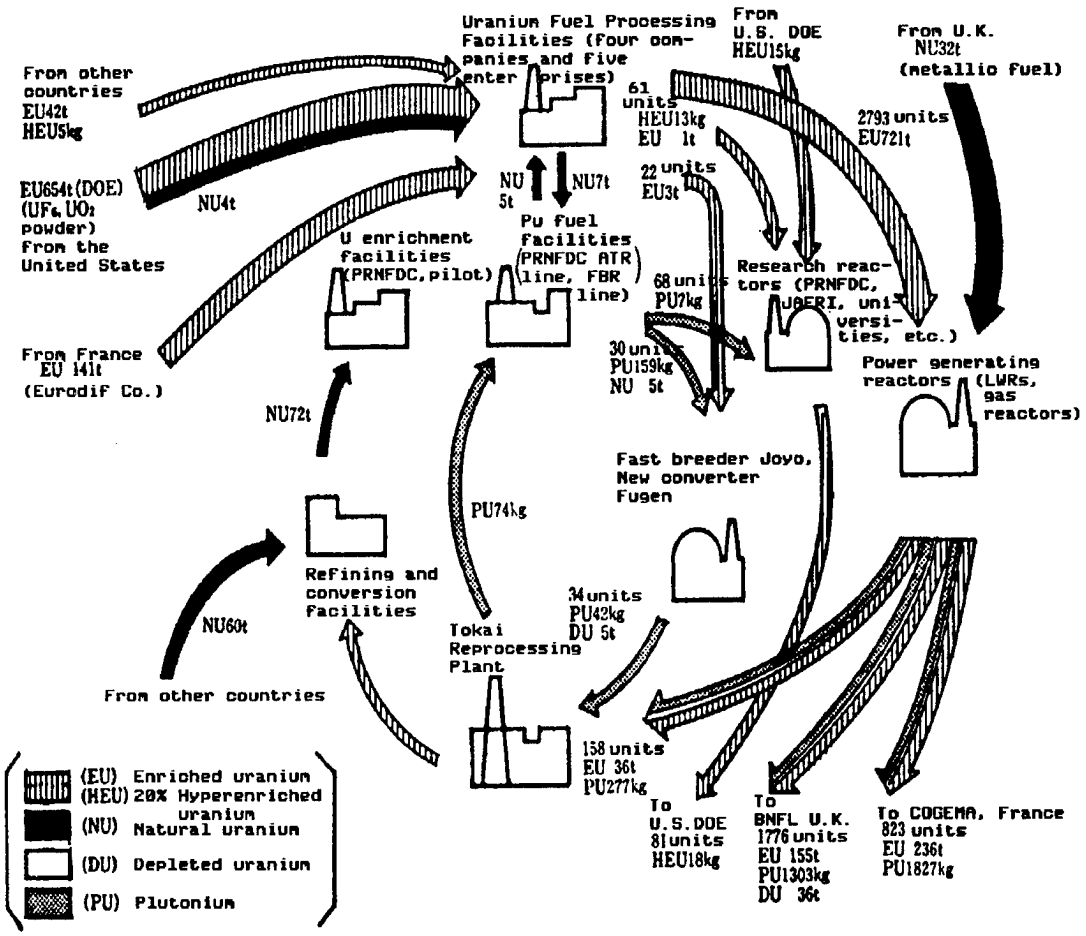
[Text] In this country, an "enthusiastic expectation" is becoming greater than ever before toward the establishment of the fuel cycle now that the technology for light water reactors is settled and their stable operation became possible. What does the fuel cycle mean to this country which depends on foreign sources for nearly all of the uranium resources it requires? What are the current status and the future image? Of the fuel cycle, what has been completely on an operational basis is only in the fuel processing field, with other fields still being in the stage of transition to commercialization. How would nuclear fuel, an "international commodity," encounter the world with Japan at the center? In what follows will be presented a glimpse of the "nuclear power challenge" which Japan is launching to achieve energy independence while glancing at the changes in the cost of fuel.

For a "Semi" Domestic-Produced Energy Road--Further Increase in Amount of Cycle

The significance of establishing a fuel cycle within the country is to have a system within a country scarce in energy resources that can regenerate energy as "semi-domestically produced energy" from uranium resources imported from abroad.

What is the current status of the fuel cycle ring which surrounds Japan?

First, to understand the flow of the fuel cycle, refer to the accompanying figure. the drawing is a slight modification of a figure contained in an annual report (white paper) on atomic energy (1985 edition) compiled by the AEC committee.



Transfer Amount of Nuclear Fuel Materials (1985)
Survey by Security and Means Section,
Science and Technology Agency

For the transfer of nuclear fuel material, change in the form and storage measurement control of nuclear material is conducted, in addition to the international inspection, conforming to the security measure agreement between Japan and the International Atomic Energy Agency (IAEA) based on the requirement of the nuclear nonproliferation treaty (NPT).

Because of this, the nation is annually expending the sum of several hundred million yen for information processing business by computer (on contract with the Nuclear Material Management Center), and a gigantic data book with a thickness of several tens of centimeters is prepared monthly, from which the above figure was summarized. It may be said that this is the only document publicized which represents the fuel cycle on a quantitative basis.

A glance at the figure clearly shows the amount of imported enriched uranium from the United States and France, depicted in the upper left corner of the figure, and the large amount of used fuel contracted for reprocessing in the United Kingdom and France, shown in the lower right corner, conspicuously indicates that the ring of the domestic cycle is still very small.

At present in Japan there are, in addition to the 34 units of commercial atomic power generating stations, the first experimental reactor Joyo and the new type of prototype fast breeder reactor, Fugen, of the Power Reactor and Nuclear Fuel Development Corp. (PRNFDC), JRR-2, JRR-4, the nuclear safety research reactor (NSRR), the material testing reactor (JMTR), and the nuclear-powered ship "Mutsu," of the Japan Atomic Energy Research Institute, research reactors at universities, such as those at Tokyo University, Kyoto, and Rikkyo, and others, and research reactors of the makers, such as Toshiba Corp. and the Japan Atomic Energy Enterprise Co., ranging from the largest with a high electrical output of 1.17 million kw to the smallest of a low thermal output of 1 w.

Of these, except for Tokai No 1 reactor of the Japan Atomic Power Generating Co., all of the commercial atomic power generating stations use 3 to 4 percent enriched uranium dioxide fuel. The fuel for the Tokai No 1 reactor (cooled with carbon dioxide) which was first imported from the United Kingdom is a natural uranium metal imported from the United Kingdom in a form of finished product, and the used fuel is transported for reprocessing to British Nuclear Fuel Limited (BNFL).

Uranium exceeding 20 percent enrichment used for research reactors at universities and Japan Atomic Energy Research Institute is imported form the United states, some of which is sent back to the United States again for reprocessing.

The used fuel from the light water reactors is transported via sea for reprocessing by ships built exclusively for this purpose to the french Nuclear Fuel Corp. (COGEMA) and the British Nuclear Fuel Ltd., in addition to being reprocessed at the Tokai Reprocessing Plant of PRNFDC.

The recovered plutonium, uranium, high activity wastes, etc., reprocessed by contract with the COGEMA and the BNFL are to be returned to this country in the future.

The domestic fuel cycle ring is still very small commercially, and accordingly, the thickness of the arrows in the figure show the flow of nuclear materials vary annually.

For instance, in the example for the year 1984, a thick arrow was indicated in the figure from France to plutonium fuel manufacturing facilities corresponding to the transportation of plutonium from France by cargo ship "Seishin Maru." The 251 kg of plutonium is that obtained at COGEMA by reprocessing of the fuel used by Kansai Electric Power Co. to be used as the fuel for the fast experimental reactor Joyo after processing at PRNFDC.

Plutonium extracted at the Tokai Reprocessing Plant of the PRNFDC is processed into mixed oxide fuel of uranium and plutonium (MOX) at Tokai Operation Works of PRNFDC to be used as the fuel for Joyo and Fugen."

Furthermore, a portion of the recovered uranium (depleted uranium of about 1 percent enrichment) is converted to uranium hexafluoride and after reenrichment at the uranium enrichment pilot plant at Ningyo Pass, is to be trial installed to the light water reactors.

Nuclear Fuel Cycle Surveyed

43062507a Tokyo GENSHIRYOKU SANGYO SHIMBUN in Japanese 27 Aug 87 p 6

[Text] The future fuel cycle industry will see a shift from R&D heretofore centered around JAERI and PRNFDC to a "transition stage toward practical use" (long-term nuclear power developmental and utilization projects adopted at the last meeting) which will be led by private enterprises centered around electric power companies. A smooth technology transfer between the two will pose a big task.

The most significant future projects planned by the private enterprises are the first commercial reprocessing plant (with processing capability of about 800 ton U/year of Japan Nuclear Fuel Service Co. scheduled to be constructed in Rokkasho Village in Aomori Prefecture, the uranium enrichment plant (enrichment capability of 1,500 ton SWU/year), and the low activity radioactive waste storage facility (storage capability equivalent to about 1 million cans of oil drum) of the Japan Nuclear Fuel Industry Co.

At the reprocessing plant, construction is contemplated by receiving and storage facilities for wastes returned from the United Kingdom and France, in addition to a storage facility for 3,000 ton U of used fuel.

In the future, there will be a necessity in the form related to the above facilities, such as, in addition to the conversion plant for supplying uranium hexafluoride to the enrichment plant, a conversion plant for uranium recovered from the reprocessing plant, a glass solidifying plant

for high activity radioactive wastes, and further, a MOX fuel manufacturing plant for thermal plutonium.

However, in speaking of commercializing fuel cycling facilities, the problem of cost will invariably surface, apart from the viewpoint of energy security. Taking any of the enrichment, reprocessing, and the development of a new type of reactor, international competition is becoming increasingly severe.

Although "the rate of the fuel cycle cost to the power generation cost is relatively low compared to other power generation method such as the thermal power generation" (Masatoshi Toyoda, vice president, Tokyo Electric Power Co.), there exists a common recognition in the electric power industry to view atomic power generation as one system which includes fuel cycle, such as uranium enrichment, reprocessing, and others, in addition to a reduction of cost for constructing atomic power generating stations, and that "it is extremely important to minimize the power generation cost for optimizing the system as a whole" (Gaishi Hiraiwa, chairman of the board, Tokyo Electric Power Co.).

Notwithstanding, the recent fall of the value of the U.S. dollar and the rise in the value of the yen are extremely rapid ($1 = ¥250 in June 1985; $1 = ¥140 at present), a rise of 44 percent in the value of the yen during the last 2 years.

This appreciation in the yen value is casting a long shadow over international competitive power, even when the field is limited exclusively to that relating to nuclear energy. In particular, uranium enrichment businesses by means of the centrifugal separation technique which has just reached the international level, is forced to cope with a severe circumstance superposed on the offensive from the United States and the European countries toward reduction of enrichment cost.

Nuclear fuel is followed constantly by another problem, the so-called "international management." This nation has signed bilateral treaties on atomic energy with such countries as the United States, Canada, and Australia. As to the nuclear fuel materials imported from these countries, the nationality management for the respective countries is required to be conducted. This is due to the necessity clarifying how far the regulatory right of each country extends, for the purpose of nuclear nonproliferation.

For example, natural uranium produced in Canada has Canadian nationality. This, of course, is not a surprise, but when this uranium is enriched in the United States, the enriched uranium is subject to dual regulations, those of the United States and those of Canada. Further, when used fuel obtained in Japan by burning the enriched uranium in a light-water reactor technology introduced from the United States, is sent to France for reprocessing, the used fuel will be subject to triple regulations--Canada, the United States, and Japan.

Moreover, recently there is a movement which attempts to establish for reprocessed recovered plutonium a regulatory right of the country where

reprocessing was rendered. In such a case, in the foregoing example, there would be a possibility of subjecting the reprocessed plutonium to even a quadruple regulation, that of Canada, the United States, Japan, and France.

Needless to say, it is desirable to confine the range, over which the regulatory rights of other countries extend, as limited as possible, from the viewpoint of rendering atomic energy as a semi-domestic energy in the true sense of the word, and also from that of energy security.

Even granting that it is inevitable for this nation, where natural uranium resource is scarce, to subject natural uranium to the regulatory right of the country of origin, the way to bring atomic energy from "semi-domestic energy" to infinitely close to "genuine domestic energy" in such case, is to endeavor to expand developmental importation, and to establish such a uranium enrichment plant and reprocessing plant, within the country, and further, to develop new type reactors such as a new type converter reactor and fast breeder through an independent technology developed in this country.

And this is the very reason why the atomic energy is called a "'technology energy,' so to speak, of resource-independent type, a product of technological power of mankind."

That burning bright red color in a reactor is not only the nuclear fuel, but also it may be said to be "technology" itself, the wisdom of mankind

New Reactor Started in Hamaoka

43062507a Tokyo GENSHIRYOKU SANGYO SHIMBUN in Japanese 27 Aug 87 p 1

[Text] A third unit (BWR, 1.1 million kw) of Hamaoka Atomic Power Generating Station of Chubu Electric Power Co. started business operation on 28 August.

With the start of operation of the unit, there are now three units, with 2.48 million kw atomic power generating facilities at the Chubu Electric Power Co., where power generation occupies about 12 percent of the total nuclear power generated by the company.

A major feature of the unit is that it adopts the "Mark-I improved type atomic reactor containment vessel." Since the content volume of the vessel has been expanded, workability inside the vessel has been improved.

Besides the above, the unit makes use of a new control panel to which is added a CRT [cathode ray tube] (display terminal device) equipped with various kinds of guidance functions, for operational convenience, and also makes use of an integrally forged low pressure turbine rotor as a part of the equipment, to further improve maintainability, and reliability.

The construction of the No 3 unit at Hamaoka was proposed at the 76th meeting of the Committee for Deliberating Adjustment of Electrical Power in October 1978, and was determined for incorporation in the Fundamental

Projects for Developing Electrical Power Sources. The second public hearing was completed in March 1981, and its construction was started in November 1982.

The loading of the fuel in the reactor was begun in October of last year, criticality was achieved for the first time in November of the same year, and the first merging took place in January of this year [1987].

The total cost for the construction was about ¥400 billion. Major equipment makers responsible for the unit were the Toshiba Corp. for the reactor and Hitachi, Ltd., for the turbine generator.

Further, with the participation of that unit, the total number of commercial-use nuclear power generating stations in operation in the nation reached 35 units, with a total output of 27,081,000 kw.

New Alanine Dosimeter Developed

43062507a Tokyo GENSHIRYOKU SANGYO SHIMBUN in Japanese 3 Sep 87 p 11

[Text] The Japan Atomic Energy Research Institute (JAERI) developed a radiation dosage measuring system which makes use of an alanine dosimeter. With this system, the measurement time can be greatly reduced, and moreover, measurement capability improved to ± 1 percent, making it possible to obtain a high-accuracy measurement of X-rays and γ-rays.

The JAERI had succeeded in jointly developing with Hitachi Wire Co. an alanine dosimeter which can be used as a practical dosimeter for the large radiation dosage range, and an electron spin resonance (ESR) device used for measuring the concentration of radicals. However, this device is expensive and is not used widely. Further, it lacks the convenience required for dose measurement, needing complicated operation and taking 5 to 10 minutes even by a skilled operator, and moreover, its accuracy is insufficient.

The JAERI has been developing an inexpensive, simplified measuring device with a high accuracy.

The system developed currently permits automatic measurement by combining a personal computer with a small conventional ESR apparatus making use of a permanent magnet, a modification of the Japan Electron Optical Laboratory's JES-3000.

It consists of the ESR body itself, an input/output conversion section, an ESR control and data operational part (personal computer), and a data output section, and is operated by a software for control operation.

The system is aimed at the stabilization of response by 1) unifying microwave output, modulation width of magnetic field, etc., 2) setting the amplification factor which covers a wide range of dosage from 1 to 10^5 Gray, and 3) controlling the temperature of the cavity (measuring

chamber). Further, setting methods for measurement samples with high reproducibility were examined.

Moreover, a reduction in the measuring time was aimed at by attaching an autosampler to the system. With this apparatus, the measuring time per sample was greatly reduced to be within 20 seconds.

In the future, in connection with the correctness of dosage evaluation, the long-term stability of the ESR apparatus will be examined by the use of standard samples of alanine. Further, a filmlike alanine dosimeter element with a thickness of 150 microns will also be manufactured in the future.

Moreover, alanine is a kind of amino acid, a portion of the molecule undergoes decomposition under irradiation of radioactive rays to become stable for a lengthy period producing radicals with concentration proportional to the dose. The dosimeter applied this principle. The alanine dosimeter developed by JAERI utilizes a polymer formed by mixing fine crystalline alanine with polystyrene in the ratio of 1 to 2.

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DECOMMISSIONING TEST, TECHNOLOGY DEVELOPMENT

43062028 Tokyo GENSHIRYOKU KOGYO SHIMBUN in Japanese 29 Oct - 10 Dec 87

[29 Oct 87 p 11]

[Text] Field testing of the decommissioning of the Japan Power Demonstration Reactor (JPDR) by the Japan Atomic Energy Research Institute [JAERI] is currently under way. As 30 years have passed since the first nuclear power generation, it is now inevitable that some reactors in Japan will have to be decommissioned soon; and that the Japanese need to acquire the technology for it. Under these circumstances, JAERI has been developing new weapons for reactor dismantling, and with these tools, it has been conducting field tests since last December. Through this series, we would like to report how JAERI is tackling Japan's first reactor decommissioning. Our reports will be based mainly on the announcements made at the Japan Atomic Energy Society.

Since the beginning of the JPDR decommissioning project last December, JAERI has been engaged in the following preparatory work for full-scale dismantling of the reactor itself.

The work involved preparations for the removal of structures inside the reactor such as the pressure vessel, the securing of sites for temporary storage of removed objects and for the decontamination of removed equipment, and the improvement in controlling access to the control zone.

Specifically, structures and equipment were removed from the perimeter of the reactor and from the dump-condensor building. Also, the access room which connects to the control zone was expanded.

The dump-condensor building will be utilized as temporary storage for removed wastes such as pipings. Already, the wastes have been divided into groups and stored according to the radiation contamination level.

The expansion of the access room for the controlled zone was effected to provide the capability to handle the large number of workers (estimated maximum, 150) needed for the heaviest-load day during the course of demantling. JAERI installed a new "Automatic Contamination Inspection Device for Removal Equipment" to facilitate the transport of the removal instruments.

One of the most important items in the field test is contamination control.

In the recent prepraratory work, the workers were required to wear personal contamination level indicators such as an APD and a film badge. Also, to tighten contamination control, the work areas were monitored for radiation.

In addition, when an atomospheric contamination was foreseen, JAERI built a greenhouse within the affected work area and set up a local air-conditioning equipment and barriers to prevent the spread of the contamination. In order to reduce personnel contamination, the workers were equipped with a respirator protection uniform.

Thanks to these measures, the levels for both external and internal contamination of the workers were below the detectable levels.

In the meantime, so far (as of the end of June), roughly 200 tons of radioactive waste has been collected. Of this, 165 tons is of made up of metals, and 35 tons are concrete debris. This figure represents 5 percent of the total weight of all the removed objects.

There were 1,600 cardboard boxes used altogether during the course of work, and about 60 filters were used for the air-conditioning equipment at the work areas.

A subsequent study showed that the figures for worker time (measured in man-days) used in the dismantling of objects totalling 1 ton at different areas are as follows: 90 man-days for the cutting and removal of the pressure vessel upper lid (10 tons); 40 man-days for the peripheral equipment of the reactor (17 tons); and 25 man-days for the equipment at the dump-condensor area (77 tons).

Currently, JAERI workers are still working on the removal of the structures and equpiment around the dump-condensor building and reactor.

According to JAERI schedule, the removal of the reactor's peripheral equipment will be completed in mid-October, and the dismantling of the structures inside the reactor using the in-house designed robots and plasma arc saws for dismantling, will start early next year.

[5 Nov 87 p 11]

[Excerpts] One of the techniques being developed by JAERI for reactor decommissioning is a plastic explosive technique for cutting designed to cut the reactor pressure vessel's connecting piping.

Fitted inside a pipe, the explosives create a radially spreading jet, which in turn cuts the pipe. This article reports the circumstances surrounding the development of the cutting technique.

The plastic explosive technique does provide an extremely effective means to cut piping, but it requires careful study of the remote control method for positioning the explosives and the safety measures.

JAERI conducted a mockup test on pipe cutting to study the specific problems that may arise at the JPDR field test, and to design an appropriate rectification.

The test consisted of experiments on the piping -- for the control rod guide tube, the sprinkler system for the reactor core, the reactor water level system, and the emergency water return system -- under conditions simulating the piping shape and material type, and the environmental factors (surface and underwater) to which the pipes are subjected.

During the test, special attention was paid to the study of such factors as the effect on nearby structures by explosive sonic booms in the air and underwater, the extent of recoiling of the cut pipes upon cutting, the extent of the water's splash due to the underwater cutting, and the operational reliability of the remote controller.

The mockup test produced excellent results, confirming the reliability of the explosive technique for the tested objects such as the control rod guide tube.

Among the effects on nearby structures, JAERI detected a large pressure on the lower end of the cut pipe, but the investigation revealed only a small deformation of 2 millimeters maximum on the neighboring pipe at the time of underwater cutting.

As for the recoiling of the cut pipe, for in-the-air cutting, the effect was small enough to contain by applying a 4.5-millimeter thick carbon steel sheet. Also, the splashing of water (due to the cutting at 5 meters deep) was about 20 centimeters high at most, indicating no spread of contamination to the nearby environment.

Further, according to the results of the remote control operation, the explosives homed in on the targets with the expected accuracy.

In order to prevent damage at piping terminals, JAERI is planning to reinforce them with impact absorption filling at the actual JPDR site.

Incidentally, JAERI performed the mockup tests from last January to March. The actual application is scheduled to take place in fiscal 1989...

In the sand pre-cooling method for pouring massive volumes of concrete, the sand is efficiently cooled to -10 to -100 degrees by means of liquid nitrogen, with a temperature of -196 degrees, in order to gain a drastic reduction of the heat generated during the curing of the mixed concrete which is made from sand, cement and water.

By suppressing the temperature increase during curing, the method can prevent development of cracks in the concrete due to the temperature difference between the inside and outside of the poured concrete.

An experiment to test this method was carried out for one month starting last August. To meet the need for actual application, JAERI has since developed a

full-scale machine for sand cooling.

In the experiment, JAERI performed the complete procedure -- from the cooling of the sand to mixing of the concrete -- based on the experiment results of the basic research by Shimizu Construction...

[12 Nov 87 p 7]

[Text] One of JAERI's new weapons for the decommissioning of JPDR is an arc saw. The pressure vessel of a light-water reactor is made of thick carbon steel plates with a stainless steel lining. An arc saw generates an arc between the rotary disk electrode and the pressure vessel by running a large current between them. The heat of the arc cuts the vessel. This article reports the development of JAERI's arc system.

In JAERI's mockup testing, a stainless-steel clad steel test body (circumference 1/1, height 1/2) which simulates the JPDR pressure vessel, was installed inside the testing water tank. The procedure, to be employed in the actual decommissioning, tested the saw's cutting power, the removal of cut pieces, and the replacing of saw blades.

The saw was remote-controlled from a control panel set up in the monitoring room adjacent to the mockup testing building.

The results verified the feasibility of remote-controlled cutting of the vessel's main body and flanges, removal and storage of the cut pieces, and blade replacement with a blade replacing device.

For horizontal cutting of the pressure vessel, the saw was fitted with carbon steel blades. For vertical cutting, JAERI used steel blades with stacked insulation layers -- the broad sides of the blades were insulated to reduce side arcs -- as well as ceramic coated steel blades. In both cases, the cutting results were favorable.

The results of JAERI's mockup test indicate a need for improvement in the positioning of the debris removal device and the blade replacing device by installing a mobile TV camera. The results nevertheless verified that the in-house developed arc saw cutting system is appropriate for the dismantling of the JPDR pressure vessel.

The actual application of the saw on JPDR is scheduled for some time in 1990.

[3 Dec 87 p 7]

[Text] In order to reduce irradiation of workers during reactor dismantling, JAERI has been developing remote-control robots for dismantling jobs in a high radiation environment. This article introduces one of the robots, namely, the heavy duty robot.

The robot is an electric motor-driven multi-joint amphibious manipulator. It is composed of two arms of a master-slave system.

The main slave arm weighs 396 kilograms while the sub unit weighs 204 kilograms. The self weight-compensation for maintenance of balance is done by a computer. The arms are capable of handling up to 100 and 25 kilograms of load, respectively. They are bilateral types equipped with a force sensor on every axle.

In addition, since the entire control of the manipulator is done via a digital computer, precise control is possible for master-slave and playback control. The robot can also be controlled by programs written in the dedicated robot language.

JAERI conducted three performance tests on the manipulator: the axle abrasion test to study the friction characteristics of the drive mechanism, the bilateral performance test, and the weight compensation test.

In the test of the manipulator's force sensor system, which incorporates a power feedback bilateral servomechanism, the bilateral ratio and the power gain, which determine the degree of sensitivity to force change, were varied for each axle to study the characteristics of the sensing system.

Also, the design for the manipulator's weight-compensation system incorporates the technique for real-time computation of the weight distribution based on the signals for the angular positions of the manipulator axles, and the technique of readjustment of the weight distribution by means of servomechanism.

JAERI tested the weight-compensation system by measuring the manipulation power at the grip of the master arm, and verified the weight compensation capability to be satisfactory.

In the meantime, JAERI has almost completed the removal of the reactor peripheral equipment and structures.

It is planning to enter into the phase of dismantling the inside structures of the reactor with its new robots and plasma arc saw next year.

[10 Dec 87 p 7]

[Text] Having nearly completed the phase, started last December, of the removal of the reactor peripheral equipment such as the pressure vessel upper lid and the fuel exchange device, JAERI is scheduled to start dismantling of the reactor's inside structures this January. This phase will last until some time in the early part of 1989.

The cutting work will progress from the top down. The robots equipped with the plasma arc torch will be used for the high elevation structures, such as the reactor core spray block. The lower support structures will be cut by using mobile gears.

The cut pieces that are contaminated with a relatively high level of radiation will be encased in a specially designed container and stored in the fuel

storage building. To make room, the spent fuels have already been transported to the reprocessing plant of the Power Reactor and Nuclear Fuel Development Corporation.

There are two other projects that JAERI is planning to do in relation to its R&D effort to develop decommissioning technology. These are a mockup testing of concrete cutting by using a "water jet method", and a modification to the "experimental device for concrete surface destruction with microwave irradiation."

With the water jet method, a water jet that contains a polishing agent is used to cut the concrete biological shields together with the steel rods inside. JAERI is planning to conduct a mockup test in 1988 and 1989. It will start implementing the technique in 1990.

As for the microwave device, JAERI will develop a steering mechanism to make it suitable for actual field testing.

Another JAERI task is the upgrading of the software. By using feedback from the field test data, the engineering codes will be upgraded for more efficient dismantling.

At the JPDR site, JAERI will start removing the biological shields and the structures inside the pressure vessel.

The work of rinsing the vessel and removing it by crane will start in 1990. In 1991, the concrete foundation for the vessel will be removed. The work of reclamation and land readjustment will follow to complete the decommissioning test.

13346

Fusion R&D, Critical Plasma Condition Discussed

43062521 Tokyo PUROMETEUSU in Japanese Nov 87 pp 50-56

[Article by Hiroshi Kishimoto, manager of Critical Plasma Project Section, Naka Research Institute, Japan Atomic Power Research Institute: "Targeting the Plasma Condition in Japan"]

[Text] 1. **Introduction**

Light nuclei, such as hydrogen, heavy hydrogen or tritium, produce fusion reactions when they are subjected to collisions and are converted into heavy nuclei, generating energy. This phenomenon is called "fusion reaction." An attempt to extract the energy thus generated for practical application is included in controlled fusion research.

A fusion reaction can be produced by heating fuel gas to a high temperature and forcing the atoms into the plasma condition, in which they are separated into nuclei (ion) and electrons in a free state, then containing the separated atoms for longer than a specific time at a specified density. Since the plasma is an aggregate of charged particles, it is necessary to use a strong magnetic field (magnetic confinement) or laser beams or particle beams (inertial confinement) in order to confine the plasma. The magnetic confinement is largely classified into a torus magnetic field, where the magnetic lines of force are confined in a doughnut shape, and an open magnetic field, where the magnetic lines of force are not confined, depending on the size of the container. The typical confinement methods based on the torus magnetic field system cover the tokamak and stellarator/helitron, while the most typical open magnetic field-based confinement method is the mirror method. In this article, the author would like to discuss the tokamak in particular. Figure 1 shows a bird's-eye view of the JT-60 (the large nuclear fusion experimental reactor developed by JAERI) as a typical example of the tokamak unit. As illustrated in the figure, fuel gas is injected into a doughnut-shaped vacuum container. Large electric currents are introduced into this container based on the principle of the transformer generating the plasma. The plasma is contained by a spiral magnetic field produced through the synthesis of the magnetic field produced by the current and the magnetic field or strong toroidal magnetic field working in the doughnut direction, applied from the outside. The plasma generated in this manner is called "joule plasma." The temperature ranges from 20 million to 30 million degrees. The second

stage-based heating is called for to obtain a temperature of more than 100 million degrees, which is enough to produce nuclear fusion. The JT-60 adopts the neutron particle incidence heating (NBI) method and the RF heating method, which radiates magnetic waves. The plasma condition which can obtain the nuclear reaction power equivalent to heating input power is called the "critical plasma condition." The plasma condition in which the nuclear fusion reaction continues and generates energy, even when the heating input comes to a halt, is called the "self-ignition condition.

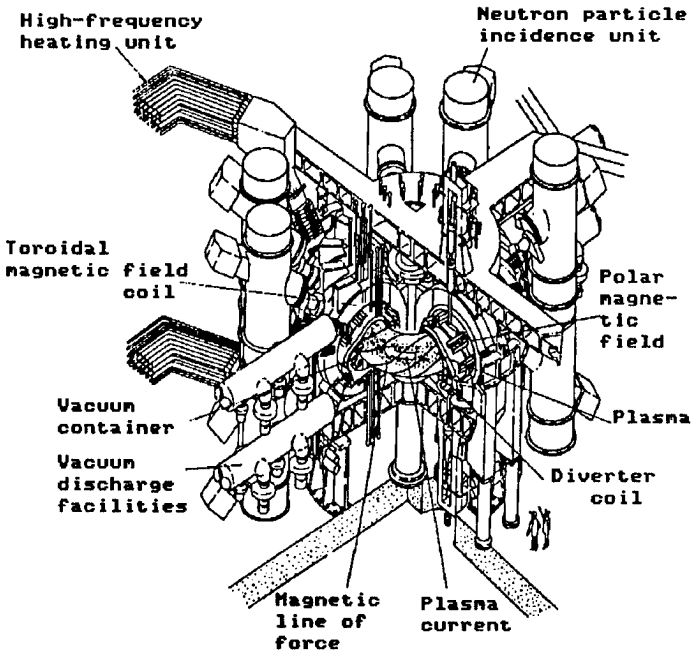


Figure 1. Bird's-Eye View of JT-60

In the next chapter, the author discusses the historical development of nuclear fusion research, the current status and trends, and the outlook for R&D of nuclear fusion, centering on the tokamak, which has reached the experimental stage.

2. Development of Fusion Research

Research involving controlled fusion has been carried out continuously for more than 30 years, starting when fusion research started. The main events occurring during this period are listed in Figure 2 in chronological order. The basic concept of magnetic nuclear fusion was mostly created in the 1950s, and succeeded in bringing up a large river torus magnetic field generation unit, which introduced a stabilization method based on the minimum B field, and obtaining the experimental results of the tokamak T-3 during the middle to latter period of the 1960s. These accomplishments have surmounted the barrier to Baume diffusion in hot temperature plasma confinement and made the breakthrough to the dramatic progress experienced by the current magnetic fusion research. In 1975 the Dobuna conference was

opened to discuss the large tokamak system, heralding the arrival of the current large tokamak era. Furthermore, interested countries started their design and research of an international tokamak-type experimental unit (INTOR) in 1978, through international cooperation, in an effort to draft the physical and technological outline for the next generation systems following the large tokamak system. Starting with the TFTR (tokamak fusion test reactor in the United States), large tokamak units, such as JET and JET-60, have been completed one after another in the 1980s. Experiments have been conducted, aiming at reaching the desired critical plasma conditions during the latter years of the 1980s.

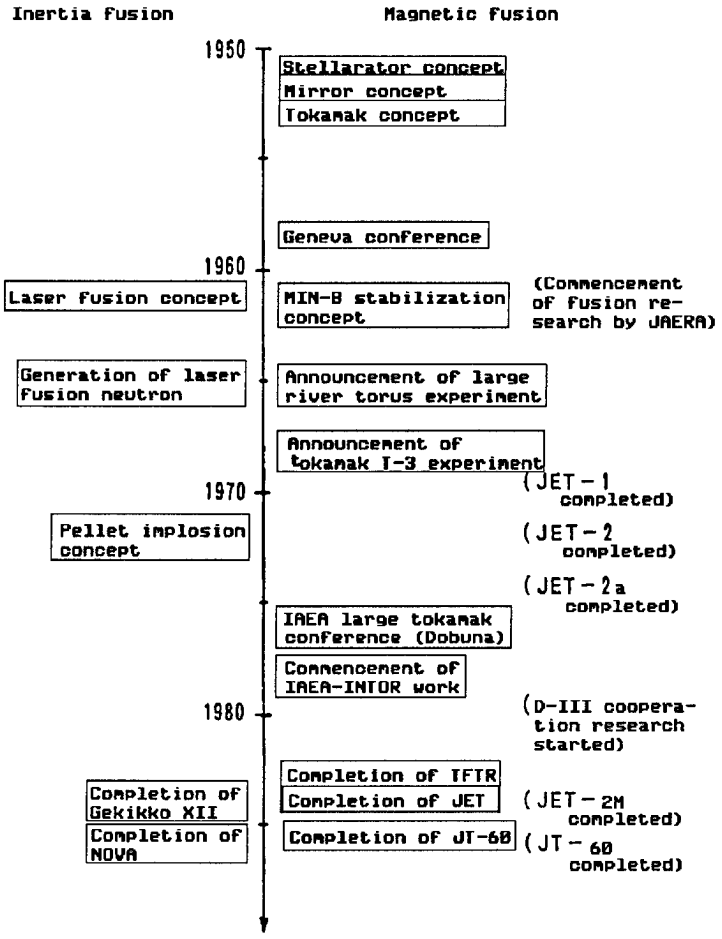
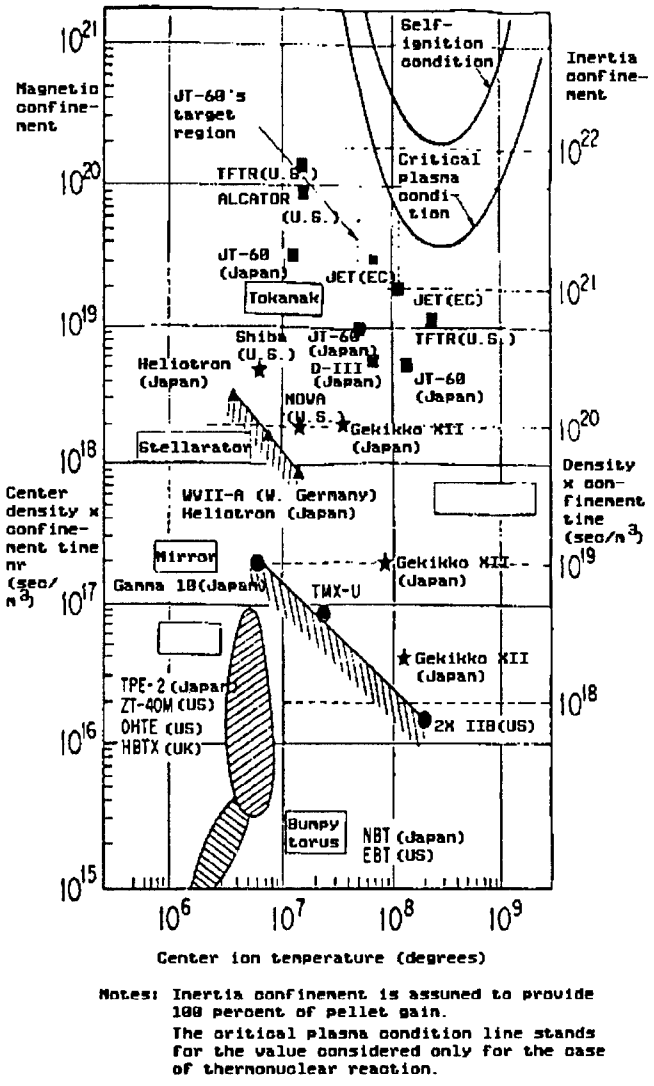


Figure 2. Progress in Nuclear Fusion Research

Japan began a first phase fusion development project in 1969. Since then, Japan has proceeded with the R&D Of torus plasma based on the multiple electrode magnetic field torus JFT-1 and tokamak units JFT-2 and JFT-2a. In 1975, Japan drafted a basic plan for second phase fusion research and development and started with JT-60, targeting the accomplishment of the critical plasma condition. In 1979, a United States-Japan scientific and technological cooperation agreement was signed in an effort to develop new energy sources. Based on this pact, the United States-Japan joint research was started according to doublet III (D III).

In addition to the tokamak units stated above, much steady effort has been made to study the stellarator and heliotron. West Germany succeeded in confining noncurrent torus plasma, which is the true objective of the stellarator system, again highlighting the significance of this system along with the heliotron E developed by Kyoto University in Japan. With the success of these experimental units, the United States, that had been detached from this field for a long time, constructed a mid-sized-fusion experimental unit ATF, returning to this field.



Notes: Inertia confinement is assumed to provide 100 percent of pellet gain.
The critical plasma condition line stands for the value considered only for the case of thermonuclear reaction.

Figure 3. Current Status of Nuclear Fusion R&D

On the other hand, inertia nuclear fusion research was started immediately following the first success of laser oscillation in an effort to study the possibilities of laser fusion. In the middle of the 1960s, success involving generation of neutrons from laser plasma was reported. The energy power produced by laser fusion has increased year by year. In 1985,

the United States completed the construction of a laser fusion reactor, NOVA, with a 100 KJ/100 TW energy drive and a target for approaching critical plasma around the completion of the JT-60 in Japan. In Japan, too, Osaka University started the operation of Gekikko XII, of 20 KJ/40 TW, in 1983, which has produced excellent results.

The author has briefly described the history of fusion research so far. Figure 3 shows the current status of research according to the Lawson diagram (in the diagram, ion temperatures Ti are plotted on the axis of abscissas, while the products, n x r_E, of density and confinement time are plotted on the axis of coordinates). The progress involving the tokamak is the most dramatic, currently at a level approaching the critical plasma condition. Next comes laser fusion. Greater expectations are placed on future progress in the stellarator and mirror.

3. Tokamak Development

The tokamak unit has been increased in scale in proportion to the progress in its research. The configuration of the unit has been subjected to marked changes as well. In the early stages of tokamak, the limiter configuration with a circular cross sectional area (plasma's peripheral areas placed contacting solid walls) was very popular. However, it has been predominantly replaced by the diverter configuration, which lifts the noncircular section plasma from the solid walls in an effort to remove the impurities or realize the H mode, which will be discussed later.

Figure 4 shows the development of the configuration and the scale of tokamak reactors with a diverter through the plasma cross sections, starting with JFT-2a. This diverter method, which generates plasma with long cross sections above or below the diverter, was originally proposed by Japan while studying INTOR. Through the subsequent development, this method has planted its roots as the standard core configuration.

Various problems involving tokamak have been resolved through the developmental stages. Table 1 summarizes the most important problems remaining and calling for early solutions. As clearly indicated in the table, the problems may be largely classified into containment characteristics, heating/electric current and core control. Japan is planning to proceed with research on the medium reactor JFT-2M, D III-D, under Japan-United states cooperation, and the large reactor JT-60, taking the responsibility for its assigned fields in an effort to resolve these problems.

Confinement Characteristics

The confinement rule and the beta limit are especially important among the confinement characteristics. Especially, an explanation of the confinement rule is the most urgent problem involved in nuclear fusion research and stands in our way as the pending problem. When high input-based heating was carried out recently, it was found that the tokamak's confinement characteristics are classified into the high performance mode (H mode) and

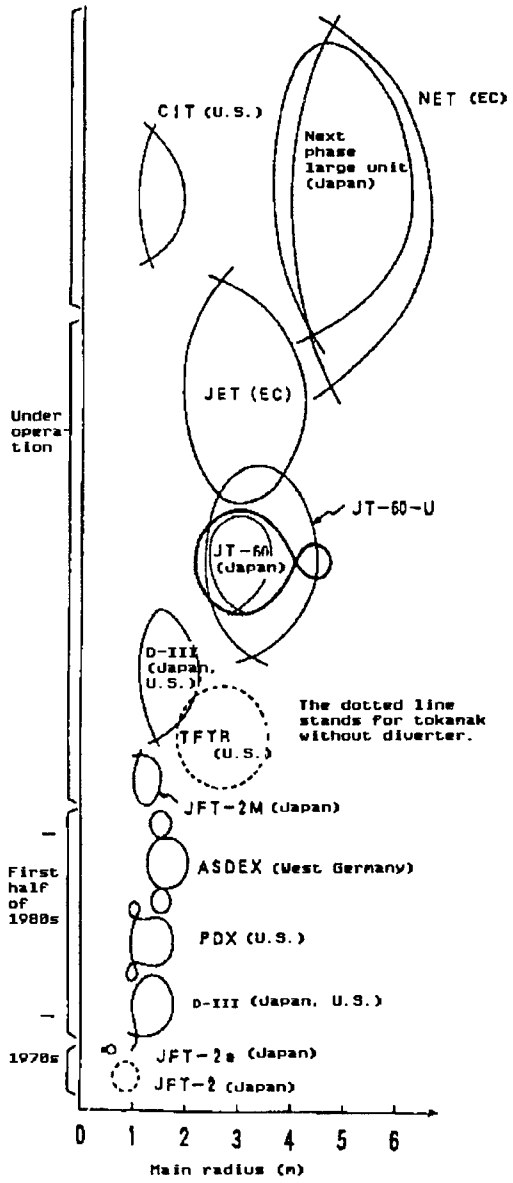


Figure 4. Development of Diverter Tokamak

low performance mode (L mode), as indicated in Figure 5, which has become the greatest highlight of the fusion research. In the L mode the confinement time drops with heating input. The plasma having a diverter upward or downward or upward/downward can be converted into the H mode, in which the confinement characteristics are excellent. The confinement time is substantially improved in proportion to the plasma current, either in the temperature or L mode. In the case of the H mode, in particular, no unified tendency has yet been found regarding how to depend on the size of the plasma or heating input. An explanation of the physical mechanism in the temperature mode and the establishment of the scale rule constitute the greatest problems facing research involving plasma in the tokamak core.

Table 1. Tokamak Units and Priority Problems of Core Plasma Research in Japan

Problem	Existing unit JET-2M, D III-D (Japan, U.S.), JT-60	Fusion next phase unit
Containment characteristics		
Plasma confinement rule	Circular/noncircular cross section L mode/H mode Side effects	Confinement rule for combustion plasma*
Beta limit	Circular/noncircular cross section	Beta limit in combustion plasma
Heating/electric current		
Heating	NBI/LHH/ICH/ECH	NBI/RF α-particle heating*
Current drive	LH wave/fast wave/NBI	RF/NBI
Core control		
Combustion control, ash discharge	Simulation experiments Diverter	Combustion control* Diverter
Impurity control	Pump limiter	
First wall protection	Selection of wall material (TiC, C)	
Stabilization control (disruption current distribution)	RF/NBI-based distribution	Confirmation based on combustion plasma

The * stands for practical items in the next phase unit alone.

As for the tokamak beta limit, Toroyon (France) proposed a definite scale rule recently, clearly explaining the experimental results. To maximize the beta value in the scale rule, it is necessary to study how to optimize the current distribution in the plasma or the plasma configuration.

Heating and Electric Current Drive

More efforts must be exerted to find the optimum heating method, and reflect this method in the next generation unit. The promising candidates may cover particle incidence heating (NBI), low region composite wave heating (LHH), ion cyclotron heating (ICH) and electronic cyclotron heating (ECH). However, the main heating for the next generation unit, aiming at nuclear combustion, is based on the α-particles generated by nuclear reaction. However, it is impossible to obtain actual data for this heating process unless actual DT (heavy hydrogen and tritium) combustion testing is carried out.

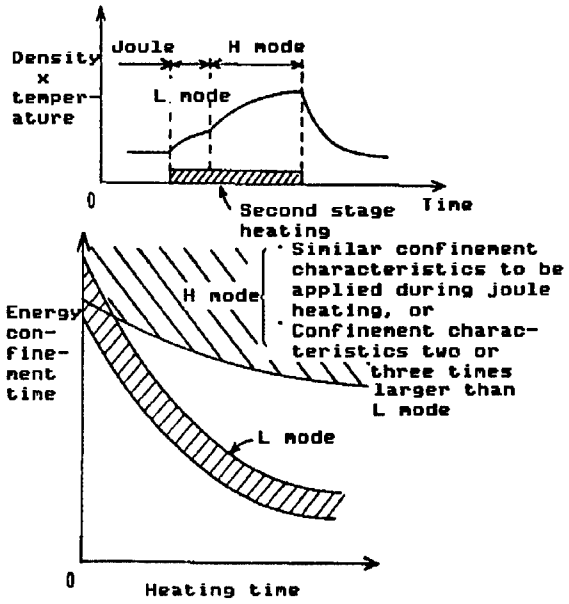


Figure 5. Confinement Characteristics in H and L Modes

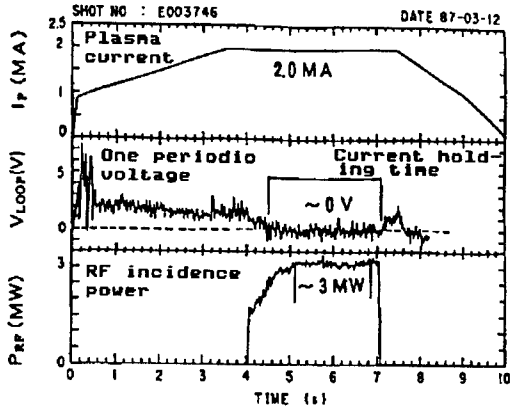


Figure 6. Highly Efficient Electric Current Drive Based on Low Region Composite Waves

JT-60 demonstrates that the low region composite wave drive (LHCD) in the low density region can be carried out extremely efficiently, as illustrated in Figure 6, similar to the electric drive current. On the other hand, more effort must be put forth to develop a high performance drive system in order to operate the tokamak on a routine operation basis.

Core Control

Core control calls for the solution of three problems. The first problem relates to nuclear combustion control and ash disposal. A full-fledged

experiment involving nuclear combustion control cannot be carried out unless using a D plasma which has reached the self-ignition region. This problem must be resolved by the next generation unit. However, a certain level of simulation experiments to exhaust the ashes may be carried out with the existing units. As a matter of fact, pioneer research has been conducted during the United States and Japan joint research involving D III.

The second problem, involving impurity control, selection of the first wall and its protection, is both an old and new problem imposed on the tokamak. As for impurity control based on the application of a diverter, striking achievements have been obtained with the JT-60. Figure 7 shows the radioactive loss as a ratio, with plasma input for the limiter configuration and divert configuration, for joule plasma and NBI plasma, respectively. The radioactive loss, which amounts to 80 to 90 percent against input in the limiter configuration, drops dramatically in the diverter configuration. NBI plasma drops to 5 percent, while joule plasma drops to 10 to 30 percent, thus demonstrating its powerful impurity control effects.

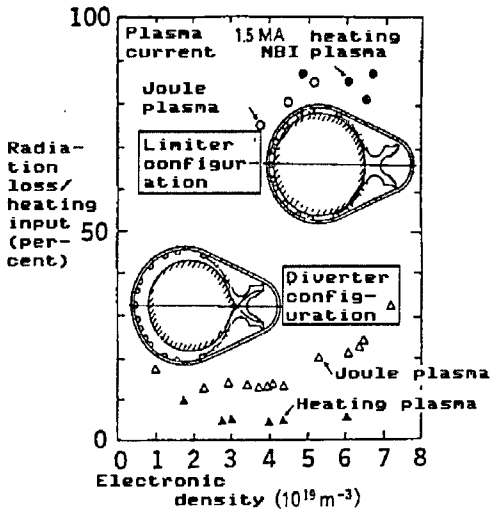


Figure 7. Radioactive Loss of Plasma in JT-60

As for the development of the optimal materials for the first wall or the protection from the plasma heat load, a decisive policy has not yet been established. More urgent and continuous efforts to resolve this problem must be dedicated in the future as well. In the beginning, JT-60 adopted molybdenum coated with titanium carbide for the first wall material. However, the coated molybdenum, which is the parent material for the first wall, was often subjected to exposure due to local heat concentration, especially during disruption. In response to this, parts equivalent to 50 percent of the surface area of the first wall were converted into graphite in the spring of 1987.

Stabilization control is mainly intended for inhibiting all-inclusive unstable natures of plasma. The disruption phenomenon is a factor hindering the stabilized operation of the tokamak. Figure 8 shows the typical wave form produced in the JT-60. The disruption generation occurs in the following process: First, the magnetic surfaces confining the plasma are subjected to damage due to the nonlinear development of unstable internal plasma, partially robbing the heat energy of the plasma immediately and forcing the plasma to lose its power balance on the whole. Then, the plasma is subjected to inward contraction and breakdown, dramatically reducing the electric current. At this time, resulting from the discharge of plasma energy, the excessive heat load is applied to the important parts of the first wall, thereby melting the wall surfaces immediately. The disappearance of the fast plasma current generates a gigantic impact magnetic force or induction voltage in structures, such as vacuum vessels or coils.

In this manner, the disruption phenomenon greatly affects the operation of the unit. However, the safety region can be selected depending on the operating conditions, which are determined by the plasma current value and the density. As a result, various disruption control methods are proposed in an effort to expand the safety region of this safety operation as much as possible. Much anticipation is placed on the results of the future research.

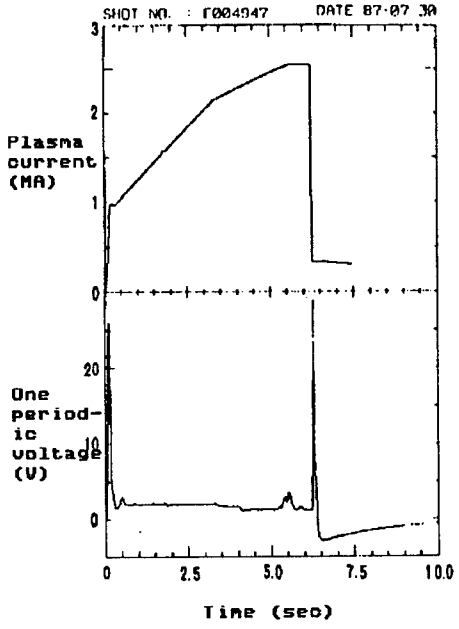


Figure 8. Plasma Disruption in JT-60

Japan's Accomplishments

The author has described the status of our core plasma research involving tokamaks. Japan has played a significant role in its research. Table 2 summarizes the pioneer technological results of tokamak research carried out by the Japan Atomic Energy Research Institute during the past 15 years. A series of achievements involving diverter plasma and the first experiment ever conducted involving the RF electric current drive from these research results have instantly upgraded the fusion research level in Japan and produced the motive force to place Japan in a position of leading the world in its research.

Table 2. Pioneer Accomplishments by Japan Atomic Energy Research Institute in Core Plasma Development

Year	Contents of accomplishment	Name of unit
1974	Generation and control of diverter plasma	JFT-2a
to 1975	Interaction of plasma and wall and pioneer research involving impurity control	JFT-2a
1978	Operation of tokamak based on extremely low safety factor (8 < 2)	JFT-2a
1979	Highly efficient (80 percent) ion cyclotron resonance heating	JFT-2a
1979	Open diverter concept for next phase unit	INTOR
1980	RF electric current drive experiment	JFT-2
1980	Accomplishment of plasma current IMA	D-III
	Experiments involving open diverter plasma	D-III
	Experiments involving ash discharge and remote cooling	D-III
1982	High beta (4.6 percent) noncircular plasma	D-III
	Highly efficient confinement mode based on open diverter	D-III
1984	Improvement in heating plasma confinement performance by pellet incidence	D-III
1986	Experiments involving highly efficient confinement mode in fixed limiter configuration	JFT-2M
1986	Highly efficient large current (to 2MA) drive by RF	JT-60

Nuclear Fusion Technology

The demand for the development of fusion technology has accelerated in proportion to the increase in the unit's size and enhanced performance. With the construction of the three great tokamak units serving as momentum, a large number of technological developments have been carried out.
Table 3 shows the main achievements in JT-60 and evaluates the technological significance. They cover the various kinds of new technological accomplishments, such as technological challenge and accomplishments in untrodden fields, development of new analytical methods, overall design and the establishment of new technology in manufacturing methods. Furthermore, these technological results have spread to other scientific and technological fields, thereby contributing toward their progress.

Table 3. Technological Development Outcome in JT-60
o: Extremely significant
x: Significant

	Technological development				
Development item	New technology	Analytical method	Overall design	Manufacturing method	Spread to other fields
High strength coil		x	o	o	x
Air-core converter power source	o	x	x		o
Large electronic beam welding technology				o	o
Low Z material coating technology	o			x	o
CAMAC system	x		o	x	x
High stabilization far-infrared laser unit	x		o	o	x
High output long pulse NBI unit	o	x	o	x	x
High output long pulse klystron	o		x	x	x
Grounding system		x	o	x	x

4. Large Tokamak Age

The construction of a large tokamak unit is intended in order to collect the past tokamak research and is targeted at the critical plasma condition, which may constitute the greatest milestone in fusion research. The three large tokamak units in the world, that is, TFTR (United States), JET (EC), and JT-60 (Japan) are already completed and running. Table 4 shows the features of these three great tokamak units.

Table 4. Features of Large Tokamak

Item unit	JT-60	JET	TFTR	T-15
Plasma ignition	April 1985	June 1983	December 1982	--
Confinement rule	L-mode	H-mode large current L mode	Supershot	(L-mode)
Beta limit value	1.5 - 2 % (circular)	3 - 4 % (noncircular)	1.5 - 2% (circular)	1.5 - 2 % (non- circular)
Heating	NBI (main) LHH (sub) ICH (sub)	ICH (main) NBI (sub)	NBI (main) ICH (sub)	NBI (main) ECH (sub)
Current drive	Highly efficient LHCD	Future project LHCD	-- --	OK ECCD
Impurity control	Closed Diverter	Open Diverter	--	--
First wall material	Graphite Titanium Carbide/ molybdenum	Graphite Beryllium (under study)	Graphite	Graphite
D-T combustion	--	--	--	Supra- conduction toroidal coil

TFTR, which was completed first, is aimed at accomplishing the critical plasma condition, including beam function based on powerful NBI and its demonstration based on DT combustion. Reportedly, the United Stats faced the L-mode obstacle immediately following the start of heating experiments and studied ways to improve and reinforce the situation, including conversion to a diverter, but discontinued its different method. In the

summer of 1986, the United States succeeded in producing a confinement performance two or three times that produced in the L-mode, called "supershot," in preparing for experiments aimed at enhancing the effects of beam fusion. This accomplishment made it possible to obtain the confinement time at an ion temperature of 300 million degrees to 400 million degrees and a fusion product of 3 x 10^{20}kev s/m^2, which is the product of density and ion temperature.

The United States plans to improve TFTR's plasma performance in the future and demonstrate the critical plasma condition based on DT combustion, targeting for 1990. After the completion of DT combustion experiments, the United States wants to convert TFTR into CIT, a compact self-ignition torus unit, during a large-scale remodeling, aiming at increasing the electric current value to 9 MA, which is very small, in the cross sectional area of the plasma and realizing self-ignition, although it will be limited to short hours.

JET, which started operation 6 months after TFTR, has a strikingly large plasma volume and noncircular cross sectional area and is capable of transmitting 5 MA of plasma current. JET has encountered several difficulties following the start of heating experiments. One is the drop in the confinement during the L-mode, while the other is the generation of gigantic sawtooth-shaped vibrations accompanied by ICH during the main heating. JET further suffered from a mixture of marked impurities. At that time, the most remarkable impurity control effects were demonstrated by applying the diverter adopted by JT-60. JET searched for a solution through research involving the diverter, which had once been proposed by Japan as the basic core system for INTOR and demonstrated by a D III. Based on the application of this open diverter, JET succeeded in producing the first H-mode for a large tokamak unit in the fall of 1986. The typical parameters centered on the plasma are:

Ion temperature: 6 kev
Fusion product: 2 x 10^{20} kev s/m^2

JET set about remodeling on a large scale immediate after obtaining the aforesaid results. JET is capable of carrying out 7 MA of discharge with a fixed limiter, and increasing the electric current (from 3 to 4 MA), even with the diverter configuration, aiming at higher performance. Reportedly, JET is planning to reinforce the electric current value in the diverter configuration in the plasma region approaching the fusion reactor core and study α-particle heating.

From the beginning, the construction schedule of JT-60 was delayed by about 2 years compared with TETR and JET, but it was provided with a diverter from the beginning, showing strikingly excellent results regarding impurity control. Attempts were made to carry out experiments with a high performance heating unit at a very fast speed. High hopes were placed on the establishment of the temperature-mode in particular. However, the results of the past experiments reveal that the JET-60 diverter, installed to the outside of the torus unit, inhibits the establishment of the temperature-mode. To counter this, JET-60 plans to increase the plasma

current in the L-mode (from 2.7 to 5 MA) and improve the confinement time. On the other hand, JET-60 has remodeled the configuration on a small scale, installing a diverter to a lower side and thus planning to realize the H-mode.

Figure 3 shows the JT-60 targets. As indicated from the figure, the target range is:

Ion temperature: approximately 10 million degrees
Product of density and confinement time: 2 to 6 x 10^{19} s/m^3.

JET has already accomplished this target range with the H-mode experiments. It is expected that JET-60 will attain the aforesaid range in its early stages by improving the above plasma performance.

JET-60 is planning to switch over to the enhanced performance research after reaching the target and improve the plasma performance further, develop the high performance core plasma and reflect these results in the next generation unit project. As for the enhanced high performance research, JET-60 is planning to remodel a vacuum container and polar magnetic field coils on a drastic scale and construct a noncircular-shaped diverter similar to JT-60-U, as illustrated in Figure 4, immediately enhancing the confinement performance, flowing 6 MA of current. It is also intended that JET-60 enhance its first rate current drive technology and develop a high density and highly efficient current drive technology, enabling it to construct a steady fusion reactor.

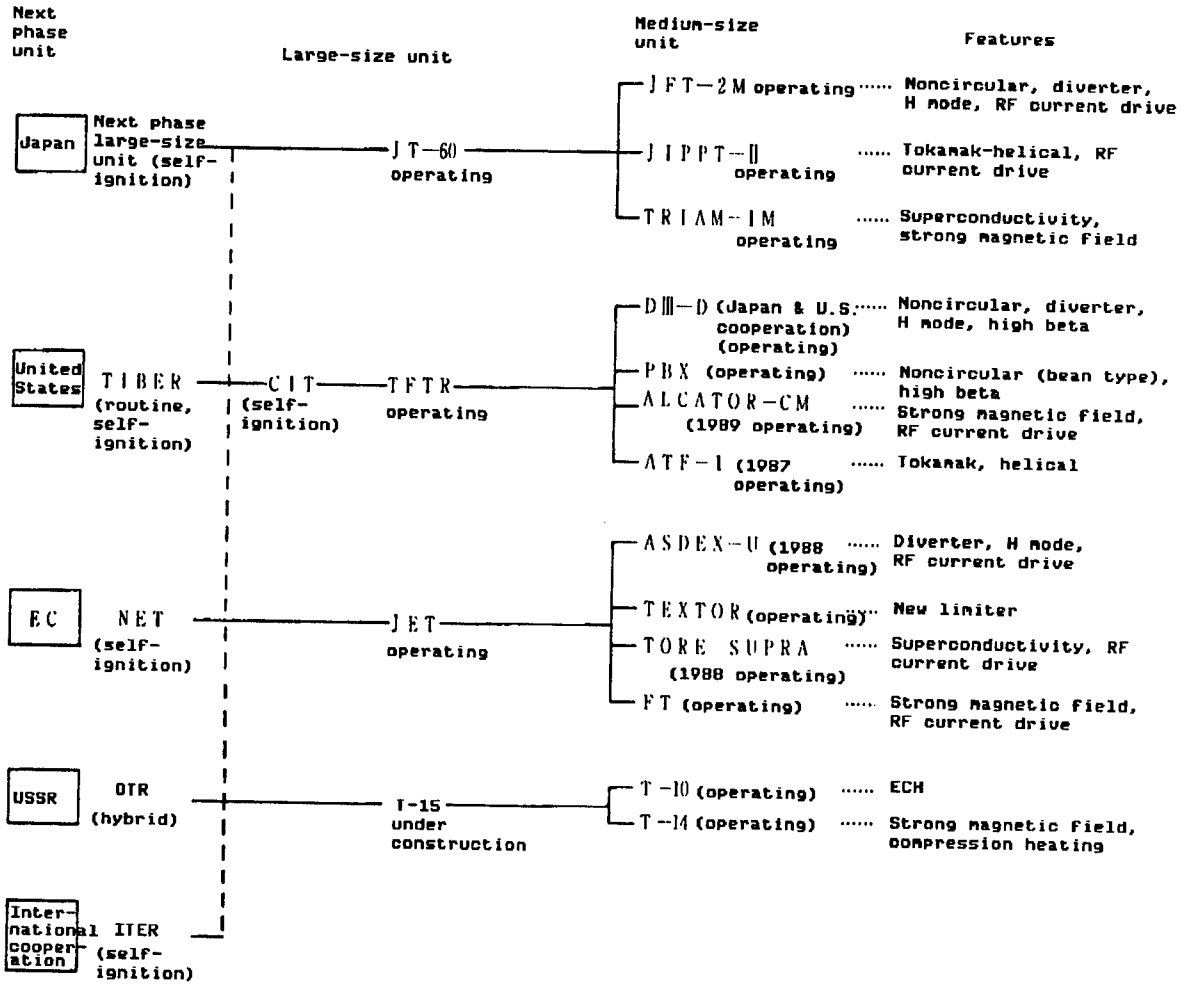
5. Future Research and Development of Fusion and International Cooperation

The next target of fusion research, after attaining critical plasma condition, is the realization of self-ignition for the next generation unit. Table 5 shows the individual next-phase large tokamak projects planned by Japan, the United States, Europe, and the USSR, who already have large tokamak units. On the other hand, next generation units are likely to be developed through international joint cooperation, thereby avoiding the potential risks involved in single-handled efforts to develop these units. This tendency is indicated by the joint design work of ITER, an international fusion experimental reactor which will begin following the pivotal United States-Soviet summit.

Figure 9 shows the scales and plasma performances of the next generation units, aiming at self-ignition, in comparison with those of the existing tokamak units. The plasma volumes will be increased by one column every 10 years if the plasma size standard is expressed in terms of plasma volume. The plasma volumes of the planned next generation units are three or four times greater than those of the JT-60-U or JET.

If the plasma performance is expressed in terms of fusion product, the fusion product of the tokamak units has increased at a rate of one column every 5 years. The fusion product of self-ignition plasma is 20 to 30 times greater than the established value of the current large tokamak units. It is predicted that the difference will be reduced in the future.

Table 5. Tokamak Type Fusion Research and Development in the World



More efforts should be made to develop various kinds of reactor engineering technologies intended for the next phase projects in proportion to the development of core plasma. The interested universities have adopted the helical system as a future experimental fusion unit and plans to proceed with researching the core plasma, which complements tokamak units.

The future research and development of fusion, centering around the research on enhanced JT-60 or the next large units, is of great concern to Japan, who is not blessed with natural resources. Japan should tackle this problem independently from the short-term energy situation and more steadily from the long-term viewpoint. The state-of-the-art technologies mentioned above accelerate the dramatic development of scientific technologies in various fields, extending their bases and fostering new scientific technologies. Japan is playing a leading role in the establishment of nuclear fusion energy, necessarily a lofty object to be shared by humankind, devoting its full efforts, which must be termed the

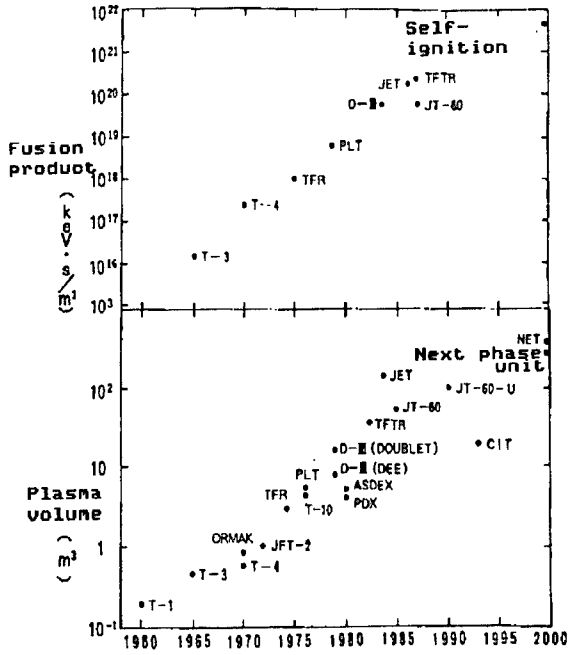


Figure 9. Progress in Tokamak Fusion

the most advanced position in the field of fusion research and her efforts have been highly evaluated on an international scale. As a result, Japan is regarded as one of the most influential members of the important fields of fusion research, and is expected to play a leading role in many other fields as well. The author firmly believes that Japan is in a position to respond to the aforesaid expectations from the international society from the long-term standpoint of developing its own energy.

20136/9365

Conditions for Originality in R&D Discussed

Research Vitality Assessment Method

43063801 Tokyo KAGAKU ASAHI in Japanese Aug 87 pp 51-56

[Article by Akito Arima, professor of nuclear physics at Science Department of Tokyo University, and Yasumasa Kanada, assistant professor of information science at Tokyo University's large-sized computer center: "Theses Become More Valuable When They Are Frequently Cited"; first paragraph is introduction by editor]

[Excerpts] Automobiles, semiconductors--In these fields, Japan has grown to such an extent that there is trade friction with the United States as well as European countries. It is leading the world in technology, but what about in terms of fundamental scientific research? Only four Nobel prizes have so far been won by Japanese scientists. The number is far smaller than that of Nobel prizes obtained by American and European scientists, because, it is said, highly creative research is not underway in Japan. Conformity is said to be a characteristic of the Japanese people; they prefer not to stand out, charging this characteristic is said to be necessary to enable the Japanese people to display their creativity.

Putting aside what posture researchers should adopt in pursuing their work, the dream we researchers have is to be honest, to conduct trailblazing research work ahead of others, and to continue research while sustaining its vitality.

In reality, there has never been an age in which cooperation among researchers was more important than today. This is particularly so in terms of big science. At a time like the present, it is essential for research groups to enhance originality and vitality in pursuing their work.

How can originality and vitality in research be assessed? In this article, the advantages and problems of assessing the vitality of researchers based on the number of theses disclosed by them and the originality of their research work according to how often their theses are cited will be discussed. Cases of both individuals and groups will be analyzed.

Japan Placed Third in Total Number of Theses, Ninth on Per-Capita Basis

Data base named INSPEC (International Information Services for the Physics and Engineering Communities) stores theses disclosed in the fields of

physics, electricity, electronics, control, and computers. This data base originated in the United Kingdom. In the field of chemistry, CAS (Chemical Abstracts Service) created in the United States is a well-known data base. There are also other data bases storing theses in other fields. Such data bases may be used to assess the vitality of individual researchers or research groups according to the numbers of theses made public by them. Discussed in this article are the results of analyses made using INSPEC with regard to physics. Incidentally, INSPEC stores only a small portion of theses written in Japanese. Generally, theses written in Japanese are rarely highly regarded physical researchers. Therefore, for the purpose of this article, theses written in Japanese and into entered in INSPEC may be ignored.

Figure 1 shows the changes in the numbers of physics theses disclosed by researchers of major countries in recent years. It indicates that the number of physics theses disclosed by Japanese researchers has generally been on the increase, reflecting the growth of economic strength of the country in the same period. Figure 2 compares the numbers of physics theses disclosed by Japanese researchers in recent years and the amounts of annual funds used by the Ministry of Education for the promotion of scientific research in the corresponding period. It shows that the two types of figures correlate closely.

Table 1 gives the total number of physics theses produced in each of the countries indicated in Figure 1 in the 10-year period of 1976 through 1985. According to the table, Japan ranks third in the world coming after the United states and the USSR as far as the total number is concerned. When it comes to the per-capita number, however, Japan drops down to ninth place.

Table 1. Total Number of Physics Theses Produced in Major Countries During Period 1976-1985 and Corresponding Number for Population of 10,000, Based on INSPEC

Country	Total number of theses 1976-1985	Number per 10,000 people
United States	315,871	13.3
Canada	31,232	12.4
West Germany	74,265	12.1
United Kingdom	57,872	10.4
Netherlands	14,958	10.4
France	54,587	9.9
Sweden	8,062	9.7
Australia	13,687	8.8
Japan	82,739	6.9
USSR	86,212	3.1

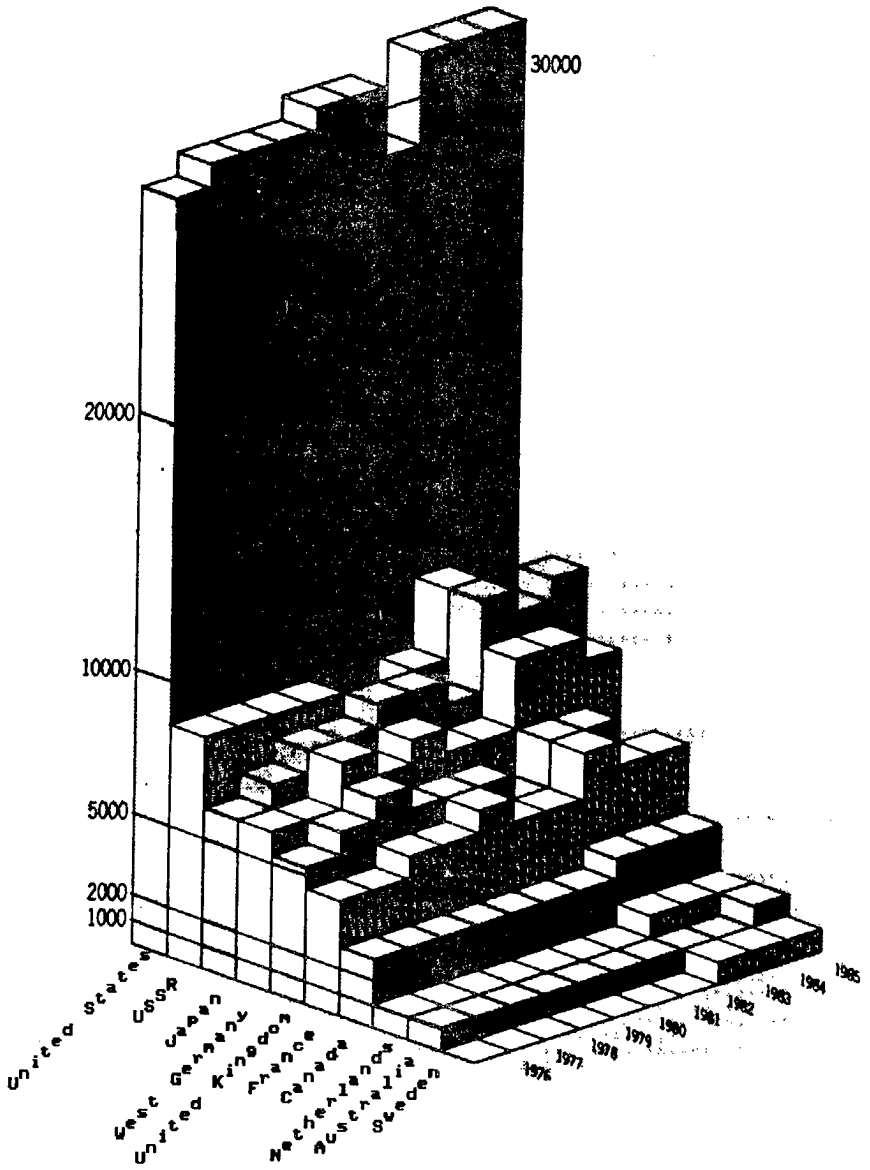


Figure 1. Changes in Recent Years in Numbers of Physics Theses Produced in Advanced Countries

On the basis of these analyses, it may be said that the contribution of Japan to the world of physics is not yet satisfactory. It may be necessary to make similar analyses in other fields, too. The achievement of the Netherlands, a relatively small country, deserves attention.

Influence of Japanese Journals Small

Assessing the research productivity just by counting the number of theses will certainly invite criticism, because such an assessment method does not take into account the quality of theses. How can the quality of theses be assessed then?

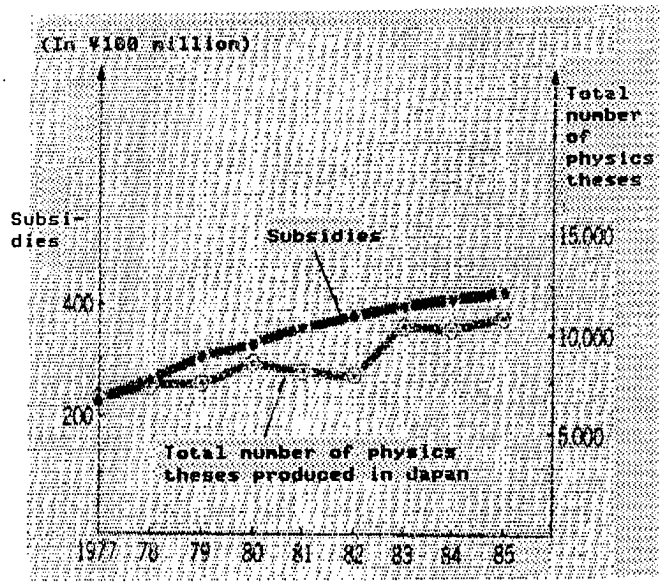


Figure 2. Correlation Between Numbers of Physics Theses Produced in Japan in Recent Years and Amount of Scientific Research Subsidies Used in Same Years

Each thesis carried in a journal is usually followed by a bibliography, depending on the journal. The bibliography gives the names of journals which the author referred to in writing the thesis, along with other relevant information such as the publication date, volume number, and author. The bibliography may include other articles by the author of the preceding thesis. Scanning such bibliographies and counting the number of times a certain thesis is referred to in other theses gives a measure of the popularity of the thesis. Such a count will be referred to as the "science citation index" herein. The propriety of thesis quality assessment based on the science citation index will be discussed later. It may be said that the method is quite reliable.

To earn a high science citation index for a thesis, it is advisable to have the thesis carried in a reputable journal which imposes strict screening. Once a thesis is carried in such a journal, it will have many changes to be cited in other theses. Analyzing how often the theses carried in a certain journal are referred to in other theses makes it possible to determine what is called the impact factor of the journal. The science citation index of a thesis carried in a certain journal is generally proportional to the impact factor of the journal. Table 2 lists the world's top 10 physics journals in terms of impact factor as well as some physics journals published in Japan, along with their impact factors.

It is possible to take into account the popularity of theses in assessing the generalized vitality of physics research work conducted in each of the countries indicated in Figure 1. Such research work vitality analysis can be made by determining, for every thesis counted, the impact factor of the corresponding journal and totaling the impact factors associated with the

Table 2. Top 10 Physics Journals Worldwide in Terms of Popularity (Impact Factor) in 1981, and 3 Japanese Physics Journals (Based on science citation index)

Name of journal	Popularity (impact factor)
REV. MOD. PHYS. (United States)	16.231
P. NATL. ACAD. SCI. USA (United States)	8.715
ADV. PHYS. (United Kingdom)	8.708
ADV. CHEM. PHYS. (United States)	8.650
NATURE (United Kingdom)	7.187
PHYS. REP. (Netherlands)	6.679
SCIENCE (United States)	6.237
PHYS. REV. LETT. (United States)	6.058
REP. PROG. PHYS. (United Kingdom)	4.820
ADV. NUCL. PHYS. (United States)	4.800
J. PHYS. SOC. JAPAN (Japan)	1.557
PROG. THEOR. PHYS. (Japan)	1.426
JAPAN. J. APPL. PHYS. (Japan)	1.071

[Journals in English as published]

theses classified by country. Figure 3 shows the results of modifying Figure 1 by taking into account thesis quality in the above-described way. In producing Figure 3, those journals whose impact factors were assessed to be smaller than one were ignored.

When Figures 1 and 3 are compared, it is noticeable that USSR, ranked high in Figure 1 is considerably degraded in Figure 3. This is because the popularity among physics researchers of the journals carrying the theses written by Russian researchers is low. In other words, the physics theses written by Russian researchers do not attract much attention from the researchers of other countries and, hence, they are not so frequently cited by researchers of other countries. Japan ranking above West Germany in Figure 1 is surpassed by West Germany in Figure 3 in which France and Britain appear nearly comparable to Japan. Thus, comparison between the two figures clarifies that, in the world of physical research, the journals published in the countries where English is spoken or in the West European countries are still predominant.

High Science Citation Index Reflect High Originality

The science citation indexes of a thesis is a barometer of the popularity among researchers. Generally, in writing an article, the author mentions rather early other theses from which he has derived a concept or had come to recognize relevant problems. He cites theses written by others on subjects similar to his own usually close to the end of his article. Theses referred to for technical information are, in many cases, cited in the middle portion.

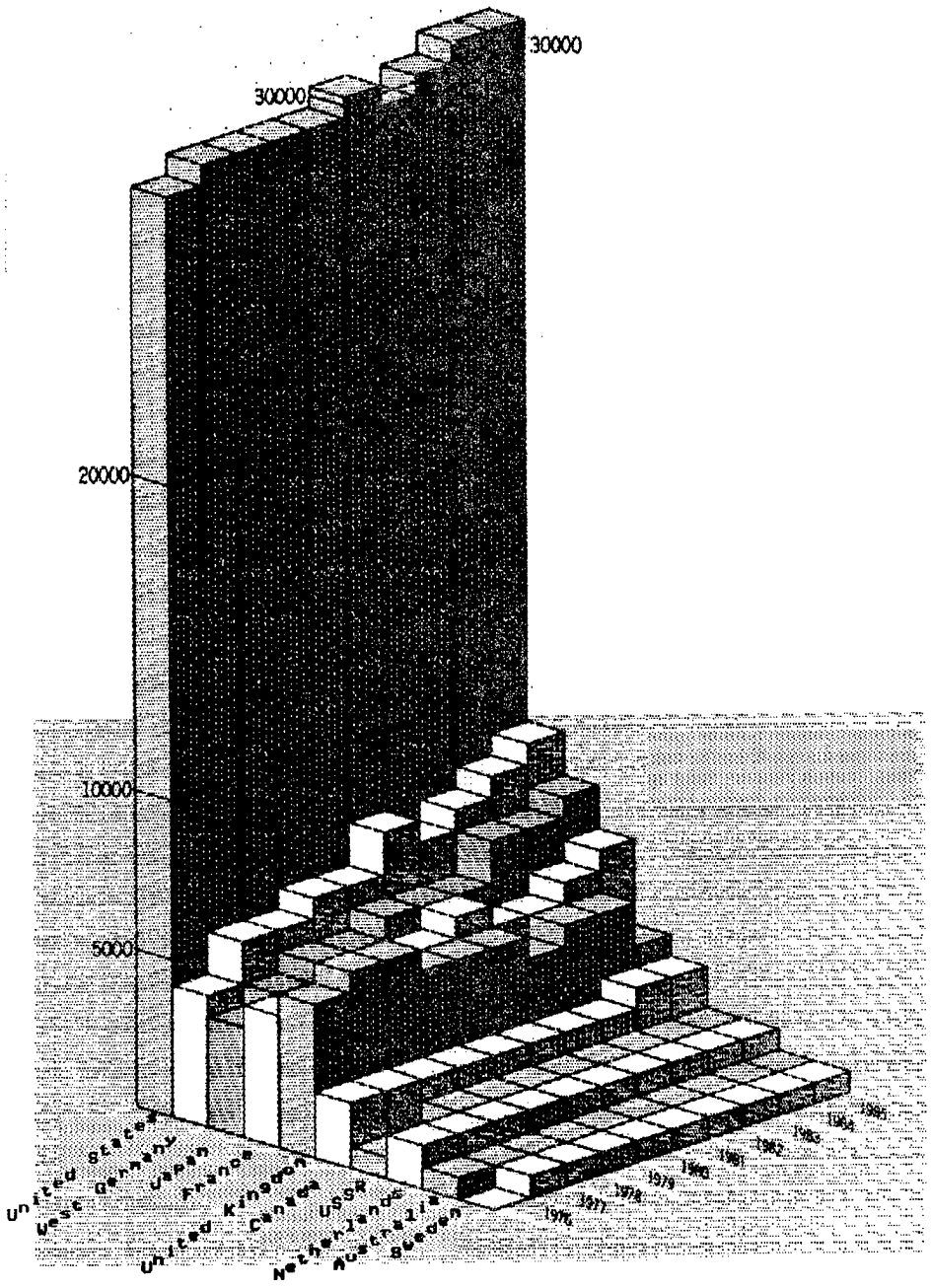


Figure 3. Transition in Recent Years of Physics Research Vitality of Major Countries Assessed by Taking Thesis Quality Into Consideration

Therefore, the importance of theses being cited varies according to its placement. It may generally be said that a thesis which is often cited in other theses near the beginning has originality. It sometimes happens that theses which are cited in other theses with particularly high frequency during a certain period have erroneous contents. Such a phenomenon occurs as many authors try to correct errors found in theses of other researchers.

Therefore, to strictly assess the quality of theses, it is also necessary to consider whether the contents of the theses are correct and in what portions of other theses they are referred to. However, it may be said that theses whose science citation indexes are high exceed in originality and quality those whose science citation indexes are low.

About 5 years ago, we examined the science citation indexes of the theses written by the professors and assistant professors for the Physics Section of Tokyo University's Department of Science. Of a total of 2,379 theses written by them in or before 1981, those referred to 100 times or more in other theses totaled 58. Among them, those referred to 200 times or more in other theses were only 19 (Figure 4--the science citation indexes include being cited by coauthors in or before 1980). Based on these findings, it may be said that theses which are cited 200 times or more in other theses are highly original and are highly evaluated.

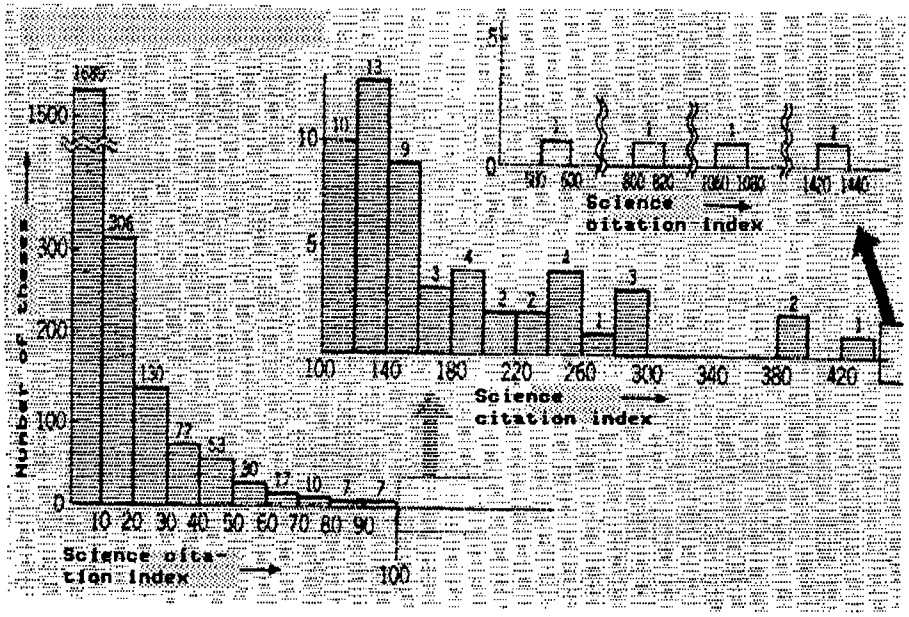


Figure 4. Science Citation Indexes Theses Produced by Physics Section of Tokyo University's Department of Science Up to 1981

The case of Ryogo Kubo was outstanding among those examined. The theses written by him in or before 1981 include 12 which were cited 100 times or more in other theses. Of the 12, 4 were cited 500 times or more in other theses. The best-known thesis written by him is on irreversible processes. It was referred to in other theses as many as 1,884 times. It is no wonder he was awarded such prizes as an Academy prize, a Boltzman prize, and an Order of Cultural Merit. The theses written by Yoshiro Ehashi of Tokyo University's Medical Department who was also teaching at the Physics Section of the same university scored a very high science citation index in our survey. He is also a winner of an Order of Cultural Merit.

Table 3 lists examples of theses written by researchers belonging to the above-mentioned Tokyo University's Physics Section and cited 200 times or

more in other theses by the end of 1986. The authors of most of the theses whose science citation indexes are very high are winners of at least one prize. It must, however, be mentioned that the prizes won are not necessarily attributable to the theses whose science citation indexes are high.

Table 3. Theses, Out of Those Written by Professors and Assistant Professors of the Physics Section of Tokyo University's Department of Science, Which Were Cited 200 Times or More in Other Theses, and Prizes Awarded to Such Theses

The theses listed were selected as follows:
1) The total science citation index for years up to 1980 of each thesis written by each physicist who belonged to the Physics Section of Tokyo University's department of Science was counted.
2) The largest science citation index recorded for each thesis in any 1 year in the period of up to 1980 was multiplied by six (representing 6 years from 1981 through 1986), and the product was added to the corresponding total science citation index counted in step 1).
3) The theses for which the sum obtained in step 2) reached 200 or more were selected as candidates for listing.
4) Of the candidates theses selected in step 3), those whose science citation index actually reached 200 or more were finally entered in the table.

Author	Coauthor	Year thesis disclosed	Science citation index	Subject of thesis	Prize
Ryogo Kubo	Tomita	1954	991	Magnetic resonance absorption	
	Nagamiya (Ken), Yoshida	1955	223	Antiferromagnetism body	Order of Cultural Merit
		1957	1,884	Irreversible process	
		1962	331	Relaxation phenomenon	
		1962	691	Cumulant expansion method	Boltzmann prize
	Izuyama, Kim	1963	299	Neutron diffraction	
		1963	218		Academy prize
	Miyake, Hashizume	1965	316	Quantum mechanics in strong magnetic field	
		1966	523	Fluctuation dissipation theorem	

[continued]

[Continuation of Table 3]

Author	Coauthor	Year thesis disclosed	Science citation index	Subject of thesis	Prize
	Suzuki (Masu)	1968	247	Ising model	Nishina prize
	Matsuo, Kitahara	1973	321	Macroscopic variable fluctuation and relaxation	
Yoshiro Ehashi		1961	431	Calcium-dependent relaxation factors	
	Lipmann	1962	305	Taking into ATP-dependent graduation	Order of Cultural Merit
	Ehashi	1964	332	New ultraprecipitating protein of myosin B	
	Kodama, Ehashi	1968	353	Troponin I	Academy prize
	Endo	1968	1,274	Calcium ions and muscular contraction	
	Endo, Otsuki	1969	517	Adjustment of muscular contraction	
	Wakabayashi, Ehashi	1971	260	Troponin	Asahi prize
		1976	248	Excitation and contraction linkage	
Akito Arima	Horie	1958	200	Magnetic efficiency of nuclear force	
	Iachello	1975	266	Boson model in which nuclear interaction occurs	Nishina prize
	Iachello	1976	587	" " "	
	Otsuka, Iachello	1977	480	" " "	
	Iachello	1978	211	" " "	
	Otsuka, Iachello	1978	234	" " "	
	Otsuka, Iachello	1978	228	" " "	
	Iachello	1981	301	" " "	

[continued]

[Continuation of Table 3]

Author	Coauthor	Year thesis disclosed	Science citation index	Subject of thesis	Prize
Yoshio Yamaguchi		1954	521	Separated nuclear force I	Nishina prize
	Yamaguchi	1954	222	Separated nuclear force II	
Toshimitsu Yamazaki		1967	355	Nuclear gamma ray angle correlation number table	Academy, Nishina, Matsunaga prizes
Masuo Suzuki	See "Ryogo Kubo"	1968	247	Ising model	Nishina, Matsunaga prizes
Takaharu Otsuka	See "Akito Arima"	1977	480	Boson model in which nuclear interaction occurs	
	" "	1978	234	" " "	
	" "	1978	228	" " "	
Takeyuki Wakabayashi	See "Yoshiro Ehashi"	1971	260	Troponin	
	Huxley, et al.	1975	200	3-dimensional image reformation	
Tadao Fujii	Anderson, et al.	1966	229	p+p → p+n	
Shuji Orito	Barbiellini, et al.	1972	226	High energy proton-Proton scattering	
Shozo Ito		1966	201	Metal growth over halite	
Keiji Inoki	Matsuda	1967	201	New sum rule for elementary particle theory	
Yoshiki Horita	Benzer	1972	200	Behavior of drosophilae	

Take the instance of Toshimitsu Yamazaki who received an Imperial Award of the Japan Academy [1987], for example. The award given him was for the achievement he made in his mesonic research work, but the article listed in

Table 3 is on a different subject. Yoshio Yamaguchi won a Nishina prize for his research work on the SU(3) model of elementary particles, whereas the articles whose science citation indexes are very high deal with nuclear forces.

Table 4 lists examples of theses which were awarded prizes and which happened to catch our attention. As the data indicate, the science citation indexes of the listed theses are all high.

Table 4. Examples of Prize Winning Theses

Author	Coauthor	Year thesis disclosed	Science citation index	Subject of thesis	Prize
Makoto Kobayashi	Masukawa	1973	1,059	Integrated theory of quark and lepton	Academy, Nishina prizes
Toru Moriya		1960	338	Weak ferromagnetic material	Nishina prize
Hisao Marumori		1964	183	Nuclear boson expansion method	Nishina prize
Toru Eguchi	Kawai	1982	138	Gauge theory	Nishina prize

In recommending topics for prizes, the science citation indexes of candidates theses will enable the originality of the topic to be appropriately assessed. Such a method will enable fair thesis-originality assessment unaffected by favoritism of the recommender, unfounded intuitive judgments, or publicity by thesis authors. Needless to say, high science citation indexes of theses do not directly ensure that the theses are superior ones. However, theses which are highly rated score, almost without exception, high science citation indexes.

Assessing the vitality of different research institutes according to the numbers of theses disclosed by them and the science citation indexes of the theses is interesting from the viewpoint of science administration, too. Using such a method, we assessed the vitality of Tokyo University's Nuclear Laboratory, Osaka University's Nuclear Physics Center, and Tohoku University's Nuclear Science Research Institute--three organizations where nuclear physics research work is conducted. The results of assessment will be introduced in the following. Tokyo University's Nuclear Laboratory was founded about 30 years ago; Osaka University's Nuclear Physics Center and Tohoku University's Nuclear Science Research Institute are about 10 and 20 years old, respectively. The facilities of the two laboratories, other than Tokyo University's, are intended for shared use by researchers from throughout the country.

At Tohoku University's Nuclear Science Research Institute, too, there are many researchers from outside the university. To assess the vitality of the three laboratories, we reviewed their annual bulletins and checked the theses written by researchers at the laboratories, including those who were from outside the laboratories. There were bulletins reporting whatever research made at the corresponding laboratory regardless of who conducted it and others in which only the results of research work made by researchers belonging to the corresponding laboratory are recorded. In our analysis we ignored differences between bulletins issued by different laboratories. We also excluded theoretical theses from the objects of our analysis.

Researcher Changes and Equipment Updating

Figure 5 shows the results of analysis we made to assess the vitality of the three laboratories. As shown, a considerable number of theses were produced at each laboratory. Judging from the science citation indexes of the theses, it appears that the vitality of each laboratory rose to a peak level about 4 to 5 years after construction of an accelerator there. At Tohoku University's Nuclear Science Research Institute, they built an electronic accelerator in 1967 and a storage ring in 1981. At Osaka University's Nuclear Physics Center, a cyclotron was completed in 1975. In the case of Tokyo University's Nuclear Laboratory, they fabricated varied accelerators; an FF cyclotron in 1957, an electronic cyclotron in 1962, and an SF cyclotron in 1975. In addition, the laboratory was in use by different research groups such as those engaged in work on nuclear physics, high energies, and, though only for a certain period, cosmic ray physics. Thus, the circumstances were a little more complicated than in the cases of the other two laboratories. Still, a trend similar to that found for the other two laboratories can be read from the science citation index curve for Tokyo University's Nuclear Laboratory shown in Figure 5.

To prevent the vitality of a laboratory from weakening, it is necessary to make personnel changes among the researchers working there and update the equipment. In the case of Tokyo University's Nuclear Laboratory, construction of a new accelerator has been proposed for 10 years or so, but the proposal has not been carried out. Tohoku University's Nuclear Science Research Institute has also been in a similar situation. For this reason, the vitality of the two world-famous laboratories has regrettably been declining. In the case of Osaka University's Nuclear Physics Center, on the other hand, the budget for building a new accelerator has been appropriated this fiscal year. It was an appropriate step, though it would have been better if such a step was taken earlier.

Transitions of the vitality of many other laboratories can also be analyzed by the same method as used by us in assessing the vitality of the aforementioned three laboratories. If the vitality of a laboratory appears to be heading for a decline, an appropriate preventive measure needs to be taken.

This paper has proposed counting the numbers of theses produced in different countries or by different research organizations or individual

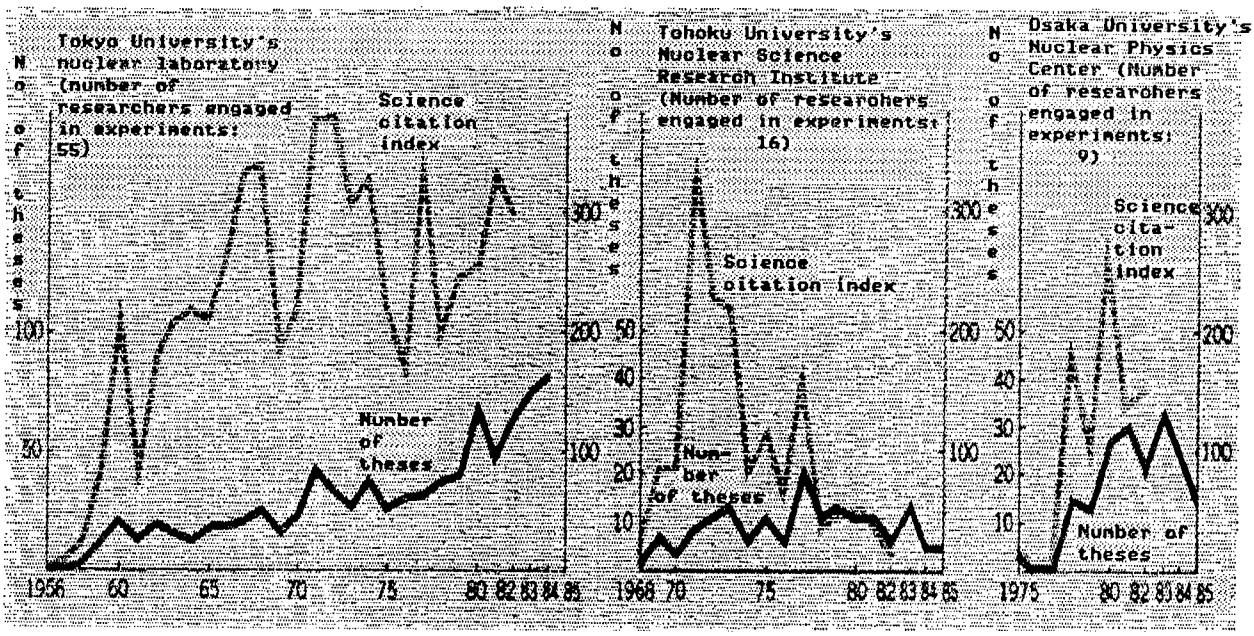


Figure 5. Changes in Numbers of Theses (on experiments) Written by Nuclear Physics Researchers of Tokyo University, Tohoku University, and Osaka University and in Science Citation Indexes of Theses
The number of researchers indicted for each university is as counted in 1985.

researchers as a way of assessing their vitality in terms of research work. It has also proposed checking the science citation indexes of theses and the impact factors of thesis-carrying journals as a way of thesis quality evaluation. As examples of analysis made in such ways, the results of counting the numbers of theses produced in major countries, in the Physics Section of Tokyo University's Department of Science, and at three Japanese laboratories where nuclear physics research work is conducted as well as the results of checking the science citation indexes of the theses produced by such countries and organizations have been introduced.

As a result of analysis we made, it has been learned that Japan stands third in the world in terms of total physics research capability and that its standing drops to ninth place when it comes to per-capita research capability. Furthermore, Japanese physicists who won a prize or prizes and the science citation indexes of representative theses written by such physicists have been indicated and the relationship between laboratory vitality and laboratory equipment aging has been analyzed.

Closed Nature of Academic World

43063801 Tokyo KAGAKU ASAHI in Japanese Aug 87 pp 57-61

[Interview with Yasuo Kagawa, professor of biochemistry at Jichi Ika Daigaku; interviewer, place, and date not identified: "Environment To Allow Outspoken Discussions To Be Held and Active Personnel Exchanges Desired"]

[Text] Scientific Research Subsidies Amounting to Less Than needed To Purchase 100 Tsubo (330 m^3) of Land in Central Tokyo

[Interviewer] Professor Kagawa, I understand that, as education chairman of the Japan Biochemistry Society, you have been taking different occasions to discuss differences between Japan and the West as to research work quality and the conditions and environments for conducting research work.

[Y. Kagawa] Recently, I went to Hawaii to attend an international conference there. On that occasion, I heard that 95 percent of the hotels in the Waikiki area are owned by Japanese. Japan is regarded as a very rich country by foreign people. Buying a hotel requires a large amount of money. However, when it comes to science, Japan does not spend enough money for fundamental research. In the United States, the funds granted by the National Institutes of Health (NIH) and the National Science Foundation (NSF) for scientific studies, centered on molecular biology, amount to as much as ¥ 1 trillion. In Japan, the scientific research subsidies given by the Ministry of Education totals merely ¥ 40 billion. This amount includes subsidies given to universities' engineering and science departments where much money is needed to promote research work as well as special subsidies for the promotion of selected research. Under the latter-mentioned subsidy system, each selected researcher is said to be given ¥ 100 million. Of the total government subsidies of ¥ 40 billion, it is only about ¥ 10 billion that is used for real basic studies in the field of biology. This is an amount approximately equal to the price of only several tsubo [1 tsubo equals about 3.3 m^3] of land in central Tokyo.

[Interviewer] Even the total amount of the government subsidies for scientific research promotion is less than one twentieth of the total amount of funds allocated for scientific research in the United States, isn't it?

[Y. Kagawa] Japan caught up to the United States in 1981 in terms of the ratio of the total amount of research expenses inclusive of those disbursed by private organizations to the gross national product. In the same year, Japan also came up to about the same level as Britain in the amount of research expenses per researcher. This indicates how large the portion of research expenses accounted for by private funds is in Japan. Whereas the government gives us little money for use in carrying out fundamental research in universities, a huge amount of money is used for technical development in the private sector. The ¥ 40 million subsidized by the government is really a small amount. Recently, a private enterprise built

a laboratory near the university where I work. That laboratory alone should have cost several tens of million yen.

[Interviewer] Is something wrong with the Japanese people's view of science?

[Y. Kagawa] In Japan, science has been taught as something authoritative, objective, and errorless. Dr P. Mitchell of Britain who received a Nobel prize in 1978 for his research work on ATP (adenosine triphosphate) synthesis came to Japan 3 years ago. In a lecture he delivered in Japan, he said that, even though people regard science as something objective and correct, what is objective and correct is a system of knowledge and that research activities comprising another aspect of science are very individual and subjective while they are in a trailblazing stage. Such an idea was astonishing to the Japanese people. According to him, scientific activities in a true sense made by scientists are subjective and individual, so that individuality is very important for science. In the Japanese education system, learning science as objective knowledge used to be a short cut to academic success.

Research Without Hypothesis Is Not Highly Rated

[Y. Kagawa] Scientists, in carrying out their research activities, should adopt a posture for criticizing the authority of science as an existing knowledge system. If science is flawless, no research is required. This is a point which many people fail to recognize. Speaking extremely, research work to be highly rated in Japan is required to result in some findings. Such work is easy to recognize from the viewpoint of authoritative science. Internationally, however, such a type of research work is not highly regarded. In the field of science, four Japanese scientists so far received a Nobel prize. They built their own hypotheses (such as the neutron theory and the frontier electron theory) against the conventional concepts. Hypotheses like those are arrived at by individuals.

Scientists such as Levi (Montaruchini) (awarded the Nobel prize for medicophysiology in 1986), Mitchell, and Leloir (awarded the Nobel prize for chemistry in 1970) won Nobel prizes for research work they made at home. McClintock who is also a Nobel prize winner was also working in a poor environment, though it was not his house. We Japanese must consider why such scientists were able to achieve Nobel prizes. I have been to Mitchell's laboratory. It was not a place where advanced experiments in biochemistry can be made. Taking out mitochondria from cells might have been the best that could be made in that laboratory. However, there were many scientific journals collected throughout the world in the laboratory and he was reading them from early in the morning. When a scientist becomes the leader of a scientist group, he becomes so busy raising funds for research by his group that he can seldom engage in research himself. In this regard, I was impressed that Mitchell was using his time to read theses and even to rewrite diagrams and tables himself. When he attends a meeting of an academic society, he asks concrete questions on data presented by other researchers. Often, when the leader of a research group

is asked a question by Mitchell, he cannot answer it. This is because the leader does not himself directly engage in the group's research work, even though his name is indicated as author. When such a situation occurs, young researchers working under the leader tend to feel respect for Mitchell thinking that Mitchell really understands the contents of the research they do. The "chemical theory" that had initially held an ascendancy over Mitchell's theory (chemiosmotic theory) started plummeting vis-a-vis Mitchell's theory in 1970 (Figure 2).

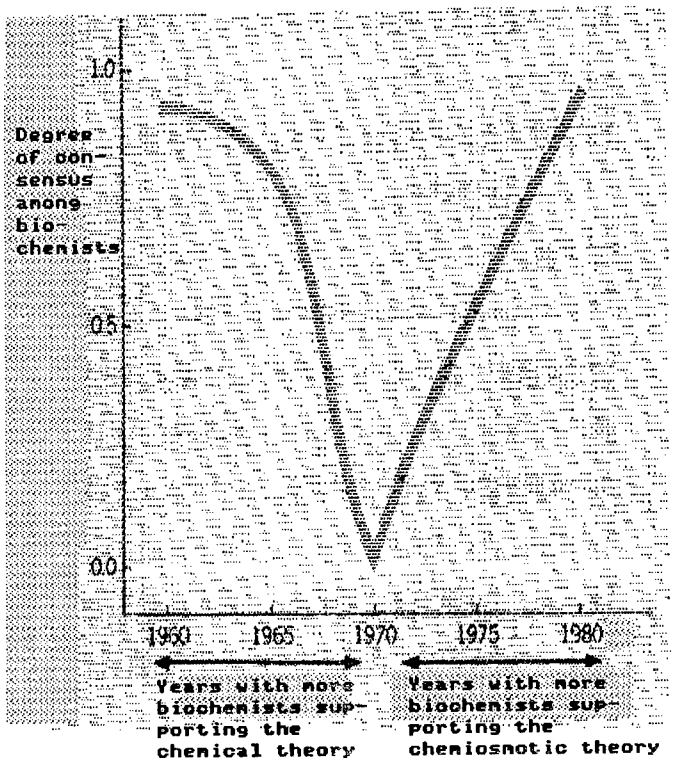


Figure 2. Transition of Researchers' Views as to Mechanism of ATP Synthesis

[Interviewer] That was a dramatic turnaround, wasn't it?

[Y. Kagawa] In science education in Japan, the procedure for asking questions of nature and deriving answers from it based on the recognition that science is something subjective and individual is not taught.

In the entrance examination for Harvard University, great importance is attached to interviewing held to probe the individuality of each applicant. Examinees who made outstanding achievement, for example, winning a musical contest, in their high schools or universities (in the case of those taking the examination for entrance to the medical department) or who have some outstanding ability are in an advantageous position. Such examinees are regarded as being highly motivated and having a sort of ability to tide over difficulty. The underlying policy is to give priority to examinees who show strong individuality and who did "something interesting." Such an

idea is not incorporated in the entrance examinations held in Japan. The Japanese entrance examination system is basically similar to the classical examination system for the government service in old-time China. Examinees are made to answer examination questions and successful examinees are selected by a demerit mark method. To implement entrance examinations based on a demerit mark system, the examining side requires some authority. Therefore, in Japanese universities, whether in the science departments or medical departments, science is treated as something free of errors and only the objective part of it is taught. What is really important for scientists is to have an eye which can discern unsolved or erroneous aspects of science.

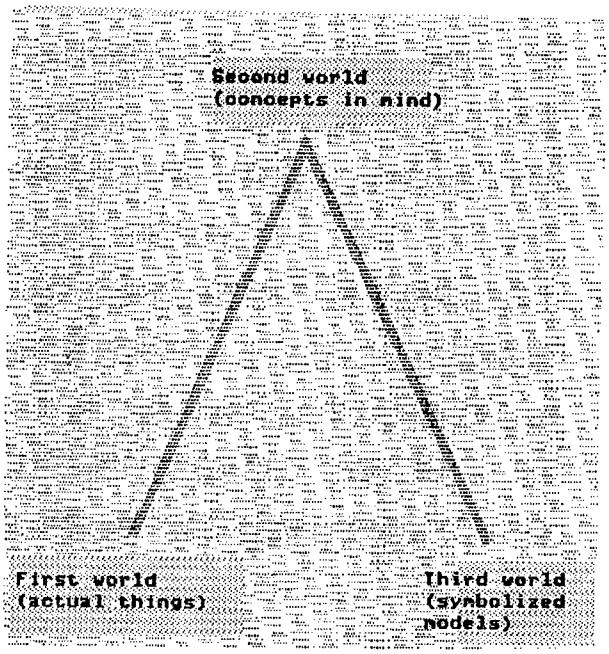


Figure 3. Relationships Among First World Where Actual Things Exist, Second World Made Up of Senses, and Third World Comprising Models

This is a diagram Mitchell showed in a lecture (Figure 3). It indicates three worlds: first, second, and third. This is not understood in Japan, but the first world is the world or things which actually exist. The second world represents scientists' minds. The third world comprises common models unaffected by scientists' individuality. The third world cannot be directly linked to the first world. They are interlinked only via the second world, that is, through thinking by individuals using their senses. Ordinary people consider that what makes up science is the natural world itself. Explaining based on Mitchell's diagram, however, the third world is made up of irregular phenomena taken out from the first world using people's individuality. This way of thinking is not explained in the school textbooks used in Japan. Creative activities cannot be recognized without individuality. In Japan, great emphasis is put on the linkage between the second and the third worlds and students are made to learn what

is written in their textbooks. They do experiments, but they are not good at observing things with their eye.

In Britain, after an experiment is made in a laboratory, the researchers freely discuss the data obtained from the experiment in the subsequent tea break. If such a tea break were to be copied in a Japanese laboratory, the researchers in the laboratory might be regarded as wasting time. In my opinion, however, it is during such a tea break that scientific activities are nurtured. Diligently collecting data is important in technical development. However, such data collection should be done mainly by engineers. To be sure, scientists are required to collect data, but they should also be able to make subjective scientific activities based on their own individuality. In Japan, scientists in general lack the ability to make such scientific activities.

I often hear Japanese researchers insisting that what they directly observed during experiments is correct. However, there are frequently cases in which experiments do not cause real phenomena to show. Therefore, it is very difficult to clarify truth by means of experiments. Scientific activities include both experiments and thinking. I always feel that Japanese are bad at discussion or dialoguing. They inherently dislike debating. There is a theory which says that the characteristic of Japanese people was formed during the ancient times when they learned to grow rice communally. The rice growing society did not accommodate individuals who raised objections. They planted rice communally. They shared water from the same river. Their way of life was different from that of the hunting people. Hunters can hunt where they like without regard to where other people hunt.

Rhetoric Did Not Develop

[Interviewer] Is the difference between Japanese and the peoples of countries in the West identical to that between the rice growers and hunters?

[Y. Kagawa] It is said that there is no real Japanese word equivalent to the English word "rhetoric." The Japanese word "shujigaku" used to mean "rhetoric" is a mere translation. It is said that, in Japan, learning how to tactfully express one's ideas, dialogue with other people, and integrate thought did not develop. Japanese people manage by guessing what other people think. In Japan, when one is to ask a question in a meeting of an academic society, he will start his question, for example, like this: "Thank you for your very fine lecture. Will you please do me a favor by answering the following question concerning the subject?" In the United States on the other hand, a question made on a similar occasion will be more straightforward. He may say, for example, "I made a similar experiment, but I failed to obtain a successful result. Are 'this and that' part of the experiment results you obtained incorrect? Let me know the conditions under which you made the experiment." The chairman to preside at such a meeting also performs his function much more strictly in the United States than in Japan. If, for example, a researcher questioned as to the contents of the thesis he disclosed fails to squarely answer the

question, the chairman will urge him to answer it again by clarifying the question asked and pointing out that the answer given was off the mark. The U.S. society is competition-oriented. In an academic meeting held in such a society, researchers reading their theses or asking questions may be said to be in the process of being tested. They can engage in scientific discussions in a scientific manner. In Japan, many people find jobs on the strength of some connection. In such society, one who questions researchers in an American way may be resented. Researchers coming to an academic meeting to disclose the results of experiments they made come with confidence that their findings based on the experiments they made are correct. When researchers who believe that the scientific findings they made cannot be incorrect are asked a question about their findings, they become angry and assume that the questioner has a suspicion that they fabricated data. I think that asking a question of a researcher about the research work made by him is different from insulting him. There is a limit to the research that can be performed, so that the results of research work cannot be perfect. Hence, further study becomes necessary.

[Interviewer] What does such a manner of Japanese scientists stem from?

[Y. Kagawa] There is a lack of personnel exchanges among institutions. Look at any old established university in Japan, for example. Most of the professors, assistant professors, and lecturers working at such a university are most likely to be graduates of that university. In the United States, university graduates leave their universities. There are even universities which are proud that few of their graduates remain in their universities. University graduates to pursue postgraduate courses invariably select graduate schools outside their universities. However, it is not like that in the closed Japanese society. To break up the old crust of such society from the standpoint of researchers, they should be willing to engage in scientific discussions with the researchers of different fields, too. In reality, however, such scientific discussions seldom take place (Figure 4). It is also necessary to assess theses written by Japanese researchers according to the science citation index (SCI: the number of times of being cited in other theses) determined on an international basis.

Asking Questions Tantamount To Challenging the University and Its Graduate Association

[Y. Kagawa] In Japan, researchers are not required to outspokenly engage in discussions at the meetings of academic societies in their career even from when they are in the stage of being nurtured. If a researcher faces a critical question after reading a paper on the results of experiments made at his university in a meeting of an academic society, the people concerned of the University become angry assuming that the question is meant to be a challenge toward the university and its graduate association. The Jichi Ika University to which I belong is a new university. Many graduates of the university are working at remote areas of the country and there are few graduates remaining at the university. The university's professors are from different parts of the country such as Kyushu, the Kinki districts, Tokyo, and Hokkaido. There is no inconvenience in the implementation of

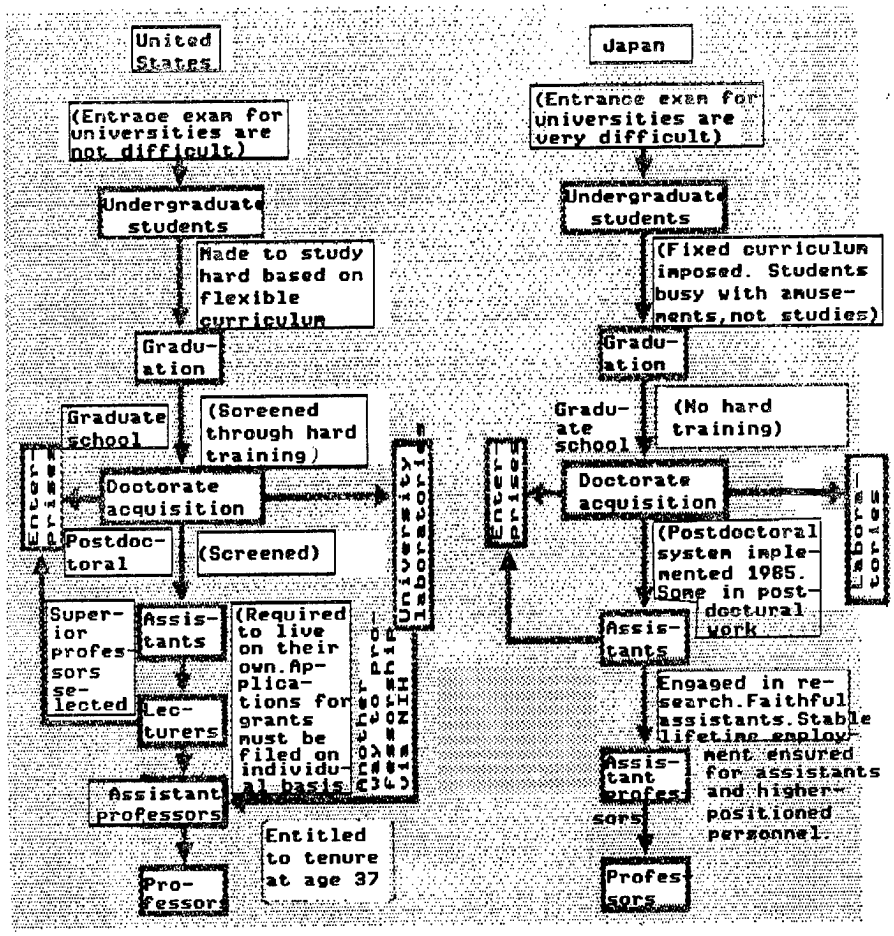


Figure 4. Steps Followed by Prospective Biochemist Professors in the United States and in Japan

education at the university. The scientific standard of the university is considerably high. It proves that, even in Japan, the professorial ranks of a university can comprise graduates of varied universities without causing any problem.

[Interviewer] What do you think should be done in Japan to improve the situation?

[Y. Kagawa] I have considered from my own viewpoint a number of conditions to be met to improve the education in molecular biology in which I specialize. One of the things I find it necessary to realize in Japan is to employ more adaptable education and research systems. It may be appropriate at the high school level to let the students learn the existing knowledge. Such an approach, however, is inappropriate for creative scientific activities. In the United States, every university publishes its teaching schedule to make it public. The teaching schedules of American universities incorporate many more elective subjects than those of the Japanese universities. Take the medical department of Stanford University, for example. They impose no fixed timetables on students. Every subject is elective. The students cannot be promoted unless they

pass the national examination in basic medical science. They cannot be graduated unless they pass the national examination in clinical medicine. No class ranking is made. The performance of different students learning different subjects cannot be ranked anyway. When I had an occasion to visit the university, I learned that each student is given a laboratory desk for use by himself or herself upon entrance to the university. The student may use the desk in whatever way he or she likes. The university's education system therefore allows the students to study their favorite subjects under their favorite professors. It is about the same at Harvard University, too. The students of its medical department are required to obtain the knowledge physicians should have, but they are also allowed to study outside the department if they are judged eligible to do so based on their performance. Such eligible students are allowed to take classes at Massachusetts Institute of Technology (MIT) located near their university (MIT-Harvard program). It would be out of the question for medical students of Japanese universities to attend the engineering department's classes. Every university in Japan is required to comply with the regulations set by the Ministry of Education. Japanese university students are obliged to learn mostly required subjects; few elective subjects are offered. They study the same subjects. The education system has no flexibility. The students educated under such a system cannot adapt to science development.

Reasons for Rejection of Applications for Government Subsidies Undisclosed

[Interviewer] I hear that, in Japan, when applications for government subsidies for scientific research promotion are rejected, the reasons are not disclosed.

[Y. Kagawa] The people assigned as members of the committee to screen the applications for the subsidies are strictly directed by the Ministry of Education not to make public the reasons why the applications have been adopted or rejected. It may present problems to disclose which committee members supported or turned down which applications. However, I think the researchers whose applications for subsidies were rejected should be advised by the name of the screening committee as to why their research work did not successfully appeal to the committee, as is done in the United States. In the Japanese academic world where sectarianism is so strong, it is a mission for the members of every academic clique to do what they can to enhance the influence of their clique. To make the situation worse, personnel exchanges are not made between different academic cliques. Therefore, even if fair-minded persons are appointed as members of the screening committee, they do not have adequate information based on which they can properly evaluate the applicants and the research work being done by the applicants. If the academic society is more open and personnel exchanges are encouraged between institutions, it may be easier for members of the screening committee to recommend researchers of different institutions as subsidy recipients. However, such is not the case presently in Japan. Under the present circumstances, if a notice of the reason why the application for subsidy filed by a research group was rejected is given to the research group, they will identify the committee member who decided on rejecting their application. Eventually, they may

want to get even with the research group to which the identified committee member belongs when they themselves become committee members in the future. The Ministry of Education may be fearful of such a development. Since the subsidies are paid from the national budget, the amount given to each successful applicant is disclosed. I myself sometimes serve as a judge to examine applications for NIH grants. In the case of NIH, each unsuccessful applicant is notified in writing of detailed reasons why his application was turned down.

In Japan, on the average, only 17 percent of the applicants for scientific research promotion subsidies succeed in obtaining subsidies. Whenever unsuccessful applicants receive a notice of rejection of their applications, they wonder why and are frustrated. In the case of NIH, the judges are organized into small groups and each group of judges carefully examines and assesses applications assigned to them. For each application which fails to be adopted, the reason mentioned by group members is compiled into a written report to be given to the applicant. The notice indicates the points disapproved by the judges of the research work being done by the applicant, clarifies the reasons why such points of the research work were disapproved, and recommends a substitute approach. This procedure enables both the judges and researchers involved to obtain hints on improving their work.

In Japan, the reasons why applications for government subsidies for aiding scientific research were adopted or rejected by the screening committee are not disclosed. No matter how carefully and sincerely the committee members assess the contents of applications for subsidies, the contents of assessment are not communicated to the applicants. The applicants whose applications were rejected are left without knowing why. They may even suspect that the results of application screening were affected by favoritism. More than 80 percent of the applicants end up dissatisfied with the results of their applying for subsidies. Some of them think of filing the same application again on the next occasion, but it is a waste of time to do so.

Need for Basic Research Stressed

43063801 Tokyo KAGAKU ASAHI in Japanese Aug 87 pp 62-65

[Unattributed summarization of lecture given by Susumu Tonegawa, professor of molecular biology at Massachusetts Institute of Technology in the United States: "Society Where Boldness Does Not Cause Trouble Is Desired"]

[Excerpts] "Japan is now an economic giant and it is in a leading position in the field of biotechnology, too. However, it should consider that the creative research which led to formation of the foundation of biotechnology was made by Europeans and Americans. Unless Japan recognizes the importance of fundamental research, it will find itself in an increasingly difficult position in the world community of nations."

The above remarks were made by Susumu Tonegawa, professor at Massachusetts Institute of Technology (MIT), whose achievement in immunological research

work has gained international attention and who is a candidate for a Nobel prize. He delivered a lecture in Chiba city as well as in Tokyo in May this year and criticized the inadequacy of Japan's attitude toward the promotion of fundamental research.

The lecture he delivered in Tokyo was entitled "To the People To Create Tomorrow's Science" and was delivered in the "international forum of young scientific engineers" (cosponsored by Japan Science and Technology Promotion Foundation and New Technology Promotion Foundation). Professor Tonegawa is a graduate of Kyoto University. After graduating from Kyoto University, he became a graduate student at the university of California. Since then, he has spent 24 years, about a quarter of a century, outside Japan, in the United States, Switzerland, and again in the United States.

He began the lecture by stating that he wanted to review the originality of Japanese science from a perspective of having stayed abroad for many years. What he subsequently stressed in the lecture follows: "Science originated in the West. The Japanese tradition of attaching importance to harmony among people does not agree with individualism needed in promoting creative research. The traditional Japanese way of respecting harmony among people cannot be changed overnight." A summary of the lecture follows:

Science and Technology Different

In Japan, science and technology are not clearly distinguished. Science is a form of human beings' recognition mechanism. A new concept is created when knowledge is integrated through the accumulation of experience and practice. However, science cannot exist based only on the integration of individual technologies. Science inevitably requires creative mental activities for coordinating and sublimating individual technologies into universal laws.

Based on historical observations, it can be said that the generation of science required the division of people into those who are engaged in production and those (leisure class) who need not work for bread. However, such division of people alone did not lead to advances in science. Scientific findings occurred when class divisions evolved in a society where people's minds were highly active. Such a state was realized first in the Greek era. Technologies such as mathematical technologies and astronomical technologies invented during the eras of the Babylonian civilization and Egyptian civilization were integrated into rational theories that were integrated into science.

I would like to discuss science in Japan in light of social conditions required for science generation. In the first place, science came into being in the West, specifically, Greece. It was then made to prosper by the people who moved from Greece to Western Europe and North America. The type of social and cultural foundation that serves to encourage creative minds is closely related to Western civilization.

An important difference found between the Western civilization and the Oriental civilization is that individualism is firmly established in the

West. Creativity requires strong individualism. In other words, one should be able to express oneself regardless of what others say.

The Japanese, on the other hand, are inclined to foster harmony among people, a characteristic not encouraging to creative scientific activities.

As for the first-mentioned social condition necessary to enable science generation, high production capacity, Japan has become an object of international criticism and envy. However, as for the second-mentioned condition, that is, environments which serve to encourage people to creative mental activities, Japan is by far inferior to the West. How is it possible for Japan to nurture creative individuals? It is very difficult to bring up thoroughly individualistic, strong-minded, and creativity-respecting individuals in a society traditionally featuring respect for harmony among people. It cannot be achieved overnight.

Importance of Fundamental Science Recognized by Enterprises

I have been conducting research overseas for a quarter of a century. Regarding the extent to which the importance of fundamental science is recognized in European and American society and the importance of social structures which encourage creativity, let me tell you my experiences.

I received a doctorate at the University of California, then I left the university to work at an immunology laboratory in Basel, Switzerland belonging to Hoffmann-La Roche, a drug manufacturer. It is isolated from the central laboratory of the firm, located in a separate building, and managed independently. Hoffmann-La Roche built the laboratory to promote fundamental scientific research, with emphasis on immunological research which has no direct bearing at all on the company. The 50 people at the laboratory include full-fledged researchers with doctoral degrees, assistant researchers, and nonresearch employees. More than 90 percent of the people working there were from outside Switzerland. Niels Jerne, a Dane who was heading the laboratory, later received a Nobel prize.

Hoffmann-La Roche pays all expenses for the laboratory, including research expenses and salaries, without requesting any return. Most of the 50 researchers were young, in their thirties. They each were provided with a small individual laboratory where an assistant researcher was also assigned. They can use their individual laboratories to carry out independent research work according to their own schedule. The company facilitates fundamental research in this way because it recognizes the importance of fundamental research as an asset to the whole of society.

Research Funds Granted to 'Potentiality'

A feature of the research system of the United States is the grant system. I now work at MIT. I have a tax-supported grant from NIH (National Institutes of Health). I will explain the NIH grant system.

Each applicant for a grant files an application of about 100 pages with NIH. The application must describe the research work the applicant intends

to do and its potentiality. At NIH, a committee made up of researchers is formed and they scrutinize several hundred applications sent in from throughout the country for several days. This year, one-fifth of the total applications passed screening made by the committee members. What is important is that they examine only the contents of the applications. Who the applicants are does not affect the results of screening at all; whether they are professors at noted universities, Nobel prize winners or the chairmen of some societies such as the U.S. Immunology Society. This policy is strictly adhered to.

The professor heading the laboratory where I was working as a student after obtaining a degree from the University of California in San Diego later won a Noble prize for his research on cancer virus. After he had become a Nobel prize winner, he applied to NIH for a grant to begin new research on breast cancer. At that time, he was already more than 60 years old. It was likely that the quality of his application was not so good probably because he was not yet so familiar with breast cancer. His first application ended in being rejected by the NIH screening committee.

In the United States, unlike in Japan, grant allocation is determined strictly according to the results of examining the contents of applications. The applicant's past careers or achievements are not taken into account.

University Changes Essential for Research Activity Stimulation

Next, I would like to talk about the postdoctoral fellowship system in the United States. It is a system under which researchers engage in postdoctoral research work for 2 to 3 years after obtaining a degree from a graduate school. In Japan, researchers having taken a doctoral degree stay at the same universities. Professors of their universities then give special attention to particularly superior ones among such postdoctoral researchers and let the selected superior researchers work as their assistants. It is regarded as an ideal course of advancement for a postdoctoral researcher to be employed as an assistant at the same university and be subsequently promoted to assistant professor, professor, and finally to professor emeritus.

It is different in the United States. For example, if a graduate-student obtains a doctoral degree at MIT, he leaves MIT to engage in his own creative work at a different university where he can receive new impetus from different researchers in a new environment. This is because he thinks it unlikely that he will be given more impetus in the same environment where he had been for 5 years.

In Japan, there are many researchers who continue research work while taking outside jobs for their living. In the United States and Europe, researchers are granted fellowships. There are scholarship systems in Japan, too, but the amounts granted to researchers are not enough for them to keep their living. Moreover, they are obligated to repay the scholarships. The Japanese scholarships are therefore loans. The NIH

gives scholarships to researchers in the form of pay. Similar systems have spread in Europe, too.

A few researchers who obtained a degree in Japan are now doing research under me at MIT. It seems that, in Japan, people in their 20's or 30's, that is, people who are in a very important stage of life in cultivating scientific creativity are placed in an economically adverse situation. Such a situation is beyond understanding of the people in the West.

There is a Japanese saying to the effect that forwardness will cause trouble. It plainly reflects the nature of the Japanese or Oriental social practice. An environment desirable for the promotion of creative activities is one contradictory to the saying. Able people should be given opportunities to display their ability.

The economic strength of Japan has risen. Japan sees high industrial potentiality in the field of biotechnology. However, it is necessary for Japan to consider where the creative findings that led to formation of the foundation of such a new technological field took place.

There were two important achievements which greatly contributed toward formation of the foundation of today's biotechnology. One is the discovery of gene recombination and the development of gene recombination technology achieved at Stanford University of the United States. The other is the discovery of monoclonal antibody by German and British scientists.

To be sure, Japan's economy is powerful; also it is leading the world in the field of biotechnology. But, it should be remembered that it is the technological field in which Japan is ahead of the rest of the world. Japan should recognize that the two fundamental and creative achievements which led to formation of the foundation of biotechnology took place outside Japan and should give more thought to the importance of fundamental research. Otherwise, it will find itself in an increasingly difficult position in the world community of nations.

Concentrate on Research in Particular Fields of Interest

How can one do creative research? Let me tell you what I gathered from my own experience.

(1) Select a subject which is really interesting to you. You cannot display your creativity while researching an imposed subject which holds no interest to you.

(2) In the field you are concerned with, find a problem which is regarded as being of great importance no matter how difficult it may be to solve. One's power of understanding is limited. You should not start working on a research subject as soon as you decide on it. You should severely review beforehand whether the research work you are going to do will contribute toward true development of the field involved. Talented researchers read many theses, have good knowledge, and logically formulate ideas; but such an approach has a drawback. Such researchers come up with well-thought-out

ideas. However, the probability of this thinking leading to significant findings through experiments carefully planned to minimize the possibility of failure is not high. In this sense, it may be said that talented people are not suited for experimental science.

(3) Young researchers such as graduate students and research assistants had better not think so much of making experiments a success. It is worthwhile to become a scientist if you can make even one creative discovery during your career. I think it is good enough for a researcher if he can cultivate an eye to scientifically observe nature and can concentrate, even if only once in his career, on unique research work which other researchers cannot even think of, without being distracted by other researchers who are intent on writing theses.

(4) Researchers should be fond of what they are doing. You should be in love with your research, as if it is your lover or baby. You should immerse yourself in science 24 hours a day. You should be in a state in which the problem you are tackling in your research crosses your head even while you are seeing a movie.

(5) It is important for young researchers to consciously exclude things such as authority and social custom from their thought. They should consciously assume individualism. Can creativity be born through teamwork? I would say "No." Teamwork is very effective in technical development, but it is not suited to original work. In pursuing original work, you should not be dependent on your colleagues.

Will Circumstances in Japan Change?

After finishing his lecture, he answered a question as follows: "How to perform scientific work can be learned by experiencing a process of thinking hard, working hard, and grasping something. After having such an experience, you will become able to enjoy science."

Dr Tonegawa receives ¥ 100 million a year as a grant from the NIH. While this amount appears very large, the net amount usable for research after deducting various expenses such as the salaries for laboratory staff members, etc. is about 40 percent of the total amount. There are many laboratories where research expenses amount to ¥ 40 million or so a year in Japan. However, when it comes to the amount of original research being conducted, Japan lags far behind the United States. "The number of people who recognize what I point out and who feel the necessity of doing something to change the situation have been increasing little by little. Sooner or later, the number of scientists conducting original research will start rapidly increasing in Japan," he said.

Importance of Creative Research Stressed

43063801 Tokyo KAGAKU ASAHI in Japanese Aug 87 pp 66-70

[Interview with Zenichi Yoshida, professor of synthetic chemistry at Kyoto University's Department of Engineering and chairman Japan Chemistry Association; interviewer, place, and date of interview not identified: "Appearance of 'Nomad' Researchers Awaited"]

[Text] **United Kingdom, France Leaders Understood Japanese Characteristics**

[Interviewer] Recently, attention has been paid to CURRENT CONTENTS, a U.S. journal dealing with the science citation indexes of theses--to see what Japanese-authored theses are often cited in other theses. Such thesis-related information appears to occasionally come up in conversation in the field of chemistry, too, doesn't it?

[Yoshida] Certainly, such a topic comes up in conversation. However, a thesis cited by many researchers does not necessarily excel in originality. To be sure, research which is referred to by many other researchers is not inferior in quality. However, it does not follow that theses which are not so often cited are inferior in quality. How often a thesis is cited in other theses is affected by the researcher population in the corresponding field. A thesis written on a subject in a field having a larger researcher population can naturally be cited by more researchers. Take R.B. Woodward who received a Nobel prize in 1965, for example. Theses written by him have not been cited by so many researchers.

Generally, theses which are cited by many researchers are those released considerably after disclosure of the original ideas. Such theses are written as the original ideas come to be assessed by many researchers. Theses incorporating original ideas are difficult to properly evaluate at first, so that they cannot attract much attention. However, what is really important are such original ideas. Original ideas can be further developed by subsequent research.

When British Prime Minister Margaret Thatcher and French President Francois Mitterrand visited Japan, they inspected advanced high technologies of Japan and highly praised the technological progress made by Japan. At the same time, they did not forget to mention: "The originals are in Europe." Such a comment may have partly been attributable to their competitive spirits, but what they said is correct. The Nobel prizes represent the highest ratings of original or creative achievements, don't they? Nobel prizes are awarded to people who are the first to do certain work and whose achievements impact on the whole world and contribute toward the progress of society. The first Japanese to receive a Nobel prize was Dr Hideki Yukawa. He received a Nobel prize for physics in 1949, that is, about 50 years after the inauguration in 1901 of the Nobel prize system. Dr Kenichi Fukui then won a Nobel prize for chemistry in 1981, that is, 80 years after creation of the Nobel prize system. No Japanese has been awarded a Nobel prize for physiology or medicine. Japanese have been producing many topics

in the fields of medicine and biology, but the world is still severe in rating Japan regardless of the sensation hitting such fields in Japan.

[Interviewer] Why is it so?

[Yoshida] I feel there is a racial factor involved. Scientists can be divided into "nomad" type and an agricultural people type. Whether a scientist is of a nomad type or of an agricultural people type can be discerned by observing how he reacts when someone else conducts historic research to impact on the world. A researcher of an agricultural people will try to improve such historic research. Many of the Japanese researchers are of this type.

Researchers of a nomad type are willing to allow any researcher competing with them in the same field to have the lead if the researcher discloses superior research work results ahead of them. After allowing a researcher to take the lead in research work in the specific field, the nomad type researchers discontinue their research in the same field and begin new research in a different field trying to outdo the scientist who took the original lead. I feel that, in Japan, there are not many cases in which researchers let pioneers keep an exclusive lead in their fields of research. Many of the Japanese researchers are those who tend to try to improve research made by others which had an impact on the world. This is particulary so in terms of technologies. Many technologies used in Japan originated in other countries.

Creativity Cannot Be Assessed by Written Examination

[Interviewer] How come Japanese researchers have such a tendency?

[Yoshida] The Japanese society incorporates seniority systems. The Japanese people are inclined to "yield to the powerful." They are afraid of failures. They hesitate to run a risk of failure. Agricultural people feel relieved when there are other people on both sides of them. They prefer to act together with other people in a group.

A centenary of stereochemistry in commemoration of J.H. van't Hoff, Dutch scientist who received the first Nobel prize for chemistry, was held at Leyden University in Holland in 1974. I was invited to the centenary and had an occasion to look at the laboratory where J.H. van't Hoff had conducted his research work and to see his school records. he was not a top student. He was several places down from the top in a class of about 20 students. Written examinations conducted at university have nothing to do with creativity. It cannot be said that students who score low in written tests are inferior in creativity. Since one's creativity is dependent on the right-hand half of his brain, I think what is important is how to educate people whose right-hand halves are superior. In this regard, Japan has not been doing well.

[Interviewer] How do you, Dr Yoshida, direct researchers in your laboratory?

[Yoshida] I have set a research policy aimed at cultivating the creativity of researchers in my laboratory. A sheet of paper on which the policy contents are enumerated is pasted on the notebook used by each undergraduate or graduate student to record experiment data.

[Interviewer] Will you please describe the paper in more detail?

[Yoshida] The points making up the research policy are printed using a word processor (Table 1). Creation is opposed to imitation. I set a line of policy intended to guide students in cultivating creativity instead of the ability to imitate. First, the university is the place for us to make creative work. Never imitate research made by other researchers and never engage in research in a hairsplitting-like manner. What we can leave for transmission to all ages is neither honor nor money. It is creative achievement. Second, creative work does not result from logical thinking alone. Young researchers read a lot of literature. They cannot resist the attraction of interesting literature. After reading interesting literature, they tend to be engrossed in thinking how to improve the research work reported in the literature. I, therefore, advise them to forget about all sorts of literature and try to catch a flash of idea of their own in a spiritual state of selflessness.

Table 1. Research Policy of Yoshida Laboratory

Yoshida Laboratory's Research Policy

1. Produce highly creative research results

a. The university is where we are to make creative work. Never try to imitate research made by others or engage in hairsplitting-like research work. What we can leave for transmission to all ages is neither honor nor money; it is creative achievement.

b. Logical thinking is important in studying and interpreting achievements. However, logical thinking does not lead to highly creative work. Obtain a spiritual state of selflessness and concentrate on thinking, forgetting all about other theses. In that state, try to catch the flash of an idea. To enhance the ability to catch a flash of idea, sharpen your sensibility. A flash of idea can lead to highly creative work.

c. Great chemical invention or discovery often results from unexpected data. Don't overlook unexpected data. Try to make unexpected data lead to great invention or discovery.

d. To do creative work, keep a challenging spirit without being afraid of failure and try to materialize a flash of idea (realization of great invention or discovery). To accomplish a goal, devise an optimum approach and continue research work in a productive, 12-hour day, and in a careful manner.

e. When a fruit of research work is obtained, write a thesis (in English) on it paying attention to the following points and have the thesis printed in one of the most highly rated international academic journals.

2. In writing a thesis, pay adequate attention to the following:

a. Stress the significance, importance, and key points of your achievement.

b. Make sure you can answer questions and solve existing problems with the thesis.

c. Ask how much contribution can your achievement make toward development of a new field?

d. How great an impact will your achievement make on the world of science?

e. Train yourself in writing good English every day.

[Interviewer] Do you mean that you forbid your researchers to read literature written by others?

[Yoshida] They should read literature. Studying new inventions and discoveries is important to establish scientifically what was invented or discovered. However, Japanese researchers in many cases study only the inventions and discoveries made by others. Such an approach is intended to please inventors and other researchers. I, therefore, recommend that young researchers do their own research rather than using their time to improve the results of others' research. As mentioned by British Prime Minister Margaret Thatcher and French President Francois Mitterrand, it is easy to improve something invented by someone. It is very difficult to produce a seed, that is, to make an original invention or discovery. To do that, catching a flash of idea is very important. Therefore, I advise young researchers to make efforts to sharpen their intuition and sensibility.

Third, great discovery often results from something unexpected. Therefore, when unexpected data is obtained through an experiment, the data should not be left unattended. Efforts should be made to let such data lead to a great invention or discovery. The foregoing three points concern ideas. The fourth point is this: If an idea is obtained, the researcher should aggressively tackle it until it is materialized. In other words, it is important to make efforts to turn an impossibility into a possibility. These points are written as a research policy of Yoshida Lab.

Reverse of Hueckel's Rule Realized

[Interviewer] Has the research policy produced effects?

[Yoshida] Yes. Benzene whose constitutional formula (benzene-ring structure) looks like a turtle shell is aromatic. A benzene molecule consists of three double bonds which comprise six each of carbon and hydrogen atoms. It was not known why such a molecular structure was

stable, but [Erich] Hueckel gave some theoretical support to the benzene structure by disclosing Hueckel's rule in 1935. In the theory, it was defined with a compound in which the number of cyclic π -electrons is $4n + 2$, is aromatic; if the number is 4n, the compound is antiaromatic. He initially disclosed a molecular orbital theory (HMO). This theory was a contribution to science. However, because the disclosure came too early, other researchers failed to duly assess it while Hueckel was active as a researcher. [Raold] Hoffmann improved the theory and applied it in his research work, and he was later awarded a Nobel prize. At any rate, Hueckel who sowed a seed in this field by making an original research was a great scientist. Following the disclosure of Hueckel's rule, world researchers started work to theoretically verify Hueckel's rule. Their approach was to actually synthesize "4n + 2" type compounds for $n = 1$, $n = 2$, $n = 3$, and so on; and check to see if the compounds agree with the Hueckel's rule. Such theory verification processes followed by different researchers contributed to the progress of studies in the field. Attempts were also made to synthesize 4n type compounds to see if they are really antiaromatic, but such attempts were unsuccessful due to the instability of compound structures involved. But, such unsuccessful attempts made their contribution to science, too.

However, even if such research made to verify a theory results in success, they only verify the greatness of the researcher who developed the theory. Verification studies comprise an important part of science development, but their importance is problematical as far as creativity is concerned. I came to wonder if the reverse of Hueckel's rule could be true, that is, if there could be 4n π-electron type aromatic compounds.

What I came to think of is impossible according to Hueckel's rule. However, if the impossibility can be turned into a possibility, a new theory can be created. Every theory is based on a model. Creative work consists in making a historic attempt. We took a chance and succeeded.

[Interviewer] What do you mean?

[Yoshida] We succeeded in synthesizing a 16- π-electron type compound called cyclic (bicalisen). It is a compound whose molecule has 16 π-electrons. Since it is a 4n type compound, it should be antiaromatic according to Hueckel's rule. We had to make great efforts to synthesize the compound. We examined the synthesized compound by such means as X-ray crystal-structure analysis and nuclear magnetic resonance (NMR) analysis to learn that it was aromatic. Thus, we succeeded in creating a new type of compound. Subsequently, I was invited as a special lecturer to an international conference held in Israel in 1981. An illustration of the compound structure we created was printed on the front cover of the January 1984 issue of the ANGEWANDTE CHEMIE, an internationally noted German journal. Creative achievement can cause a sensation in the world. Maybe, it is an effect of creativity. Reading literature is important, but we must be careful not to be confined to the views of the authors. Knowledge obtained by reading literature is instrumental in having discussion with others, but it may stand in our way when we want to obtain a flash of

creative idea. Our success in synthesizing a 16 π-electron type aromatic compound is an example of creative work.

Many Others Run After Topical Subjects

[Interviewer] Japanese scientists are making great contribution to the studies on superconductors, aren't they?

[Yoshida] I don't find it appropriate for researchers to run after topical subjects. Even ceramic superconductors which are being much talked about can no longer be a fresh subject from the viewpoint of creativity. To be creative, we should try to become the first in the world to do something new which nobody has ever thought of. This is important. There are many researchers, not only in Japan but also in all other parts of the world, who are inclined to adopt research subjects which have come into high focus. To make creative achievement, we are required to adopt a subject while not much attention is given to it. Therefore, for researchers to do creative work they must keep a severe attitude and endure hardship in their work. We are desirous of turning impossibilities into possibilities or, in other words, becoming the first in the world to do something new. We wish to invent or discover something whose effect will impact on the world for 100 or even 1,000 years. It is such an invention or discovery that the Japanese researchers are now required to make.

As for superconductors, the sensation was triggered by an IBM research laboratory in Zurich. It should have originated in Japan if Japan wanted to be considered creative in the field.

Regarding the above-mentioned 16 π-electron type compound, we are studying its electron system structure, physical properties, and functions for the purpose of developing a new theory. To develop a new theory which can stand for the ages, we should take our time. It may be inappropriate to be speaking like this mentioning my own work as an example, but it is necessary to tackle a challenging goal of making the impossible possible. In the field of chemistry, few great creative achievements have recently been made either in Europe or the United States. Recent advances are minor ones only. This can be said particularly of young researchers. I wonder if it is because young researchers avoid taking pains in their research work. Certainly, a process of great creative research work involves a great deal of hardship. You cannot easily formulate a thesis. It is difficult to obtain subsidies. Researchers, however, should be able to devotedly concentrate on research work to achieve their goal no matter how severe their economic status is. Young researchers want to become the lion of the day. They like to do work which gains attention.

Study in a true sense cannot bear fruit so quickly. I assume that even Professor Fukui was not at first certain what would come out when he was working on the frontier theory. I think that researchers tackling really creative work have a hard time in the early stages of their work.

It is relatively easy to carry on research the results of which will be introduced in textbooks for university studies, but it is more difficult to

obtain a result which will be included in the contents of textbooks for high-school students. Making achievement which will be written in textbooks for primary school pupils is really difficult.

Should Surpass Europe and United States by Wide Margin

[Interviewer] Hueckel's theory was denied. What replaces it?

[Yoshida] We must develop a new theory. For that purpose, we must adequately study the structure and physical properties of the new compound. The cyclic (bicalisen) consists of two (calisens). We have been producing compounds consisting of more (calisens) including three (calisens), four (calisens), etc. We are thinking of proposing a new theory after adequately studying the structures and physical properties of such new compounds.

When a fruit of research work is obtained, it is advisable to disclose it in a noted international journal or announce it in an international conference. The result of research work which can produce a great impact will not be immediately supported by other researchers, but they will start believing it when decisive data is shown.

I tell students this: It is chemistry that is at the core of such fields as material technology and biotechnology. The importance of chemistry will continue growing in the future. Therefore, you should make efforts to become first-rate chemists in the world. Topflight chemists who are respected on a global basis will receive invitations to give lectures throughout the world. As the number of such Japanese researchers increases, Japan will be rated more highly.

[Interviewer] What is the prospect for Japanese chemists to be awarded a Nobel prize in the near future?

[Yoshida] There are some who appear eligible for a Nobel prize. The top level of Japanese chemistry has risen close to the world's top level. In some areas, Japan is at the top. However, those Japanese chemists who can be said top-rate comprise only a small portion of all Japanese chemists. If all the Japanese chemists come up to the world's top level, Japan will win a Nobel prize year after year. The Japanese chemists should not be satisfied by being rated as comparable to their European and U.S. counterparts. They should surpass their counterparts in Europe and the United States by a wide margin. To make the 21st century the era of Japan, Japanese researchers must make creative research. After all, Japan cannot but depend on human resources.

Creativity Discussed

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[Article by Shunichi Akasofu, geophysicist and manager of the University of Alaska's Geophysics Laboratory in the United States: "Absurd and Nonabsurd"]

[Excerpts] **Meaning of 'Creativity' Uncomprehended**

Recently, there is much talk about creativity in science and enterprise. However, it is surprising that not many people base their discussion of creativity on the definition of creation in science and industry. It seems to me that, for the above reason, creativity is discussed in many cases based on a vague concept of "creating something out of nothing." There are many people who gave up being creative, feeling that creativity is something beyond the reach of ordinary people. There are also some who say that the Japanese people lack creativity.

If it was true, Japan must have disappeared from the earth a long time ago. That kind of incorrect observation in the world of science as well as industry appears to be caused because the word "creativity" is not correctly understood.

Formerly, the concept of "creativity" used to be discussed mainly among artists. In the world of science, it is not well recognized that engaging in science really means engaging in creation. I think that, because the definition of creativity is not correctly understood in the fields of both science and industry, highly creative performance or work actually made in such fields is not recognized as being creative. This is why it is often said that the Japanese people lack creativity.

Let me first define the creativity in science. As defined by many philosophers of science, the creativity in science consists in establishing a new system of thought based on existing data or theories. In other words, it is synthesizing existing knowledge into a new integrated system.

It is not unusual that, as a result of creative work in science, a number of facts which were previously regarded as being unrelated are synthesized as closely interrelated facts into a new integrated system of thought.

Take Newton, for example. He made it known that both planetary motion and the falling of apples from trees--two phenomena which appeared unassociated in any way--are governed by the same force called gravity. The planetary motion was studied by astronomers before Newton. The phenomenon of apples falling from trees must have been known even by primitive men. Therefore, the two phenomena are facts known before Newton's discovery. Yet, nobody before Newton considered that there is a connection between them. Einstein's special theory of relativity is also a new system of mechanics developed by integrating Newton's mechanics and Lorentz' transformation theory (already existing at that time) based on the hypothesis that the velocity of light is a universal definition.

Evolution Theory One of Best Products of Creativity

Darwin is the greatest mind in the history of science. In the evolution theory which is a new system of thought developed by him, living things such as monads, starfish, cuttlefish, crabs, horses, phanerogams, fern, mushrooms, algae, etc. which seemingly have no connection among them are synthesized into an integral system based on the hypothesis that monads make evolution. The evolution of living things cannot be directly observed. Therefore, the evolution theory may be said to be a hypothesis. However, it may be said that the theory is one of the best products of the human mind's creativity.

As seen from the foregoing, enduring achievements in the history of science were made by integrating existing data and theories into new systems. Synthesizing a new system in such a way constitutes an act of scientific creation.

Whereas the word "analysis" is very frequently used among scientists, the word "synthesis" is not. The first phase of real scientific activity involves creation, that is, establishing a new system of thought by means of synthesis. This is not well recognized. Regrettably, many scientists appear to be convinced that analyzing data, namely, the second phase of scientific activity is their supreme mission. Even at graduate schools, synthesis is not much talked about, although students are taught how to analyze. It is a pity if scientists are content with obtaining a large quantity of data or with handling new data merely to examine whether such data agree with an existing theory. It is sheer waste if a researcher, after obtaining valuable data which may give him a chance to establish a new system of thought, holds himself back from working on the data only because it does not agree with an existing theory.

There is no fundamental difference between creation in science and in industry. The difference between the two worlds in terms of creation is that, whereas creation in science is realized using existing scientific data or theories, creation in enterprise is achieved utilizing existing products. In any case, ti is very difficult to come up with creation which can inspire the admiration of all people.

I think it necessary for me to try here to remove a false idea of science held by the layman as well as many scientists. It is generally said that scientists are objective whereas artists are subjective. Even among scientists, there are many who firmly believe this. But, this is totally wrong. It is not too much to say that such a misunderstanding on the part of scientists makes scientific creation difficult. Think of the question of the causes of glacial periods repeatedly experienced by the earth, for example. There are more than 70 theories to explain the causes of the ice ages; they are broadly divided into two categories: one comprising internal-factor theories (theories attributing the ice ages to factors which developed on or inside the earth) and the other comprising external-factor theories (theories attributing the ice ages to factors which developed outside the earth). According to the theories of the former category, the relationships between atmospheres are unstable where glaciers

exist and, when the relationships lose equilibrium, the growth of glaciers is promoted. The theories of the latter category include those typical ones which explain that the ice ages occurred when the solar system crossed interstellar spaces filled with dense gases causing the solar rays shed on the earth to be weakened or when gigantic meteorites fell on the earth causing a large quantity of soil to be sprayed into the sky to partially shield the earth from the solar rays. These two categories of explanation of the ice ages are largely different. The difference between them may be larger than that between two pictures of the same object painted by two different artists. Thus, there are cases in which scientists are more subjective than artists.

Why is it that not only laymen but even scientists have a false idea that scientists are more objective than artists? Let me analyze why, as recognizing the reason why is extremely important in understanding what "engaging in science" means. For this purpose, let's consider the case of theorizing how the glacial periods occurred. There were very many factors which might have contributed to the occurrence of glacial periods. When scientists try to determine why the glacial periods occurred, they first collect as much data as possible on glaciers, then they analyze the collected data. Based on the results of data analysis made by them, they respectively select a set of factors which, they think, comprise the most fundamental cause of occurrence of the glacial periods. Naturally, different scientists select different sets of factors. In this sense, they are the same as different artists abstracting the same object differently (one of the most typical examples of such abstracting is regarding the earth and the sun as two shapeless points having masses, i.e., two material points in thinking of the revolution of the earth around the sun).

If a scientist develops a new theory to explain why the glacial periods occurred based on a set of factors he selected by himself, it is an act of synthetic integration, namely, an act of creation. When he follows such a process of creation, he is more subjective than an artist depending on the case. When the scientist proceeds beyond such a process, he certainly becomes objective. He is no longer allowed to engage in thinking in a manner inconsistent with the basic laws of science. If he speculates while ignoring the laws of science, he is entering the sphere of science fiction.

However, it is true that dramatic progress in science often results from other than theoretical studies. There are cases in which great scientific achievement results from an inspiration. It is due to a sort of difficulty involved in distinguishing between scientific thought and inspiration that there are cases in which a new theory is confused with fiction.

Successful Enterprise Blocks Progress

One of the most important factors to enable the development of an enterprise is creativity. Why is it so difficult to practice creativity when the importance of creativity to business is so apparent? The difficulty is due to the success of the enterprise.

Take wristwatches, for example. Wristwatches used to be devices in which hands are accurately driven via gears by spring force to tick away the time. The technique for producing such wristwatches reached the highest level in the wristwatch industry of Switzerland. I hear that it was a Swiss wristwatch technician who first proposed digital watches at that time. In the Swiss wristwatch industry, the idea of digital watches seems to have been taken as an insult to the craftsman-like spirit of its people. In fact, the spring-driven wristwatches were at a highly advanced level and they were selling well. The idea was later adopted by wristwatch manufacturers of other countries allowing such manufacturers to greatly expand their sales. Eventually, the Swiss watch industry experienced very hard times, although it has already revitalized itself on the strength of fresh attractive designs of its products. I do not think that creative technological advances in wristwatches are finished. I wonder what kinds of wristwatches will be introduced in the future. I look forward to seeing them.

What was stated in the preceding paragraph applies to the world of science, too. The toughest obstacles to creation and innovation in the field of science are currently successful theories and models. To accurately grasp this problem, let me first review what T. (Kuhn) stated in his work titled "Structure of Scientific Revolution." In the book, he uses the word "paradigm," a Greek word meaning a clear model or exercise like that carried in a school textbook. A reason he selected the word for use in his book is that all exercises carried in school textbooks can be solved.

No matter how difficult a practice problem is to solve, there is a solution to it as long as it is a practice problem. This is important. Let me explain why. According to (Kuhn) in the field of science, there can be a time when a high degree of consensus is attained among a group of scientists as to a theoretical hypothesis and the problems to be solved within the framework of the hypothesis. A consistent convention established as a product of such consensus among scientists is defined as a paradigm by (Kuhn).

In explaining what a paradigm is, he likens a group of researchers working on a common model to a group of people working at a jigsaw puzzle. Assume a group of scientists trying to put together the puzzle pieces of Snoopy, a well-known cartoon dog. While concentrating on the puzzle, the researchers will try not to think of any jigsaw puzzle other than the Snoopy. They will then come to believe that, no matter how difficult the puzzle is, there is a solution to it. In other words, they unconsciously start recognizing the model they share as if it is an exercise carried in a school textbook. In such a state of mind, they never become skeptical about the hypothesis despite whatever difficulty they encounter in their research work. To be more precise, when a paradigm is established, statistical inquiry is prevented. They even come to blame their own ability when they cannot solve such a paradigm.

When one likens scientific research work to a jigsaw puzzle of Snoopy, he must realize that the puzzle pieces actually include many strange and wrong ones. In addition, the puzzle also has many spaces to which the puzzle

piece in hand (an observed fact) does not fit; that is, there are many facts yet to be discovered.

When a researcher picks up a strange puzzle piece while working at what appears to be a Snoopy puzzle, he may react in three ways. In the first way, the throws it away by regarding it as a wrong puzzle piece (one for a different puzzle). In the second way, he firmly believes that there should definitely be a space to which the puzzle piece fits. In the third way, he studies the puzzle piece suspecting that the puzzle he is working at may be of a subject other than Snoopy. Thus, if he has no doubt as to the hypothesis that the puzzle is of Snoopy, he will find the puzzle piece strange. However, if he comes to guess that the puzzle is, for example, of a cat, he may find that the puzzle piece that seemed strange is not actually strange. He may even discover the spaces for other puzzle pieces which have been left with no spaces found for them. Such a consequence is nothing else than scientific creation; because a new system of thought has been created based on known data comprising puzzle pieces including those which seemed strange.

Subsequent to such a development, more scientists may come to believe that the puzzle is of a cat and the idea that it is a Snoopy puzzle may eventually be discarded. (Kuhn) calls such a consequence a scientific revolution. In the process leading to such a scientific revolution, heated discussion often takes place between the mainstream scientists advocating the Snoopy puzzle theory and the reformist group researchers supporting the cat puzzle theory.

Scientific Revolution Makes Truth Multifaceted

"Truth" is like a complicated polyhedron with each of its facets representing a paradigm. Every time a scientific revolution occurs, an additional facet is added to the polyhedron. When a scientific revolution has occurred, "truth" consists of at least two facets: one representing an old paradigm and the other representing a new one. If another scientific revolution occurs while "truth" has two facets, the number of its facets increases to three.

Thus, in the world of science, we come to know more about the polyhedron of "truth" every time a scientific revolution occurs. Needless to say, there are not a few cases in which a scientific revolution leads scientists in a wrong direction. There are cases in which incorrect facets of "truth" are added to the polyhedron to give it a wrong appearance. But, scientists sooner or later come to know of such incorrectly added false facets of "truth."

Why does an enterprise require creation and innovation? It is because creation and innovation make up the only means that enables the enterprise to keep existing while meeting and adapting to the requirements of relentlessly changing society and times. Doesn't this remind us that living things evolve to adapt themselves to climate changes and other environmental changes? Those living things which were not quick enough in adaptation disappeared from the earth one after another.

In the United States, more than 100 manufacturers of automobiles and radios emerged and disappeared. Recently, there have been many instances in which big companies producing items which are very difficult from the company names, and they are changing even items newly introduced to their lines. Dentists finding fewer decayed teeth to treat are beginning to find it difficult to remain in business. Many dentists have begun practicing orthodontics.

What is it like in the world of science? There are many scientists who assert that, since engaging in science is sacred work which consists in pursuing truth, scientists, unlike business men, need not behave like racing dogs. Such scientists are unaware that an act of pursuing truth in reality belongs to a paradigm and that it consists in giving a polish to the scientific model.

It is a fact that special books written by scientists become obsolete in several years (or even before publication depending on the case), but there are many scientists who do not recognize that fact. Scientists who assume leading positions in their fields are those who generate a scientific revolution and build a paradigm based on the model they created in the process of generating the scientific revolution. They are different from those who refined models developed by others. At the present day, there are many scientists working in the same field. It is like there are many electrical appliance manufacturers. Naturally, there is competition involved in the world of science, too. We are now in an era in which high quality research work alone is not enough to become a winner in a competition. In many cases, research which attracts attention is not only superior in quality but also unconventional.

How To Find AA Class

Many things are said about creativity education. Since creativity varies from person to person, there cannot be any uniform education for creativity. People who have the highest level of creativity need no creativity education. The problem is how to find people rated AA class in terms of creativity. When such people are found, they should be placed in as free an environment as possible. Obtaining special treatment for highly creative persons is in reality very difficult. Generally, such people are destined to be treated indifferently for many years in laboratories or in private firms. In some instances, persons who are regarded as very bright and score high on achievement tests are selected for education in creativity; a lot of money is wasted on them.

People of mediocre abilities cannot grasp the inspiration of highly creative people, so that in many cases, what highly creative people propose is flatly denied as absurd. I do not say that ideas inconceivable to ordinary people are always correct. I just think it necessary for each university, laboratory, or industry to create an environment which allows such ideas to be freely discussed to determine their true value.

One of the pleasures of engaging in science is that there are cases in which seemingly absurd ideas turn out reasonable. It is said that the

greatest enjoyment to a scientist is having a moment when he can say, "I told you so." Such a moment may be when a seemingly absurd idea turns out reasonable. Even if a seemingly absurd idea remains absurd, there can be cases in which the process of studying such an absurd idea greatly contributes in some way or another toward establishing a new system of thought. Breakthroughs cannot be made as long as scientists remain working only on "reasonable" ideas.

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MPT, MITI PROPOSALS

43066025b Tokyo ENERUGI FORAMU in Japanese Nov 87 pp 146-147

[Text] Ministry of Posts and Telecommunications (MPT)

MPT's budget proposal has taken on a very different look this year. For fiscal 1987, MPT's proposal for general accounts had a vertical outlook: 1) development and promotion of new media and frontier technologies, 2) advancement of international cooperation, and 3) development and promotion of the usage of radio wave resources. Whereas for fiscal 1988, the budget proposal shows a horizontal perspective: 1) advancement of the regional development of vital, information oriented societies, 2) updating of telecommunication facilities that cushion industrial structural changes, and 3) promotion of international information networking. This change has taken place due to a change in MPT's philosophy as exemplified in its "Major Guideline for Telecommunications Policies" which serves as the basis for drafting of the budget proposal. MPT is preparing to transform itself into a policy making ministry from its current rubber-stamping status by taking advantage of the telecommunications deregulation.

The estimate of the total amount (general account) for fiscal 1988 is 24,806 million yen, up by 1.3 percent over the previous year's amount. Of this amount, 2,738 million yen, which is 14 percent greater than the previous year, goes to information and telecommunication related services.

The specific details are listed in the accompanying tables. The eye-catching items are the basic R&D programs for frontier telecommunications technology, and the R&D programs for radio wave application technology and space telecommunication technology.

In the field of frontier telecommunications technology, MPT will seek cooperation between industry, government, and academia in order to specifically advance superfast telecommunications and bio-communication technology, and it will also promote joint research between European countries and America. As for the radio wave application technology, because of the trend of rapidly increasing demand for radio wave usage that accompanies the demand for cable systems, MPT will develop technology for new frequency bands where milliwave sensing systems and submicrowave digital mobile communications can be used. For space telecommunication technology, MPT's Radiowave Research Laboratory [RRL] and NTT will jointly conduct R&D for the Broadcasting and Telecommunication Satellite (BCTS) which will be used to provide integrated, high performance mobile satellite telecommunication services -- combined services of telecommunication and position measurement functions -- as well as high density video satellite broadcasting services.

In addition, MPT will continue implementing the construction of tele-ports, teletopias, telecom plazas, and telecom research parks which are designed to help form cosmopolitan metropolis and help promote regional development. To finance these programs, MPT is planning to establish an interest free loan system funded by the revenue generated from selling NTT stocks. The loan system will be designed for the third sector so that various information and telecommunication developments can be promoted.

Ministry of International Trade & Industry

An inevitable problem that society will have to face is the man-machine interface as progress is made in high quality telecommunication networks, and as high tech computers and data processing systems proliferate. A computer, with a design emphasis on technology alone, that is difficult for humans to use is just a useless box.

MITI in its draft for the fiscal 1988 budget proposal incorporates the problem of the man-machine interface; the draft contains a research framework under the title of "Advancement of Networking and a User Friendly Interface" to encourage R&D on man-machine interfacing. MITI wants to establish the basic technology for information related devices that are easy to operate. It is planning to organize an incorporated foundation to start interface research with participants from device manufacturers and users from the publication and printing industries.

MITI estimates an expenditure of approximately 120 million yen for the first year and plans to invest 12 billion to 13 billion yen over six years. In order to achieve compatibility among information related devices and systems, MITI will push development of a common access data base system for different computers. In addition, while incorporating a new program of developing general purpose devices with integrated functions, such as multifunction terminals that can handle voice, computer data, and video signals, MITI will devise specific programs in order to realize the concept of a "High Tech Information Intensive Metropolis" under which urban functions are to be improved by introducing advanced information systems. It is notable that for a ten year program for the development of information related technology that utilizes the record breaking high critical-temperature superconductors, MITI

has allocated 1.08 billion yen for the first year.

o Interest Free Loan Programs (MPT)

(Unit: 100 million yen)

Program	FY88 Amount requested	FY87 (Supplimentary) Amount requested	Comments
Development of information and technology foundation, treated as social capital	1,028	335.7	
1. Key programs for regional radiowave applications	212	-	Installation of regional multi-media towers
2. Regional ISDN installation	106	-	Priority installation of regional ISDN (integrated services digital network)
3. Installation of telecommunications facilities at designated regional developments	53	-	Comprehensive installation of communication facilities such as optical fiber cables in designated regions
4. Teletopia	556	255.1	Development of new media for Teletopia use
5. Installation of facilities for Private Sector Utilization Law	101	80.6	Installation of facilities at telecom-plazas and tele-ports

o Fiscal Investment and Loan Programs (MPT)

(Unit: 100 million yen)

Program	FY88 Amount	FY87 Amount

	requested	requested	Comment
1. Promotion of telecommunication facilities	1,003	821	
Installation of key telecommunications facilities	370	429	For type I telecommunications business
Promotion of intensive use of telecommunications	116	-	Telecommunication system design
Advancement of data processing and telecommunication systems	40	61	Teletopia, video telex
Installation of regional, highly information intensive key communication facilities	89	51	Telecom-plazas, tele-ports
Installation of key facilities for regional radiowave uses	95	-	+ | Supplementary | provisions for | businesses who | qualify for interest +-free loans through | fiscal investment | and loan services | | +
Regional ISDN installation	20	-	
Installation of telecommunication facilities at designated developments	13	-	
Promotion of international cooperation for telecommunication technology	260	280	Promotion of importing communication satellites
2. Pomotion of high density video satellite services	30	-	Expenditure from Special Account for Industrial Investments
3. Promotion of key technology	Being adjusted	290	Loans from Special Account for

Fiscal 1988 Budget Outline for Information and Telecommunication Related Programs [MITI]

General Account Related Programs (Including special project accounts and small/medium business accounts that are related to the general account of the Agency for Machinery & Information Industries [AMII])

(Unit: 1,000 yen)

Program	FY87 budget	FY88 budget	Increase/Decrease
International joint development of aircraft	4,699,683	4,407,248	^ 292,435
(Diversification of Electronics Special-Project)	(898,003)	(400,894)	(^ 497,109)
Unmanned space experiment system	427,500	508,173	80,673
(Diversification of Electronics Special-Project)	(1,290,494)	(3,400,451)	(2,109,957)
R&D for basic computer technology	4,051,129	3,806,386	^ 244,743
(Diversification of Electronics Special-Project)	(1,580,000)	(1,950,499)	(370,499)
R&D for future diversified data processing environment	0	119,986	119,986
Management of IPA program funds	650,000	553,187	^ 96,813
(Industrial Investment: General purpose programs)	(2,100,000)	(2,700,000)	(600,000)

(Industrial Investment: Sigma project)	(2,900,000)	(3,000,000)	(100,000)
(Small/Medium Business: Promotion of information intensive technology among small/medium businesses)	(704,700)	(656,469)	(^ 48,231)
(Industrial Investment: Common R&D environment for key devices for a highly information intensive society)	(0)	(300,000)	(300,000)
Concept for information university	68,264	84,910	16,646
Updating and promotion of database and information supply services	84,268	80,311	^ 3,957
R&D measures for applications of model information systems	50,762	46,591	^ 4,171
Diagnosis support systems	64,841	64,731	^ 110
(Site selection for Electronics Special-Project)	(104,571)	(350,000)	(245,429)
Area management system for multi-media	28,000	100,000	72,000
Common linking system for factory automation	35,510	110,230	74,720
Transport system	32,000	140,300	108,300

for new city waste				
Business expense subsidies for counselling for plant construction technology (ODA)	53,992	53,992		0
Survey of industries with intensive high tech orientation	102,117	71,492	^	30,625
Space robots	0	7,990		7,990
Next generation aerospace vehicle	10,342	24,093		13,751
Funds for measures against radiowave interference	1,508	10,944		9,436
Environmental measurement, securing of measurement safty	14,020	13,110	^	910
General Account, AMII	10,499,444	10,349,318	^	150,126
(Electronics Special, Industrial Investment, Small/Medium)	(9,577,768)	(12,758,313)		(3,180,545)
Total	20,077,212	23,107,631		3,030,419

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END

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