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SCIENCE & TECHNOLOGY

JAPAN

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SCIENCE & TECHNOLOGY POLICY

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JAPANESE NEGOTIATORS ON U.S. SPACE STATION STATUS

OW100313 Tokyo KYODO in English 0204 GMT 10 Aug 87

[Text] Washington, 9 Aug (KYODO)--Japan's policy of restricting the use of space to nonmilitary purposes may be applied to the proposed U.S. space station, parties concerned disclosed Sunday.

A preliminary agreement to this effect was reached in recent negotiations between Japan and the United States, they said. The arrangement opens the way for Japan to participate in the U.S. space station project, the Japanese negotiators said.

Canada and the European Space Agency have also been asked by U.S. President Ronald Reagan to participate in the project. Reagan emphasized the planned space station will be used for peaceful purposes.

However, the U.S. defense department later suddenly expressed its intention to take part in the prouect, and the U.S. Government produced a draft agreement which included a clause saying the space station could be used for national security purposes.

This provision, understood to mean permission for the Pentagon to use the station caused Japan to have reservations about the project, and there was a prospect at one time that Japan might withdraw.

The U.S. has now agreed, however, to let Japan build its own laboratory in the U.S. space station, manned by Japanese nationals, and to observe the non-military principle, the negotiators said.

A Japan-U.S. agreement concerning the space station project will be finalized by this year and submitted to the Japanese Diet for approval, they said.

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CSO: 4307/035

STATUS, TRENDS IN RESEARCH ON INTERNAL COMBUSTION ENGINES

Tokyo NAINEN KIKAN in Japanese Jun 87 pp 9-19

[Article by Shoichi Furuhama, professor of Musashi Institute of Technology]

[Excerpt] 1. Introduction

In Japan, a K.K. New Combustion System Research Institute (K.K. Shin Nensho System Kenkyujo) headed by Takashi Suzuki as president, has been established as a think-tank company with the support, mainly, of the nation's diesel vehicle manufacturers. Its reported purpose is to study the new conceptional engine during a 6-year period, hopefully expecting to achieve great results.

With the above background, this article presents a portion from some of those recent papers which deal chiefly with diesel engines, seeking trends for the future.

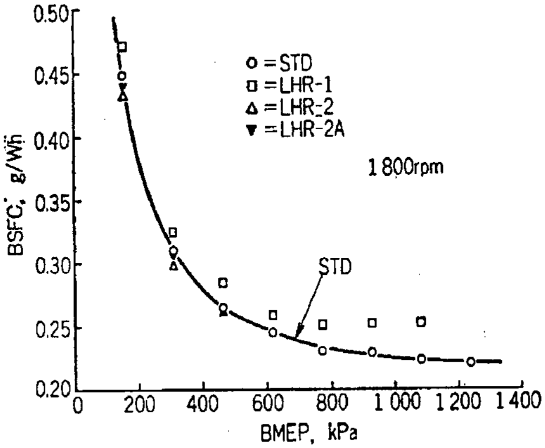
2. Evaluation of Ceramic Adiabatic Engine

2.1 From Operation Data

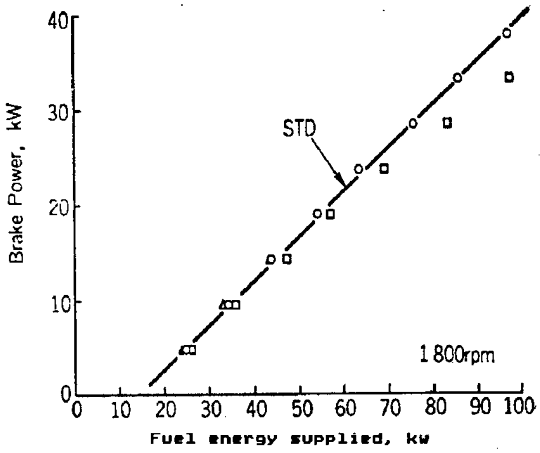
The general evaluation of adiabatic engines to which engine makers worldwide have long devoted themselves, seems to be nearing its end. At the SAE-International Congress held in Detroit in February this year, 23 related papers were assembled and presented for 2 full days, attracting a large audience of people who would not give up hope for the ceramic engines. Two or three among the papers will be introduced here.

In the past, announcements on the performance of these engines were mostly the results of computer simulation and where actual results of real operation were desirable. The report from the GM Research Laboratory was on the results of a test with a direct injection single plunger engine with a bore of 130, a stroke of 153 mm, and a compression ratio of 16:1. It was operated at 1,200 rpm and 1,800 rpm. With STD: water cooling criterion, LHR (low-heat-rejection) -1: noncooling, it had the same suction/exhaust air pressure as STD, with the same air amount as LHR-2:STD and had the same pressure difference before and after the engine at LHR-2A:same as before.

Each uses a turbo and an aftercooler. Further, the LHR engine in this case had a high Ni alloy-surfaced piston top and cylinder head and a stainless



(a) Fuel consumption rate



(b) Output

Figure 1. Performance of LHR (low heat loss) Engine

steel suction port liner with an air layer and has inner surface of the cylinder coated with chromium oxide to prevent oxidation by high-temperature gas. Figure 1(a) shows that LHR consumes more fuel than STD and (b) shows that output is rather low at the same level of fuel supply. Figure 2(a) and (b) indicate that LHR naturally shows larger heat radiation, for lubricating oil and from the surface of the machine, respectively. This, in turn, minimizes the increase of exhaust energy, shown in (c).

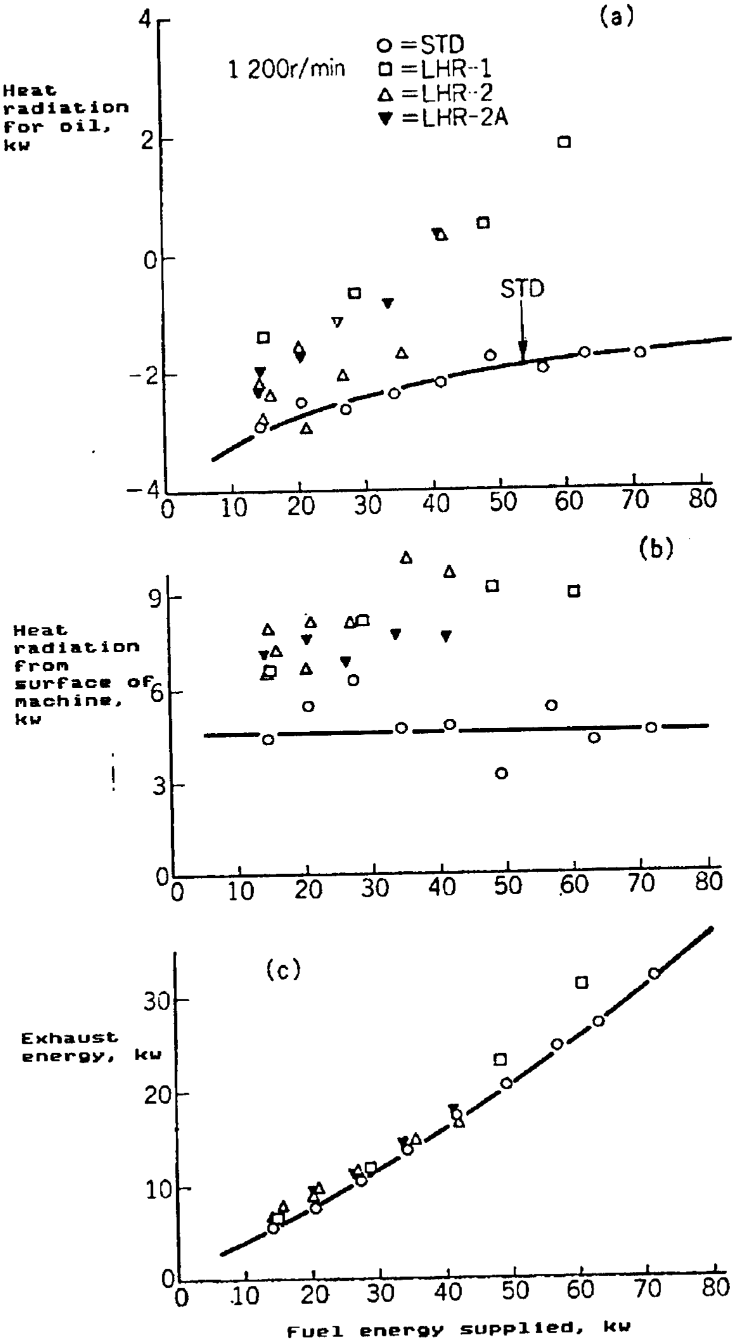


Figure 2. Each Heat Loss of LHR Engine

In a report from Ford Motor, a ceramic engine shown in Figure 3 with a bore of 80 and a stroke of 80 mm was operated by a ringless piston. Figure 4(a) shows the results of blowby measurement made at the time. As expected, it is naturally larger, compared with that of a metallic ring product, and is not practical. Yet, the report says that if the leaks can be stopped without using a ring, ISFC should become lower since there is no ring friction, as

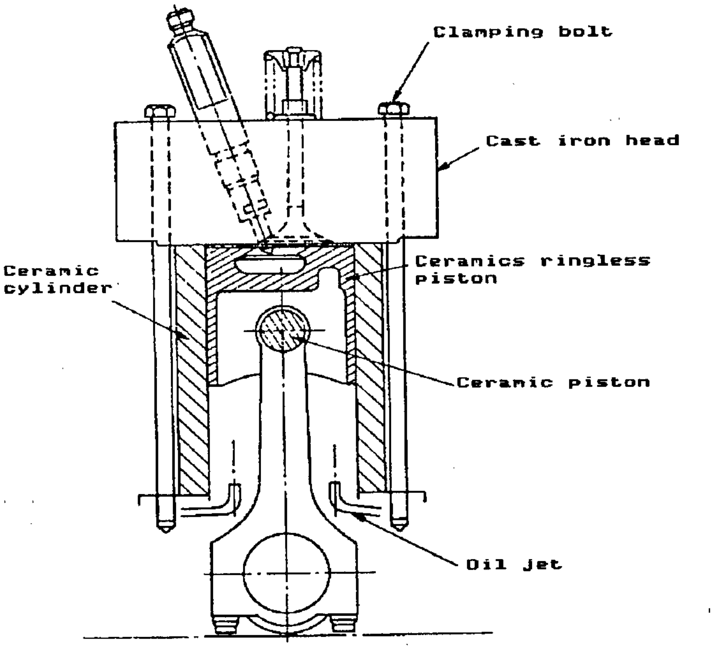
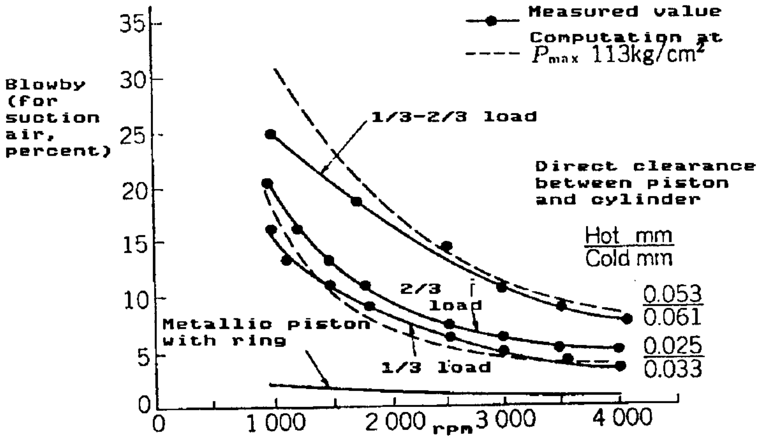
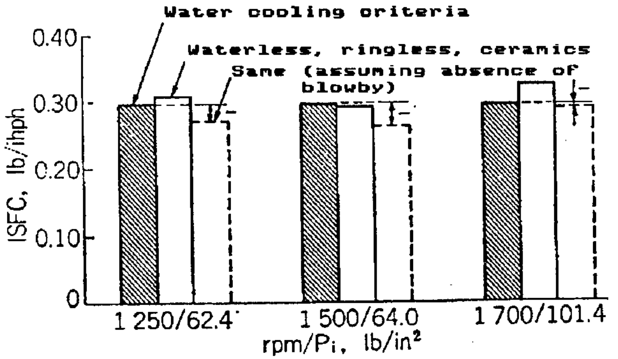


Figure 3. Ceramic Ringless Piston Engine Provided for Test



(a) Gas leakage



(b) Graphic display of fuel consumption

Figure 4. Gas Leaks From Ringless Ceramic Piston

indicated in (b). This is impossible and, in the author's view, the test bespeaks the difficulty of making a practical ceramic engine. Actually, on meeting with the reporter and the Ford [officials], their feeling seems to so indicate.

2.2 Measurement of Heat Loss on Combustion Chamber Walls

(1) The author, et al., had, several years since, conducted measurement of heat loss to combustion chamber walls and found that in the measurement results, heat loss q increased in the case of ceramic walls though, by rights, q should decrease as T_g-T_w diminished by the rise of T_w in the next equation

$$q = \alpha(T_g - T_w) \qquad (1)$$

and this is considered to be due to the fact that α increases for some reason. This did not merely concern ceramic surfaces but, on the contrary, similar results were obtained when surface temperature of exhaust valves and insulated metal surfaces was high. So, it was imagined that such phenomenon occurred mainly when wall temperature was high to a certain extent.

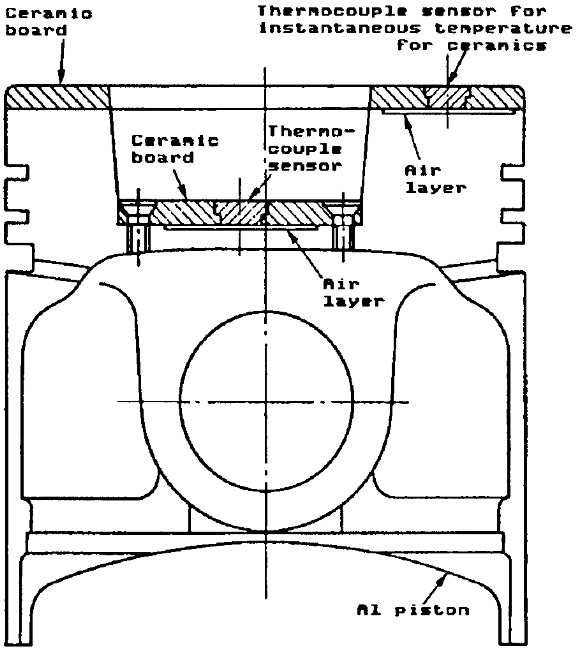
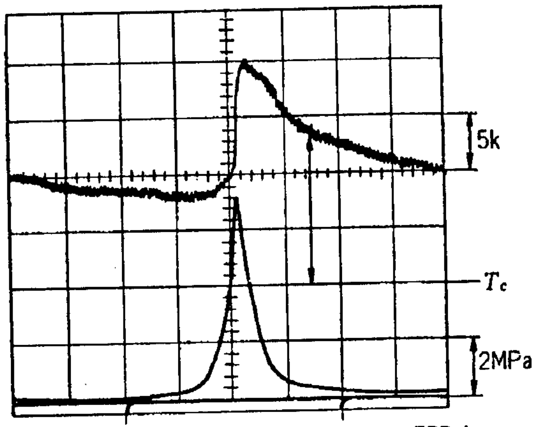


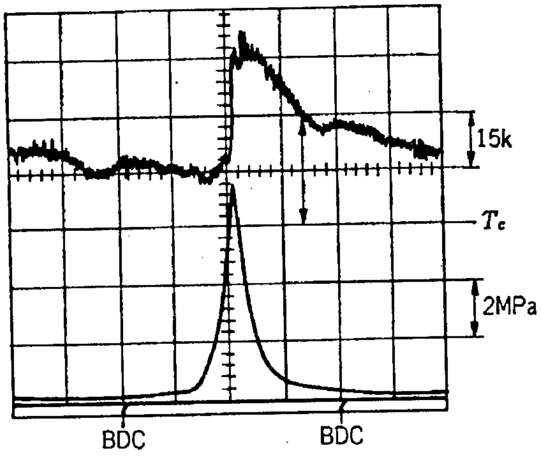
Figure 5. Position of Measurement of Heat Flux in Diesel Piston

Figure 5 shows the piston the author, et al., used for their test. It had a bore of 104, a stroke of 118 mm and a compression ratio of 17.9:1 and was for a practical four-cylinder engine. They measured instantaneous temperature at two points: top and bottom of the piston combustion chamber and computed q and α therefrom. Figure 6 shows temperature change at the top. The amplitude is 35°C for ceramics against about 13°C for the standard Al-piston. But to



Surface average temperature T_m - 538 k,
Tc: cold junction temperature

(a) Al alloy

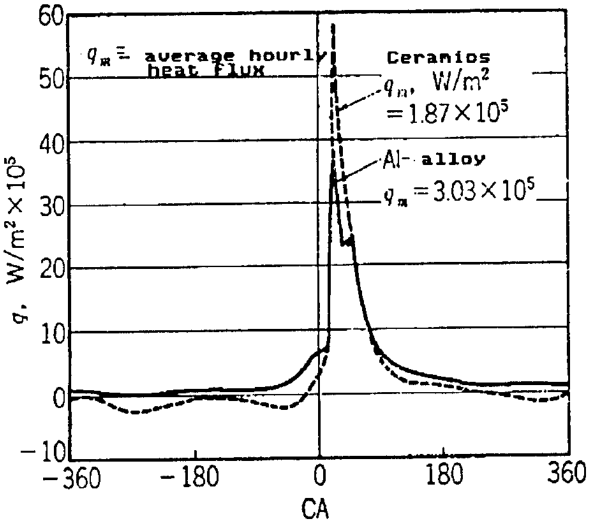


T_m=776k

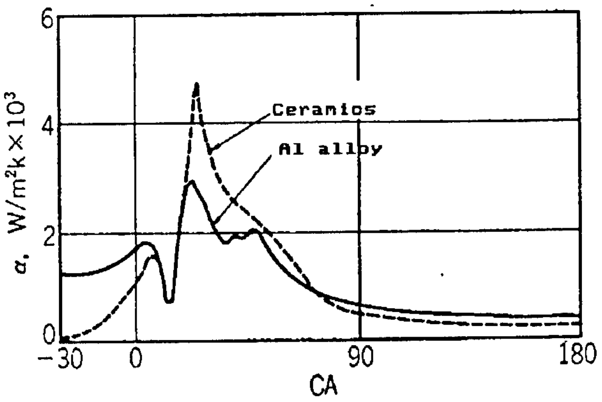
(b) Ceramic board

Figure 6. Surface Temperature Fluctuation of Piston in One Cycle (3,000 rpm, total load)

obtain per-unit-time and area heat inflow, namely, heat flux q from this, q must be based not only on temperature amplitude but also velocity change and the material's heat conductivity λ and heat capacity cp because temperature changes somewhat below the surface to be determined from λ and cp has a smaller amplitude than at the surface and there is a delay of phase. But as shown in Figure 7(a), q during combustion is larger in ceramics. T in Equation (1), is the average temperature in the entire combustion at a certain point computed from the pressure line diagram. So, α is reversely counted and, as in (b), q is large in spite of the fact that $(T_g - T_W)$ is small; thus, α increases all the more.



(a) Heat flux q

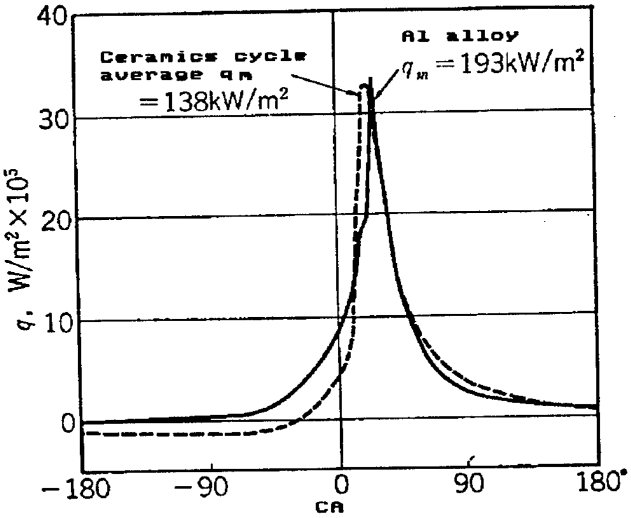


(b) Coefficient of heat conductivity α

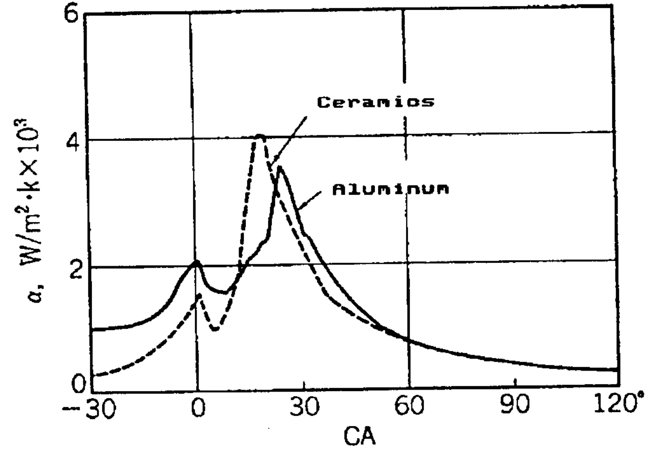
Figure 7. Heat Outflow at Piston Top

When measuring at the bottom, the values of q for both materials are much the same, as in Figure 8, and the effect there is smaller than at the top. Specifically, the only effect is that α rises to the extent of compensating for the T_W height margin of about 210°C. Figure 9 shows heat losses at different strokes. The heat flux qm indicates the mean temperature in between that and is larger in ceramics than in Al regarding action strokes directly related to piston work, but its total discharge is smaller than that of Al because heat flows back to gas on other strokes. This means that effective work on the piston decreases, but the chances are that exhaust energy may increase through decrease of heat radiation of the cooling water.

It was not recognized up to now that α is affected by the temperature and the material of the wall surface. So, naturally many questions came up about such result, especially because it shattered majority of hopes for a ceramic adiabatic engine. Chief among those questions and views are:



(a) Heat loss



(b) Heat transfer coefficient

Figure 8. Heat Transfer at Bottom of Piston Cavity

(i) Is the measurement correct?

(ii) Why is it affected by temperature and materials?

(iii) What about measuring conduction and radiation separately?

None of these can be solved except by more advanced future studies, but, in the author's imagination, the problem is in T_g Equation (1) in that T_g represents the average temperature of gas, and not the temperature of the surface vicinity. If surface temperature T_w is high, it is due to the fact that the formation of air-fuel mixture is accelerated in the vicinity of the surface, flames spread near the surface and the boundary layer of heat transfer becomes weak. It is considered that the air layer is heavy at the cavity bottom as indicated in Figure 8 and its effect is relatively small.

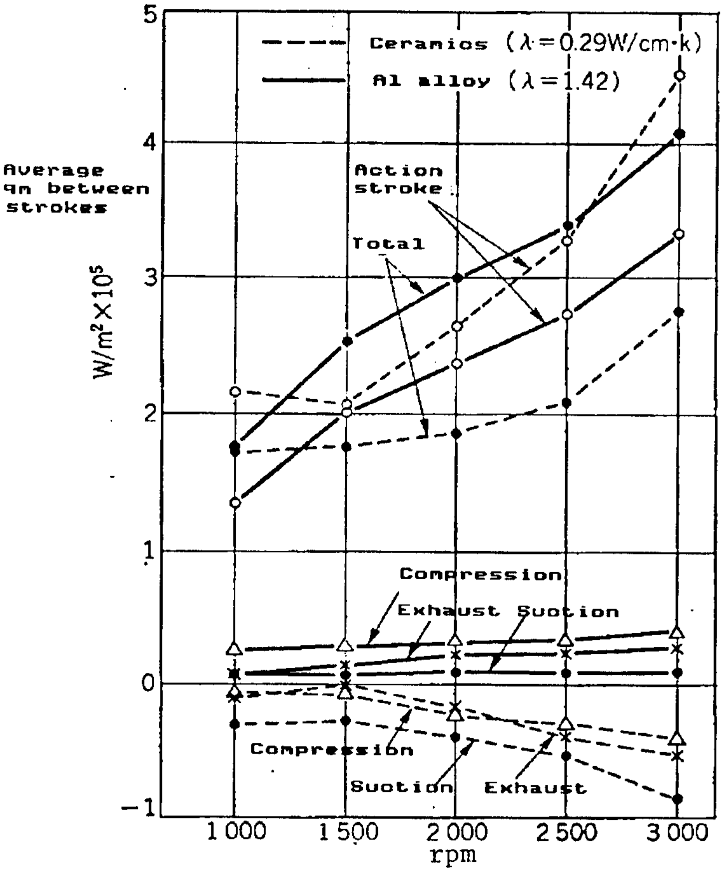


Figure 9. Heat Losses at Respective Piston-Top Strokes

(2) Woschini of the famous Munchen Institute of Technology in West Germany expressed agreement with the results and views of the author, et al., immediately after the paper was published because they too had obtained similar test results. Actually, the following results were announced in MTZ in december 1986. The engine tested had a bore of 125 and a stroke of 140 mm and was of the direct jet single cylinder type. The piston was insulated by fastening a heat-resisting-material ($\lambda \fallingdotseq 0.11$) top face to an Al-piston via an insulating material.

First, as can be seen from the pressure line chart in Figure 10 and the progress of heat generation, the insulated piston is inferior to the Al-piston by dotted line in performance. Computation from the measurement of instantaneous surface temperature (Figure 11) disclosed that this was not due to differences in combustion, blowby, and friction but because of a large α at the initial period of combustion. So, Woschini used the constant C_2 in his own equation

$$\alpha=130d^{-0.2}\,p^{0.8}\,T^{-0.53}\left\{C_1C_m+C_2\frac{V_HT_1}{P_1V_1}(P-P_0)\right\}^{0.8} \tag{2}$$

as the function of T_w after modifying it by $T_w > 600$ K.

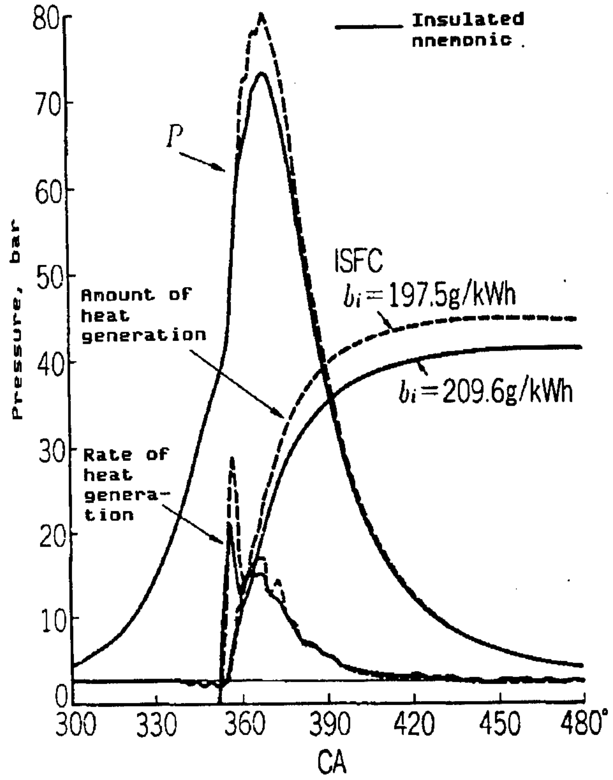


Figure 10. Pressure and Heat Generation Progress When Using Insulated Piston

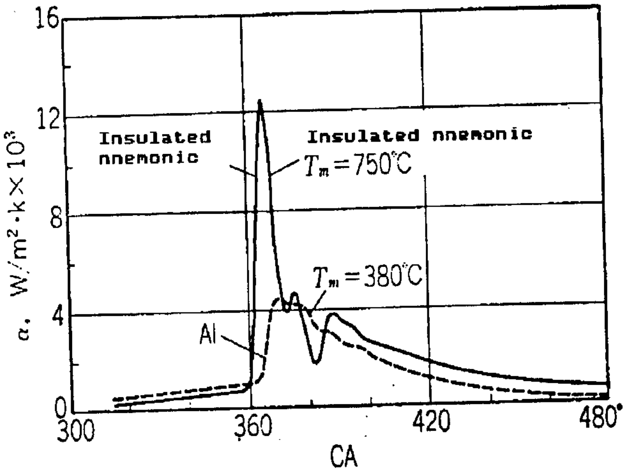


Figure 11. Effect on Heat Conductivity

$$C_2 = 2.310^{-5}(T_W - 600) + 0.005 \quad (m/sK) \qquad (3)$$

This is based on test values shown in Figure 12.

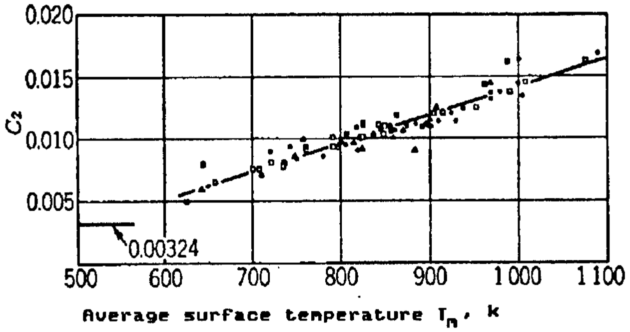


Figure 12. C_2-Tm Characteristic

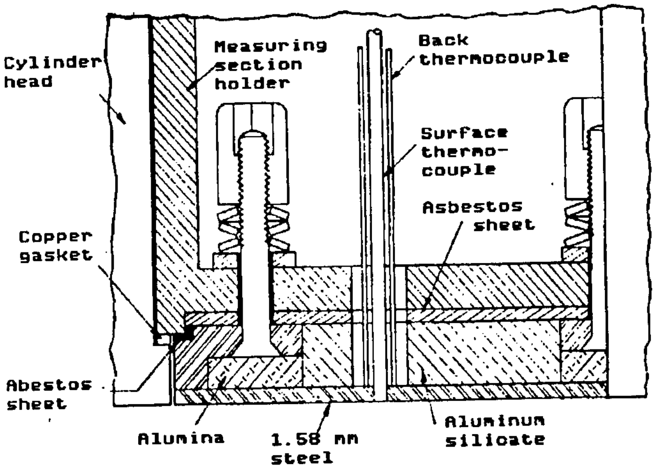


Figure 13. Surface Instantaneous Temperature Detecting Element for Insulated Metal (Steel) Surfaces

(3) Meanwhile, at the Wisconsin university, by insulating a 1.58 mm steel plate with aluminum silicate (λ = 0.01 w/cm^{o}C) facing the combustion chamber, as shown in Figure 13, for part of the ordinary cast-iron head connected a constantan 1.55 mm wire to the surface of the steel by 1-μm plating with the J-type (iron-concrete) as the center for the surface thermocouple. Further, it used three K-type (chromel-alumel) 0.5 mm wires for rear area temperature. Thereby, measuring the heat flux for the insulated metal surface, formed a hot junction by covering the surface of PSZ (partially stabilized zirconia, λ = 0.0245) with 1-μm platinum film and rhodium film as a ceramic board, as shown in Figure 14, and embedded an 0.025 mm K-type thermocouple for rear area temperature.

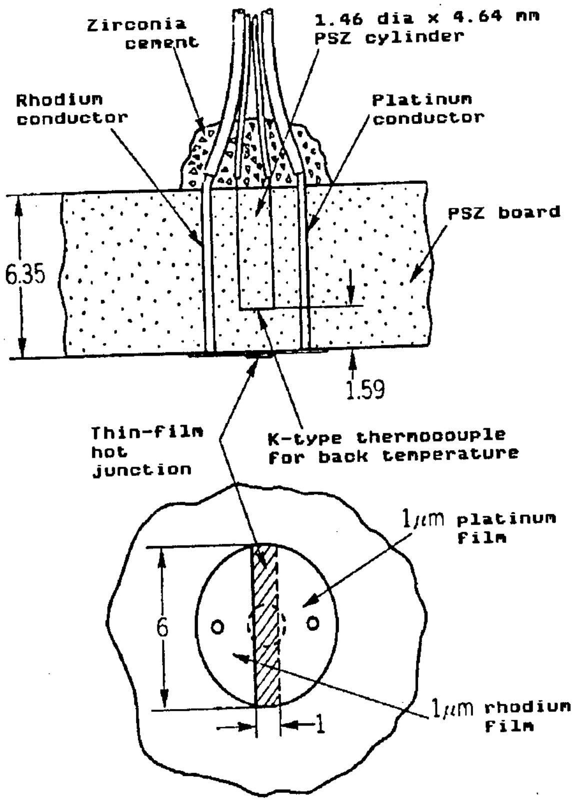


Figure 14. Thin Film-Type Surface Thermocouple for PSZ Boards

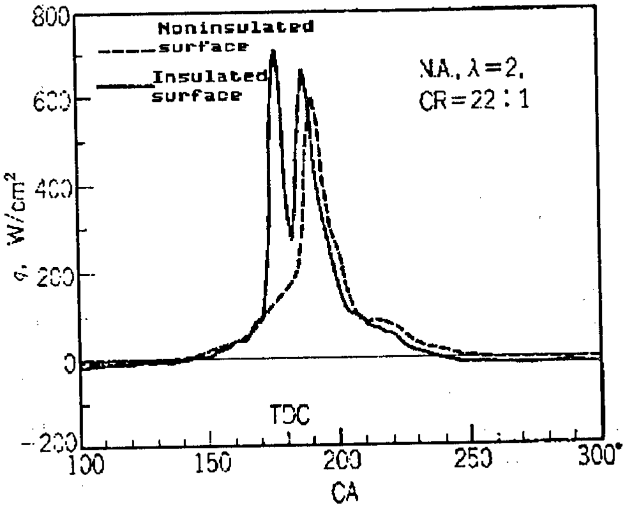


Figure 15. q Values for Insulated and Noninsulated Metal Surfaces

By such measuring methods, insulated metal surfaces (440°C) have larger q than ordinary noninsulated metal surfaces (240°C), as shown in Figure 15, where tendency agrees with Wochini's results and ours. But ceramic surfaces (330°C) showed much less heat radiation than noninsulated metal surfaces (200°C), as shown in Figure 16. In the papers, the reason for this is that since zirconia surface is smooth and difficult for soots to adhere, radiated heat reflects.

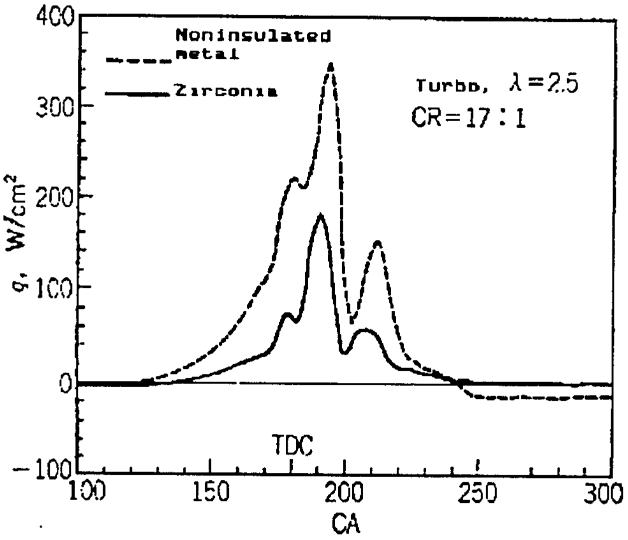


Figure 16. q Characteristics of Zirconia

(4) Problems With Measuring Methods

The first problem concerns whether, in the above various studies, true surface instantaneous temperature was measured accurately or not. As long as thermocouples are used, as at present, temperature fields are inevitably disturbed by their insertion and it is, therefore, necessary to minimize their use. In the author's group's ceramic surface temperature measurement (Figure 17), for instance, the sensor section has the (2) thermocouples of the 0.15 mm Fe (λ = 0.675) wire and the 0.18 mm Ni (λ = 0.90) wire (not shown in the figure) are fastened to the (1) and (6) ceramics (λ = 0.1) walls by the (4) adhesive agent and their surface is plated with (3) Ni special method plating for 10 μm. (5) is an insulating cylindrical layer to make a one-dimensional heat flow so as to facilitate computation by the λ = 0.0079 (alon) ceramic adhesive agent. Here, (2) is 0.15 mm Fe whereas (3) is 10 μm Ni, and Ni the computation of isothermic lines, temperature at the hot junction is about 5°C lower because of the presence of (2), as in the figure, than where there is no (2) and, as the result, the computed value of q falls by 20°C. If the wire diameter could be made to 0.05 mm, this difference could practically disappear.

It is known that if the plating thickness is too thin, temperature in the plated layer on (2) is not uniform and, therefore, big differences occur. Namely, the smaller (2) is, the better and (3) is an appropriate value. Meanwhile, Medtherm products are commonly used in the United States and also in West Germany, but it is hard to understand why this company produces (2) of 0.4 to 1.5 mm thickness and (3) thin plated of 1 μm.

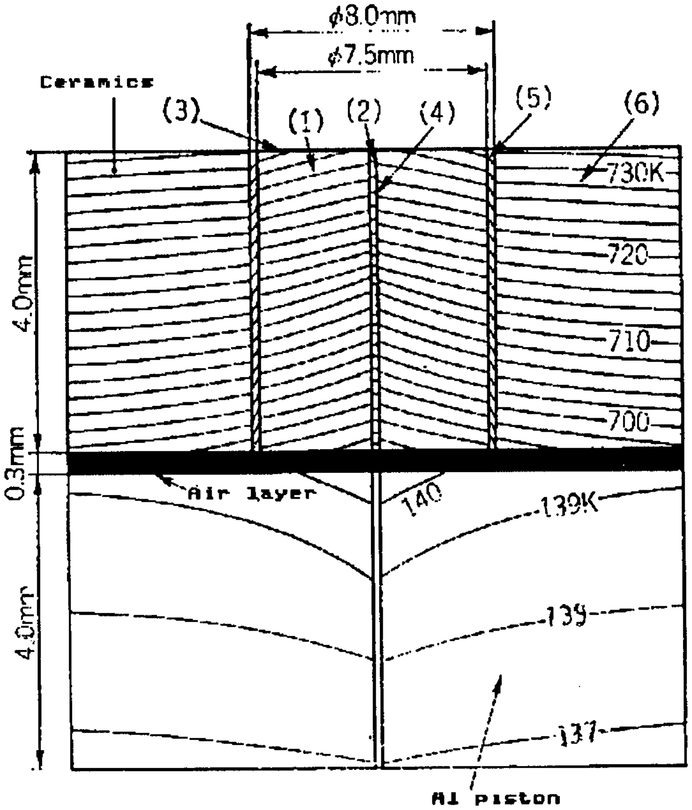


Figure 17. Isothermic Line Chart at the Time Iron (2) Is Embedded in Ceramics (1) (Computation)

Because of these problems, it is strongly hoped for a basically improved measures for development. And at the same time, once again felt the importance of counsel with Annand when I met him at Manchester University some years ago that "researchers of internal combustion engines should study the boundary layers in combustion chamber walls."

2.3 Other Problems and the Future

(1) As the pioneer Kamo says, it shall still take considerable time before such problems as processing and durableness can be solved for ceramics as components for combustion chamber walls. With this prospect, he is now proceeding with developing of ceramic coating technique.

(2) High Temperature Resisting Lubricating Oil

According to Kamo and Bryzik, et al., the cylinder surface temperature of a ceramic engine without water is within the tolerable limits at a low output, but, at full power, it reaches 550-560°C, the dead point position on the ring. Since even the presently available heat resistant synthetic oil is good for only 400°C at the most, a solid lubricating agent or gas bearings has been considered but, oil, after all, is promising and by 1990 is expected to advance to 550°C.

(3) Temperature Stress

The cracking of diesel pistons due to thermal fatigue is caused by rise of temperature at starting time at the time of sudden acceleration and is believed to be in cycles of several tens of times a day. If temperature fluctuates by more than 100^{o}C between each cycle, breakage due to thermal fatigue should occur in a short time. Assanis, et al., and Keribar, et al., computed this temperature change. According to the former, the amplitude of ZrO_2 in the surface temperature change of three types of ceramics shown in Figure 18: ZrO_2 (λ = 0.006w/cm·K) 1.5 mm coating, PSZ (λ = 0.02) insert and RBSN (λ = 0.05) piston, reaches 235^{o}C. Further, in a two-dimensional computation at the edge of a piston's combustion chamber, an amplitude of 500^{o}C occurred between crank angle θ = 300^{o} (at minimum temperature time) and the maximum time $\theta = 400^{o}$, as shown in Figure 19.

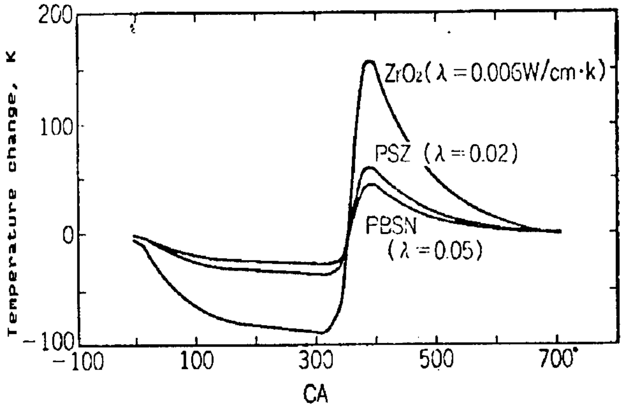


Figure 18. Types of Surface Zirconia and Computed values of Temperature Change

(4) Future Direction

Anyway, it has become almost clear that the effect of power recovery cannot be expected from the insulation of combustion chamber walls. but the use of such characteristics of ceramics as reduced weight, heat resistance, heat insulation, decreased thermal expansion and greater wear resistance is being developed for respective components and a portion such as subsidiary combustion, exhaust valves and cam tappets, have already been commercialized.

3. DPF (Diesel Particulate Filter)

3.1 Outline

The U.S. regulation on particulates (composed mainly of soot) discharged from diesel vehicles in 1988 is 6 g/BPSh, and reportedly attainable without using a DPF. However, commercialization of DPFs are said to be indispensable for the ruling of 0.1 for buses and 0.2 for heavy duty trucks in 1991 and further 0.1 for all in 1994. In the past, the ceramic honeycomb type as shown in Figure 20 [omitted] operative type has been exclusively tried to collect soot

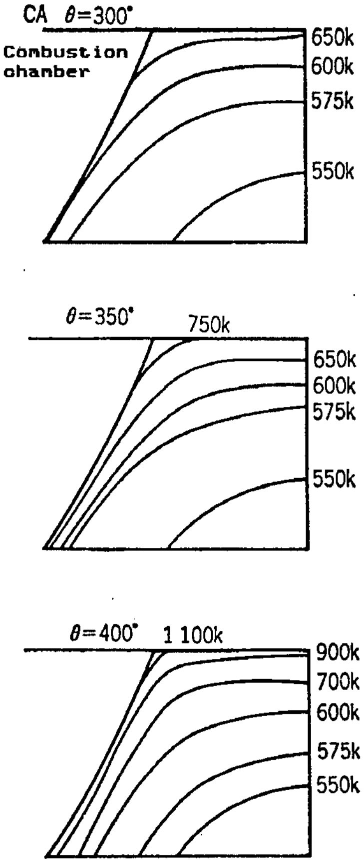


Figure 19. Temperature Change at Edge of Ceramic Piston Combustion Chamber (Two-dimensional computation)

and the problem was to timely remove the accumulated soot because the choking caused the rise of engine backing pressure. Generally, oxidization, that is, an attempt to burn it but, under most operating conditions, it does not burn as is because of the low exhaust temperature.

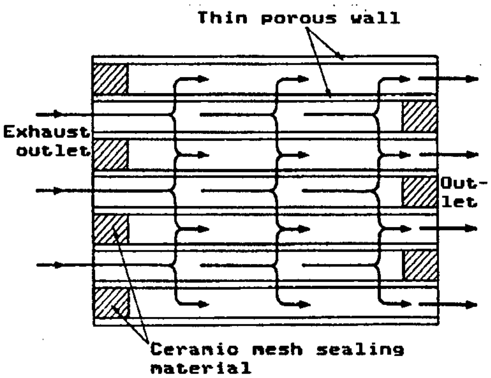


Figure 20. Ceramic Honeycomb DPF

So, methods including a) attaching an oxidation catalyst to ceramics, b) adding a catalyst to the fuel, c) narrowing down suction on exhaust to make it hot, and d) heating exhaust with a burner, were taken. For these, it was necessary to resolve such problems as 1) thermal breakage of ceramics, 2) lowering of engine performance, 3) energy consumption, 4) creating other pollutional exhausts, 5) weight and capacity, and 6) complexity of control.

3.2 Ceramic Fiber Coil Type

What Bentz and Mann and Hummel of West Germany developed was somewhat different frm the above common type. It uses cord-like ceramic instead of a honeycomb as a filter element. The Figure 21 [omitted] element operates in the Figure 22 container. This container is characterized by its high filtering efficiency as shown in Figure 23 but it chokes quickly. As an oxidation accelerating method, there is the process of controlling water solutions of CuCl, CuCl and NH_4NO_3, $Cu(ClO_4)_2 \cdot 6H_2O$. etc. as indicated in Figure 24 and jetting the solution timely into the exhausts. It reacts even at a low exhaust temperature as shown in Figure 25 and can reduce backing pressure by quickly removing soot. But the problem with this method is also durability. Fibers break as in Figure 26 [omitted]. Another problem is the effect of oxides on the health since an oxidizer is used at about 7 g at a time in traveling 100-150 km.

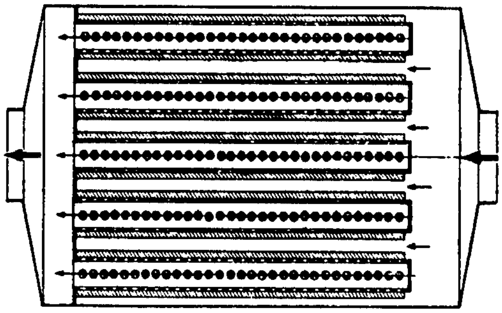


Figure 22. Action of Fiber Coil-Type DPF

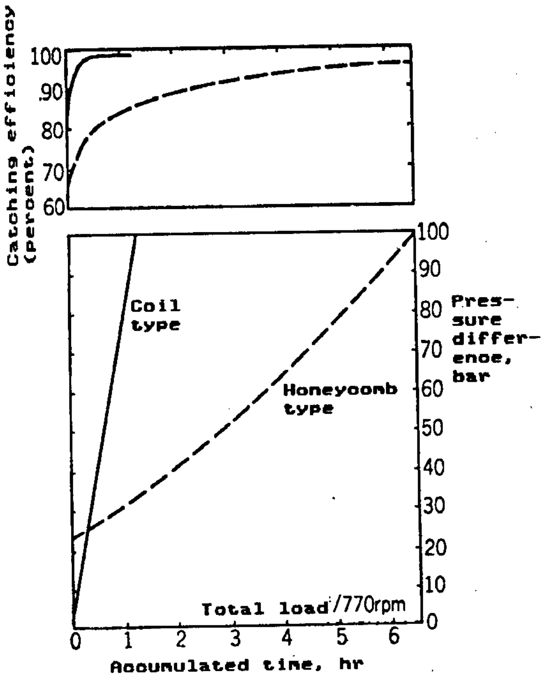


Figure 23. Soot Catching Characteristics of Fiber Coil DPF

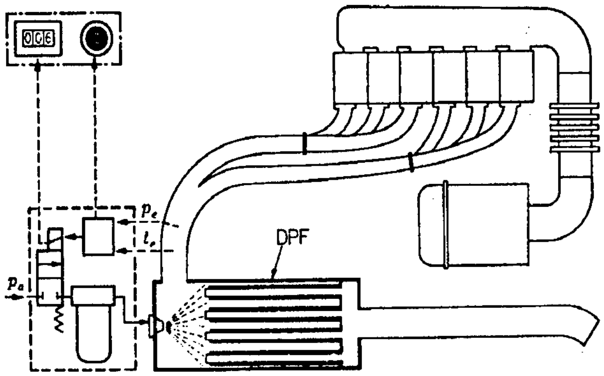


Figure 24. Oxidizer Solution Supply System

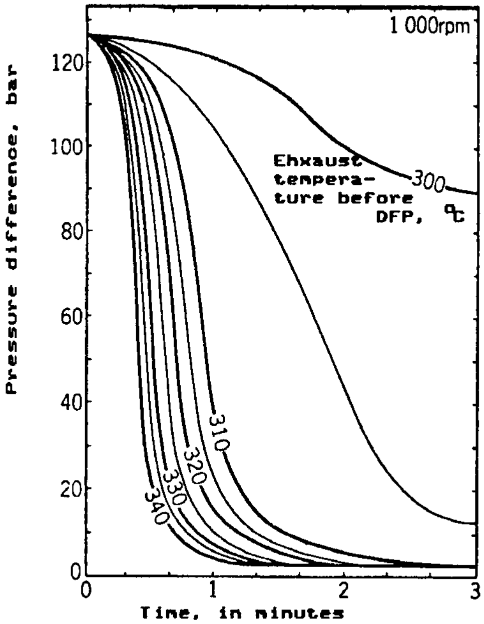


Figure 25. Exhaust Temperature and Soot Removing Capacity

3.3 Measures To Improve Durability

In the author's impression gained from the past progress of development, it seems that success or failure in improving the durability of the honeycomb type with a catalyst will be decisive in realizing a practical DPF. If this is impossible, perhaps the realization of an alcoholic fuel must receive serious consideration, as advocated by Walsh. By the way, hopes can be had on the recently conducted detailed analytic research aimed to improve the honeycomb.

NGK Insulators, Ltd., has found that, regarding the size and wall thickness of cells, thick and numerous cells can accumulate great volume of soot at the point when pressure falls, thin cells are more resistant to thermal shocks, but, as shown in Figure 27, maximum temperature is low in proportion to the thickness of cell walls, and is safe. Yet, it turned out that cell density does not have much to do with this and melting damage occurs at 1,400°C, near the melting point.

In Pattas group's computation of soot combustion, the amount of soot accumulated, the temperature of gas having relation to the concentration of oxygen in the gas relatively determines the critical temperature of the post-combustion period. Figure 28 indicates reaction rate dm/dt increases with the rise of exhaust temperature T from

$$\frac{dm}{dt} = \alpha \cdot \exp(-E/RT) \cdot m_c \cdot (O_2) \qquad (4)$$

but at the time of high-temperature combustion, (O_2) it decreases and reaction is thereby restricted.

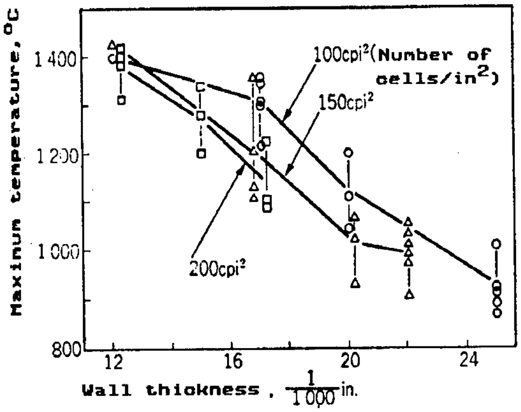


Figure 27. Effect of Numbers and Wall Thickness of Cells on Maximum Temperature

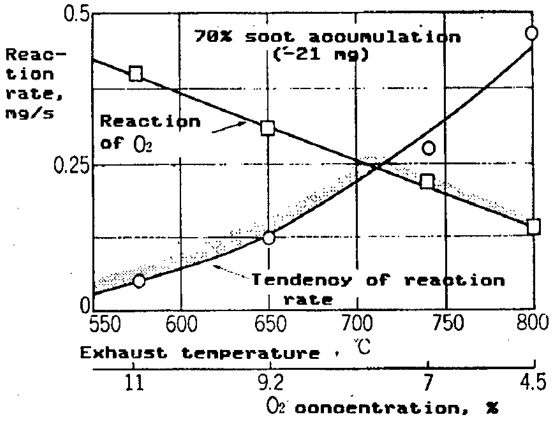


Figure 28. Oxidizing Velocity Characteristics of Soot

How to distribute temperature uniformly from this temperature characteristic of honeycombs and to control critical temperature section is being elucidated.

Archen Institute of Technology in West Germany and others ignite uniformly, using a heating wire placed at the exhaust inlet, as shown in Figure 29 [omitted]. Result: As shown in Figure 30, it gradually decreases from the inlet (1) 2, 3, 4 as it nears toward the outlet. Thermal breakage occurs when a section near the outlet, such as Point 4, is overheated to more than 1,000°C which can be prevented. However, power necessary for the heating is 10 kw at 4.66"x6".

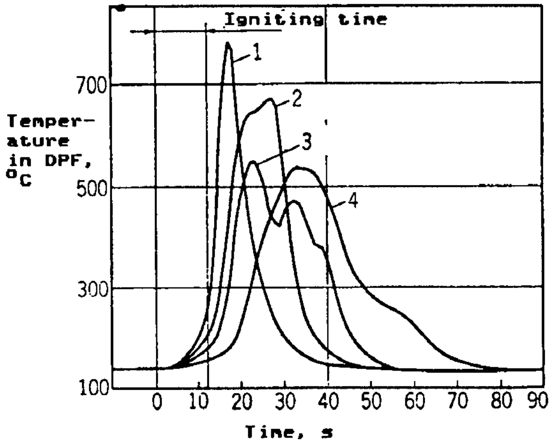


Figure 30. Temperature Change at Different Points in DPF

4. Turbo or Mechanical Supercharger?

It has been quite some time since the exhaust turbine supercharger turbo was made practical as a gasoline engine supercharger, but its defect, inferior acceleration responsivity, has not been improved much and the supercharger, believed to be inferior in point of power losses, is now being noticed and the usage by combination of both is being planned. Let us now see the latest trends in superchargers.

4.1 Comparison of Both

According to Singer of GM, the advantages of both are as indicated in Table 1 and they are equal in fuel economy. So, conceiving superchargers as shown in Figure 31 indicating their detailed performances. In Figure 32 which compares their rising temperature rates as an indication of their efficiency, the roots ranks low. In Figure 33 which shows data indicative of superiority in emission, the turbo is inferior for the reason, basically, of the slow response of exhaust energy.

Table 1.

Item	Superiority
Performance	Equal
Octane value	Equal
Emission	Supercharger
Responsivity	Supercharger
Temperature	Supercharger
Fuel economy	Equal
Supercharge pressure controllability	Turbo
Highland performance	Turbo
Complexity	Equal
Durability	Turbo
Packaging	Turbo
Vibration, noise	Turbo

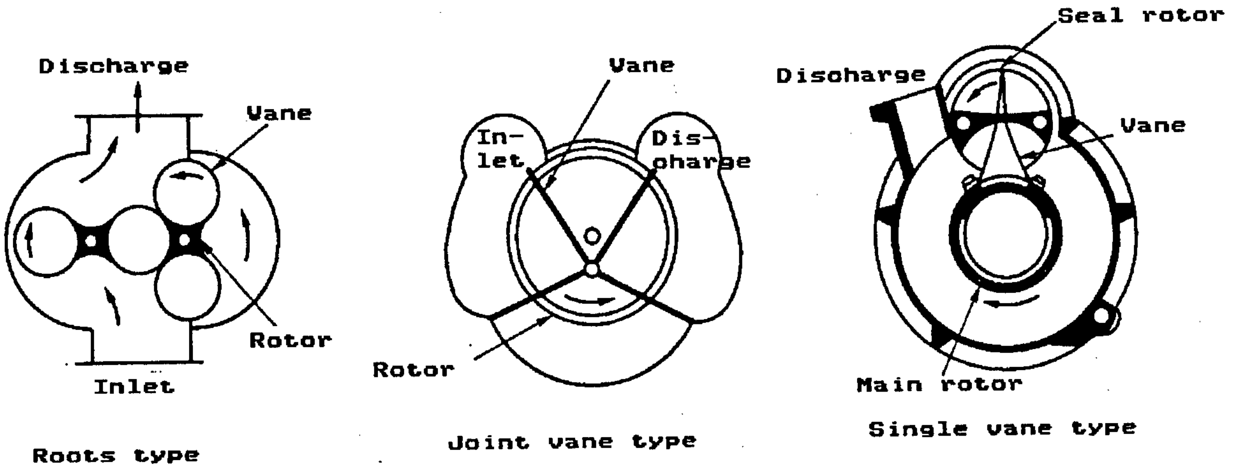


Figure 31. Supercharger Examples of Supercharger Structure

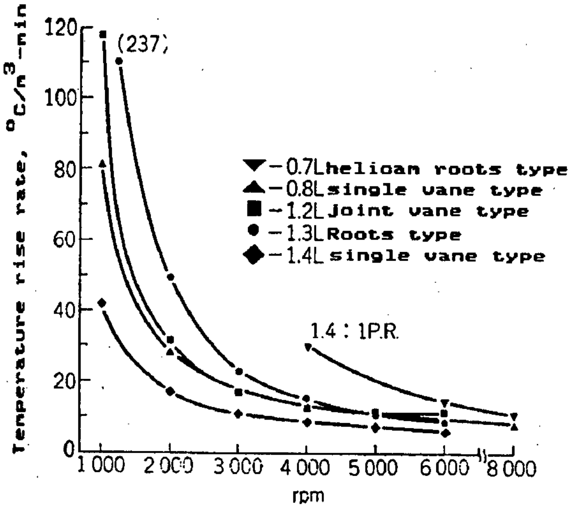


Figure 32. Temperature Rise Characteristics of Different Superchargers

Then, according to the Eaton Co., which regards the responsivity of the turbo as the worst problem in passenger car use, Figure 34 compares the Roots supercharger, the turbo and the variable vane angle turbo, which is an intermediate type. It also showed that, even with the ceramic vane, the turbine inertia fell 50 percent, but the responsivity did not improve proportionally. The turbo gives a 7 percent higher output because, at high velocities, it is more efficient than the Roots, but its air discharge characteristic does not seem to suit the engine and it was considered that the delay period from the start of operation aimed at acceleration until the increase of enthalpy of the turbine inlet exhausts is essentially large for such reasons as the large intracircuit volume and the existence of heat losses. In the Roots type, meanwhile, adiabatic efficiency is low and air

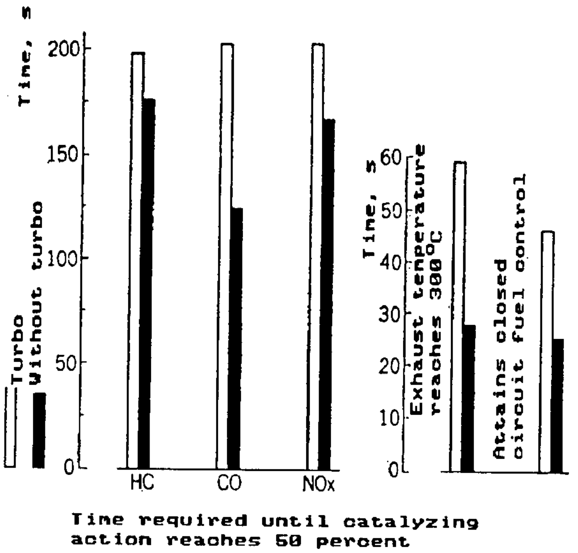
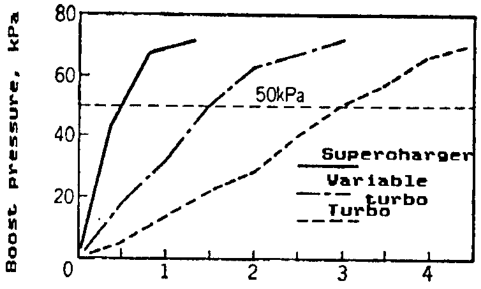
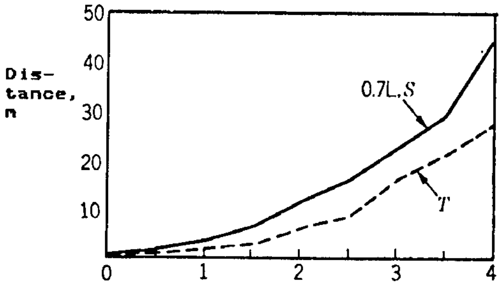


Figure 33. Time Required From Cold Start Until Action of Exhaust Purifying Catalyst



(a) Comparison of boost responsiveness



(b) Traveling distance of vehicle, 2.4L engine

Figure 34. Comparison of Responsiveness of Turbo and Supercharger

temperature rises because of large leaks and large mechanical and fluid frictions. Further, there are losses due to backflow at time of discharge because the air is not internal compressed. Its performance is as indicated in Figure 35.

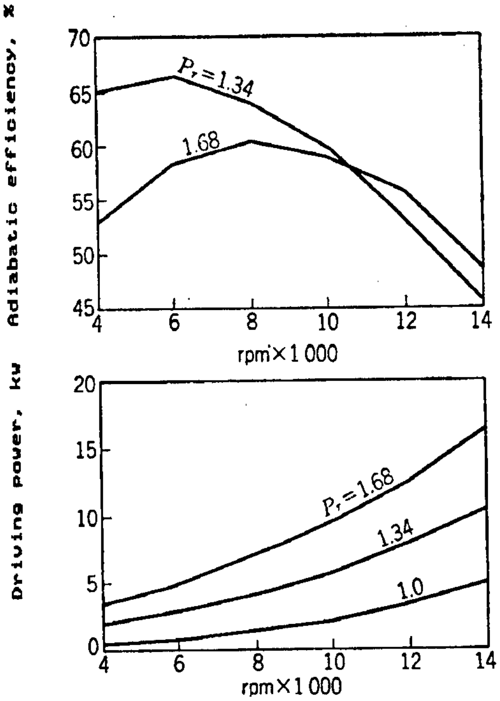


Figure 35. Characteristics of Roots 0.7L Supercharger for Number of Revolutions

4.2 Trial of New Superchargers

From the above, it is natural that much should be expected of the development of superchargers with higher performance. Regarding the supercharging of small engines, many displacement compressors were studied and developed before the turbo but few--with the exception of the Roots--have been made practical and, can be said a puzzle game of the mechanical engineers. Let us now see the next two examples, which may or may not be guaranteed as having solved this difficult problem, for reference's sake.

Figure 36 [omitted] shows that VW developed, based on a 1905 original by a Frenchman. Its 1.5-wind spiral plate (1) just oscillates in the space with a stationary plate (2). According to VW, it is attached to the 1.3 baby VW Polo coupe, driven by a belt at revolutions 1.7 times those of the crankshaft, attains a 72 kPa maximum boost at 10,200 rpm, gives 85 kw output increased 54 percent at engine 6,000 rpm, has little friction, is quiet, is 65 percent more efficient than the Roots and has a total weight of 4.9 kg.

Then, there is the KKK rotary supercharger of Kuhnle, Kopp, and Kausch. It was invented by Felix Wankel. With a structure illustrated in Figure 37 [omitted], central rotor R_1 and outer rotor R_2 with three lugs are interlocked so that they may be engaged and turn at the rotation ratio of 3:2. Its stoke volume and structural volume ratio is as large as 1:1.42. It excels the Roots in that its internal compression ratio is 1.5 to 1.6, thus minimizing impact, its maximum speed is 12,000 rpm, its pressure ratio is 1.8, its temperature rise is only 70°C, η_{ad} = 77 percent and its total efficiency is as high as 65 percent.

5. Postscript

This article deals only with the adiabatic diesel, the DPL and the supercharger, which are a mere fraction of all engines. Remarkable progress has recently been made with respect to combustion, which is vital to the engine, and relative laser measuring technology. Also, light weight, lubrication necessary for high output, and heat load countermeasures are included in the latest themes of research.

These latest trends seem to show that the research to solve problems in developing advantages inherent to the internal combustion engine has begun to be expedited. To this end, many precise measuring methods must be developed, which is not possible by just elaborating on past principles. To develop latest methods, there must be help from not only mechanical engineering but also electrical-electronics and chemistry.

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CSO: 4306/6590

CHARACTERISTICS OF DISTRIBUTED FEEDBACK LASERS DISCUSSED

Tokyo BOEI GIJUTSU in Japanese Apr 87 pp 53-56

[Article by Hitachi, Ltd.]

[Text] 1. Summary

As a semiconductor laser used for optical communications, the Fobry Perot (FP) laser, which operates in the 1.3 μm band, has already been put to practical use. The FP laser uses the cleavage plane of a crystal as a resonator, and its line width is as large as 3-4 nm (half value width) because it acts in the multiplex mode spectrum at the time of high-speed modulation.

The transmission loss in an optical fiber at 1.3 μm is 0.5 dB/km. This is large in comparison to the figure of 0.2 dB/km at 1.55 μm, but since there is no wavelength dispersion in an optical fiber of 1.3 μm, the 1.3 μm band has been used in the multiplex mode laser to avoid the wavelength dispersion effect. When the FP laser is used, the product of the transmission band and the transmission distance is 20-30 km Gbit/s. Thus, since the wavelength dispersion characteristic of the optical fiber restricts expansion of the band and distance in optical communication, a laser that acts within a single spectrum even under high-speed modulation has been sought as a light source.

The distributed feedback (DFB) laser and the distributed Bragg reflector (DBR) laser, have both been researched and developed as such single spectrum lasers. These lasers form a diffraction grating in the crystal near the emission region, and form a resonator by the feedback of the light of the Bragg wavelength. The DFB laser can currently obtain a performance level equivalent to that of the FP laser, which is being put to practical use in the 1.3 μm and 1.55 μm bands. By using the DFB laser in the 1.55 μm band, the product of the transmission band and the transmission distance has exceeded 100 km Gbit/s, which is more than five times that of the FP laser.

2. Characteristics and Structure

The DFB laser has a diffraction grating in the crystal, as mentioned above. Figure 1 shows the structure of the DFB laser. The diffraction grating is formed on the InP substrate crystal, and is designed to prevent disappearance during crystal growth. The oscillation wavelength of the DFB laser is determined by the following formula:

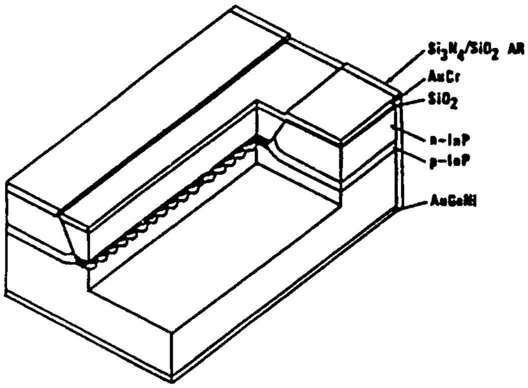


Figure 1. Structural Drawing of BH-Type DFB Laser

$\lambda p = 2 \, n \, \Lambda \, o$

where n is the effective refractive index and Λ o is the cycle of the diffraction grating. The Λ o determines the oscillation wavelength, and a fine cycle diffraction grating of about 1.3-1.55 μm is required. The interference exposure method using a gas laser of He-Cd, Ar, etc., is widely used at present to form such a fine diffraction grating.

The FP laser uses the cleavage plane of the crystal as a resonator, but in the DFB laser the FP mode oscillation must be controlled. It is possible to control the FP mode oscillation by lowering the reflection index at the crystal end. The most popular method is to coat the crystal end of the laser with an antireflective coating and to set the reflection index at one end under several percent (reflection index at the crystal cleavage plane = 30 percent).

The guide layer consists of a mixed crystal of four elements--In, Ga, As, and P. It lies between the diffraction grating of the DFB laser and the activated layer that is the emission region, and it plays an important part in the feedback of the light from the diffraction grating to the activated layer. The product kL of the coupling coefficient kw with the light and resonator length L in this part will become an important parameter in ensuring that the DFB laser acts in a single mode.

The DFB laser of the buried hetero (BH) structure as shown in Figure 1 acts in a single mode even during high-speed modulation in the stabilized side mode (spatial light distribution).

3. Performance and Element Specifications

Table 1 summarizes the performance characteristics and specifications of the DFB laser. Basically, the performance of the simple DFB laser substance does not greatly differ from the FP-type BH laser at either the 1.3 μm or 1.5 μm wavelength. It is different in that the full width at half maximum of its far field pattern is greater than that of the FP laser because of the latter's structural restriction.

Table 1. Characteristics of 1.5 μm DFB Laser

Item	Symbol	Test Condition	Rating			Unit
			min.	typ.	max.	
Threshold Current	Ith	–	–	25	50	mA
Optical Output Power	Po	Kink free	5	–	–	mW
		$I_F = I_{th} + 20mA$	1.5	–	–	
Monitor Power	Pm		0.6	–	–	
Lasing Wavelength	λp	Po=3mW	1530	1550	1570	nm
Spectral Width	Δλ		–	–	0.1	
Side Mode Suppression Ratio	Sr	Po=3mW	–	33	–	dB
Beam Divergence Parallel to the Junction	θ∥	Po=3mW, FWHM	–	30	–	deg
Beam Divergence Perpendicular to the Junction	θ⊥		–	40	–	
Rise Time	tr	10~90%	–	–	0.5	ns
Fall Time	tf	90~10%	–	–	0.5	

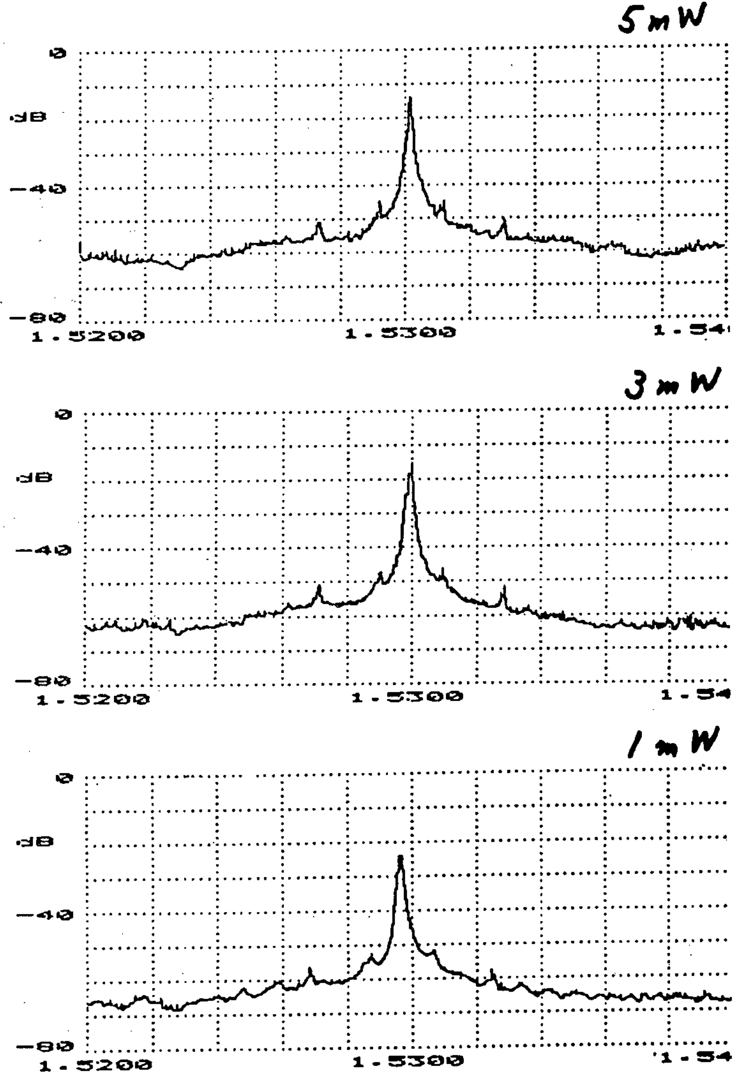
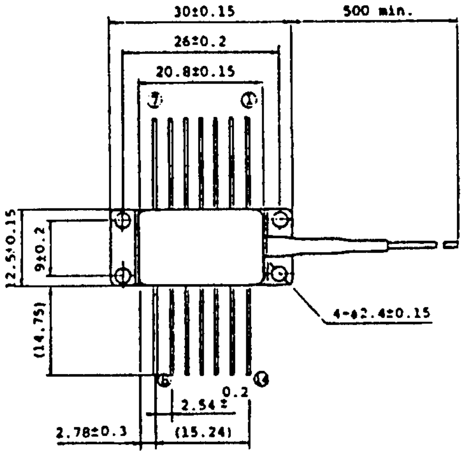


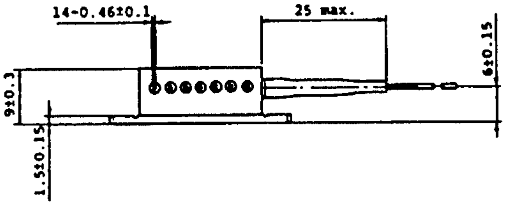
Figure 2. Examples of DFB Laser Spectrums

The spectral line width of the DFB laser is as narrow as 10-30 MHz, but the line width will expand during high-speed modulation over 1 Gbit/s even if it is operating in a single spectrum.

Figure 2 shows the typical spectrums of the DFB laser. In long distance and wide band optical transmission, the mode suppression ratio between the main mode of the DFB laser and other modes will become a problem, but the mode suppression ratio is over 35 dB, which is a sufficient value for practical use.

Table 2. Characteristics of Packaged DIL-Type 1.5 μm DFB Laser

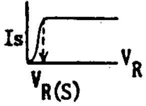




■OPTICAL AND ELECTRICAL CHARACTERISTICS(Tc=25℃)

Item	Symbol	Test Condition	Ratings			Unit
			min	typ	max	
Threshold Current	I t h	—	—	3 0	5 0	m A
Optical Output Power	P f	Kink Free	1. 0	—	—	mW
		$I_{F=Ith+20mA}$	0. 3	—	—	mW
Lasing Wavelength	λ p	Pf=0.5mW	1 5 3 0	1 5 5 0	1 5 7 0	n m
Spectral Width	Δ λ		—	—	0. 1	n m
Side-Mode Suppression Ratio	S r	Pf=0.5mW, CW	—	3 3	—	d B
Rise Time	t r	IBias=Ith, 10~90%	—	0. 2	—	n s
Fall Time	t f	IBias=Ith, 90~10%	—	0. 3	—	n s
Photo Diode Dark Current	I_{DARK}	$V_{R(PD)}$=5V	—	—	3 5 0	n A
Monitor Current	I s	$V_{R(PD)}$=5V, Pf=0.5mW	0. 3	—	—	m A
Photo Diode Capacitance	C t	$V_{R(PD)}$=5V, f=1MHz	—	1 0	2 0	p F
Sensitive Saturation Voltage	$V_{R(S)}$	Note 1	—	—	2	V
Cooling Capacity	Δ T	Tc=60℃, Pf=0.5mW	4 0	—	—	℃
Cooler Current	I c	ΔT=40℃	—	—	1. 4	A
Cooler Voltage	V c	ΔT=40℃	—	—	1. 8	V
Thermistor Resistance	R_{TM}	—	—	1 0	—	k Ω
Thermistor B-Constant	B	Note 2	—	3 4 0 0	—	k

Note 1



Note 2

$$B=\frac{\ln R_1-\ln R_2}{\frac{1}{T_1}-\frac{1}{T_2}}$$

Table 2 shows the specifications of the packaged laser module coupled with the single mode fiber. There are various forms of the module, such as the DIL (dual in line) type and BF (butterfly) depending on their use. The specification of the BF module is shown here. This optical module has an InGaAs/InP three-element PLN photodiode Peltier element within, which is designed so that high-speed modulation up to 3-4 Gbit/s is possible.

Since the small signal band of the BH-type DFB laser is 3-4 Gbit, long-distance optical transmission over 1 Gbit/s using this DFB optical module will become possible.

4. Conclusion

By putting the DFB laser acting in a single spectrum to practical use, a significant expansion of the transmission band and transmission distance in optical communication will become possible. Although there is insufficient extended use data to assess the reliability of the DFB laser, the 1.3 μm and 1.5 μm DFB lasers are thought to have a reliability almost equivalent to the several thousand hour reliability of the FP laser, and in the future they will probably be used widely in long-distance optical communications, taking the place of the 1.3 μm band FP laser.

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PNC'S EXPANSION OF NUCLEAR R&D FRONTIER DETAILED

Tokyo ENERUGI FORAMU in Japanese Apr 87 pp 110-112

[Excerpt] Approach Run for New Start

In October 1967, the Power Reactor and Nuclear Fuel Development Corp. (PNC) was established pursuant to the "Power Reactor and Nuclear Fuel Development Corporation Act." Ever since, the PNC has been engaged in the research and development (R&D) of advanced thermal reactors (ATRs), fast breeder reactors (FBRs), and nuclear fuels, covering the entire field of nuclear power development. However, the PNC currently faces a great turning point.

The PNC has accumulated technological data based on the design, construction, and operation of a prototype reactor called "Fugen" (electric output = 165,000 kw) that enables the PNC to forecast practical applications of ATRs. Based on this experience, the Electric Power Development Co. has begun work on a demonstration reactor with an electrical power output of 600,000 kw. The company hopes to begin operations in 1997 and to demonstrate technology that will meet the demand for both increased capacity and improved economy.

As for the construction of a fast breeder, the experimental reactor "Joyo" (thermal output = 100,000 kw) reached its critical value in 1977. Incorporating the test results, together with new research achievements and the satisfactory operational experiences of the experimental "Joyo" reactor, efforts are now underway to construct a prototype reactor dubbed "Monju." The target for reaching the critical value is set for 1992. This technological experience and knowhow is scheduled to be transferred to the private sector centering on the Electric Power Development Co. In fact, negotiations about various cooperation plans are currently underway.

As for the development of nuclear fuels, various research activities have been carried out to devise ways to process spent fuels in greater safety and to recover the uranium or plutonium from spent fuels for effective reapplication. In 1974, the PNC began construction of the Tokai factory, the first reprocessing plant in our country, and began full-scale operation in January 1981. This plant was also constructed to serve as a pilot plant that could be used to establish reprocessing technology for the next practical stage.

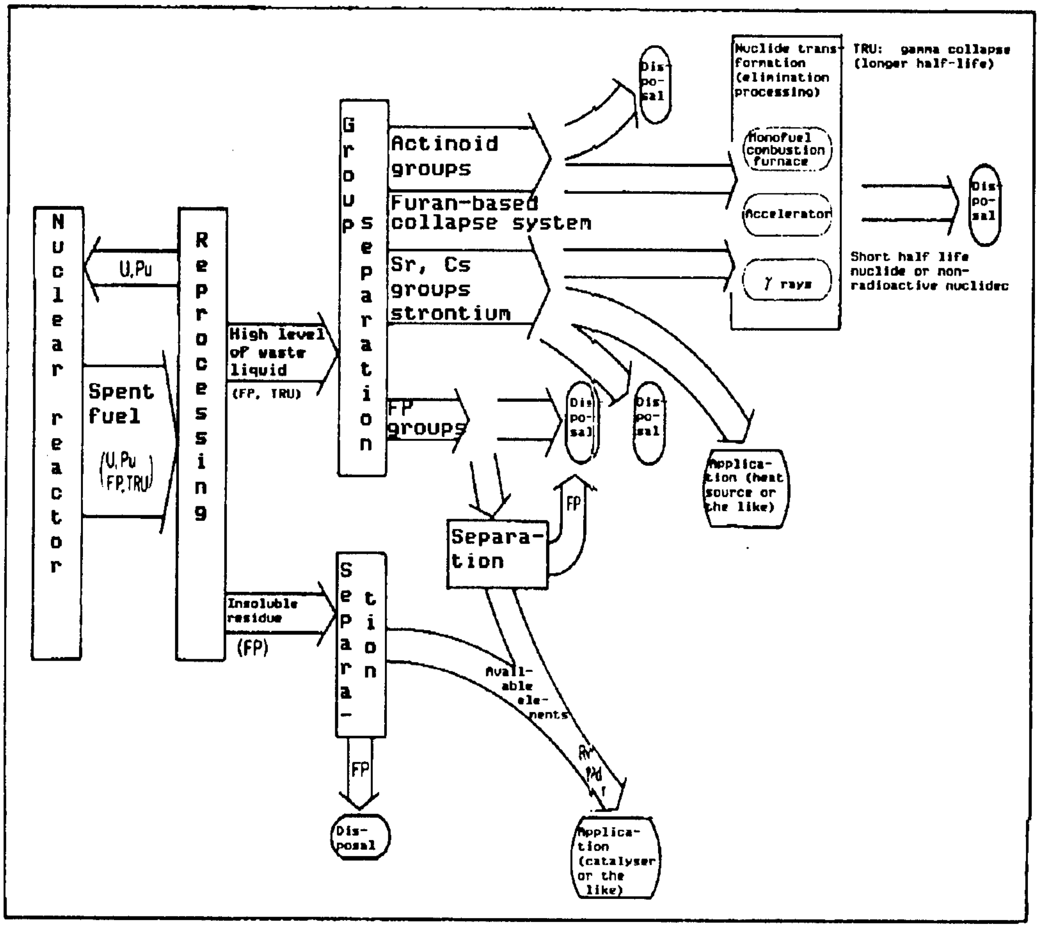
As for enriched uranium, a prototype plant is currently being constructed on the Ningyo pass. It is scheduled to open in 1988. The PNC is carrying out the reprocessing of enriched uranium in cooperation with the Japan Nuclear Fuel Service Co. It is also involved in technological cooperation with the Japan Nuclear Fuel Industry Co., where it is endeavoring to transfer the PNC's accumulated technical knowhow for reprocessing enriched uranium to assist in the construction of a nuclear power plant that can operate on a commercial basis.

As described above, the PNC occupies a place on the leading edge in the development of nuclear power technology in our country, and has currently secured a firm footing toward reaching its original target. This means that the PNC faces a great turning point in deciding whether or not to switch its current research attitude from the traditional "overseas catch up" mentality to a more creative research behavior that is harder to attain but necessary for more positively taking the initiative as an international leader.

The PNC has already begun to move toward a new departure in the midst of apparent environmental changes that call for Japan to meet the increasingly diversified need for nuclear power more aggressively, to contribute to nuclear technology in general, and to assume the responsibility of a leading country in the R&D of nuclear technology. In fact, the PNC has accumulated a great deal of technological experience, and its researchers and engineers have a number of ideas of their own. Attempts are being made to create the next generation of nuclear technology by fully applying these "PNC research resources." The PNC defines this attempt as the "immediate research frontier," and is determined to ferret out new technological problems to be solved by giving specific attention to the seeds and needs of both domestic and foreign technologies. It further intends to tackle research that may provide new information by making the most of the PNC's accumulated knowhow not only in the area of technical development but also scientific research in a broader sense. When promoting nuclear research as described above, the PNC finds it more suitable to adopt a group-oriented organization that gives specific attention to the fluidity of more flexible-minded researchers rather than the traditional fixed organizational structures. To this end it is studying the establishment of in-house research groups while calling at the same time for the participation of researchers from the outside organizations.

The "frontier research" that is scheduled to start in FY 87 covers: 1) the "Phoenix Project" that may change the conventional nuclear cycle dramatically; 2) the development of laser application technology in terms of nuclear power; and 3) artificial intelligence (AI)-based improvements in safety and economy. However, when evaluated on the basis of the PNC's entire work volume, it may well be said that these jobs on the technological edge have just started. The PNC strongly hopes that its bold challenge to the "research frontier" will have a great impact on the development of the PNC's projects, such as its revolutionary nuclear power application system and the like.

The name of this project is derived from the concept that the wastes, which have hitherto been considered less, must be recycled for practical application. The PNC has joined in the development of "nuclide transformation nuclear elimination technology." This constitutes the central theme of this



Conceptual Diagram of Phoenix Project

project, which is being carried out with the Japan Atomic Energy Research Institute.

The PNC's main task is to research and develop technology that can remove nuclear fuel from radioactive elements such as strontium 90 or americium 241, which exist in high-level of radioactive wastes, by injecting high energy gamma rays.

There are several methods available for producing high energy gamma rays. The PNC is planning to discharge gamma rays by generating high-speed electrons and applying the electrons to the uranium.

It will be necessary in the future that a generation unit able to produce more than 10 MeV of energy be installed in order to take the first big step toward the embodiment of "nuclide transformation/nuclear elimination," which the PNC has dreamed of.

In order to make effective use of radioactive wastes, it will be necessary to establish a rare metal recovery process by developing the technology to recover white metal elements (ruthenium, rhodium, and palladium) in particular, even to the point of recovering rare elements from the insoluble residues of FBR reprocessing, and by speeding up the development of technology to separate the isotopes.

The time schedule for the nuclide transformation technology calls for advancement in theoretical research into gamma radiation in parallel with standard tests, aiming at practical application after the year 2000. This assumes that R&D will follow an ideal and smooth course in parallel with design work on the gamma ray generation unit.

The Phoenix Project is familiar with other ideas besides the application of gamma radiation. However, recent technological innovation has increased the chance for its practical application. This is a revolutionary concept that may dramatically change the traditional concept of the nuclear fuel cycle, unless its progress is unexpectedly hindered. Therefore, this research theme may be considered quite ordinary, but it will be indispensable to "the frontier of nuclear research."

Development and Application of New Laser Technology

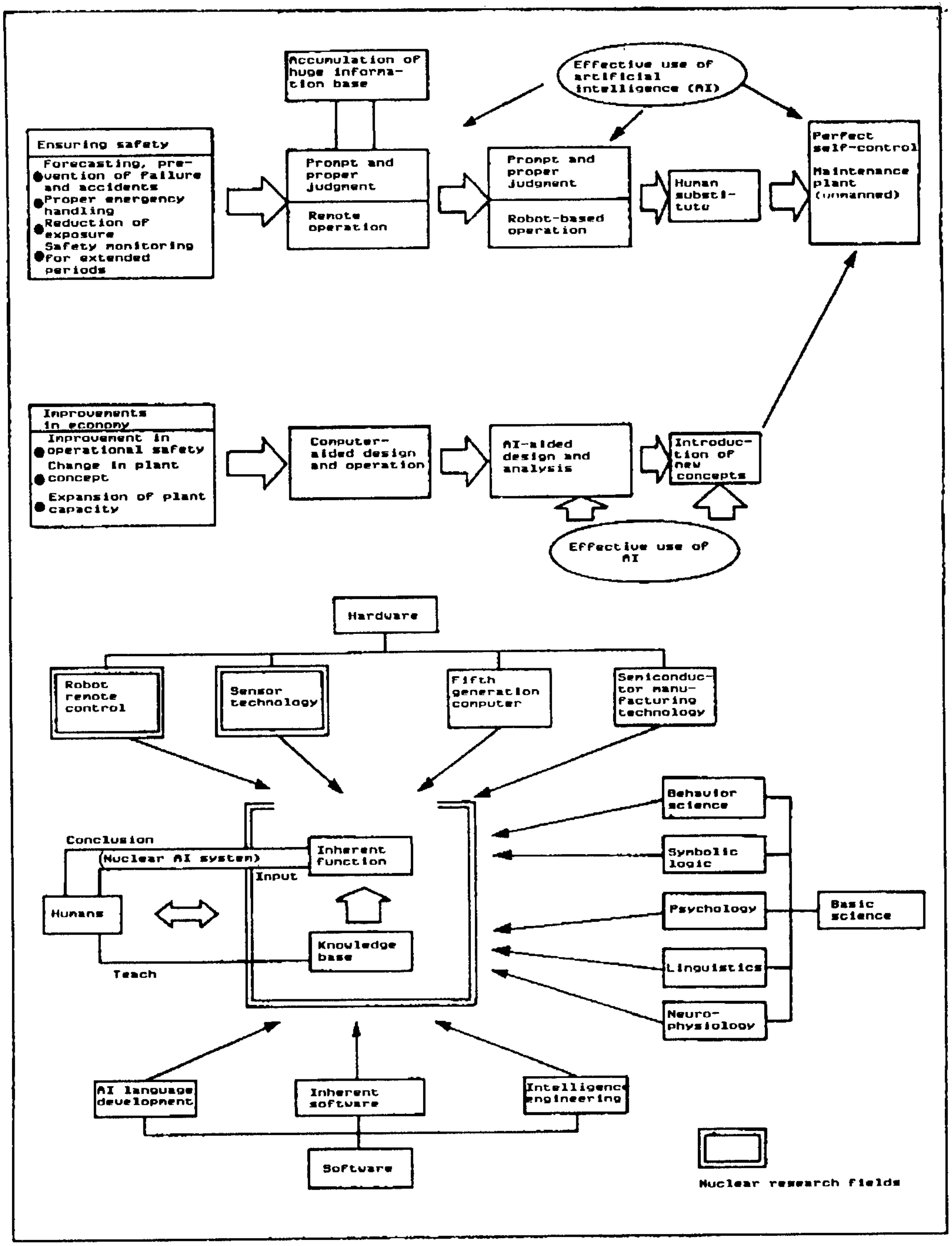
The use of lasers is often cited in the context of atomic power without due consideration, and as it covers a number of different fields it demands closer examination. The laser makes it possible to use light that can be precisely controlled in terms of time and space, and this has led to a host of technological breakthroughs in the information field in conjunction with advanced electronics.

Even in the field of atomic power, both inertially contained nuclear fusion and the process of uranium enrichment adopt the laser, but these are nothing but preliminary attempts, judging from the entire range of laser applications.

Greater expectations are placed on the development of more advanced technology that will be safer, more effective and more acceptable to society by further developing the processing of materials based on the application of laser beams and diversifying their applications. This calls for developing more advanced technology in the key fields of the nuclear development, such as the adjustment of nuclear fuel (enrichment or the like), reprocessing, the processing of the radioactive wastes and the high frequency heating of plasma, as well as in the fields of isotope separation, materials, environments, and radiology.

To meet the demands for laser application in the nuclear field as described above, it will be necessary to improve the output of lasers and to enhance shortwave laser oscillation so that the wave crest may be continuously controlled (free electron laser) and the pulses may be reduced.

The PNC holds the view that the development of new lasers is a key technology for the establishment of the nuclear fuel cycle. This judgment rests on the assumption that the applications for new lasers, if developed, should be defined. However, the PNC prefers an engineering rather than a scientific approach to the development of new lasers.



Conceptual Diagram of AI Development

More specifically, the PNC is determined to develop laser application technology and to be "systematic" in its approach to the development of new technology. The PNC plans to accumulate information about various optical characteristics that involve the adjustment of valency intended for the processing of radioactive wastes and the reprocessing required for reducing waste. It will also collect data on the basic process for enriching uranium, thereby incorporating this accomplishment into the development of its process technology.

Introduction of AI Will Lead To Dramatic Progress in Safety and Economy

Strict safety maintenance is demanded for the development of nuclear technology. The investigation into the Three Mile Island accident in the United States reveals that the multiple safety systems worked immediately after the disaster occurred. However, a number of alarm units in the central control room sounded simultaneously, which hitherto had not been experienced. As a result of this unusual warning operation, the operators became confused, and committed such human errors as misjudgment and improper operations.

It is hoped that this situation can be remedied through the development of AI that can immediately infer the causes of any phenomenon that may be new to humans, thus taking the place of human attendance and executing proper judgment and control.

The PNC includes AI research as a primary task in its nuclear frontier research program. In fact, the PNC is expected to study AI problems from various standpoints in the future.

The PNC has previously tried to promote the development of AI as an expert system. It is expected that AI in the context of "frontier research" will become more advanced and more powerful in the future.

The PNC holds the view that an intelligent robot, which can work at high levels of radiation is necessary both to improve the intelligence capacity of the plant and to eliminate the need for human attendance. As for remote control operations, the PNC also finds it important to develop "tel-existence" technology that allows an operator to have a sense of on-site presence as if he were actually present and working inside the robot. The final object of this technology is to fulfill the dream of a completely unmanned plant fully endowed with AI and able to carry out self-analysis of all its environments, such as a perfect self-control capacity, a self-maintenance and repair capacity, and a self-studying capacity (including the accumulation of data).

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CSO: 4306/2562

HIGH LEVEL RADIOACTIVE WASTE TREATMENT REPORTED

Tokyo PUROMETEUSU in Japanese Jan 87 pp 76-79

[Report by Environment and Resources Department of Power Reactor and Nuclear Fuel Development Corp.: "Technological Development Status of High-Level Radioactive Waste Processing and Disposal in Japan"]

[Text] Great expectations are placed on nuclear power as a pillar of Japan's alternative oil energy sources, since natural resources are scarce in Japan. This is primarily because energy sources can be domestically produced in part. It is not an exaggeration to say that all-out efforts are presently being made in Japan's nuclear power field to ultimately arrive at this position. What is meant by partial domestically-produced nuclear energy follows:

The fuel once spent for power generation with uranium procured from overseas as the feedstock is reprocessed, and the plutonium produced during combustion of the fuel in the nuclear reactor and unburned uranium are recovered in order to allow them to be reused. This reuse permits a reduction of Japan's dependence on foreign resources.

The flow series in connection with this reuse of plutonium and uranium is called a "nuclear fuel cycle." Technologies indispensable for establishing this nuclear fuel cycle are "processing" and "disposal" of "high-level radioactive wastes" generated from such reprocessing.

In this report, the technological development status of processing and disposal of high-level radioactive wastes in Japan is introduced and the status of efforts to solve problems involving international standardization is also reported.

1. Vitrification of High-Level Radioactive Wastes

In Japan, high-level radioactive waste normally refers to high-intensity radioactive nitrate solution (or its solids), including the fission products segregated at the reprocessing plant. This solution is currently stored in a waste liquid state in stainless tanks at the Tokai Reprocessing Plant of the Power Reactor and Nuclear Fuel Development Corp. (PRNFDC), which is the only reprocessing facility in Japan.

Basically, this high-level radioactive waste liquid is solidified in stable configurations, stored for cooling for 30-50 years and disposed of more than several hundred meters underground.

The definition of high-level radioactive wastes varies from country to country. Therefore, care should be taken with this definition. In other words, the countries which take a basic view of reprocessing, namely plutonium utilization, hold a view similar to that of Japan. However, other countries, such as the United States and Sweden, regard spent fuel itself as high-level radioactive waste, so reprocessing work is not done there.

For a long time, a large number of people have been studying into what solids high-level radioactive waste liquid should be converted, from the viewpoint that the solids should be suitable for the disposal of radwastes subsequent to this waste liquid. As a result, vitrification solids have been overwhelmingly accepted worldwide by those involved. The typical reasons for this are as follows:

(1) Glass is noncrystalline and various elements can be melted into glass as in the case of liquid. If the water contents are removed from high-level radioactive waste liquid containing various elements and the waste liquid is melted into glass, this liquid can be converted into vitrification solids.

(2) We are aware that, in ancient times, glass was produced through natural volcanic action and still exists in its original state. Also, we know instances in which the glassware which was produced long ago in ancient Egypt was buried in the earth for 5 centuries and extracted from the earth.

Therefore, glass is highly resistant to water and air. When used for radioactivity shielding windows, glass is protected against radioactivity, and is, therefore, highly durable.

(3) Glass production has a very long history, and technology for the handling and production techniques of glass has been commercially established. This means that solids with thorough quality control can be produced at a lower cost, if the vitrification process for the high-level waste liquid is adopted.

The authors believe that glass should be used for high-level radioactive wastes, for the above reasons. People are liable to consider the brittleness of glass to be a disadvantage. Accordingly, the characteristics of glass must be understood and evaluated, with due consideration given to this disadvantage.

The commercial production processes for these vitrification solids have been broadly classified internationally into two processes. Figure 1 gives explanations of the two processes. With the LFCM process, glass frit and high-level waste liquid are fed from the top of the large glass melter fabricated of refractories, and water and nitrate contents are removed inside the melter where the components of the waste liquid are melted into the molten glass.

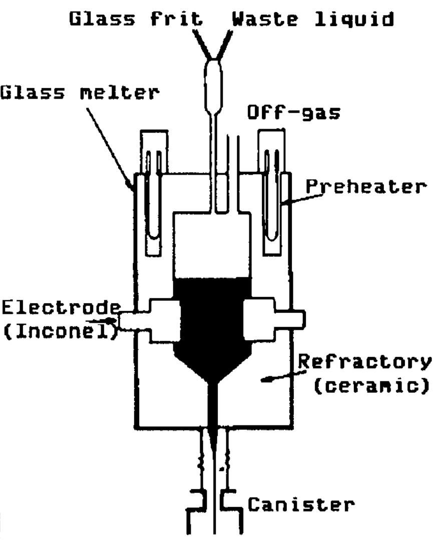
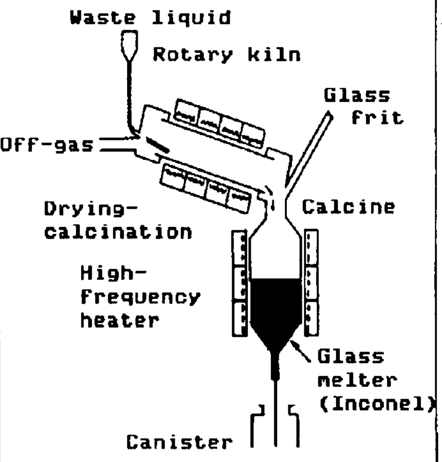
Process	Process
LFCM process	**A V M** process
	
Items Process configuration: Glass melter Melter heating system: Direct current Driving Joule Heating Melter material: Ceramic Waste liquid: Liquid feed systen Processing capacity: Large volume is easy	Items Process configuration: Rotary calciner Glass melter Melter heating system: High-frequency heating Melter material: Metal (Inconel) Waste liquid: Power feed after waste liquid is calcinated Processing capacity: Large volume is difficult (processed with a number of systems)

Figure 1. Comparison of Glass Melting Processes

With the AVM process, high-level waste liquid is heated in the rotary kiln in which nitrate contents have been removed and components of radwastes pulverized. Then, these pulverized radwastes are fed to the separate metal glass melter for melting into the glass.

With either of the two processes, the glass which has melted and flowed into the bottom is received in the vessel, called a stainless canister, for cooling and hardening. This cooled and hardened glass is normally called a vitrification solid.

The canister is welded to its cover after a fixed amount of glass has filled it. The AVM of the AVM process represents a combination of each of the first letters Atelier de Vitrification of Marcoule, meaning vitrification workshop of the Marcoule Nuclear Industrial Center in France, which developed this process. At this industrial center, more than 1,000 vitrification solids were produced as of July 1986 and contributed greatly to the establishment of the international understanding that the vitrification process is a proven technology.

The PRNFDC, as the only organization storing high-level waste liquid in Japan, has promoted this vitrification technology for the past 10 years. Technology which the PRNFDC has been tackling is the LFCM process. LFCM is a combination of each of the first letters of "liquid feed ceramic melter," and the process is advantageous for the scaling-up of the melter as compared with the AVM process. The United States and West Germany have been promoting technological development under this process. The vitrification facility called PAMELA which was completed at CNE/SCK in Belgium using the technology of West Germany has been operating for almost 1 year.

Aspects of PRNFDC's technological development include the improvement in ceramic melter technology and also the achievement of remote-controlled maintenance. The technical staff which thoroughly tackled the development of technology for the ceramic melter produced improved technology such as the prevention of accumulation of deposits at the bottom which was a result of improvement in the melter bottom construction, and the control of dust generation resulting from the introduction of the new glass frit feed process. It has been noted during the technological development that technical cooperation with the United States and West Germany has contributed greatly to the formation and share of the international technical foundation. PRNFDC's improved technologies have been highly evaluated by the technical staffs of the United States and West Germany, and the remote-controlled maintenance technology is a result of international cooperation, having been jointly developed with the United States.

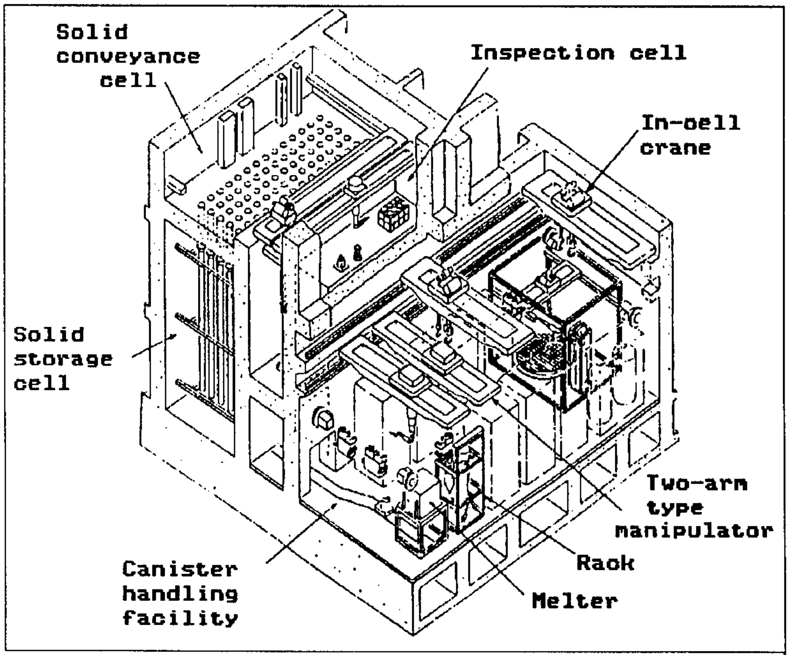


Figure 2. Bird's-Eye View of Solidification Cell

The construction of a full-scale vitrification plant using this technology will be started in 1987. Figure 2 shows a partial design of the vitrification plant.

2. Geological Disposal

Measures for disposal of high-level radioactive wastes have been widely studied, not only by each country but also on the international level. This is because it has been universally recognized that a common issue internationally is to clarify what measures should be taken and what should be done to allow such measures to become satisfactory, for the following characteristics of radwastes:

(1) High-level radioactivity
(2) Heat generation
(3) Inclusion of long-lived radioactive elements

"Wastes" in Japanese in most cases refers to the disposal of equipment or materials, etc., since it is unnecessary. However, a new method of approach to properly evaluate the configurations of the radioactive wastes disposed of in relation to human society is being internationally established. Therefore, the sense of new mission not felt in the word "disposal" is being incorporated.

This sense of new mission refers to the following:

(1) The health of the present and next generation shall not be negatively affected.

(2) The environment shall not be adversely affected for a long period.

(3) Burdens shall not be placed on the next generation.

The measure which is being internationally established in response to these requirements is geological disposal.

The reasons for this are as follows:

(1) Geological disposal allows radwastes to be confined underground for a long period of time. (Underground confinement is physically and chemically safer.)

(2) It is unnecessary for human beings to take active care of radwastes in order for safety to be maintained.

(3) Each country can find a site for geological disposal of its own.

(4) The conventional civil and mining technologies can be fully used for the construction of the disposal site and the cost involved therein is in the appropriate range.

Mentioned above is the background for considering geological disposal to be a promising disposal method. Next, the authors offer a prediction as to how this system can accomplish the segregation of radioactive wastes from the human environment for a long period.

The geological disposal of radioactive wastes refers to the fact that they are stored deep in the ground as long as possible in a nondiffusion form. This has been mentioned repeatedly. In other words, conditions conducive to radioactive waste elements remain heavy in disposal sites and sparse in nondisposal areas. These conditions will be maintained for a long period using natural operation. That a certain element exists in thick and thin states is, in fact, a very normal phenomenon and is found n natural mineral deposits.

In mineral deposits, the conditions of thick existence of several elements such as iron and copper, etc., only therein are formed in the nature. High-level wastes contain most of the elements, and the disposal site can be said to be an artificial mineral deposit of all elements. Therefore, studies ultimately arrive at what should be done to allow the intentionally produced artificial underground deposit of the "disposal site" to be continued.

The underground water and chemical environment diffuse elements from this artificial mineral deposit. The chemical environment is in fact a very important condition. Physically speaking, water is a carrier of the elements. How much this diffusion is prevented or promoted is one of the chemical conditions. In other words, the prediction of continuation of this long segregation function can be made in combination with the understanding of the geological safety and the underground water movement, and also with an explanation of the chemical phenomenon by means of thermodynamics.

Since uncertainties exist, however, studies of the following steps to be taken at the initial stage where factors (of increasing uncertainties), such as heat and radiation, are considered have recently made progress. As a result increasing confidence has been attained regarding the continuation of this segregation function using a combination of artificial barriers and natural barriers.

The results of these studies are as follows:

(1) Glass is covered with artificial material to prevent elements from escaping, thereby narrowing the uncertainty range.

(2) Artificial materials which contribute to the formation of chemical conditions (based on thermodynamics) and do not oxidize for a long period are applied around glass.

(3) The phenomena of adsorption and infiltration of elements to and into the geological environment have been solved.

With these findings, the image of the geological disposal method by which radwastes are stored and segregated has been changed from one of a special method to one of an everyday method.

In Japan, based on the basic policy worked out by the Atomic Energy Commission, the PRNFDC, the Japan Atomic Energy Research Institute, and the Geological Survey Agency are proceeding with research directed at allowing geological disposal to be realistic in the year 2000. In particular, the PRNFDC is positioned as the core promotion organization of this group, and will select the candidate disposal site, etc. Thus, it is strengthening the research promotion organization. The realization of geological disposal requires the understanding of the people. Most important, research results involving disposal must be simply and plainly explained to obtain the national understanding.

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1. Control of High-Level Radioactive Wastes-Survey of Proving Activities, OECD/NEA, April 1985.

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FY86 NUCLEAR POWER PLANT OPERATING RATE REPORTED

Tokyo GENSHIRYOKU KOGYO SHIMBUN in Japanese 9 Apr 87 pp 4,5

[Text] FY86 Operating Results for Japanese Nuclear Power Plants

According to a survey by the Japan Atomic Industrial Forum [JAIF], the rate of plant utilization (including "Fugen") for Japan's nuclear power plants recorded for FY86 was 75.7 percent. Although it fell slightly short of the preceding fiscal year (75.8 percent), which recorded an all-time high, it maintained a 70-percent level for the fourth year running, and indicated satisfactory operation. For Japan, which executes a regular 3-to-4-month inspection once each year, this is, for all practical purposes, the maximum level. We take pride in the fact that it is a markedly high result compared even with such results of advanced nuclear-power countries as America's 58.3 percent (1986 calendar year) and France's 69.9 percent (1986 calendar year). Here we shall present a summary of the FY86 operating situation based on MITI materials and JAIF data on operation results.

The 70-Percent Level for 4 Year Running: An Outstanding Operation Setup

The Practical Operation Rate is 100 Percent

New Operation Starts: One Reactor of 1.16 Million kW

In FY86, on 17 February, the Japan Atomic Power Co.'s Turuga No 2 reactor (PWR [pressurized water reactor], output: 1.16 million kW) began operation.

This brought the number of Japan's nuclear power plants to 34 reactors (including the "Fugen") with a total output of 25.846 million kW, and the proportion of total electric generation volume occupied by nuclear power generation is estimated to be approximately 27 percent.

When we view the FY86 rate of plant utilization by type of reactor, the average for BWR's [boiling water reactor] (16 reactors with a total output of 12.917 million kW), was 75.9 percent, for PWR's (16 reactors with a total output of 12,598 million kW) it was 75.8 percent, for GCR's [gas-cooled reactor] (1 reactor with an output of 166,000 kW) it was 63.4 percent and for ATR's [advanced thermal converter reactor] (1 reactor with an output of 165,000 kW) it was 68.5 percent.

On the other hand, when we look at it in terms of each power plant, excluding the Tsuruga No 2 reactor which newly began operation, the one which achieved the highest rate of plant utilization was the 96.7 percent of the Kansai Electric Power Co., Ltd.'s Takahama No 3 (PWR, output of 870,000 kW), which was followed by the 90.1 percent of the Tohoku Electric Power Co., Inc.'s Second Fukushima No 1 reactor (BWR, output of 1.1 million kW), the 89.8 percent of Kyushu Electric Power Co., Inc.'s Kawauchi No 1 reactor (PWR, output of 890,000 kW), the 85.8 percent of Kansai Electric Power's Oi No 2 reactor (PWR, output of 1.175 million kW) and so on.

Including these there were 13 reactors which achieved a utilization rate of 80 percent or greater, and there were 9 other reactors which achieved a level of 70 percent or greater.

Next, when we look at the plant-utilization rate up to now, with the exception of FY77 it has been improving steadily; and the main causes for this are (1) the shortening of the term of regular inspections, (2) the lengthening of the operation period, and (3) a decrease in the number of troubles.

Among these, in regard to the shortening of the regular inspection period, among the reasons for this can be cited the fact that the volume of repair and maintenance work for such things as initial troubles and stress and corrosion cracks, which has been the greatest cause of prolongation of regular inspections up to now, have declined, and, in addition, the fact that efficient regular inspection has become possible because equipment improvements have been implemented for new plants making use of past experience.

In regard to regular inspections, though there is some fluctuation, in FY86 the 110 days recorded in the preceding fiscal year was shortened by 7 days. In concrete terms, 11 reactors completed their regular inspections (parallel off to parallel) within 3 months, with the 56 days of Kyushu Electric Power's Genkai No 2 reactor (PWR, output of 559,000 kW) at the top.

Furthermore, the lengthening of the operating period is due to improvement of plant and equipment, enhancement of reliability by thorough quality control, and alterations in fuel design such as a rise in the degree of enrichment.

Incidentally, in FY86 eight reactors achieved a long-term continuous operation of 1 year or more, led by the 427-day non-stop operation of Kansai Electric Power's Oi No 2 reactor.

In addition, in regard to the decline in trouble, there can be cited, most importantly thorough quality control of inspection and repair, prior-prevention countermeasures by making use of data on domestic and foreign accidents and breakdowns, and the fact that improvement of the reliability of the plants themselves has been attempted by there having been added various kinds of improvements in technology represented by plans for improvement and standardization of light water reactors.

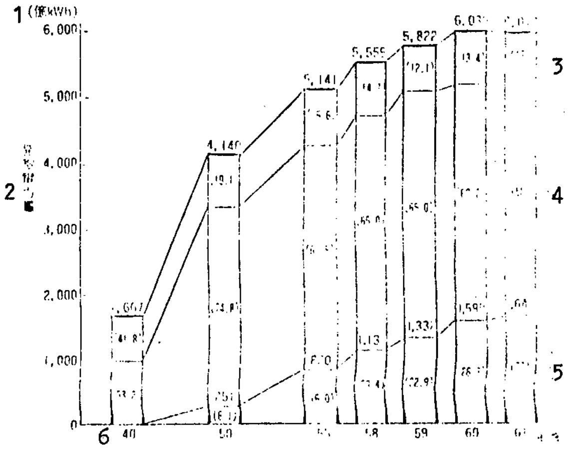

Figure 1. Transition in Annual Volume of Generated Electricity (Numbers in parentheses represent percentages)

Key:
1. (100 million kWh)
2. Volume of electricity generated
3. Hydroelectric power
4. Thermoelectric power
5. Nuclear power
6. FY65, 75, 80, 83, 84, 85, 86

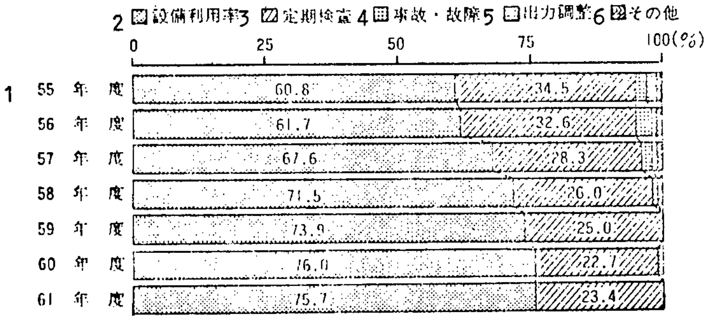

Figure 2. Transition in the Operating Situation

Key:
1. FY80
   FY81
   FY82
   FY83
   FY84
   FY85
   FY86
2. Plant-utilization rate
3. Regular inspection
4. Accidents, breakdowns
5. Adjustment of output
6. Other

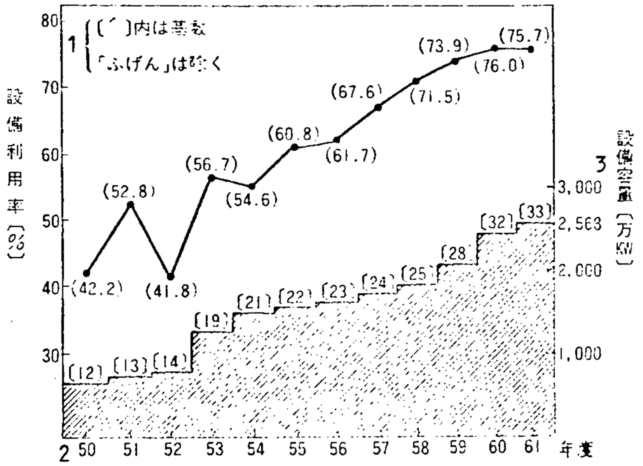

Figure 3. Transition in the Plant Utilization Rate

Key:

1. Figures in brackets are cardinal numbers
   "Fugen" is excluded
2. FY75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86
3. Plant capacity [10,000 kWh]

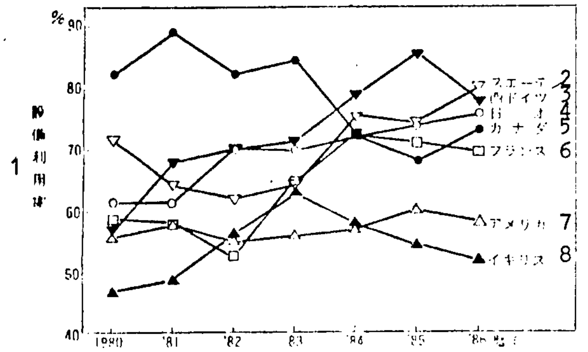

Figure 4. Transition in Plant Utilization Rates for Nuclear Power Plants of Leading Nations (calendar year)

Key:

1. Plant utilization rate
2. Sweden
3. West Germany
4. Japan
5. Canada
6. France
7. America
8. England

Table 1. Examples of Long-Term Continuous Operation (365 days or longer)

FY in Which Ended	Plant Name	Number of days	Remarks
1982	Genkai No 1	367	Nonstop
1983	Fukushima second No 1	400	Nonstop*
	Ikata No 2	401	6-hour interruption in mid-course due to lightning striking a transmission line
1984	Fukushima second No 1	366	Nonstop*
	Ikata No 2	393	Nonstop
	Genkai No 2	415	5-minute independent operation inside plant in mid-course due to lightning striking a transmission line
1985	Hamaoka No 1	397	Nonstop
	Ikata No 1	391	Nonstop
	Ikata No 2	418	Nonstop
	Genkai No 2	404	Nonstop
1986	Kashiwazaki/Kariwa No 1	374	Nonstop*
	Mihama No 1	370	22-minute independent operation in plant in mid-course due to lightning striking a transmission line
	Mihama No 3	404	Nonstop
	Takahama No 3	422	Nonstop
	Oi No 2	427	Nonstop
	Ikata No 1	397	Nonstop
	Ikata No 2	397	Nonstop
	Genkai No 2	400	Nonstop

(Notes:) (1) The number of days is the number of days from the start of generation of power accompanying the completion of a regular inspection to the shutdown of generation of power due to the start of a regular inspection.

(2) * includes a test-operation period

Table 2. Transition in Term of Regular Inspections (CGR, average excluding Mihama No 1)

FY in Which Begun	75	76	77	78	79	80	81	82	83	84	85	86
Average term	178 (5.9)	243 (8.1)	156 (5.2)	205 (6.8)	152 (5.1)	125 (4.2)	135 (4.5)	125 (4.2)	126 (4.2)	118 (3.9)	110 (3.7)	103 (3.4)

(Notes:) Figures in parentheses are the number of months (number of days divided by 30, fractions are rounded off).

FY86 includes plan.

Table 3. Transition in the Number of Months of Operation (average of all plants)

FY in Which Begun	75	76	77	78	79	80	81	82	83	84	85	86
Months of Operation	9.0	8.9	7.6	8.9	8.9	9.4	9.9	10.9	10.9	11.6	11.9	11.9

(Notes:) The period from the start of power-generation accompanying the completion of a regular inspection to the shutdowns of power-generation due to the start of a regular inspection was taken to be the number of months of continuous operation (number of days divided by 30, fractions are rounded off). (Excludes periods of mid-term shutdowns and shutdowns due to accident.)

FY86 includes plan.

Excludes new plants which started operations during the fiscal year.

Table 4. Frequency of Shutdowns of Operation Due to Troubles During Operation (excludes troubles during test operation) (items for which a report was made in accordance with law)

(1) Automatic Shutdowns

FY	75	76	77	78	79	80	81	82	83	84	85	86
Frequency*	0.7	1.2	0.6	0.9	0.5	0.7	0.6	0.4	0.6	0.1	0.2	0.2

* Times divided by reactor-year (number of automatic shutdowns in FY) divided by (total power-generation hours in FY divided by 8760)

(2) Automatic Shutdowns Plus Manual Shutdowns

FY	75	76	77	78	79	80	81	82	83	84	85	86
Frequency*	1.6	1.9	0.8	1.3	1.1	1.1	1.3	1.0	0.8	0.3	0.5	0.4

* Times divided by reactor-year (number of automatic shutdowns plus manual shutdowns in FY) divided by (total power-generation hours in FY divided by 8760)

34 （上段は時間稼働率〔%〕
下段は設備利用率〔%〕） 35 単位：稼働時間〔H〕
発電電力量〔MWH〕

1 発電所名	20 型式	21 認可出力〔万KW〕	22 4月	23 5月	24 6月	25 7月	26 8月	27 9月	28 10月	29 11月	30 12月	31 1月	32 2月	33 3月	〔稼働時間〕 〔発電電力量〕	36 61年度計 37 稼働時間	38 発電電力量	%	
2 東海	GCR	16.6	100 79.6	100 79.6	100 79.9	100 82.2	48.6 39.8	0 0	15.2 8.8	76.3 62.1	95.9 80.0	100 84.0	100 81.0	100 84.0	〔744〕 〔103,751〕	6,826	921,482	注1	77.9 63.4
3 東海第二	BWR	110.0	0 0	0 0	88.3 82.6	100 100	100 98.3	100 100	100 100	100 99.6	100 100	100 98.6	100 98.4	100 96.9	〔744〕 〔793,181〕	7,212	7,822,966	注2	82.3 81.2
4 敦賀1	〃	35.7	99.7 94.8	35.5 34.8	0 0	16.8 9.1	98.1 95.3	100 100	100 99.1	100 100	100 99.7	100 99.5	100 97.1	100 99.0	〔744〕 〔262,982〕	6,925	2,415,678	注3	79.1 77.2
〃 2	PWR	116.0	–	–	–	–	–	–	–	–	–	–	100 100	100 99.0	〔744〕 〔854,839〕	1,032	1,188,919	注4	100. 99.3
5 女川	BWR	52.4	60.0 59.7	0 0	0 0	81.6 76.3	100 100	100 100	100 100	100 100	100 97.4	100 100	100 93.5	100 99.8	〔744〕 〔389,208〕	6,871	3,544,691	注5	78.4 77.2
6 福島第一-1	〃	46.0	100 100	100 99.1	100 98.2	100 99.6	0 0	0 0	0 0	2.1 0.5	98.5 94.8	100 100	100 100	100 100	〔744〕 〔342,240〕	5,836	2,656,110	注6	66.6 65.9
〃 2	〃	78.4	100 100	100 99.3	100 100	100 100	100 100	100 100	100 98.3	81.4 77.9	100 98.4	100 97.2	50.0 47.6	0 0	〔0〕 〔0〕	7,546	5,844,015	注7	86.1 85.1
〃 3	〃	78.4	0 0	36.2 31.0	100 100	100 100	100 100	100 100	100 100	100 100	100 100	100 100	100 98.2	100 98.5	〔744〕 〔574,488〕	7,565	5,882,706	注8	86.4 85.7
〃 4	〃	78.4	100 100	100 98.4	100 98.6	100 100	100 98.5	3.3 2.7	0 0	0 0	0 0	0 0	86.8 79.4	100 100	〔744〕 〔583,296〕	5,023	3,869,864	注9	57.3 56.3
〃 5	〃	78.4	63.3 62.3	0 0	0 0	0 0	10.5 4.8	100 99.1	100 100	100 100	100 100	100 100	68.8 68.2	96.8 93.7	〔720〕 〔546,756〕	5,388	4,159,452	注10	61.5 60.6
〃 6	〃	110.0	100 99.3	100 100	100 100	100 97.9	100 99.9	100 96.8	100 98.8	13.1 12.6	0 0	0 0	9.2 4.6	100 96.5	〔744〕 〔789,850〕	6,036	6,513,170	注11	68.9 67.6
7 福島第二-1	〃	110.0	100 100	100 100	100 100	100 100	100 100	100 100	80.1 77.0	100 100	100 99.1	100 100	100 99.0	9.7 8.7	〔72〕 〔71,080〕	7,940	8,686,380	注12	90.6 90.1
〃 2	〃	110.0	0 0	23.5 18.1	100 100	100 100	100 100	100 100	100 100	100 100	100 99.4	100 95.5	100 100	100 98.7	〔744〕 〔807,780〕	7,471	8,121,550	注13	85.3 84.3
3	〃	110.0	100 98.8	100 99.2	100 98.1	0 0	0 0	1.1 0.2	99.9 96.1	100 100	100 99.7	100 99.9	100 99.9	100 100	〔744〕 〔818,400〕	6,559	7,142,200	注14	74.9 74.1
8 柏崎刈羽1	〃	110.0	100 100	100 93.7	100 99.0	100 99.0	100 99.0	46.7 45.9	0 0	0 0	39.7 34.6	100 100	100 100	100 99.4	〔744〕 〔813,130〕	6,463	7,021,160	注15	73.8 72.9
9 浜岡1	〃	54.0	0 0	34.1 28.8	100 100	100 100	100 100	100 100	100 100	100 98.0	100 100	100 100	100 94.9	100 97.8	〔744〕 〔392,768〕	7,550	4,019,509	注16	86.2 85.0
2	〃	84.0	100 98.1	100 99.9	100 96.5	100 95.7	100 97.1	17.5 15.9	0 0	0 0.	25.3 17.3	100 99.4	100 100	100 100	〔744〕 〔624,859〕	6,146	5,021,726	注17	70.2 68.2
10 美浜1	PWR	34.0	100 99.9	100 99.9	100 99.9	100 99.9	100 97.0	100 99.9	100 99.9	100 99.9	62.6 61.9	0 0	0 0	73.9 61.9	〔550〕 〔156,495〕	6,872	2,295,076	注18	
〃 2	〃	50.0	4.7 4.0	0 0	68.1 59.2	100 99.9	100 96.0	100 99.8	100 99.9	100 99.9	100 99.9	100 99.9	100 99.9	100 99.9	〔744〕 〔371,711〕	7,100	3,497,866	注19	
〃 3	〃	82.6	100 99.8	100 99.8	100 99.4	100 100	100 99.8	100 100	100 99.8	100 100	100 100	17.5 16.8	0 0	0 0	〔0〕 〔0〕	6,730	5,544,702	注20	

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11	高浜 1	〃	82.6	100	100	100	100	100	100	1.3	0	0	0	34.1	100 [744]	5,374	4,380,832	注21	
				100	100	100	100	100	100	0.7	0	0	0	24.3	100 [614,458]				
	〃 2	〃	82.6	0	0	0	0	24.3	100	100	100	100	100	100	100 [744]	5,269	4,298,584	注22	
				0	0	0	0	15.9	99.9	99.9	100	100	100	100	100 [614,458]				
	〃 3	〃	87.0	100	100	100	100	100	100	100	100	100	100	100	62.6 [466]	8,482	7,372,013	注23	
				100	100	100	100	100	100	99.6	100	100	100	100	61.9 [400,979]				
	〃 4	〃	87.0	21.4	0	47.6	100	100	100	100	100	100	100	100	100 [744]	7,073	6,093,797	注24	
				20.7	0	39.3	100	100	100	100	100	100	100	99.5	100 [647,255]				
12	大飯 1	〃	117.5	100	100	100	21.5	0	0	0	0	21.5	100	100	100 [744]	4,664	5,271,750	注25	53.2
				100	100	100	21.4	0	0	0	0	9.1	88.8	100	100 [874,100]				51.2
	〃 2	〃	117.5	100	100	100	100	100	100	100	100	100	100	54.9	0 [0]	7,713	8,829,880	注26	88.0
				100	100	97.6	98.4	100	100	100	100	100	90.1	40.8	0 [0]				85.8
13	島根	BWR	46.0	0	0	39.2	100	100	100	100	100	100	100	100	100 [744]	6,858	3,131,376	注27	78.3
				0	0	35.4	100	100	100	99.0	100	100	100	97.6	100 [342,240]				77.
14	伊方 1	PWR	56.6	100	100	100	100	100	63.3	0	1.7	100	100	100	100 [744]	7,044	3,926,487	注28	80.4
				100	100	99.9	99.9	99.8	63.1	0	0.4	87.6	100	100	100 [420,932]				79.
	〃 2	〃	56.6	100	100	100	100	100	100	100	100	100	58.1	0	14.1 [105]	7,137	4,005,094	注29	81.5
				100	100	100	100	100	100	100	100	100	57.9	0	6.5 [27,486]				80.8
15	玄海 1	〃	55.9	100	100	100	100	45.3	0	0	0	0	69.4	100	100 [744]	5,197	2,810,014	注30	59.
				99.9	99.9	99.9	99.5	44.1	0	0	0	0	48.5	99.9	99.9 [415,629]				57.4
	〃 2	〃	55.9	100	100	100	100	100	100	100	100	100	74.3	0	36.7 [273]	7,426	4,086,293	注31	84.8
				100	100	100	99.9	100	100	100	100	100	73.9	0	21.9 [90,993]				83.4
16	川内 1	〃	89.0	0	90.2	100	100	100	100	100	100	100	100	100	100 [744]	7,967	7,001,446	注32	
				0	76.9	100	100	100	100	100	99.9	100	100	100	100 [662,061]				
	〃 2	〃	89.0	100	100	100	100	100	70.1	0	4.3	100	100	100	100 [744]	7,112	6,238,222	注33	
				100	100	99.9	100	100	69.7	0	1.1	89.8	100	100	100 [662,064]				
17	小計または平均		2,568.1	70.3(72.5)	69.4(73.5)	82.6(70.3)	85.0(70.2)	82.1(76.7)	75.1(77.1)	68.6(77.8)	68.1(75.0)	79.5(83.7)	81.9(84.4)	78.5(82.9)	81.6(80.4) [20,042]	216,407	163,615,010	76.9(7	
	(カッコ内は前年度)		(2,452.1)	69.5(71.2)	69.8(76.6)	84.2(73.0)	82.8(70.8)	80.8(72.5)	75.3(73.0)	68.7(76.3)	65.7(73.6)	74.9(80.6)	80.5(82.1)	77.4(81.6)	78.9(79.0) [15,069,469]	(206,143)	(153,273,575)	75.7(7	
18	ふげん	ATR	16.5	100	100	100	69.2	43.1	100	100	100	100	20.8	0	1.8 [13]	6,116	990,484	注34	
				99.0	94.0	100	69.1	36.4	100	100	100	100	20.7	0	0.5 [580]				
19	合計または平均		2,584.6	71.2(73.5)	70.3(74.5)	83.1(71.2)	84.5(68.2)	80.9(74.2)	75.8(74.6)	69.6(75.4)	69.1(72.7)	80.1(82.2)	80.0(83.1)	76.2(81.4)	79.3(81.0) [20,055]	222,523	164,605,494	76.7(	
	(カッコ内は前年度)		(2,468.6)	69.7(71.4)	69.9(76.7)	84.4(73.2)	82.7(70.4)	80.5(72.0)	75.5(72.5)	68.9(75.7)	66.0(73.1)	75.1(80.2)	80.1(81.8)	76.9(81.2)	78.4(79.1) [15,070,049]	(209,917)	(153,868,811)	75.7(	

注1. 第19回定検(61.8.16～11.21)(61.11.2併入)
燃料取替機検査のため停止(61.11.25～12.2)
2. 第7回定検(61.1.20～6.20)(61.6.4併入)
3. 第16回定検(61.5.16～8.22)(61.7.28併入)
主蒸気ドレン管漏洩による点検停止(61.3.29～4.1)
落雷による自動停止(61.8.2)
4. 営業運転開始(62.2.17)
5. 第2回定検(61.4.19～7.22)(61.7.7併入)
6. 第12回定検(61.8.1～12.19)(61.12.1併入)
7. 第9回定検中(62.2.15～)
格納容器床ドレン量増加に伴う停止(61.11.3～11.8)
8. 第8回定検(61.1.10～6.3)(61.5.21併入)
9. 第7回定検(61.9.2～62.2.27)(62.2.4併入)
10. 第7回定検(61.4.20～9.12)(61.8.25併入)
原子炉水位高による停止(61.8.25～8.29)
原子炉再循環ポンプ(A)メカニカルシール不具合による原子炉手動停止(62.2.20～3.2)

注11. 第6回定検(61.11.5～62.3.24)(62.2.26併入)
原子炉水位高による停止(61.11.4)
12. 第4回定検開始(62.3.4～)
相分離母線ダクト部異音発生に伴う停止(61.10.13～10.19)
13. 第2回定検(61.3.1～6.10)(61.5.25併入)
14. 第1回定検(61.7.1～10.15)(61.10.1併入)
15. 第1回定検(61.9.15～62.1.13)(61.12.19併入)
16. 第8回定検(61.1.18～6.11)(61.5.21併入)
17. 第7回定検(61.9.16～62.1.20)(61.12.24併入)
18. 第8回定検(61.12.20～)(62.3.9併入)
19. 第10回定検(61.4.2～7.2)(61.6.10併入)
20. 第8回定検(62.1.6～)
21. 第9回定検(61.10.1～)(62.2.19併入)
22. 第8回定検(61.3.28～9.18)(61.8.24併入)
23. 第2回定検開始(62.3.20～)
24. 第1回定検(61.4.7～7.11)(61.6.16併入)
25. 第6回定検(61.7.11～62.1.28)(61.12.25併入)

注26. 第6回定検中(62.2.16～)
27. 第11回定検(61.1.9～7.2)(61.6.19併入)
28. 第8回定検(61.9.20～12.25)(61.11.30併入)
29. 第4回定検中(62.1.19～)(62.3.27併入)
30. 第9回定検(61.8.15～62.2.6)(62.1.10併入)
31. 第5回定検(62.1.24～)(62.3.20併入)
32. 第2回定検(61.3.1～5.28)(61.5.4併入)
33. 第1回定検(61.9.22～61.12.24)(61.11.29併入)
34. 燃料取替等による計画停止(61.7.22～8.18)
第6回定検(62.1.7～)調整運転開始(62.3.31)

$$時間稼働率=\frac{発電時間数}{暦時間数}\times 100(\%)$$

$$設備利用率=\frac{発電電力量}{認可出力\times 暦時間数}\times 100(\%)$$

Table 5. Summary of FY86 Nuclear Power Plant Operations

[Key on following pages]

[Key for Table 5]

Key:

1. Name of power plant
2. Tokai
3. Tokai second
4. Tsuruga 1
5. Onagawa
6. Fukushima first 1
7. Fukushima second 1
8. Kashiwazaki/Kariwa 1
9. Hamaoka 1
10. Mihama 1
11. Takahama 1
12. Oi 1
13. Shimane
14. Ikata 1
15. Genkai 1
16. Kawauchi 1
17. Subtotals or averages
    (figures in parentheses are for preceding FY)
18. Fugen
19. Totals or averages
    (figures in parentheses are for preceding FY)
20. Type
21. Authorized output
    [10,000 kW]
22. April
23. May
24. June
25. July
26. August
27. September
28. October
29. November
30. December
31. January
32. February
33. March [operation hours]
    [volume of electricity generated]
34. (Upper row is hourly operation rate [percentage]
    (Lower row is plant utilization rate [percentage]
35. Units: operation hour [H])
    volume of electricity generated [MWH])
36. FY87 totals
37. Operation hours
38. Volume of electricity generated

[Key continued on following page]

[Key continued]

39. Notes 1-34 respectively

Notes:
1. Nineteenth regular inspection (8/16 to 11/21/86) (11/2/86 included)
2. Seventh regular inspection (1/20 to 6/20/86) (6/4/86 included)
3. Sixteenth regular inspection (5/16 to 8/22/86) (7/28/86 included)
   Inspection-shutdown due to leak in main steam-drain pipe (3/29 to 4/1/86)
   Automatic shutdown due to lightning strike (8/2/86)
4. Start of operation (2/17/87)
5. Second regular inspection (4/19 to 7/22/86) (7/7/86 included)
6. Twelfth regular inspection (8/1 to 12/19/86) (12/1/86 included)
7. In midst of ninth regular inspection (2/15/87)
   Shutdown accompanying an increase in the volume of the housing-container-floor drain (11/3 to 11/8/86)
8. Eighth regular inspection (1/10 to 6/3/86) (5/21/86 included)
9. Seventh regular inspection (9/2/86 to 2/27/87) (2/4/87 included)
10. Seventh regular inspection (4/20 to 9/12/86) (8/25/86 included)
    Shutdown due to height of nuclear-reactor water level (8/25 to 8/29/86)
    Manual shutdown of nuclear reactor due to problem with mechanical seal for nuclear reactor recirculation pump (A) (2/20 to 3/2/87)
11. Sixth regular inspection (11/5/86 to 3/24/87) (2/26/87 included)
    Shutdown due to height of nuclear-reactor water level (11/4/86)
12. Start fourth regular inspection (3/4/87)
    Shutdown accompanying occurrence of an unusual noise from the (mutual isolation bus) [sobunri bosen] duct (10/13 to 10/19/86)
13. Second regular inspection (3/1 to 6/10/86) (5/25/86 included)
14. First regular inspection (7/1 to 10/15/86) (10/1/86 included)
15. First regular inspection (9/15/86 to 1/13/87) (12/19/86 included)

[Key continued on following page]

[Key continued]

16. Eighth regular inspection (1/18 to 6/11/86) (5/21/86 included)
17. Seventh regular inspection (9/6/86 to 1/20/87) (12/24/86 included)
18. Eighth regular inspection (12/20/86) (3/9/87 included)
19. Tenth regular inspection (4/2 to 7/2/86) (6/10/86 included)
20. Eighth regular inspection (1/6/87)
21. Ninth regular inspection (10/1/86) (2/19/87 included)
22. Eighth regular inspection (3/28 to 9/18/86) (8/24/86 included)
23. Start second regular inspection (3/20/87)
24. First regular inspection (4/7 to 7/11/86) (6/16/86 included)
25. Sixth regular inspection (7/11/86 to 1/28/87) (12/25/86 included)
26. In midst of sixth regular inspection (2/16/87)
27. Eleventh regular inspection (1/9 to 7/2/86) (6/19/86 included)
28. Eighth regular inspection (9/20 to 12/25/86) (11/30/86 included)
29. In midst of fourth regular inspection (1/19/87) (3/27/87 included)
30. Ninth regular inspection (8/15/86 to 2/26/87) (1/10/87 included)
31. Fifth regular inspection (1/24/87) (3/20/87 included)
32. Second regular inspection (3/1 to 5/28/86) (5/4/86 included)
33. First regular inspection (9/22 to 12/24/86) (11/29/86 included)
34. Planned shutdown due to fuel replacement etc. (7/22 to 8/18/86)
Sixth regular inspection (1/7/87)
Start adjustment operation (3/31/87)

$$\text{Hourly Operation Rate} = \frac{\text{Number of Hours of Power Generation}}{\text{Number of Calendar Hours}} \times 100\ [\%]$$

$$\text{Plant Utilization Rate} = \frac{\text{Volume of Power Generated}}{\text{Approved Output X Number of Calendar Hours}} \times 100\ [\%]$$

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KYOCERA'S CORPORATE PHILOSOPHY, PERSONNEL ASSESSED

Effects of Corporate Structure

Tokyo ZAIKAI TEMBO in Japanese Apr 87 pp 145-155

[Article by the editors of the magazine and economics journalist Shoichi Nanba: "Once Again a Study of Kazuo Inamori"]

[Text] Kyocera Has Not "Completely Surrendered"

The year 1985 must surely have been a "nightmare" for both the super prime business Kyocera and Kazuo Inamori, who is the company's top executive.

After the events of that year, Kyocera was severely questioned over its "business morals" and was subject to a chorus of "Kyocera criticisms," which replaced the litany of praise from the media and business managers for the rapid progress it had made since its establishment.

This was the first setback for Kyocera as well as Kazuo Inamori.

Moreover, it was disclosed that Kyocera was a "failing student," lacking in business morals as a member of society, instead of being an "honor student" as an enterprise pursuing profits. The gap between Kyocera's "common sense" and society's "common sense" was also brought into light.

The "prime management" of Kyocera together with Inamori's actual management philosophy must once again be questioned.

First, let us review the series of scandals.

In February 1985, Dietman Kazunari Inoue of the Socialist Party raised the issue of a possible three-point violation of arms export restrictions by Kyocera before the Standing Budget Committee of the House of Representatives. This was a request for the Ministry f International Trade and Industry to investigate and guide the suspected delivery of integrated circuit (IC) package parts for the "Tomahawk" cruise missile by Kyocera's U.S. subsidiary, KII, to General Dynamics, a U.S. arms manufacturer.

In April, Dietman Inoue again inquired into Kyocera, this time before the Standing Audit Committee, saying, "Kyocera has been manufacturing and selling artificial bones and artificial joints to be implanted in the human body without the consent of the Ministry of Health and Welfare for 5 years. This is a violation of the Drugs, Cosmetics, and Medical Instruments Act." To be exact, the artificial joint in question is an artificial knee joint called "Bioceram," which has been sold in large quantities to national, public, and private hospitals throughout Japan. According to a subsequent survey by the Ministry of Health and Welfare, the number of unapproved artificial knee joints used totaled 1,063 and there were 61 hospitals national involved alone. There were also approximately Y360 million in material expenses and approximately Y1 billion in medical treatment expenses involved. Since health insurance is applied against the expenses, the amount claimed in unjustified insurance fees is said to be a total of Y2 billion, involving 800 hospitals.

Dietman Inoue also pointed out that Kyocera was manufacturing and selling cordless telephones, which is approved only for the Nippon Telegraph and Telephone Public Corp. (NTT). This violated the Wireless Telegraphy law and the Telecommunication Business Law. He also raised the issue of Kyocera's unapproved sales of cordless telephones at the same Standing Audit Committee in May. Subsequently, it was discovered that approximately 35,000 telephones were sold illegally by Kyocera under the name "Free Call" for a period of about 2 years beginning in may 1983. The value of these sales amounted to approximately Y900 million.

Because of these dishonorable incidents, Kyocera was suspended from manufacturing medical instruments for 35 days by the Ministry of Health and Welfare for violating the Drugs, Cosmetics and Medical Instruments Act. It is an undeniable fact that Kyocera's corporate image has been deeply damaged by these incidents. Its effects were readily seen in the company's stock price. In May, the stock price fell below Y5,000 and by October it had slipped to Y3,730.

On 30 May, Kyocera published a notice of "apology" for its violation of the Drugs, Cosmetics and Medical Instruments act and for its unapproved telephone sales in the morning editions of the major newspapers. It offered an apology for the disgraceful incidents and advised that the company would stop manufacturing and selling the unapproved artificial knee joints and cordless telephones and would collect them. This was the first indication of Kyocera's intentions toward society.

Although we do not mean to throw cold water on Kyocera's posture, we cannot help but feel there is a deep gap between society's "common sense" and Kyocera's "common sense," particularly as we view the various explanations Inamori has presented to the press as the incident unfolded.

For instance, Inamori's comment on the allegations that his company was exporting arms against the law raised before the Diet to NHK was: "I am deeply disturbed with these irresponsible rumors." It must be said that this comment lacks "sociality," coming as it did from the president of a top-ranking firm and a prime company representing Japan, and, moreover, as one individual of the society. To say the least, he is being questioned by the Diet, which is the highest organ of sovereign rights, representing the people on a serious allegation involving the nation's political posture. Inamori is honor-bound to give a just explanation, all the more if it were merely a rumor.

Although the company appears to have "fully surrendered" in the artificial bone and cordless telephone incidents, as they were clearly violations ultimately, it appears that they seem to have taken a measure of satisfaction from the alleged crime.

Inamori has admitted that he has approved manufacturing and selling artificial bones and cordless telephones, knowing of the violations, from the start. However, he seems proud that the products were well-made and spotless, and have served to help people, in the case of artificial bones. This is a sophism or chopping of logic. In an interview in the December 1985 edition of a small magazine he defends himself, as follows:

"In the case of the artificial ceramic bones, we have repeated the process of obtaining approval and conducting clinical tests, starting from an artificial tooth. When we received approval for the back joint, a doctor asked us to make an artificial knee joint for patients suffering form cancer of the bone. We first insisted that we needed a separate approval for this part, but ended up making them for the sake of the cancer patients. We did not consider it to go against our conscience as it is the same material that many people implant in their bodies, although in a different area. However, as we cannot deny that it is a legal violation, we did not defend ourselves."

In another magazine, he relates as follows:

"Even if I was in charge, I would have done the same thing, moved by the doctor's words. In the Kuala Lumpur incident, for example, there are exceptional exemptions of the law."

This is sufficient to describe Inamori's "humanism."

If the artificial knee joints had been supplied to the doctors (hospitals) free of charge, there would have been no violation of the Drugs, Cosmetics and Medical Instruments Act. The violation occurred because of business activities that involved sales with payment for the pursuit of profit. While Kyocera began full-scale sales of artificial knee joints to national hospitals in 1983, the company applied to the Ministry of Health and Welfare for manufacturing approval only in March of the year that the scandal broke (1985). If the product in which the company takes such pride was so urgently needed, why couldn't they have filed an application earlier?: And again, the issue here is not the quality of the product. It is strictly a legal issue concerning "unapproved sales."

The issue cannot be resolved simply by saying: "Don't do anything bad or against the law." There are rules that everyone must obey in order to live in society. And Kyocera has been disdained by society for breaking such rules and allowing its own profit to take precedence (in this case, Kyocera's logic).

Inevitability of "Scandal" Due to Kyocera's Extra-High Earnings

Are Kyocera's "illegal business ways" the dead end of its rapid progress--called "Kyocera's miracle"--or does it simply reflect a temporary rashness frequently seen in rapidly advancing businesses?

It is necessary to inspect the actual facts concerning Inamori's economic ideal and Kyocera's rapid progress.

In 1929, Inamori founded Kyoto Ceramic (the predecessor of Kyocera) at the age of 27. The capital for the company was all borrowed, and it started out as a small factory with only 27 employees.

It was the stock market that first "acknowledged" this company as a prime business.

Thus, Kyocera offered shares for public subscription on the Kyoto Stock Exchange and the Second Section of the Osaka Stock Exchange in October 1971.

The initial stock price was Y590. In March of the following year, however, it exceeded Y2,000. This precipitous rise further accelerated the stock, which by 1974 was listed in the First Sections of the Tokyo and Osaka stock markets.

In 1975, Kyocera finally achieved the number one stock price in Japan (Y2,990) surpassing Sony, which had been at the top for the past 44 years, in spite of the difficult economic environment created by the oil crisis. And in 1984, Kyocera's stock price shot up to Y11,290, the highest in history.

The reason behind this superactive stock was, of course, Kyocera's successful financial affairs. This in turn was the result of Inamori's business style, which consists of debt-free business operations and retained profit. The company's present retained profit (funds on hand) is well over Y100 billion.

And it all begins with Kyocera's corporate structure, which brings high earnings.

In 1985, its sales amounted to approximately Y280 billion with profits of approximately Y72 billion. While this is not a very high earnings ratio, the company expects sales of approximately Y250 billion with a profit of approximately Y35 billion this term in the midst of a depression in the semiconductor industry. Kyocera's earning strength appears to be demonstrated in creating profits, in spite of the decrease in profit and income over the preceding year.

What, then, is the secret of Kyocera's high earnings? One can unexpectedly find a clue in the gap between the real state of Kyocera and its corporate image.

For instance, Kyocera was praised by the press as the "king of venture businesses" during the venture business boom. It is also generally considered to be a highly profitable manufacturer of original products using advanced technologies. However, in actual fact, it is not a highly profitable enterprise, neither as a high technology nor as a venture business.

In other words, Kyocera is not a high technology company.

Kyocera owes its rapid progress to its ceramic IC packages, of which it is unquestionably the top maker with a 70 percent share of the world market. While its share of sales output is gradually decreasing yearly, due to the stagnation of the plastic IC package and semiconductor businesses, it is still its main profit-making product.

However, the IC package is not a high technology product. It is merely a protective container of silicon chips used for wiring purposes. There are several domestic makers capable of making products at Kyocera's level.

The reason for Kyocera's extremely high share of the market for its product lies in its strength in price competition. As a rival maker says: "Anyone can make IC packages today, only not with such a high yield rate as Kyocera. This 'technical ability' is unapproachable." Kyocera's unapproachable low price gives it an advantage.

Kyocera's sales price is not determined by adding a certain percentage to the manufacturing cost. When there is keen competition, the company receives orders at the users' asking price and searches for profit from that price. On the other hand, when it is in a superior position, it can demand "sales at the item's value," thus, Kyocera's strategy is to raise its markup to the limit. It is sales based on added value.

In this sense, Kyocera has neither a technological group nor high technology. Instead, there exist superior skills and a group of technicians. What is demanded is the skill for product development and not technical development in high technology fields.

In order to survive severe price competition, the makers must acquire a keen and thorough cost consciousness.

This is embodied in Kyocera's unique "amoeba system" in its production and business sections.

An "amoeba group," which consists of 5 to 50 individuals, corresponds to sections and divisions in other companies. In an "amoeba group," where ability is given priority over seniority, there may be young leaders supervising older employees. However, if the leader does not produce good results, he may be replaced anytime.

The production process is divided among the "amoeba groups" and the intermediate product can even be sold between "amoeba groups." The added value (sales minus prime cost) of each "amoeba group" is calculated each month and is then divided by the total working hours of the group, which provides an index of efficiency. The "amoeba groups" are listed in order of merit.

While the results allegedly do not directly affect their salaries, a sense of rivalry naturally emerges among the "amoeba groups" and successfully inculcates cost consciousness to the very last employee.

A small booklet called "Kyocera Philosophy" not only relates Inamori's management style which Inamori has repeatedly discussed in conferences and lectures, but also touches on the spiritual aspects of life and his attitudes toward life. These ideas are meant to focus his staff along the same vector in the pursuit of efficiency. The booklet is repeatedly referred to at parties and meetings to remind employees to always be keyed up.

Inamori does not regard his staff as employees but treats them as "partners." Thus, Kyocera is not considered an enterprise but instead is regarded as a cooperative. The common consciousness of the staff is raised through parties and embodied in the "amoeba system."

Consequently, every Kyocera person is compelled to face the same direction. A heretic is not permitted. Inamori also claims: "I only need partners who consent to the Kyocera philosophy." Thus, employees who do not go along with the company's ways must leave.

This is why Kyocera is jeered for having the highest product yield rate but the lowest employee yield rate.

For these reasons, Kyocera appears to be a "labor-intensive industry" rather than a high technology industry. It is like the shipbuilding or coal industries, or the National Railways in the midst of a structural depression. The company seeks profit by rationalization and cost-cutting, and not by activation of the enterprise itself through new technical development.

Consequently, long working hours with concentration and substantial work--in other words, an efficient yield rate--are demanded of the workers.

In order to raise this yield rate, the advancement of "technology" and hardworking employees are necessary.

Kyocera's major plants are the Fusho plant in Shiga Prefecture and the Kawauchi plant and Kokubu plant in Kagoshima. Many of its plants are located near cities that were about to be left behind by urban development. Kyocera obtained a "cheap" and high quality labor force in these districts.

The Kokubu plant, for example, is located in Kokubu, which is nicknamed "City of the Self-Defense Force and Kyocera" for its dependency on both. As can be seen in the words of a Japanese folksong that goes, "from Kirishima comes flowers, from Kokubu comes tobacco," Kokubu was formally a city of the tobacco industry. However, as its major commodity, hand-wrapped cigarettes, became unpopular, its population started to decline.

Then came Kyocera. Needless to say, the local people were in favor of its advent.

The local population is basically simple and hardworking. They are even more eager to work and patient for being able to get a job in their hometown.

The Kyocera philosophy proclaims: "The company is owned by the employees with the goal of making every employee happy. If the employees work hard to

History of Kyocera

Date	Major events
Apr 1959	Kyocera Ceramic established with capital of Y3 million, Danya Miyagi appointed as first president
Apr 1960	Tokyo branch office established
May 1963	Shobu plant in Shiga first established
May 1964	Seiji Aoyama appointed second president, Danya Miyagi promoted to chairman
May 1966	Kazuo Inamori appointed president, Seiji Aoyama promoted to chairman
Aug 1968	Capital increased to Y80 million
Jul 1969	Kawauchi plant in Kagoshima set up, Kyocera International established in United States for sales
Jan 1970	Mass production of multilayer ceramic packages for LSI circuits begun
Mar 1971	Capital increased by Y360 million, San Diego plant of (Fairchild) (U.S.) taken over
Oct 1971	Capital increased to Y560 million, listed on Osaka Stock Exchange (Second Section) and Kyoto Stock Exchange
Mar 1972	Capital increased to Y610 million
Jul 1972	Main office moved to Yamashina-ku, Kyoto City
Sep 1972	Capital increased to Y700 million, listed on Tokyo Stock Exchange (Second Section)
Oct 1972	Kuniwake plant set up in Kagoshima
Sep 1973	Capital increased to Y1,044 million
Mar 1975	San Diego Plant of Honeywell (U.S.) taken over, main office and plant of Kyocera International moved
Sep 1975	Japan Solar Energy founded
Feb 1976	American Depositary Receipt (ADR) issued in United States
Aug 1977	Cressantver founded
May 1978	New Medical founded
Apr 1979	Capital increased to Y3 billion

[continued]

[History of Kyocera continued]

Date	Major events
Sep 1979	Capital participation in Cybernet Industry
Nov 1979	Kagoshima Electronics founded
May 1980	Listed on New York Stock Exchange, participation in PPC market
Aug 1980	Yokaichi plant set up in Shiga
Aug 1981	Kyocera Office Machinery (presently Kyocera Electronic Equipment) founded
Sep 1981	Solar water heater put on market, ceramic plug for automobiles developed
Oct 1982	Cybernet Industry, Cressantver, Japan Cast, and New Medical are amalgamated and named Kyocera
Apr 1983	Kagoshima Electronics is also amalgamated to become Hayato plant, Kagoshima
Oct 1983	Yashika is taken over
Jan 1984	Information Planning Headquarters set up
Apr 1984	Inamori Foundation established, Central Research Center moved to Tokyo
Jun 1984	Daini Dendenkosha Planning founded
Oct 1984	Solar Energy Center founded in Sakura plant in Chiba
Jan 1985	Videotex Center established
Apr 1985	Unapproved sales of artificial bones and joints disclosed
May 1985	Unapproved sales of cordless phones disclosed
Oct 1985	President Kazuo Inamori takes additional post as chairman
Jun 1986	Kyocera brand camera put on market
Oct 1986	Kinju Anjo appointed president, Kazuo Inamori remains chairman

improve business results, the company will make unlimited progress and, as a result, stabilize the living standards of all workers. Contributing to the company's business results in some form by devoting oneself completely to one's work leads to the happiness of every worker." What will happen if this philosophy is taught in the working atmosphere described above?

Although the idea of the common destiny of the company and its workers is not new, people in the regional districts can accept this idea more readily than urban people, as a sense of community still remains in such areas. Business-like relations take the place of emotional relations. It is simply not for making money. The "idea" that working hard will make everyone happy accelerates the will to work and concentration by workers who have a sense of community.

In short, the secret of Kyocera's high earnings is its "people." These Kyocera men with the same values advance along the same vector. The result of the enthusiasm and skills of these people, which yield labor regardless of time, is strong and competitively priced products. Thus, Kyocera requires many of these Kyocera men. This is the reason for the spiritual inclination in Inamori's economic philosophy.

Kyocera's series of scandals do not seem to be accidental or inconsistent with a company that strongly demands identification, whether it is good or bad. Rather they must be regarded as the inevitable outcome of Kyocera's corporate structure.

Kyocera as Typical "Taiko" Preferred by Japanese

Kazuo Inamori was born 30 January 1932 in Kagoshima City as the second son of seven children.

His father, Taichi, worked as a printer in the city under the sign "Inamori Choshindo." He was a steady and cautious person and also a skillful craftsman strong in mechanics.

Meanwhile, Inamori's mother, Kimi, was a strong-minded, shrewd businesswoman who took charge of business matters in place of Taichi, who was not articulate. Thus, Taichi devoted himself to his printing work. It may be said that their characters, which are quite the opposite, worked well together.

Inamori seems to have inherited the strong points of both his parents. His character comes from his mother and his technical ability from his father. The Inamori family was bombed out of their house and suffered considerable damage during the war. Thus, they were badly off after the war, especially having many children.

As he reached junior high and high school age, Inamori also had to bear the burden of the family's financial circumstances.

Inamori's life before he founded Kyocera was in short, completely devoid of luck. He twice failed to pass the entrance examination of a notable local junior high school and had to be treated for a lung condition between examinations.

He was almost forced to give up high school because of financial difficulties, but had his own way due to his natural persistence. However, he failed to enter the university of his first choice, the Medical Department of Osaka

University, and instead entered the Engineering Department of what was then Kagoshima Prefectural University.

He worked his way through college, but the year 1955 marked the beginning of the "age of the job shortage." Although he was finally able to apply for a job in Teikoku Oil, he was quickly rejected. He barely managed to enter a glass-making firm in Kyoto, Matsukaze Industry, through some contacts of a former teacher.

However, as this company was having financial difficulties, he was often paid late and even suffered a suspension of pay. There was a period when his sister moved to Kyoto to work and fix his meals. Thus, his future was by no means rosy.

Inamori thought little of it and often stayed overnight at his office to do research. At the time, he was researching the development of ceramic commodities, which would later become Kyocera's most influential products. The result of his studies would naturally be used at Kyocera. Inamori's perseverance, would lead to a turning point.

He had no way of knowing this at the time.

Such a personal history, full of unfavorable turns, has contributed to Inamori's charismatic image as someone who has risen to the very top of a growth industry. For instance, the reason that "Kyocera's Book"--Inamori's biography--is selling well is probably due to the elements of "Taiko" in his history, which is esteemed by the Japanese. His is a typical success story, a second Konosuke Matsushita. He is a hardworking man who has suffered through much toil and labor.

During his childhood, he was the boss of the neighborhood and learned that uniting other children and looking after them were basic principles for understanding other people's minds. Inamori's powerful appeal, the result of his strong leadership and magnanimous care of subordinates, is the same today.

During the period he worked for Matsukaze Industry, he was naturally hard up financially and at the worst of times. Oddly enough, however, he made a number of significant acquaintances during this period that later helped him to succeed.

First of all, there was Genzo Yoshida, who in a sense is the founder of the "Kyocera Philosophy."

Yoshida was sent to Matsukaze Industry, which was facing worsening business results, as the head of an investigation commission for Dai-ichi Bussan. Dai-ichi Bank, the company's major bank, had worked as a mediator to provide capital support.

Yoshida called Inamori, whom he had noticed because of his penchant for hard work to his hotel one day to ask him of his opinion of Matsukaze's situation. Inamori is said to have given his views frankly and even proposed measures to solve the problems.

Listening to Inamori's views, Yoshida explained, "Bravo! You have a philosophy!"

And thus, Yoshida became a mentor to Inamori.

Another benefactor was Seiji Aoyama, a close supporter of Inamori who understood him best and at times admonished him.

Aoyama was a director of Matsukaze but not one of Inamori's direct superiors. However, he highly evaluated him early on and looked after him whenever possible.

When Inamori resolved to resign from the office over a conflict with the head of the Technology Division, his direct superior, Aoyama considered setting up a company so that Inamori's talent would not be wasted. He introduced Inamori to his friends, Ikko Nishieda and Yu Kokawa, to get their advice.

Kokawa looked at the 27-year-old Inamori and said; "You must be out of your mind, Aoyama, to think of creating a company for a young boy just out of school and to ask me to finance this company."

Nishieda, however, listened to Inamori carefully and made his decision. "There was something in your speech that moved me, Mr Inamori. I have decided to have you work."

And he added: "But try not to be used by money. I am making a company for you, because I admire your character. You must divide the stock among the people who gather around you, since it is the company of all these people, too."

Nishieda mortgaged his house and lot to raise the money he invested in a new company for Inamori.

Nishieda's concept is employed today in Kyocera. For instance, the company is considered a sort of community that demands comradeship by dividing its stock among the employees.

Kokawa also cooperated in the capital subscription under the condition that Aoyama would join the new company.

Kyocera would probably not exist today without Aoyama's and Nishieda's cooperation.

Inamori became an admirer of Nishieda and visited him occasionally to ask for instructions. Kyocera's "management theory" is also Nishieda's concept.

It was professor Masao Uchino of Kagoshima University who first noticed Inamori's talent as a technician rather than as a manager.

While Uchino did not reach Inamori at the university, he was one of the examiners of his graduation thesis on inorganic chemistry and helped him to enter Matsukaze Industry.

Although Inamori was majoring in applied chemistry, Matsukaze Industry, a glass maker where he was employed unofficially, was looking for an inorganic chemistry student. Thus, a "conversion" was made that led to Inamori's first encounter with ceramics.

While his graduation thesis was written almost casually, Uchino highly evaluated it and encouraged him: "I think your thesis and explanation are superior to those written by students at Tokyo University."

Inamori continued to meet Uchino even after graduation to discuss technical problems, and each time received encouragement.

While there were other people who influenced Inamori, these five persons are the ones who are related to Kyocera.

Now Is the Time To Review the Dogmatic Management System

If "management was nothing but figures," Kyocera's "High stock price and high earnings" would be the proof of Inamori's superior ability as top manager.

If the greatest ability of a leader is to bring out the talent of his subordinates as much as possible, unite them under one sense of value and drive them toward a set goal with a self-sacrificing spirit, Inamori would be considered a leader of the first rank without any objection. This is clearly seen in the self-sacrificing Kyocera men who work frantically and without concern for time toward a target, united under the Kyocera philosophy.

A U.S. economic journal, FORTUNE, describes Kyocera as "Inamori's firm regime," while a former Kyocera employee testifies: "Kyocera is not like an army. It is an army."

However, if everyone is happy with the system, there is no reason for an outsider to say anything about it.

But such a dogmatic one-man management system often makes the company a "closed society." It is also true, however, that such a company in which quick judgments and strong leadership can be displayed is highly capable of making rapid initial progress or later in new fields.

However, the situation changes after the company passes through a certain stage in its development. Strong leadership is likely to turn into "self-complacency" or "dictatorship' and to press the company's logic on society. As a result, the company falls under the illusion that it enjoys "extraterritoriality."

The 1985 incident tells us that Kyocera and Inamori are no exceptions.

The background and environment of Inamori's lack of corporate morals were actually formed along with Kyocera's rapid growth.

Inamori's seniors, who were born in the Meiji era and who understood him and influenced his ideas, are no longer around him.

During the 1973 New Year holiday, Inamori brought all of his workers--1,200 of them--to Hong Kong with the company bearing all expenses. The new main office building had been completed the preceding year and the company's stock was listed in the First Sections of the Tokyo and Osaka stock exchanges the following year. Kyocera was, indeed, at the height of progress, that year.

During this peak period, Nishieda, Uchino, and Kokawa successively passed away. Aoyama also withdrew from actual business affairs last year.

Thus, there is today no man who stands above Inamori either nominally and actually. In other words, there is no longer anyone who will reprove him or correct his mistakes.

When Inamori became the president of the company, Aoyama gently advised him to take more care of his appearance: "You know, you're not just an independent individual now. You're the president of a company listed on the stock exchange. You represent your company as well as your workers. Although a rich attire may go against your principles, I think you should compromise and wear a good business suit."

Inamori is said to have yielded, saying: "Indeed, you are right."

Inamori's acquiescence is certainly due to the fact that it was Aoyama who spoke these words, as he always looked after him. However, it is doubtful whether there is an atmosphere in Kyocera now in which such an incident could happen.

This is the result of Inamori's gathering his subordinates and his "believers" around him as directors. In a sense, he has become something of a "god."

The preface of the Kyocera bible, "Kyocera Philosophy," which is composed of 4 divisions and 50 articles, asserts as follows:

"As part of the management concept and basic means of management, the president occasionally gives a moral story and encourages the managing staff. He realizes 'how man should be' or 'how one should ever be' all the time one is engaged in work and he puts this into words. We must not only understand them but also learn them by experience, or they will be useless. As every single word expressed by the president is precious, they must all be digested and their true meaning must be read. This is Kyocera's original and eternal principle. It is the spirit of Kyocera and an indomitable concept that must be passed on to our workers eternally. We must go through every word, appreciate them, and make them the norm of our daily living and work."

As long as Kyocera continues to be a labor-centered company, Inamori cannot step down from being a "god."

For Kyocera, the "religion" is the source of its high yield rate that in turn guarantees high earnings. However, even if he were to be viewed as the founder of a new religion, his ability as a modern manager in contemporary society is to be doubted. His task now is to personally step down from his present position as a "god" and to work in an organization as a socially acceptable manager while retaining Kyocera's high earnings.

Leadership Styles Compared

Tokyo ZAIKAI TEMBO in Japanese Apr 87 pp 157-161

[Article by the editors: "From Inamori's Autocracy to Collective Leadership; Leadership of President Anjo Questioned"]

[Text] Kyocera recruited 16 individuals, mainly IC design technicians, from Tokyo Electronics (Toshio Kotaka, president). This was to strengthen Kyocera's LSI (large-scale integrated circuit) Design Office, which was established in June of last year.

Semiconductor technology is advancing at a rapid rate. In order to secure competitive techniques, training and strengthening personnel (technology formation) which is the driving force of innovation, is the fundamental task. However, there is only a limited number of up-to-date "brains" and not enough time to develop others.

Recruiting personnel (head hunting) is becoming quite common in the electronics world, particularly in the area of semiconductors. Thus, recruiting personnel from the electronics trading firm of Tokyo Electronics was nothing new.

However, a well-informed person on the subject of personnel changes of this industry says in subdued tone: "Whatever reason or opportunity there was, the mass transfer of 16 persons is not usual." He added with a wry face: "It can be viewed either as the reflection of Kyocera's impatience or as the first leap toward a greater Kyocera. This is the point."

Kyocera located its main office in Kyoto on a site that was once occupied by the Imperial palace. The originality and the "Japanese dream" of Kazuo Inamori, both the founder and chairman of Kyocera, are also well known. He has raised his company from a small factory of 27 workers started in 1959 to a large enterprise with annual sales of Y250 billion and 13,000 employees.

According to a party affiliated with Kyocera, the company has none of the problems that typically occur in large enterprises because of its "amoeba system." This system, which is also designed to nurture its staff, consists of small "amoeba" groups of 5-50 persons for each product of the manufacturing line. Each "amoeba" group is a self-supporting body that does business within the company. Although the business results of the "amoeba" do not directly affect the salaries or promotion of the workers, "amoebas" with high earnings are honored. There are at present approximately 50 "amoeba" groups that are engaged in fierce competition.

Smaller enterprises and pimples are said to break when they grow larger, due to the continuance of rough estimates. If there is a just management system, they could simply enlarge the system as the company gets larger. Kyocera falls under this category.

New Governing Body Born by Appointment of Trueborn Kyoceraman

Good or bad, Kazuo Inamori (graduate of the engineering Department of Kagoshima University, 55 years old) is the "face" of Kyocera. He has built the present-day Kyocera by his charismatic and almost fanatic passion for ceramics, which has come to be called the "Inamori religion." Ryuzaburo Garai, the president of Canon, which has joined with Kyocera in the rapidly growing area of using amorphous (noncrystalline) silicon photosensitive bodies as new image sensors for OA devices says: "The greatmess of Mr Inamori lies in the fact that he has no selfish motives whatsoever in his business or in his company."

Inamori's spirit of self-annihilation was a surprising discovery to Garai, who exchanged drinks with him at Gion (Kyoto), Inamori's home ground, 3 years ago. Garai's image of Inamori up to that point was as a one-man manager of a fast growing company. A type of man who may talk big but, when it comes to the bottom line, may indifferently appoint a relation as a successor, regardless of his ability.

In Canon, which is slightly older than Kyocera, Garai worked for the late Otearai, the substantial founder and manager of Canon who also had outstanding originality and a unique management philosophy. Thus, he knew the fulsomeness of such people at the critical moment.

On 24 July 1986, Inamori proved that Garai, his new supporter, was not wrong. He handed over the president's seat to Kinju Anjo (graduate of Economics Department of Tokyo Keizai University, 52 years old) who was the vice president at the time. He gave the post he had held since 1966 (he has also held the post of chairman since 1986) to Anjo, who has been with the company from the very start, after graduating from the university.

"I actually intended to hand over my position to Anjo 2 years ago," Inamori disclosed. However, just when he was confirming his determination, the company's violation of the Drugs, Cosmetics and Medical Instruments Act through sales of artificial bones made of ceramics and the sale of cordless telephones without approval were detected.

"If I resign from the president's post now, that would be like running from the enemy." Always the challenger, Inamori's combative nature led him to postpone his resignation, although he remained determined to hand over his position to Anjo at an early date.

At the announcement of the appointment of a new president at the Kyoto Grand Hotel on 24 July of the following year, Inamori said: "Our business results of the first half of this year will reach the bottom and undoubtedly recover during the second half, beginning in October. That is why I have decided to leave the company's management to Mr Anjo." He was full of smiles over being able to realize his goal after a year and a half.

He was also joyful over having adhered to his much repeated opinion: "One of the greatest roles an enterprise can play is to pursue the happiness of its employees and family, both materially and morally. In order to do so, business management must not be made one's property. I have no intention of having a relation succeed me in my post."

Personnel Recruiting as Driving Force of Progress

Needless to say, the members of the press who gathered at Kyoto Grand Hotel, including those who were fed up with Inamori's constant refusal to meet the press, formed a new opinion of him.

Inamori's action contrasts with that of another figure. This is Koichi Tsukamoto, the president of Wacol, who announced the appointment of his eldest son, Noko half a year later in January 1987.

Whether the solution worked out by Inamori is right or Tsukamoto's solution is right must be judged from the future business results of both companies.

However, when the cases of Matsushita Electric Industrial Co., which transferred the president's post from Matsushita Konosuke to Matsushita Seiji to Yamashita Toshihiko to Tanii Akio, and Sharp Corp., which passed on the post from Hawakawa Tokuji to Saeki Akira to Tsuji Haruo are compared to that of Sanyo Electric Co., where the top post was filled by a succession of relatives, from Itane Toshio to Itane Yasuro to Itane Kaoru to Itane Toshi, it appears that a family business becomes more difficult to run as the company enlarges, given the recent energies of these companies.

Shigo Moriyama, the vice chairman of the company (graduate of the Law Department of Kyoto University, 61 years old) entered the company in 1983 after working at the Ministry of International Trade and Industry as the director general of the Agency of Natural Resources and Energy. Haruki Tomonori, a Kyocera adviser (graduate of the First Engineering Department of Tokyo University, 59 years old) entered the company in 1980 after leaving the post of president of the former Cybernet Industry. Ryozo Endo, also an adviser to the company (graduate of the Graduate School of Waseda University, 65 years old), entered the company in 1983 after holding the post of president of the former Yashica Co. Except for Asa Kaminishi (graduate of the Economics Department of Kyoto University) also an adviser to the company who has been Inamori's friend since Matsukaze Industry and entered the company in 1963, all the senior workers of the company have transferred from previous posts to enter Kyocera.

Tomonori and Endo joined Kyocera together with their staffs when their former companies were taken over. However, this does not alter the fact that they changed jobs upon entering the company.

Inamori says: "It is necessary to recruit talent from other companies, that is, to take in new blood for the advancement of a company. Naturally, this is done after making sure the person can work under the goals set by the company."

Managing Director Masaaki Hiwatari (graduate of the Engineering Department of Kagoshima University, 53 years old) entered the company in 1959 after working for Heian Shindo Industry. Managing Director Yoshiko Hamano (graduate of the Engineering Department of Kanazawa University, 55 years old) entered Kyocera after a post as a visiting researcher at the Massachusetts Institute of Technology. Keisuke Hasegawa, also a managing director (graduate of the Economics Department of Kyushu University, 52 years old) entered Kyocera after a post in Daido Senko. Keozo Yasuda, another managing director (graduate of the Economics Department of Tokyo University, 56 years old) entered the company in 1984 after working as the director general of the Science and Technology Agency.

As for the executive directors, Masayuki Yamamoto (graduate of the Science and Engineering Department of Ritsumeikan University, 52 years old) entered Kyocera in 1962 after a post at Riken Dengu Manufacturing. Moriyasu Shinzaki (graduate of the Economics Department of Tokyo University, 54 years old) entered the company in 1977 from Sanwa Bank. Katsumi Nishimura (graduate of the Law Department of Doshisha University, 53 years old) entered in 1975 from Kyoto Bank, while Masao Kadoda (graduate of the Economics Department of Yokohama National University, 55 years old) joined the company in 1978 from Sanwa Bank.

Managing directors and executive directors who have always worked for Kyocera are Vice President Kensuke Ito (graduate of Doshisha University, 49 years old) Managing Director Reido Aoyama (graduate of the Engineering Department of Osaka University, 54 years old), Managing Director Shoichi Hamamoto (graduate of Tottori Technical high School, 51 years old), and Executive Director Kenichi Okagawa (graduate of the Department of Humanities and Sciences of Kochi University, 52 years old), four in all. Even if Executive Director Toshitada Inamori, Inamori's brother (graduate of Kagoshima Vocational high School, 57 years old) is included, 12 out of the 17 directors (excluding the chairman and president) have come from different companies.

While their reasons for entering the company differ, they were all "captivated by Inamori's magnetism as a businessman" (Shingo Moriyama).

Majority of Directors Coming From Other Companies

The backbone of Inamori's ability to manage "big shots" such as Moriyama and Tomonari lies, after all, in his "self-sacrificing" spirit, with which Garai was greatly impressed, and with Inamori's tireless pursuit of technology and business.

Perhaps Inamori can be likened to his predecessors in his hometown, Takamori Saigo and Toshimichi Okubo. Would it be an overexaggeration to say that Inamori possesses both Saigo's unselfish broadmindedness and Okubo's cool rationality? We have not asked Inamori which of these two men he prefers....

In Kyocera, there are four headquarters for separate products (fine ceramics, commodities, electronic equipment, and optical equipment) which are further divided into 20 departments. Their target is the "Greater Kyocera" by achieving an annual sales of Y1 trillion. Inamori looks to precision machinery, automobile parts, and electronic parts of the Ceramics Department and bioceram (medical material), solar energy, electronic equipment, information equipment, and peripheral equipment for computers of the commodity department as prospective products that can serve as driving forces toward this goal.

Semiconductor technology is a key to these "driving forces." The already mentioned mass recruiting of capable technicians comes from the fact that "recruiting talent from other companies or taking in new blood to advance an enterprise" is especially important in this field.

Meanwhile, as a high profit-making enterprise, Kyocera is also facing a business slowdown due to the "computer slump" in the United States that began 2 years ago and the subsequent rise in the value of the yen.

The optical and commodity sections could not cover the loss incurred by semiconductor and electronic parts, which together account for more than 50 percent of the company's sales. Thus, expectations are high for Anjo, who was credited by Inamori for his business sense, since the key point will now be to push the expansion of popular commodities such as artificial crystal jewelry, Cressantver, and cameras. The group of directors who will support the new president, Anjo, as the commander consists of 11 individuals, all of whom have transferred from other companies.

Tachinori Nagai (graduate of the Department of Letters of Keio University, 55 years old), entered Kyocera in 1973 from Gokuto Trading Co. Kikuo Nomura (graduate of the Economics Department of Yokohama National University, 51 years old) joined the company in 1971 from Kurimoto Iron Works. Yoshiro Kawakami (graduate of the Engineering Department of Tohoku University, 57 years old) joined Kyocera in 1979 from Oki Electric Industry, while Takashi Nakayama (graduate of the Law Department of Meiji University, 50 years old) entered the company in 1970 from Daiwa Securities. Kenjiro Kimura (graduate of the Engineering Department of Osaka Prefectural University, 56 years old) joined in 1977 from Sharp, and Toshiji Kosaka (graduate of the Engineering Department of Fukui University, 51 years old) entered Kyocera in 1976 from Murata Manufacturing. Toshihiko Teshiroki (graduate of Kitaho Vocational High School, 52 years old) became a member of the company in 1982 from Cybernet Industry, while Soichi Akiyama (graduate of the Engineering Department of Shizuoka University, 51 years old) joined in 1983 from Yashica. Meanwhile, Koichi Nakamura (graduate of the Engineering Department of Tokyo University, 47 years old) entered Kyocera in 1985 from Epson (Seiko Epson at present) and Shigeo Hori (graduate of the Department of Politics and Economics of Waseda University, 52 years old) joined the company in 1973 from Riccar Sewing Machines. Stewart Luvitz (graduate of George Washington University, 52 years old) entered the company in 1973 from the law firm of Spence, Lee, Horne, Jubase, and Luvitz.

Like Mr Nakamura, the most recent arrival who is in charge of the information equipment business that Inamori views as a prospective field, these men are all "mighty warriors." Nakamura played a leading part in the sales of personal computer printers, which became familiar under the name Epson in the United States. Although he has not revealed the details of his defection, it is well known that his departure has hit the Information Equipment Division of Seiko Epson hard.

Emphasis on Organizing Ability and Removal of Charismatic Practices

How will Anjo, with his sincere personality, lead those who were originally attracted by Inamori's aggressiveness? According to a person who knows Kyocera well, Anjo's highly combative spirit is in no way inferior to Inamori's. It is no exaggeration to say that Kyocera's present status owes much to Anjo, although until recently he seemed to be hiding behind Inamori. This is exactly why Inamori gave his seat to Anjo, which was not simply a reward for his service. Moreover, some even say that Kyocera has entered the second establishment period with Anjo's new system.

According to a survey of Kyocera conducted by a newspaper company 2 years ago, there were many who complained about "the absence of a system to develop personnel in a long-term perspective," an "insufficient education system of daily businesses," "too much dependency on the president (Inamori)," and "obscure directions by directors" as the major weaknesses of the company.

A considerable gap has emerged between Inamori's philosophy and his workers' ideas. The former claims that personnel training can be realized through the "amoeba system" and that a management structure based on this system can be expanded as it is by simply adjusting its scale.

Some local businessmen further contend that Inamori's age has ended. While he has excelled as a creator, he appears to go beyond the limit of Japanese managers, whose supreme order is perpetuity.

With the advanced information society just ahead, Inamori's face and challenging spirit have sown several seeds, such as Daini Dendenkosho, Inc., which started operations last October, and new business developments by an association of more than 30 different businesses including the toymaker Taito. These undertakings have sharply increased over the past 5 years.

These new ventures, his timely handing over of the president's post and his choice of personnel must all be considered as the acts of "a man who knows his own possibilities and limits." However, Inamori's activities as chairman of Kyocera, which are indispensable for realizing the "Greater Kyocera," must naturally be based on the "myth" of the high growth enterprise.

Vice Chairman Moriyama's continued efforts as the inconspicuous assistant, increased support for the head of the Department to Promote Affiliations, Kaminishi, Vice President Ito's steady leadership, and Executive Director Hamano's further development as the brains and head of the General Planning Department are all necessary. Meanwhile, greater dynamism by the younger workers including Nomura, chief of the Mechanical Tools Division of the Commodity Enterprise Department; Nakayama, chief of the Solar Energy Division of the Commodity Enterprise Department; Nosaka, chief assistant in the General Planning Department; Akiyama, chief of the Research and Technology Division of the Optical Instruments Department; and Nakamura, chief of the Information Equipment Division of the Electronic Equipment Department, together with developing personnel for the next generation are also required. Needless to say, however, Anjo's leadership will be the greatest factor in determining the future of Kyocera.

In any case, a new age has started for Kyocera with its shift from a one-man runaway to a group leadership based on organizing force.

Advancement Into New Fields

Tokyo ZAIKAI TEMBO in Japanese Apr 87 pp 164-171

[Article by Takao Kanamori: "What Kyocera Must Do To Advance Into New Fields"]

[Text] What the Stock Price Reveals

The public is indeed coldhearted.

Just until 2-3 years ago, the press unanimously praised Kyocera and Kazuo Inamori. However, when the "artificial joint incident" occurred, they suddenly changed their minds and started to ignore the company completely. The NIKKEI BUSINESS JOURNAL issues a special edition on the best manager of the year, selected by its readers at the end of each year. The year before the "artificial joint incident" surfaced, Kazuo Inamori was selected by the readers as the best manager. However, in the year the incident occurred, he dropped to fourth worst. While Kyocera was extensively discussed in NIKKEI BUSINESS's feature article "Study on Power" just before the incident broke, the readers were cool once the incident occurred. It still was not so bad when Kyocera was being attacked by the press, since it meant that public interest had not completely turned away from it. However, a great part of the press now avoids Kyocera. This coldhearted "disregard" must be hard on Kyocera, all the more as its prime period was long.

A news report about Kyocera has finally appeared after a long absence. It said that Kyocera intended to issue convertible bonds worth Y60 billion in March. While this was to be Kyocera's first issue of domestic convertible bonds, the issuance of such bonds has little news value in this age of super-low interest rates. But the information that the U.S. firm Merrill Lynch would be the associate managing underwriter for the bonds was a notable development.

As is well known, Japan's bond market is completely under the control of the top four securities companies, including Nomura Securities. Thus, while gaining entrance to the underwriting business has long been the fervent wish of foreign securities companies, the wall erected by the big four companies is high and wide.

A foreign company had never before acted either as the supervisor or assistant supervisor in the flotation of bonds by Japanese enterprises (on the Japanese market). If Kyocera were to have Merrill Lynch act as the assistant supervisor in issuing its convertible bonds, this would break the taboo of the securities world. In other words, Kyocera would still have the "power" to convince the top four securities companies and the Ministry of Finance.

Kyocera can criticize the closed Japanese capital market and even play a part in easing economic friction by giving Merrill Lynch an entrance to the underwriting business, especially in the midst of growing economic friction between Japan and the United States. Contrary to the supposition that this is a scenario that only Kyocera would envision, the reaction of Kabutocho was completely different:

Except for Daiwa Securities, which is Kyocera's principal manager, other securities companies no longer have any desire to act as the assistant manger for Kyocera. Years ago, many of the companies that were tone-deaf to high-technology suffered from the illusion that Kyocera was a great high technology enterprise just because it was making IC packages. In fact, however, Kyocera has no ability to design IC circuits nor does it have minute processing technology. A package is only the wrapping paper of an IC. The vice manager of such a company can be readily offered to Merrill Lynch. First of all, look at the price of Kyocera's stock (Research Division of a leading securities firm).

The value of a share of Kyocera's stock in the middle of February was Y4,000. While this s still a blue chip stock by any standard, there is a great gap between the publicly subscribed price at the time the company made a capital increase to issue at market price in February 1985 and the ruling price. The publicly subscribed price was, in fact, Y9,600. While Kyocera conducted a two to three stock split later on, Y6,400 must have been the break even price for investors who bought stock at Y9,600 per share 3 years ago. Thus, they have suffered a 37 percent loss. Kabutocho's objection to the convertible bonds comes from the fact that Kyocera has already inflicted great damage on its customers.

Furthermore, the Japanese stock market experienced great excitement in the past year due to unprecedented sums in idle funds. Even electricity stock that has a "reputation" for being inactive, such as Toshiba and Mitsubishi Electric, doubled and the stock price of Matsushita Electric Industrial rose from its floor price of Y1,160 in February 1986 to Y2,230 at the end of the year. However, Kyocera's stock price fell from Y5,000 in January 1986 to the ruling price of Y4,000.

The news that Kyocera would add Merrill Lynch as vice supervisor disappeared. Perhaps Merrill Lynch agreed with Kabutocho's view of Kyocera.

The Principle Post Sways With Difficulties in Diversification

Management is, after all, judged by its results. If Kyocera's business results made a solid upswing despite rise in the value of the yen, Kabutocho, the press, and the public would have had a considerably different view of Kyocera, regardless of the "artificial joint incident." However, in actual fact, Kyocera's business activities had suffered "a crushing defeat."

The company that in March 1985 posted the greatest profit since its foundation with a recurring profit of Y72.4 billion suffered a 46 percent drop in its profit to Y39.3 billion by March 1986. Unable to stop this downward drift, its gains at the middle of September 1986 had declined by 39 percent over the same period since the preceding year. Kyocera has revealed its weakness against the strong yen, no different from ordinary companies.

In fact, the structure of Kyocera's earnings may be facing a "crisis" more serious than ordinary companies.

Without having to use the words of a stock company examiner, Kyocera's mainstay item is still its IC ceramics packages. Since the company succeeded in obtaining orders from IBM in 1966, these IC packages have been the driving force behind Kyocera's rapid advancement. With a 70 percent share of the world market, it is by far the top maker in this field. IC packages comprise 38 percent of the company's sales. This is considerably lower than the comparable figure of 48 percent in FY 1982, but nevertheless represents a great part of Kyocera's gains. This dependency on IC packages, however, has begun to backfire on Kyocera.

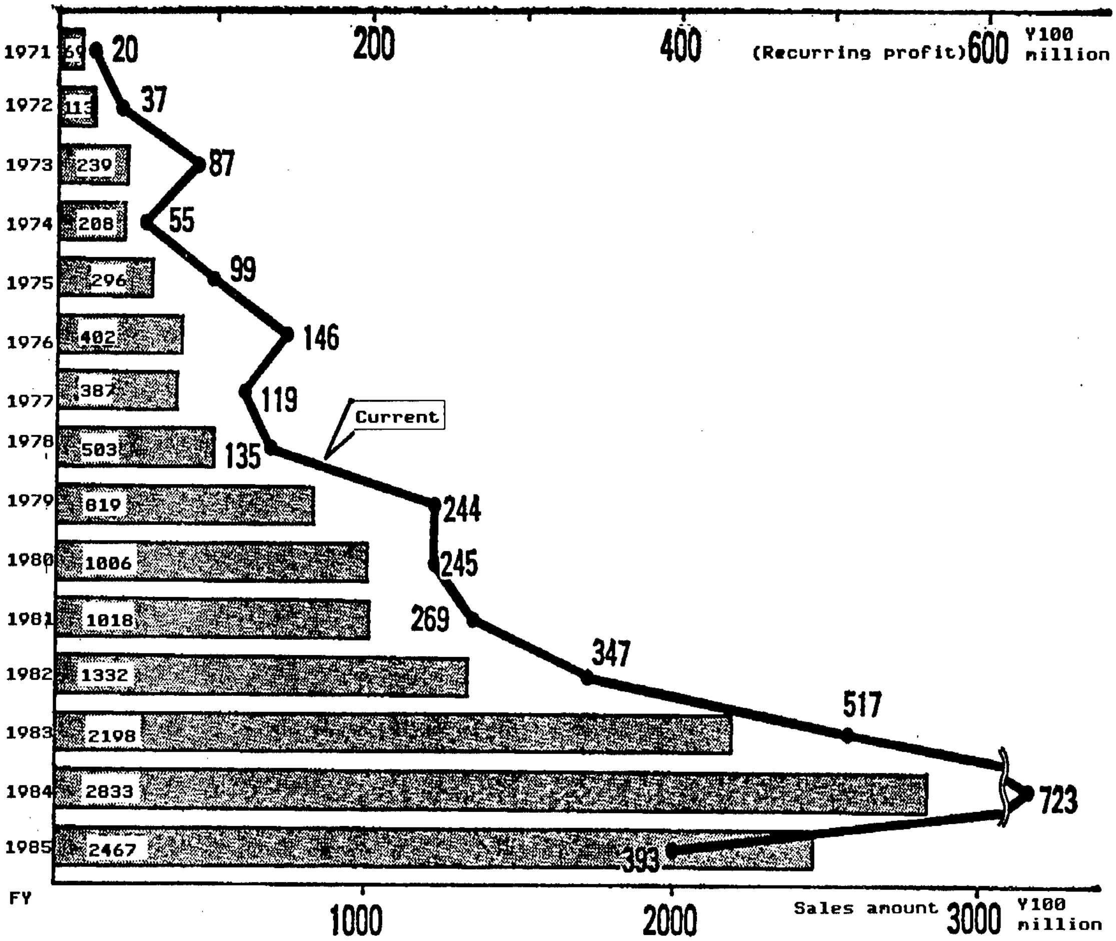
Because of the business slump in semiconductors for 2 consecutive years, in addition to the rise in the value of the yen, the sales of IC packages have plummeted from Y118.6 billion in the March 1985 term to Y79.5 billion in the March 1986 term. Sales have also dropped 7.6 percent over the same term of the preceding year from the middle of September 1986 with no sign of improvement in the latter part of this month. The IC ceramic package is influenced not only by the silicon cycle (wave of boom and recession in the semiconductor market). Epoxy resin (plastic) packages, a strong rival, emerged in the latter half of the 1970s. They overtook ceramic packages almost instantly and presently occupy a 90 percent share of the market for IC packages. There is no way that ceramics can compete with epoxy resin as the latter is 40-50 percent cheaper, easier to process, and can be made about 40 percent smaller.

However, as ceramic packages are used in the latest ICs before they enter the mass production stage and also in ultrahigh ICs, there is no need to fear for the disappearance of the ceramics market. The latest IC must also use epoxy resin after entering mass production, since priority will be placed on cost. This shift is further accelerated during periods when there is a severe price competition over semiconductors and the oil market is stable at a low level, as is true today. In other words, as long as Kyocera depends on its mainstay item, ceramic packages, it must repeatedly face a structural "wall against progress."

Kyocera naturally recognized this bottleneck long ago. This is why the company has worked to extend its businesses based on ceramic technology while simultaneously promoting diversification through mergers and takeovers. These attempts, however, cannot be said to have brought satisfactory results.

First, Kyocera must forward operations for expansion. Its ceramic electronic parts facility is nowhere near Murata Manufacturing, which also has its base in Kyoto. Ceramics for industrial machinery is by nature unprofitable. Bioceramics--including artificial teeth and artificial bones--in which Kyocera was taking a great lead has recently hit an impasse due to the "artificial joint incident." Artificial jewelry (Cressantver) which has been publicized as the proof of Kyocera's technical power, is also falling through. Thus, dealer's inventories of Cressantver were dramatically curtailed from 1984-1985. Shops directly operated by Kyocera reopened in Harajuku and Umeda in order to rebuild the distribution system. However, the leading Cressantver agencies are said to be emphasizing the sales of natural jewelry at the same time to attract customers. Kyocera has much to contend with.

The plan for diversification by merger and acquisition has also fallen short of anticipated results. It was in October 1982 that Kyocera took over Cybernet Industry. The company made an advancement into the electronic equipment field based on Cybernet's technology. However, as its sales route was not established, it had to depend on the unsteady OEM production system. The production items, which consisted of hand-held computers, desk-top personal computers, and satellite transceivers, were also selected simply by chance. Thus, its sales in the electronic equipment field, which increased to Y48 billion in 1983, 3.8 times the sales of the previous year, naturally dropped down to 64 percent of the preceding year in 1984. While turnover registered a 25 percent increase in fiscal 1985, this ended as only a passing relief for the company as sales dropped again by 4 percent in the middle of September 1986.



Kyocera's Sales Volume and Recurring Profit Trends
(FY 1971-1985)

The proceeds of the Optical Division, which started out via a takeover of Yashica in 1983, have been steadily dropping. When they began selling its fully automatic single-lens reflex "230AF" camera against Minolta's "A7000" at the end of last year, the market for AF single-lens reflex cameras was already falling apart.

"Ultimate Secret" of Kyocera Dynamism

As Kyocera's expansion and multipolarization strategies are analyzed at the present point in time, it is difficult to find any dexterity in Kyocera and Chairman Inamori as strategic managers. However, "Kyocera power," which has attracted many admirers, could not be just a phantom. Its balance sheet of earnings and expenses shows that its current yield on funds for FY 1985 was 10 percent and that its ratio of net worth was 84 percent, which by any standard are rates of enterprises in good standing.

The problem is how to generate earnings to meet the absolute standards of Kyocera.

It has become fairly well acknowledged today that Kyocera is actually not a high technology enterprise. According to the "Company Handbook," Kyocera's research and development expenses against its sales are 4 percent, which is not especially low or high. Its mainstay item, IC packages, is as much the product of on-the-spot trial-and-error methods as it is of on-the-spot wisdom and technology. While the embodiment of on-the-spot wisdom is surely enough to boast of, this type of technology is a common feature of many prime Japanese businesses and not original to Kyocera.

If its earning power cannot be explained by its technology, one would naturally want to seek the secret in the highly equipped automation of its production process, which is synonymous with the high productivity of its personnel. However, Kyocera's productivity is actually fairly low. The sales per capita of Rome, another electronic parts maker also located in Kyoto, is Y40.93 million compared to the Y19.13 million for Kyocera, which is less than half that amount. In order to achieve high earnings even under these conditions, a thorough reduction of "extra" costs and labor "density" to pursue this reduction with persistency are required. These are guaranteed by Kyocera's original amoeba system.

In a regular company, profits and costs are managed by each department. In Kyocera, however, each process and occupation are units of management. "Management" may not be the right term. It is a system that drives each amoeba to compete for greater added value per hour, voluntarily. An amoeba of the Business Division, for instance, will try to purchase items from the Production Division as cheaply as possible and to sell the items to users outside the company at the highest price possible. Meanwhile, an amoeba of the Production Division will try to purchase materials at the lowest cost possible and to cut costs to the minimum. When the profit target is not achieved, the staff of the amoeba will pay out of their own pockets. Working overnight while giving an overtime pay is a daily occurrence. Their "wild enthusiasm" to reach the target drives them.

This "wild enthusiasm" will certainly not materialize merely by subdividing the units of management and making them compete against each other. There must be a spirit within the amoeba that generates such "wild enthusiasm." It is the spirit of the Kyocera philosophy.

President Inamori eagerly talks of this Kyocera philosophy in the company leaflet.

"We all believe in the unlimited ability of man through the past, present, and future of Kyocera. We shall always be kindled with passion and hold a scientific mind in order to constantly pursue this belief. We shall be cultivators at times, and always have the courage to jump into a whirlpool. We shall also be comrades and vow to maintain heart-to-heart relations. At other times, we shall discern the true nature of matters and discuss management philosophy. Under the motto 'Return to the Spirit at the Time of Foundation' we are devoting our utmost efforts to continuously pursuing the vision we have seen and to further advancing the company to become the world's Kyocera."

The realization of self-expression through Kyocera enables the workers to devote themselves entirely to the union of comrades, called Kyocera. President Inamori scolded, cried, laughed, and drank with his workers and threw ashtrays to them in order to drive the Kyocera philosophy home to his workers. Thus, they come to identify themselves with the enterprise, Kyocera, and to seek joy in unselfish devotion to their company. Needless to say, the "proof" of this faith is seen in the higher added-value per hour of each amoeba. This is where the ultimate secret of Kyocera lies.

Kyocera's greatest misfortune lies in the paradox that its secret of high earnings is simultaneously setting absolute "limits" to the company. Kyocera must have realized this well during the recent "artificial knee joint incident."

The incident itself need not be explained. It concerned a fundamental violation of the Drugs, Cosmetics and Medical Appliance Law, since Kyocera was selling artificial bones without manufacturing approval. While this incident itself was a problem, what was more serious for Kyocera was that what the company did was not necessarily "wrong" according to Kyocera's philosophy.

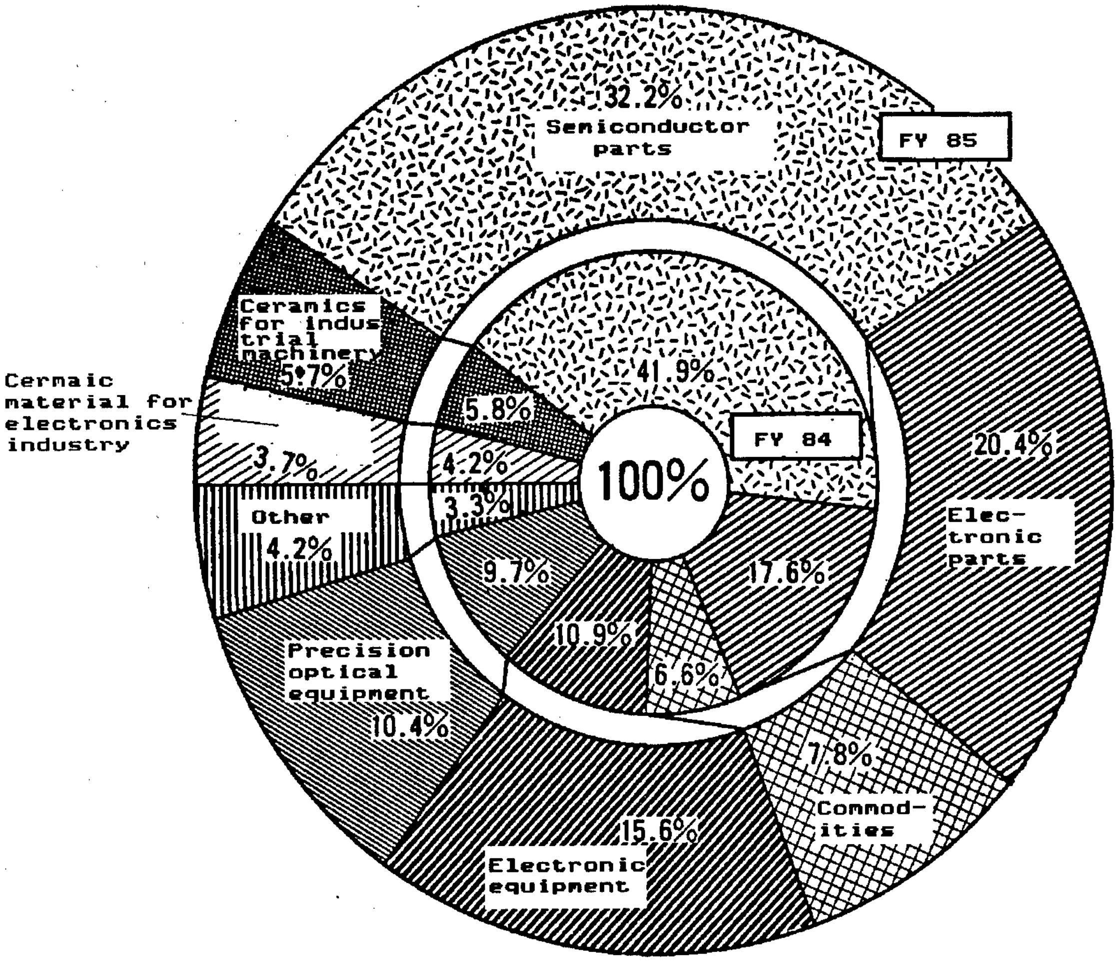
In July 1986, President Inamori passed his position on to Vice President Kinju Anjo. This could have been a turning point for Kyocera. But, the present chairman, Inamori, abandoned this chance by selecting Anjo as his successor. In his speech at the time he was entrusted with full power, Anjo said: "I have worked with him (Chairman Inamori) for more than 20 years. I will not step out of the set course. There is no speck of doubt in me that this is right. It is my task to follow the Inamori path down to the details."

The Daini Dendenkosho Inc. and Kyocera's Dilemma

Kyocera has always followed the Kyocera philosophy and consequently has refused "self-criticism." However, this has cost them dearly. Daini Dendenkosho Inc., of which Kyocera is the top shareholder, is forced to follow a difficult route.

It was indeed quite bold of Chairman Inamori to establish Daini Dendenkosha Inc. and thereby advance into the telephone and telegraph field at an early stage. Although new companies are currently rushing into this field, such as

Growth of Kyocera's New Business Fields



Nippon Telecom, Nippon High-Speed Communications and Tokyo Electric's TT Network, the telephone and telegraph field of 1984 was a hotbed for the Ministry of Posts and Telecommunications, Nippon Telephone and Telegraph Public Corp. and professors of this field. Inamori advanced into this environment alone (while involving Secom, Sony, and Mitsubishi Corp.) and has approached a wide range of industrial circles to gather a capital subscription for the Daini Dendenkosha. It must be said that it was neither Prime Minister Nakasone nor President Shindo of Nippon Telephone and Telegraph Public Corp. but Inamori who put the telephone and telegraph field into private hands.

Daini Dendenkosha was, of course, clearly positioned in Kyocera's business strategy. The first object was the dividend of the business itself. The second object (which is the greatest target) is the accumulation of communications technology involving communication business and rapid expansion of the information equipment field based on the accumulated technology. By being linked to Daini Dendenkosha, Kyocera's Electronic Equipment Division cannot only break away from its rootless dependency on OEM but can also acquire opportunities to challenge new kinds of media equipment. In fact, Kyocera established the "Japan New Media System," a maker of new media equipment for household use, jointly with Phillips in July 1985. Strategically, this was perfect.

However, even this complete strategy is greatly affected by the "self-conceit" of the Kyocera philosophy, which was disclosed by the "artificial joint incident." First, Managing Director Kosei Chimoto, head director of Daini Dendenkosha at the business level, resigned as a director of Kyocera in May 1985 to devote himself to the affairs of Daini Dendenkosha. Chimoto, an elite with a doctorate obtained in the United States who originally worked for the Nippon Telephone and Telegraph Public Corp., was recruited by Chairman Inamori for the corporation. Although Chimoto has not voiced his reasons for leaving Kyocera, his original line of business in the telephone and telegraph field must have made his work for Daini Dendenkosha more important than Kyocera. He may have judged that it was better to detach the corporation from Kyocera in order to protect it.

Indeed, as opposed to 1984, there was no merit to having Kyocera standing in the wings. Just recently, Daini Dendenkosha competed with Nippon High-Speed Communications of the Toyota group for the territory of mobile phones and was assigned the western part of Japan by a decision of the Ministry of Posts and Telecommunications. This was obviously inferior to the area assigned to Nippon High-Speed Communications, which was allotted the metropolitan Tokyo area and the Chubu area. Its market size was less than half of that received by Nippon High-Speed Communications.

In fact, Daini Dendenkosha had decided to apply the system used by the U.S. Motorola firm before fighting for a share of the mobile phone territory. It sought to gain "reinforcement" from U.S. influence and pressure, but this was a complete failure. In short, Kyocera proved to be a negative influence that even nullified the "reinforcement" effects.

This was inevitable as public support could not be expected in the wake of the "artificial joint incident." Moreover, Kyocera made another blunder through its unapproved sales of cordless phones (also a product of the Kyocera philosophy?) and cannot face the supervisory office of the postal services administration.

Possibility for Reform of Kyocera Philosophy

Properly speaking, the terminal for the Daini Dendenkosha's mobile hones should be ordered from Kyocera. However, if Kyocera openly supplies materials for the corporation, this may accentuate the coldness of the public. In order to have Daini Dendenkosha succeed, it is best to keep Kyocera inconspicuous while putting forward the firm's public properties. This, however, will take away half the value of Kyocera's strategy for the corporation. This indeed is a bitter fact for Kyocera.

Reconsideration of the position of Daini Dendenkosha also leads to giving a second look at the medium-to-long-term perspective of Kyocera's strategy. At present, Kyocera is standing at an important crossroads that will affect is philosophy as an enterprise. In fact, this is far more serious than the structural slump faced by the steel and iron and shipbuilding enterprises.

From the viewpoint of a third party, Kyocera should free itself from the limited logic and orals of a corporative body and heighten its "affinity" with

New Competitive Firms in the Telephone and Telegraph Field

Company name/Location--Daini Dendenkosha Inc. (DDI)
Toranomon Minato-ku, Tokyo

Foundation date/Authorized date--June 1984/June 1985

Capital/Number of subscribers--Y8 billion/225 firms

Representative (Career)--Shingo Moriyama (present vice chairman of Kyocera, former director general of Agency of Natural Resources and Energy)

Main share holders--Kyocera 25.05 percent; Sony 5 percent; Secom 2.5 percent; Ushio Inc. 2.5 percent; Mitsubishi Corp. 2.5 percent

Leased line service (Start, number of users)--October 1986

General service--September 1987 (scheduled)

Estimated turn to surplus--FY 1991

Business items--Mobile phone service planned to start in Western areas beyond Kansai Sanyo route (Hiroshima, Fukuoka) and Tohoku route (Sendai) to be expanded in 3 years.

Company name/Location--Nippon Telecom
Otemachi Chiyo-da-ku, Tokyo

Foundation date/Authorized date--October 1984/June 1985

Capital/Number of subscribers--Y9 billion/300 firms

Representative (Career)--Isshin Mawatari (former vice president of Japan Railways

Main share holders--Japan Railways 33.4 percent

Leased line service (Start, number of users)--August 1986 (Approximately 200 firms)

General service--October 1987 (scheduled)

Estimated turn to surplus--FY 1991

Business items--Installation of optical fiber cable along Bullet Train. Expansion of present Tokyo-Osaka service to Tohoku, Hokuriku and Sanyo Lines to connect Morioka, Niigata, and Fukuoka.

[continued]

[Continuation of New Competitive Firms in the Telephone and Telegraph Field]

Company name/Location--Japan High-Speed Communications
Roppongi Minato-ku, Tokyo

Foundation date/Authorized date--November 1984/August 1985

Capital/Number of subscribers--Y8.3 billion/290 firms

Representative (Career)--Mitsuo Kikuchi (former chairman of Tokyo Expressway Public Corp.)

Main share holders--Toyota Motor Corp., Road Facilities Mitsui Group, Mitsubishi Group, Sumitomo Group--6 percent each

Leased line service (Start, number of users)--November 1986 (Over 100 firms)

General service--September 1987 (scheduled)

Estimated turn to surplus--FY 1991

Business items--Installation of optical fiber cable along highway. Mobile phone service to start from fall of 1988 in Tokyo and Chubu areas.

Company name/Location--Tokyo Telecommunication Network (TT-Net)
Akasaka Minato-ku, Tokyo

Foundation date/Authorized date--March 1986/August 1986

Capital/Number of subscribers--Y10 billion/224 firms

Representative (Career)--Kazuo Fujimori (present vice president of Tokyo Electric)

Main share holders--Tokyo Electric 48.5 percent; Mitsui & Co. 15 percent; Mitsubishi Corp. 15 percent

Leased line service (Start, number of users)--November 1986 (approximately 70 firms)

General service--November 1987 (scheduled)

Estimated turn to surplus--FY 1989

Business items--Independent line (optical fiber cable laid all over Kanto district by using telephone poles to cope with NTT.

[continued]

[Continuation of New Competitive Firms in the Telephone and Telegraph Field]

Company name/Location--Space Communication
Uchisaiwaicho Chiyoda-ku, Tokyo

Foundation date/Authorized date--March 1985/June 1985

Capital/Number of subscribers--Y5 billion/28 firms

Representative (Career)--Hiroshige Minakawa (present adviser of Mitsubishi Corp., former vice president of same firm)

Main share holders--Mitsubishi Corp. 24.5 percent; Mitsuibishi Electric 19.4 percent; Mitsubishi Heavy Industries 10 percent

Leased line service (Start, number of users)--December 1988 (scheduled)

General service-- --

Estimated turn to surplus--FY 1995

Business items--Contacting 30-40 users such as TV stations. First launch scheduled for November 1988. Total communication system from sending to receiving information as goal.

Company name/Location--Japan Communication Satellite (JC-SAT)
Toranomon Minato-ku

Foundation date/Authorized date--February 1985/June 1985

Capital/Number of subscribers--Y13.9 billion/3 firms

Representative (Career)--Yo Kamiya (present counselor of C. Itoh & Co., former vice president)

Main share holders--Co. Itoh & Co. 40 percent; Mitsui & Co. 30 percent; Fuse Communications 30 percent

Leased line service (Start, number of users)--October 1988 (scheduled)

General service-- --

Estimated turn to surplus--FY 1985

Business items--First satellite scheduled for July 1988 and second in middle of 1989. Subscription for 32 x 2 transponders completed.

Major Affiliated Companies of Kyocera (Domestic)

Company name/ location	Date of establishment	Representative	Rate of shareholding	Capital	Sales	Business items
IBM International Shimokyo-ku Kyoto City	Nov 84	Soya Nishimura	29.6%	135	9	Business related to foreign language instruction
Kagoshima Oxyton Chuo-ku Kobe City	Mar 83	Hiroshi Okuno	25%	150	667	Manufacture and sales of compressed and liquefied gas
Kyocera International, Yamashina-ku, Kyoto City	Oct 74	Kazuo Inamori	100%	10	105	Insurance agency
Kyocera Kosan Jungumae Shibuya-ku, Tokyo	Feb 73	Katsumi Nishimura	100%	50	1,060	Real estate
Kyocera Electronic Equipment, Yaesu Chuo-ku, Tokyo	Mar 86	Tetsu Yamamoto	100%	200	4,327	Sales and rental of electronic office equipment
Japan Solar Energy Yamashina-ku Kyoto City	Oct 75	Kazuo Inamori	100%	300	1,354	Development and sales of solar batteries
Daini Dendenkosha Toranomon Minato-ku, Tokyo	Jun 84	Shingo Moriyama	25.5%	8,000	--	Information service
Tomioka Optics Oome City, Tokyo	May 49	Akio Otsuka	100%	240	4,802	Manufacture and sales of various lenses and optical machinery
New Medical Yamashina-ku Kyoto City	Jan 79	Kazuo Inamori	100%	30	72	Development and sales of medical machinery and instruments
Videotex Center Shinjuku, Shinjuku-ku Tokyo	Jan 85	Yoichi Tao	20%	1,250	3	Biodirectional character and graphic information communication systems
Miyagi Electric Machinery Manufacturing, Chukyo-ku, Kyoto City	Sep 34	Toshiro Tsuji	30.3%	99	2,466	Manufacture and sales of electric machinery
Inamore Studio Kuniwake City, Kagoshima	Dec 83	Reido Aoyama	100%	1	--	Development and manufacture of new ceramic art

[continued]

[Continuation of Major Affiliated Companies of Kyocera (Domestic)]

Company name/ location	Date of establishment	Representative	Rate of shareholding	Capital	Sales	Business items
Taito Chiyoda-ku, Tokyo	Aug 38	Yojiro Suekaku	22.5%	448	--	Manufacture and sales of indoor and outdoor amusement equipment
Japan New Media System Setagaya-ku, Tokyo	Jul 85	Haruki Tomonori	50%	200	--	Development, manufacture and sales of home interactive systems

(Daini Dendenkosha will be a place of "discipline"). If a new Kyocera philosophy can be reconstructed for such an open corporative body, its contributions to Japan's business society will be immeasurable. But it must be added that this could also lead to Kyocera's fall to an ordinary company, if not properly handled.

Another possibility is to dash headstrong while holding fast to the present Kyocera philosophy (although they must be careful not to make a "second offense" with future legal violations). In this case, the competition front must be organized. Telephone and telegraph related businesses that have considerable contact with society and that deal with finished consumer products must be avoided as much as possible and instead Kyocera should concentrate its maximum business force in the electronic parts field. As the amoeba system and Kyocera philosophy are clearly linked to its manufacture of ceramic IC packages, Kyocera seems to fit best in this field. Its recent hit products, which include thermal printer heads and amorphous silicon drums, also come from this field. Encroaching on the share of the market for ceramic electronic parts such as laminated condensers, ceramic filters, and radiators enjoyed by the Murata Manufacturing Co., which is the leader in this field, should not be difficult if Kyocera tries hard. Under this scenario, Kyocera may expect to grow a step further until its philosophy generates the next inner inconsistency.

Kyocera's future path will naturally be determined by Chairman Inamori. At the moment, he does not have any intention of changing the Kyocera philosophy.

One thing can be said, however: It is doubtful that the Chairman Inamori who in 1975 said, "I am afraid of myself now that I have risen to my present position. I was pure at the time the company was founded. I long for that pureness. I am made much of today and the conditions around me are different. That is why, I always ask myself whether I am as modest as I used to be and if I am continuing the same efforts as before," and the present Chairman Inamori are in the same position.

In the same year the "artificial joint incident" occurred, Inamori founded the "Kyoto Award" and selected the Nobel Foundation, Professor Carman, Professor Shanon and Olivier Mecian as the winners. The winners were all world authorities who had no need to be honored by the Kyoto Award. If he had followed his original intention at the time of the company's foundation, he could have devoted all efforts to discovering young unknown scholars who are earnestly pursuing straight themes. The actual Kyoto Award, which was attended by the Queen of Sweden, ended up as completely the opposite. It turned out to be an odd award that praised the glory of the winners for their fame.

If this was one of the destination points of the Kyocera philosophy, there must have been some distortion in the philosophy from the start or some deviation on the way.

If a serious innovation ever occurs in the Kyocera Philosophy that brings fresh dynamism to Kyocera, this would be the time for Chairman Inamori to recognize the gap between the destination and departure points, in amazement.

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