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Japan Report

SCIENCE AND TECHNOLOGY

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JAPAN REPORT

SCIENCE AND TECHNOLOGY

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SJAC REPORT SUGGESTS AVIONICS SALES TO U.S.

Tokyo AEROSPACE JAPAN-WEEKLY in English 22 Dec 86 pp 7-8

[Text]

The Society of Japanese Aerospace Companies (SJAC) said in its recent report titled "Business Strategy for Aircraft Component Market" that avionics are the most promising products for the Japanese aircraft industry to develop the market in the U.S. But the report pointed out that an effective way of avionics sales is either to buy U.S. firms or to establish joint ventures with them.

The report was compiled by SRT International under contract from SJAC. According to the report, it is quite difficult for the Japanese aircraft industry to export fuel systems and environment control systems of which markets are overwhelmingly dominated by U.S. firms. Instead, the report pointed out that Japan has a good chance to sell avionics and hydraulic systems to the U.S. market.

However, the report emphasized that it is not effective for Japanese firms to export their products directly to the U.S. by themselves in consideration of growing antipathy against Japanese products. It suggested that Japanese firms tie up with U.S. counterparts.

In exporting aircraft-related products, the Japanese firms will have to give serious consideration not only to competitive prices and good qualities but also reliability and consolidated post-sale services because aircraft requires stable component supply during 15-20 years of service life. The Japanese firms have to take such situations into account in making inroads into the U.S. market, the report concluded.

/9317
CSO: 4307/012

MHI REPORTS ON YS-11 OPERATIONAL RESULTS

Tokyo AEROSPACE JAPAN-WEEKLY in English 22 Dec 86 pp 8-9

[Text]

Mitsubishi Heavy Industries, Ltd. (MHI), being responsible for the customer support of the YS-11, has reported on the operation and maintenance results of the aircraft both at home and abroad for the first half of 1986 (January - June).

According to the report, a total of 159 YS-11s were operated during the six-month period in the world. The figure has unchanged over the past five years.

Of the total YS-11 fleet, there are 67 aircraft serving in Japan, which break down to 35 aircraft operated by Toa Domestic Airlines, 27 by All Nippon Airways and Nihon Kinkyori Airways and five by Southwest Air Lines.

The 37 aircraft operated by foreign airlines break down to 22 aircraft (up three from the previous six-month period) by Mid Pacific Airlines, six by Provincetown/Boston Airlines, three by Reeve Aleutian Airways and six by Simmons Airlines. These are all U.S.-based airlines.

Although the figure remains unchanged, Fort Worth Airlines disappeared from the YS-11 operators' list because it sold three aircraft to Mid Pacific Airlines.

Other commercial users include Airborne Express (which owns 13 aircraft) and TRAMC of Zaire (one aircraft). Accordingly, a total of 118 YS-11s are still operated by the private sector. The remaining 41 aircraft are being operated by the governments of foreign countries and Japan.

As of the end of June this year, the accumulated flight hours of these YS-11s amounted to 4,497,721 hours and 28 minutes. The number of takeoffs and landings was 5,124,498. An average flight time for each flight was less than one hour.

This means that the YS-11s can stand very frequent takeoffs and landings. Together with the fact that no YS-11s have dropped out over the past five years, the aircraft has proved its rigidness.

In the meantime, the average dispatch reliability of the YS-11s operated by the three Japanese airlines and two U.S. airlines (Mid Pacific and Reeve Aleutian) was as high as 99.39%.

/9317
CSO: 4307/012

USES OF MANUFACTURED LIQUID HYDROGEN EXAMINED

Tokyo ZAIKAI in Japanese 29 Jul 86 pp 144-145

[Article: "Business Radar -- Pioneer of Space and Aeronautical Fuel"]

[Text] Iwatani & Co., Ltd. in the Vanguard of Development of Liquid Hydrogen

Interest in space and aviation has increased. For example, the U.S. President Ronald Reagan has advocated the concept of a "dream airplane" which will provide service between Tokyo and Washington, D.C. in 2 hours in the near future. The fuel which will be used in this dream airplane is liquid hydrogen. The liquid hydrogen has been developed as a fuel for space rockets. It is anticipated that civilian demands for such liquid hydrogen will increase considerably in the future. The Iwatani Group has long been paying attention to the liquid hydrogen as a promising fuel, and now has become the only group to manufacture and sell liquid hydrogen in Japan.

The TNSC (Tanegashima Space Center) of the NASDA (National Space Development Agency of Japan) is a base for launching application satellites such as the communication satellite "Sakura," and the meteorological satellite, "Himawari" which is well-known for weather forecasting.

More than 400 years ago, in 1543, the Portuguese introduced guns into the Tanegashima island. Now, this island is attracting attention as a space industrial base equipped with all the high technology in Japan.

Japan Liquid Hydrogen Co., Ltd. (head office: Tokyo; President: Takashi Matsuda) has set about the construction of a plant for manufacturing liquid hydrogen. This plant is to be the largest in Japan. The company is a manufacturer specialized in the production of liquid hydrogen for space rockets. In 1984 it was established under joint investment from the Iwatani Group and MHI (Mitsubishi Heavy Industries, Ltd.).

The plant will be constructed at a cost of Y4.5 billion at Minami-Tane-cho in Tanegashima, and is scheduled for completion in April 1988. The capacity of manufacturing liquid hydrogen is 10,000 kiloliters a year which is the largest in Japan. It has been decided that subsequent to fiscal 1988, liquid hydrogen of 10,000 kiloliters will be used annually to perform the combustion tests for rockets, "H-I" and "H-II" and to launch these rockets at the TNSC.

The plant is attracting attention because the technology for manufacturing liquid hydrogen is unique.

Up to now, liquid hydrogen has been manufactured by using a method in which gas associated during manufacturing of caustic soda is recovered and refined.

However, Japan Liquid Hydrogen Co., Ltd. has adopted a method of reforming methanol in manufacturing liquid hydrogen. This method employs methanol as a raw material.

Methanol is widely used as an industrial raw material in various fields, and can be readily procured and transported throughout Japan. For this reason, when various industrial products are manufactured by using methanol as a raw material, there will be no problem in the location of plants.

Unique Technology

Japan Liquid Hydrogen Co., Ltd., has already built the No 1 Plant at Tashiro-cho in Akita Prefecture. This plant manufactures liquid hydrogen on the basis of the above method of reforming methanol. There is the MHI's Tashiro Field Laboratory in Tashiro-cho, and tests for engines of various rockets are performed there.

After the methanol reforming method had been established, the No 1 Plant was completed. This plant is known as the Tashiro Plant established in response to the demand for liquid hydrogen.

Before the plant was completed, liquid hydrogen had been transported from Amagasaki Plant of Iwatani Gas Co., Ltd., affiliated with Iwatani & Co., Ltd., to Tashiro-cho. The distance between this plant and Tashiro-cho is 1,300 kilometers. This is really inconvenient; and in addition, there was worry about the possibility of accidents occurring during transport.

The development of revolutionary technologies will greatly change not only the production system of fields related to this development work, but also the order of the industrial world. It can probably be said that thanks to the development of the methanol reforming method, the Iwatani Group has further consolidated its monopoly in the field of liquid hydrogen.

Two companies presently manufacture liquid hydrogen in three plants, Iwatani Gas Co., Ltd., and Japan Liquid Hydrogen Co., Ltd. The annual production capacity of these companies reached 18,640 kiloliters.

It is anticipated that the amount of liquid hydrogen needed annually subsequent to fiscal 1987 will be 10,000 kiloliters. The above three plants will be able to meet the demand for liquid hydrogen for 5 or 6 years to come.

It seems that for the time being, the use of liquid hydrogen will be limited to rocket engines. For this reason, the superiority of the Iwatani Group will probably remain firm, because the Iwatani Group has constructed the plant for manufacturing liquid hydrogen at the space developmental base and has become a pioneer in this field.

It is said that the SST (supersonic transport) advocated by President Ronald Reagan will be realized in the 21st century. There is a strong possibility of liquid hydrogen being used as a fuel in the SST dream airplane which will link Tokyo with Washington, D.C., in only 2 hours.

The space industry has entered into the high technology age, and the need for liquid hydrogen increases every year.

Coexistence and Shared Prosperity with Local Areas

Incidentally, one thing that does not change with time is the relation between the localities and businesses in the area.

Japan Liquid Hydrogen Co., Ltd. manufactures liquid nitrogen as well as liquid hydrogen. Liquid nitrogen is frequently used to quickly freeze marine products by using a cryogenic temperature of minus 196 degrees centigrade. A plan for using liquid nitrogen is being promoted with a view to freezing prawns.

Japan Liquid Hydrogen Co., Ltd., has already established the "Tanegashima Cultivation Development Center" in collaboration with Minami-Tane-cho and local enterprises, and has started cultivating giant freshwater prawns (macrobrachium rosenbergii).

Giant freshwater prawns live in subtropical zones, and grow to a length of 30 to 40 centimeters. They are tasty and it is expected that the demand for such prawns will increase considerably.

Prawns cultivated in the center will be quickly cooled with liquid nitrogen, and will be shipped to all areas of Japan. The mild climate and natural features of Tanegashima are attracting attention.

Production of fuel for space rockets and cultivation of prawns. It seems that Tanegashima will come into the limelight as a model of coexistence and shared prosperity with local areas in the high technology age.

20,143/9599
CSO: 4306/2512

DEFENSE INDUSTRY

DEFENSE, MILITARY ACTIVITIES UPDATE

Revised Laws To Allow JSDF's VIP Transport Mission

Tokyo AEROSPACE JAPAN-WEEKLY in English 22 Dec 86 p 1

[Text]

The House of Councillors' Cabinet Committee passed on December 10 the bills aimed at revising two major defense-related laws. The bills, approved with the support of the Liberal-Democratic Party and the Democratic Socialist Party, was formally enacted on the following day at the House of Councillors' plenary session.

The bills will permit the Japanese Self-Defense Forces (JSDF) to increase for the first time in three years the number of its personnel by a total of 606 persons which break down to 352 for the Maritime Self-Defense Force (MSDF), 231 for the Air Self-Defense Force (ASDF), and 23 for the Joint Staff Council.

The proposed amendments also call for increasing the Self-Defense Reserves by 1,300 persons of which GSDF accounts for 1,000 and ASDF for 300. The Self-Defense Reserve System for ASDF will be newly established under the revised laws.

The revised laws will also allow JSDF to carry VIPs, including national guests, on aircraft at the request of the government and other national organizations within the framework of not causing any obstruction in performing original duties. For this purpose, JSDF will be allowed to possess VIP transport aircraft.

Japan so far has no aircraft for exclusive use by the government to carry VIPs including national guests, Imperial family, and high government officials. As a result of the revised laws, it has become possible for JSDF to own aircraft for this purpose.

The three Aerospatiale AS332L Super Puma, which the government purchased earlier for VIP air transport during the Tokyo Summit meeting last May, are now operated regularly by JSDF.

FS-X Joint Development Survey Team Visits U.S. DOD

Tokyo AEROSPACE JAPAN-WEEKLY in English 22 Dec 86 pp 2, 3

[Text]

The Defense Agency (JDA) sent a seven-man survey team, led by Internal Bureau R&D Director General Ryozo Tsutsui, to the U.S. on December 13 to study the proposed joint development of the FS-X next support fighter.

Other members include officials from the Air Staff Office's Defense Department, the Equipment Bureau, and the Technical R&D Institute (TRDI). During their stay in the U.S. until December 19, they will visit the U.S. Department of Defense (DOD) to discuss the FS-X program in terms of both the joint development with the U.S. and Japan's own development.

The Japanese defense authorities concerned hope to give a go-ahead to the FS-X development program in FY 1987. The Air Staff Office and TRDI as well as JDA were briefed last October by General Dynamics (GD) and McDonnell Douglas (MD) on their respective joint development proposals.

The survey team aims at being well informed about the DOD's intention to make fair and equal comparison between the proposed joint developments and other options of modifying the existing aircraft as well as pure domestic development.

Concerning the modification of the existing aircraft, JDA plans to retrofit the F-4EJ fighter aircraft. However, the F-4EJ modification to start in FY 1987 is aimed at improving three interceptor units. It is believed not to be aimed at the FS-X.

In the case of domestic development, JDA's master plan calls for giving a go-ahead to the FS-X development in FY 1987 with a view to forming the first operational unit in FY 1996.

Another option initially proposed was to introduce a foreign aircraft. The candidates considered for this option were the General Dynamics F-16, the McDonnell Douglas F/A-18 and the Panavia Tornedo. However, since these foreign

The inspections after the contract will be rather simple concerning the design, structure and rigging in consideration of the results of the studies already made by MSDF. So, there will be only four inspections.

First, the aircraft will undergo the planning inspection in early FY 1987. This will be followed by related test inspection, overall inspection and flight inspection.

CH-47J Deployment Plan

Tokyo AEROSPACE JAPAN-WEEKLY in English 22 Dec 86 p 3

[Text]

The first three CH-47J helicopters for the Ground and Air Self-Defense Forces will be delivered by the end of the current fiscal year. Of the three helicopters, the Ground Self-Defense Force (GSDF) will receive two helicopters and will deploy one each at its Aviation School in Akeno, Mie Prefecture, and its Kasumigaura Branch in Tsuchiura, Ibaraki Prefecture, after operational tests which will be performed from January to March next year.

GSDF will start the CH-47J pilot training and maintenance crew training in FY 1987. Another three helicopters to be procured by GSDF in FY 1987 will be deployed at the 1st Helicopter Brigade, in addition to training purposes.

The Air Self-Defense Force (ASDF), on the other hand, received its first CH-47J on December 16. After operational tests which will be performed by the Air Proving Wing from January to October next year, this helicopter will be deployed at Iruma Air Base. ASDF plans to form a provisional helicopter air transport unit at Iruma in October with another helicopter to be procured in FY 1987.

The CH-47 series include the A, B, C and D military versions, the Model 234 commercial version, and the Model 414 for overseas operation. The CH-47J introduced by Japan's GSDF and ASDF is based on the Model 414 or almost the same as the D version of the U.S. Army.

The fully equipped CH-47J weighs about 50,000 pounds. Powered by two Lycoming T55-K-712 engines, it has the maximum continuous power of 3,149 s.h.p. (or 4,500 s.h.p. emergency power). Fitted with fiber glass rotor blades, the aircraft are believed to have limited capabilities to operate from the latter half of the 1990s to the early 21st century, JDA once favored the domestic development plan.

This year, however, the joint developments proposed by GD and MD have taken a concrete shape. And Japan now cannot ignore these proposals for political and economic reasons.

As a result, JDA seems to incline for the joint development with the U.S. on condition that Japan takes the initiative. In the case of the joint development, it is almost impossible to start the FS-X development in FY 1987. The go-ahead will be delayed until FY 1988.

MSDF Completes Studies on KM-2 KAI Trainer

Tokyo AEROSPACE JAPAN-WEEKLY in English 22 Dec 86 p 3

[Text]

The Maritime Self-Defense Force (MSDF) has completed studies on the KM-2 Kai next primary trainer. MSDF will place an order for one KM-2 Kai with Fuji Heavy Industries, Ltd. (FHI) at the end of FY 1986.

Although the new aircraft is basically modified from the KM-2, its powerplant is changed to a turbine engine and other modifications are also added to the external shape. As the modifications included some newly developed sections, MSDF conducted careful studies on such sections. The studies will be turned over for inspections, that will begin in FY 1987 after the contract signing.

For the KM-2 Kai, FHI initially proposed the KM-2D powered by a turbine engine. Not accepting the FHI proposal as it is, MSDF asked the company to add some improvements to KM-2D such as comfort and angular range of the view.

MSDF first studied the aircraft based on a mockup model fabricated by FHI. It asked, for example, to move the joint of the canopy section a little backward from the initial design to improve the upper view.

Including this modification, MSDF made the second studies last September based on the results of wind tunnel tests. Then, MSDF pointed out three problems including the antenna pattern. FHI reported on improvements of these problems for the third or the last studies.

helicopter has the maximum cruising speed of about 160 knots, the service ceiling of about 20,000 feet, and the cruising range of about 300 nautical miles. It is equipped with an automatic flight control system and triple cargo hooks.

Other major equipment and systems of the CH-47J include: 7,500-s.h.p.-delivered-power transmission system; self-ceiling and crashworthy fuel systems; pressured fuel supply system; automatic flight control system; module hydraulic systems; auxiliary power unit; AC generator; AC generator for ground maintenance; crews guide indicator; seats for 55 personnel; cargo hooks in front, middle and aft sections; internal and external winchs; internal cargo handling system; additional fuel tanks; rotor brake and so on.

TRDI Completes Tests on AQM-1 Target Drone

Tokyo AEROSPACE JAPAN-WEEKLY in English 22 Dec 86 p 5

[Text]

The Technical R&D Institute (TRDI) has completed all technical and operational tests of the XJ/AQM-1 air-launching target drone, which is being developed in cooperation with the Air Self-Defense Force (ASDF) for use in firing training of both the AIM-7F radar homing missiles and the AIM-9L infrared homing missiles to be installed on the F-15 and F-4EJ fighter aircraft.

TRDI succeeded in the first firing test of the AIM-9L missile launched from the F-4EJ on November 26. The second firing test of the AIM-9L on December 2 was also successful using the F-4EJ as the platform. With the successful second test, TRDI and ASDF completed all technical and operational tests on the target drone, which have been conducted since May 1985.

From now on, TRDI will compile the technical test results into a report to an equipment examination council. Upon approval by the council, TRDI will end the development program. ASDF will also report on the operational test results to seek approval for official use of the drone at operational units. These procedures will be completed by the end of March next year.

The XJ/AQM-1 is an inexpensive and disposable target drone to replace the expensive BQM-34AJ high-speed target drone currently operated by ASDF. ASDF plans to install the new drones on both sides of the F-4EJ's wing.

The drones will turn twice in accordance with the pre-programmed flight path for firing training of both the AIM-7F and AIM-9L missiles launched from either the F-15 or the F-4EJ. Its flight time is about 15 minutes. It will be capable of self-destruction.

Major specifications are: about 3.6 meters in overall length, about 2.0 meters in width, about 1.0 meter in height, about 0.35 meters in diameter, 200 kilograms in overall weight, and Mach 0.9 or faster in speed (at an altitude of 30,000 feet). Its flight altitude is between 2,000 feet and 30,000 feet.

TRDI has invested some ¥2.5 billion in developing this subsonic unmanned target drone powered by a jet engine.

First Spin Test of XT-4

Tokyo AEROSPACE JAPAN-WEEKLY in English 22 Dec 86 p 6

[Text]

The Air Proving Wing of the Air Self-Defense Force conducted the first spin test on the XT-4 new medium jet trainer (No.4 prototype) off the coast of Komatsu on November 25.

The spin tests are aimed at investigating how much the aircraft is capable of recovering its attitude if it falls in a spin by accident. To assure the safety during the tests, the aircraft is fitted with a spinchute to be released in the rear section in case of emergency.

The spin tests will last about a year for the A, B, C and D stages in accordance with the military specifications.

/9317
CSO: 4307/011

OUTLOOK FOR ELECTRONICS INDUSTRY BY YEAR 2000 VIEWED

Tokyo DENSHI in Japanese No 4, 1986 pp 2-3

[Article: "Will the Electronic Industry Reach ¥100 Trillion by the Year 2000?"]

[Text] The year 1985 was turbulent for both domestic and overseas markets characterized by such negative factors as declines in demand for semiconductors, trade friction, and high yen exchange rates. Our electronic industry produced goods worth ¥17.8 trillion, up 6.3 percent from the previous year.

Several research organizations have announced long-term forecasts regarding the possible size of the electronic industry in the year 2000. They all point to the possibility that it could exceed ¥100 trillion while recording continued growth in the neighborhood of 12 percent per year. In other words, it is anticipated that in 15 years this industry will be 5.5 times larger than it was in 1985. There is no denying that the electronic industry is one of the Japanese industries marked by high growth. But a question comes to mind: "Can it continue to grow at this rate?"

Reports by these research organizations all contend that this is possible. They note that at the core of the industry's growth is computers and ICs, which together will occupy more than 50 percent of the market in all likelihood. Peripheral equipment and parts will also expand with the addition of new products.

It is felt that the computers and ICs [integrated circuits] shoring up the information society will in turn become the source of high-technology products. If the annual production of the electronic industry can be assumed to reach ¥100 trillion, this would be close to 15 percent of GNP. Since it is currently about 6 percent, this would represent an increase of nearly 10 percent--an increase befitting the leading industry.

This past January, MITI made public its estimate of the size of the high-technology industry and reported it to the Industrial Structure Council. This report estimates that the production of semiconductors and ICs will be ¥31.9 trillion and applied products ¥244.2 trillion; new materials ¥5.4 trillion, and applied products ¥41.6 trillion; and biotechnology ¥5 trillion and applied products ¥2.1 trillion. The total production in the three high-technology fields thus amounts to ¥330.2 trillion. Of this total, the semiconductor and IC applications products incorporate not only existing electronic equipment but all the products using semiconductors and ICs in one way or another.

This is a very bold estimate. Since these three high-technology fields--semiconductors and ICs as well as new materials and biotechnology--are all related to our electronic industry, depending on the definition, the size of the electronic industry will increase further.

The size of the market in the year 2000, as announced by the Japan Economic Research Center in March 1985 is ¥111 trillion--consumer ¥14 trillion, industrial ¥50 trillion, and parts ¥47 trillion. An annual growth rate of 12 percent (1990-2000) is projected. It is estimated that in this market, ¥24.8 trillion will be for computers and ¥29.5 trillion for ICs, nearly 50 percent of the total.

In May 1985 the Japan Machinery Export Association made public a report compiled by the Committee on the Outlook for Exports of Next-Generation Machinery. According to this report, in the year 2000 domestic production of what is considered the next-generation electronic products is estimated to be ¥82.5 trillion. The study divides these products into semiconductors (including ICs--¥26.4 trillion; computers--¥25.2 trillion; office equipment--¥5.7 trillion; communications equipment--¥10.9 trillion; and consumer electronic equipment--¥14.3 trillion. When general electronic parts and instruments are added, a total of ¥100 trillion can be anticipated. An annual increase of 11.1 percent (1990-2000) is forecast. The total production of computers and IC's (semiconductors) in this study is expected to reach ¥51.6 trillion in the year 2000.

In August 1985, the Japan Electronic Industry Promotion Association announced its projects for 1990 in a report entitled "Long-Term Forecast of the Electronic Industry." This report forecasts a total of ¥30.83 trillion--¥5.43 trillion for consumer electronics, ¥12.56 trillion for industrial electronics, and ¥12.84 trillion for parts--with an annual increase of 12.6 percent (1983-1990). In 1990, the production of computers is estimated at ¥7.37 trillion and that of semiconductors and ICs at ¥7.74 trillion for a total of ¥15.11 trillion, or 48.9 percent of the grand total.

Other projections include a think tank estimate that puts computer production in the year 2000 at ¥28 trillion and IC production at ¥22 trillion, with the combined production occupying 50 percent of the total production of electronic products.

Also, a report entitled "Tasks and Outlook for Industrial Electronic Equipment," compiled in March by the Electronic Industries Association of Japan, predicts that in 1995 the production of industrial equipment will be ¥35 trillion, with ¥22 trillion for existing products and ¥13 trillion for new products. Also, the figure of ¥15.34 trillion is forecast for computers, so it is estimated that production of these electronic products will occupy 44 percent of the total production of industrial equipment.

In 15 years it will be the year 2000, the beginning of the 21st century. Since an adequate target for making a long-term forecast is available, many organizations are now engaged in forecasting for 2000. It must be noted, however, that because this type of prediction is based on analogs, it is far more difficult than searching for Halley's comet. While the comet search produces a result in a short time, it takes 15 years to find out the accuracy of the long-term forecast.

At any rate, these figures are projections of only the hardware. Now that we are entering the high-level information or software-oriented society, there is great interest in the future of software. The software industry is so variously defined that its size can be estimated only in rough approximations. It is estimated as follows by the foregoing organizations:

Japan Economic Research Center--¥1.7 trillion in 1985, ¥4.9 trillion in 1990, and ¥25 trillion in 2000;

Japan Machinery Export Association--¥260 billion in 1984, ¥1.2 trillion in 1990, and ¥11.4 trillion in 2000; and

Japan Electronic Industries Promotion Association--¥520 billion in 1983, ¥880 billion in 1985, and ¥3.4 trillion in 1990.

Since the software industry decreases or increases its scope, depending on how it is defined, it cannot be grasped as easily as the hardware industry. Nevertheless, all predictions agree that the software industry will continue to grow at a much higher rate than that of the hardware industry. It is also certain that it will occupy a critical position as a new added value industry resulting from producer's goods--the hardware.

A look at the production of the electronic industry in 1985 shows ¥3.3 trillion for computers, ¥1.9 trillion in video tape recorders, and ¥1.8 trillion for ICs, with these three items contributing about 40 percent in the entire production of the electronic industry. How much increase have these three items made in the last 10 years? Computers rose 5.5 times, and ICs 9.3 times. A dramatic 33.5-fold increase was made by video tape recorders. In the coming 15 years, a 13- to 14-fold increase in computer production and a 15- to 16-fold increase in ICs are predicted, while the figure for video tape recorders is only a 3-fold increase. The production of consumer equipment in the year 2000 is estimated to be no more than ¥14 trillion, or about 10 percent of the entire production of the electronic industry.

Long-Term Forecast for the Japanese Electronic Industry

(Units: ¥1 trillion and percent of increase)

		1990	Average rate of increase	2000	Average rate of increase
Consumer (Video tape recorders)	①	5.43 (2.35)	5.4 6.5		
	②	7.00 (3.20)	9.7 (7.8)	14.00 (6.30)	7.2 7.0
	③	6.60	6.6	14.30	8.0
Industrial (Computers)	①	12.56 (7.37)	12.4 13.8		
	②	14.80 (7.30)	16.5 17.2	50.00 (24.80)	12.9 13.0
	③	15.00 (7.40)	17.0 14.6	41.80 (25.20)	10.8 13.0
Components (IC)	①	12.84 (6.80)	17.4 29.1		
	②	13.90 (6.70)	15.3 23.8	47.00 (29.50)	13.0 16.0
	③	(7.30)	19.6	(26.40)	13.7
Total	①	30.83	12.6		
	②	35.70	14.0	111.00	12.0
	③	28.90	14.1	82.50	11.1

① Japan Electronic Industry Promotion Association (average rate of increase 1983-1990)

② Japan Economic Research Center (1985-1990, average rate of increase 1990-2000)

③ Japan Machinery Export Association (1984-1990, average rate of increase 1990-2000)

20107/9365
CSO: 4306/572

TRENDS OF ELECTRONICS INDUSTRY IN 1985 REVIEWED

Tokyo DENSHI in Japanese No 4, 1986 pp 10-23

[Text] I. Outline of the Electronics Industry

After a period of inflation following the oil crisis, the world economy is now searching for ways to achieve balanced development through progress in international cooperative relationships in order to bring about a "new period of growth free from inflation."

In 1985 our economy switched from the expansive trend of 1984 to a diminishing one as a result of the deceleration of the U.S. economy, very high yen rates since early in the fall, and a slowdown of exports to China. The world economy is also in danger of taking a downturn because of a number of problems, including a deflation caused by a drop in resource energy prices through structural oversupply, financial deficits of advanced nations, and the problem of cumulative debts.

Under these circumstances, high-technology industries play the leading role in vitalizing the economy. As the representative of this field, the electronics industry governs much of the industrial and export structures of our country. Electronic products deeply penetrate a broad spectrum of our society from industry to the home, and their role and influence are immeasurable. Also, because our electronic industry is a world leader in technology and distribution, it is essential for this industry to make every effort to further mutual understanding and coexisting relationships with other countries. Contribution on a global scale is what must be tackled in the course of its development.

The 1985 production of the electronics industry was ¥17.842 trillion, 105.6 percent of the previous year. The rate of increase represents a drop of 26.8 percentage points from the 32.4 percent of 1984.

Our electronic products, which are accepted in the world markets because of their excellent adaptability, have become increasingly dependent on overseas markets, but 1985 saw these markets stagnate because of a worldwide slowdown in demand. Production, which was brisk the previous year, rapidly dwindled. With the effect of higher yen rates, the industry found itself in the grip of a recession at year's end. Monthly records of production and exports show that exports in August registered a decrease compared to the same month a year ago for the first time in 34 months, and that production in September indicated a decrease over the same month the previous year for the first time in 35 months. A monthly export decrease against the same month 2 years earlier was recorded until January 1986, when the last data were taken.

In terms of specific items, integrated circuits (ICs) dropped to such an extent that one began to hear of an "IC recession." Called the "rice of industry," IC production in 1984 increased by 73.2 percent over the previous year, reaching roughly ¥2 trillion. Since the middle of 1985, IC production has been below the rate of the previous year, and annual IC production dropped to ¥1.841 trillion, or 93.3 percent of the previous year, indicating a negative growth for the first time in 10 years. This is the result of a slowdown in exports initiated by a chill in demand from the U.S. computer market, which is described as "the computer slump." IC exports to the United States amounted to ¥219.5 billion, 59 percent over the previous year. Monthly records show that November's exports were 34.3 percent of the same month in the previous year--one-third the level of the previous year. Semiconductors reflect the character of the equipment industry. Through capital investments in 1983 and 1984, their production capacity increased, while demand diminished as explained above. Consequently, a balance in demand and supply rapidly gave way, and inventories in excess of 1 billion pieces persisted while the stock rate (stock/shipment) remained at a level exceeding 1-1/2 months. While the stock rate remained in the neighborhood of one-half a month in 1984, it tripled in 1985. As for general electronic parts, a slowdown in demand for home video tape recorders, which are major consumer goods, and the higher yen rates at the year end created serious problems. Nevertheless, annual production managed to exceed the level of the previous year slightly with ¥2.864 trillion, 100.4 percent of the previous year. As a result, 1985 production of electronic parts reached ¥5.98 trillion or 98.6 percent of the previous year, the only decrease in the three fields of the electronics industry.

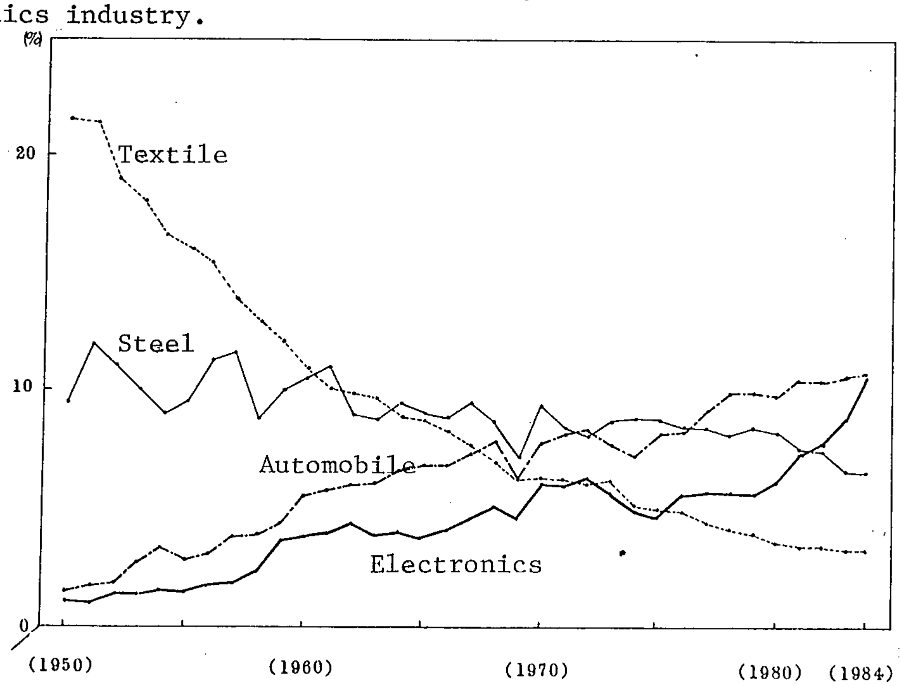

Figure 1. Transition of Component Ratios of Principal Types of Manufacturing Businesses
*Based on shipments in yen volume listed in Industrial Statistical Table. Office equipment not included in the electronics industry.

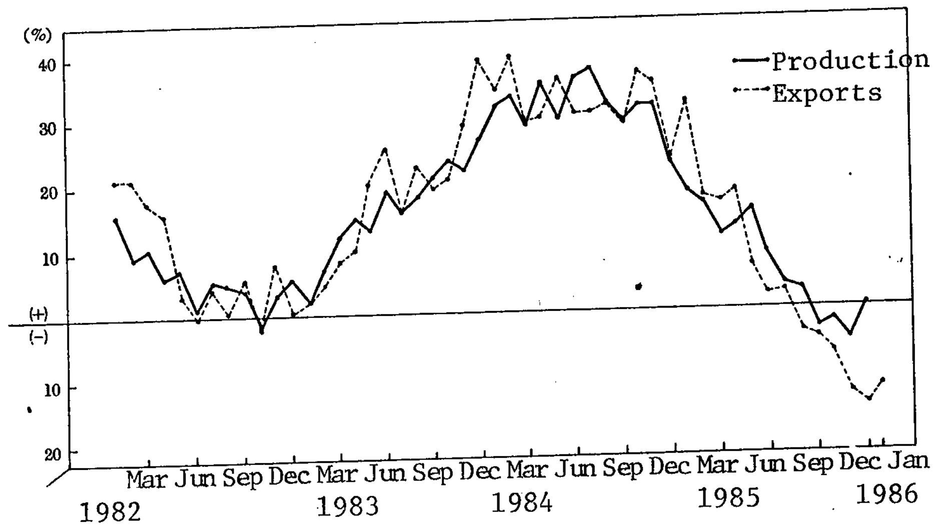

Figure 2. Monthly Production and Exports of the Electronics Industry in Percentage Compared to the Same Period in the Previous Year

The environment surrounding the electronic industry is turbulent and uncompromising. It is against this background that the production of industrial electronic equipment, with data and communications equipment as the core, amounted to ¥6.926 trillion, 113.3 percent of the previous year, maintaining double-digit growth for 8 consecutive years and nearing the ¥7 trillion mark. The communications equipment and computer markets were subject to two historical impacts--a liberalization of the communications business and the takeover of NTT by private management. Expectations are high that competition will stiffen with a resultant expansion of the market. The production of computers and allied equipment, which occupies about 50 percent of the total production of industrial electronic equipment, achieved a favorable record at ¥3.327 trillion, 114.1 percent of the previous year. This consists roughly of ¥1.364 trillion for computers, 123.3 percent of the previous year--a high increase achieved through the introduction of new products and the spread of office automation--and ¥1.963 billion for allied equipment, only a single-digit growth of 108.6 percent of the previous year. Internationally, Japanese computers enjoy high quality ratings. In particular, peripheral equipment is at the highest level. Consequently, its annual production increase over the past 10 years has exceeded that of computers. However, peripheral equipment is now facing a difficult business situation, partly as a consequence of a computer recession in the United States. Printer production trends indicate that since the middle of 1985, printer production has been decreasing by over 10 percent from that of the previous year.

Production of consumer electronic equipment was ¥4.935 trillion, 104.6 percent of the previous year. The production of home video cassette recorders, which was a powerful moving force in the first half of the 1980's, amounted to ¥1.911 trillion, 91.4 percent of the figure for the previous year. Although its moving force was slightly weakened, the video camera--mainly sold as a unit with a much-anticipated new product, the digital audio disk player, or

Table 1. Share of Electronic Products = $\frac{\text{Exports of Japanese Electronic Industry}}{\text{Total Japanese Exports}}$

Units: Percent and ¥100 million

Calendar year	Classification: Share of electronic products	Exports of Japanese electronics industry	Total exports from Japan
1976	14.0	27,991	199,346
1977	13.1	28,272	216,481
1978	13.6	27,911	205,558
1979	14.4	32,355	225,315
1980	14.8	43,351	298,825
1981	16.4	53,620	334,690
1982	16.7	57,546	344,325
1983	19.6	68,395	349,093
1984	22.3	89,992	403,252
1985	22.0	92,111	419,557

Source: Customs Clearance Statistics, Ministry of Finance

Table 2. Exports and Imports of the Electronics Industry

Units: ¥100 million, percent

Classification / Calendar year	Exports (A)	Imports (B)	(A)/(B)	(B)/(A)
1981	53,620	7,020	46,600	13.1
1982	57,546	7,918	49,628	13.8
1983	68,395	8,016	60,379	11.7
1984	89,992	10,312	79,680	11.5
1985	92,111	10,333	81,778	11.2

Source: Customs Clearance Statistics, Ministry of Finance

Table 3. Exports and Imports of the Electronic Industry With Respect to the U.S. Market

Unit: ¥100 million

Classification / Calendar year	Exports (A)	Imports (B)	(A)-(B)
1981	16,212	6,201	10,011
1982	18,126	5,168	12,958
1983	25,485	5,295	20,190
1984	40,943	6,769	34,174
1985	40,597	6,671	33,926

Source: Customs Clearance Statistics, Ministry of Finance

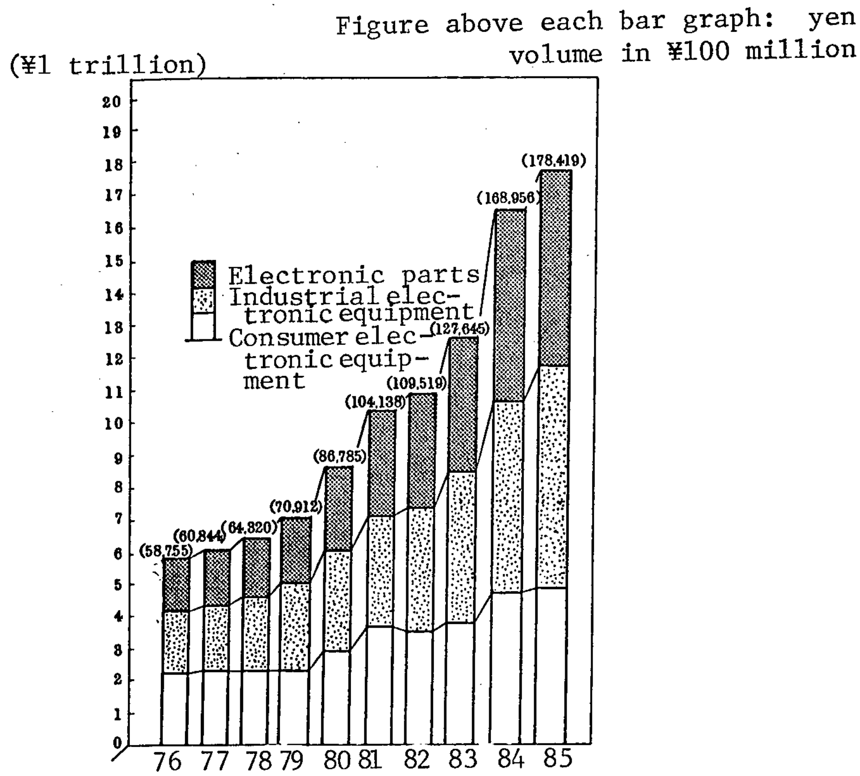

Figure 3. Electronics Industry Production

Source: Statistics are drawn primarily from MITI's Dynamic Statistics of Production and partially rearranged.

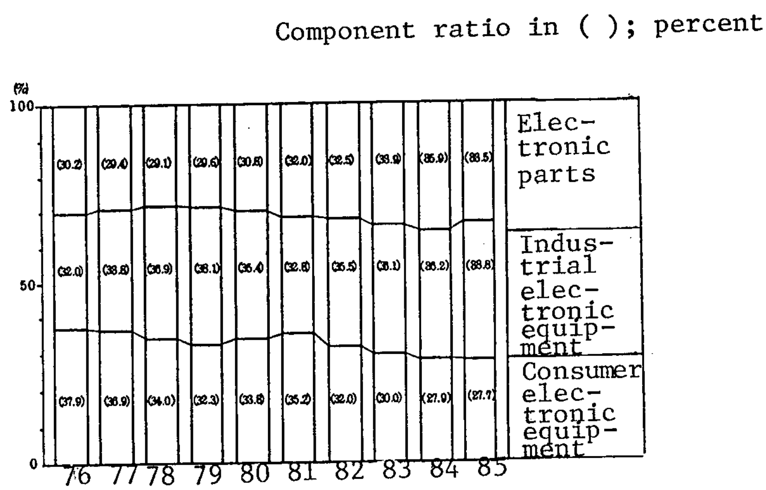

Figure 4. Composition of Production by Field in the Electronics Industry

Source: Statistics are drawn primarily from MITI's Dynamic Statistics of Production and partially rearranged.

Figure above each bar graph: yen volume in ¥100 million

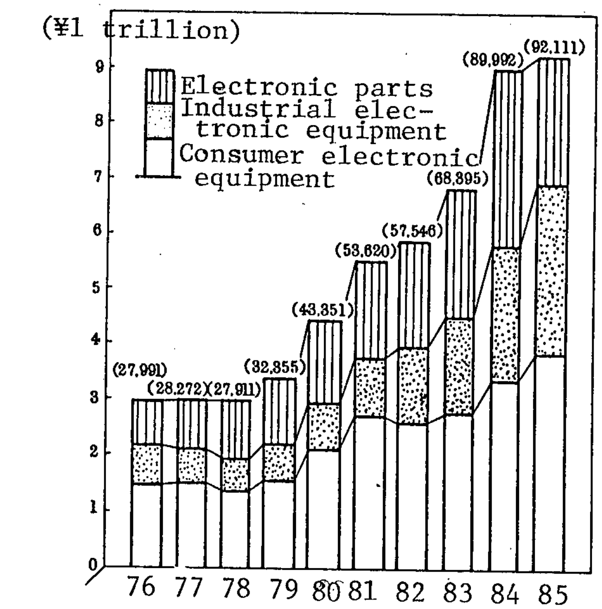

Figure 5. Electronic Industry Exports

Source: Customs Clearance Statistics, Ministry of Finance

Figure above each bar graph: yen volume in ¥100 million

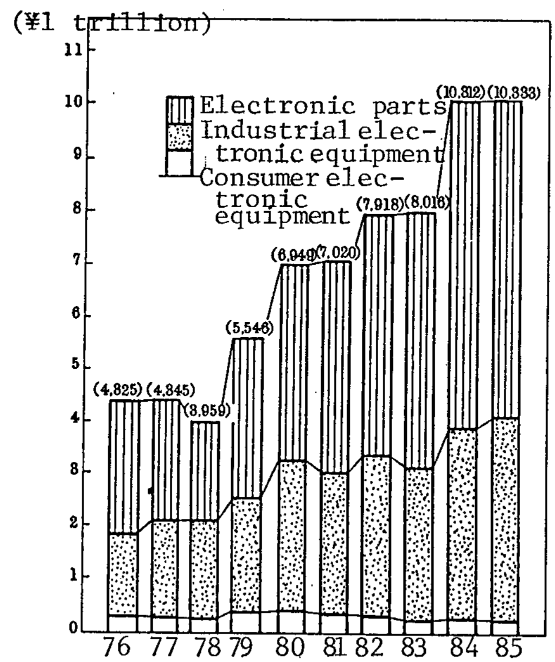

Figure 6. Electronic Industry Imports

Source: Customs Clearance Statistics, Ministry of Finance

with the video disk player or the video cassette recorder--is selling smoothly with good indications that it may grow into a full-scale market of its own. The total production of these three items amounted to ¥557.5 billion, 224.6 percent of the previous year, holding 11.3 percent of the total production of consumer electric equipment. As for color television, which is a mature product, because of a substantial increase in exports to China, its production increased to 119.6 percent of the previous year, ¥897.1 billion with 17.9 million units. This was the highest in terms of both production and units. This was the highest in terms of both production and units. Color television exports to China included 6.42 million units, 277.9 percent of the previous year (chassis and kits included). As an annual export to one country, this is more than double the highest record of its kind, the 1976 export of 2.97 million units to the United States. However, due to China's worsening foreign exchange situation, the China boom that lasted 1 year reversed direction sharply in the second half of the year, and December exports to China decreased to one-half that of the same month the year before. In January 1986, exports to China were reduced by 80 percent.

In 1985, exports of the electronics industry reached ¥9.211 trillion, 102.4 percent of the previous year. This slight increase was the result of a slump in the U.S. market. As a result of this low growth, the electronics industry's share of total Japanese exports was 22 percent below that of the previous year, the first drop in 8 years. On the other hand, imports totaled ¥1.033 trillion, 100.2 percent of the previous year. Balancing exports and imports shows a figure of ¥8 trillionin the black for the first time, although the rate of increase registered a large decline from the previous year. It should also be noted that the positive balance of exports to and imports from the United States, which had been increasing, is now decreasing.

Our electronics industry is trying to ease trade friction through industrial cooperation by combining overseas production and an expansion of imports as much as possible. At the same time, its mission is to lead the international electronics industry by further developing technologies.

II. Consumer Electronic Equipment

Production of consumer electronic equipment in Japan amounted to ¥4.935 trillion in 1985, 104.6 percent of the previous year. Despite a large increase of more than 20 percent in 1984 over the previous year, 1985 saw a dwindling rate of increase, and after September production fell to a level below that of the same month in the previous year.

In terms of products, home video cassette recorders, which provided the driving force for expanding the production of consumer electronic equipment in the first half of 1980's, showed a negative growth in yen volume for the first time, because of an annual production that had reached 30 million units and an increasingly saturated market. Therefore, no moving force came into play. Although home video cassette recorders showed a stagnant trend in 1985, it is expected that the development of new products including video cameras and other allied equipment will continue to be actively pursued. Also, since more than 100 million units have already been sold the world over, it is expected that a

Total consumer equipment = 100 percent

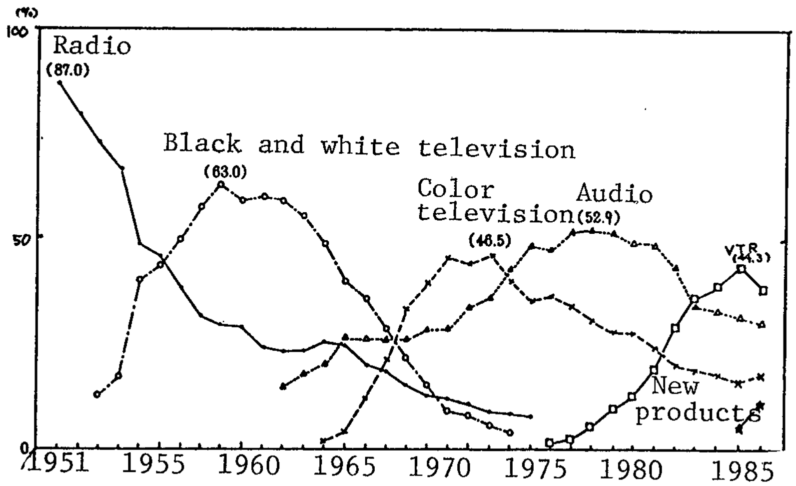

Figure 7. Component Ratios of Production of Principal Consumer Electronic Equipment

Based on MITI's Dynamic Statistics of Production

New products: Digital audio disk player, Video disk player, Video camera

Table 4. Production Records of New Products

Units: 1,000 units, ¥1 million, and percent

		Digital audio disk player	Video disk player	Video camera	Total
1984	Quantity	769	403	1,571	--
	Amount	45,586	47,697	154,891	248,174
	Component ratio to production of consumer	1.0	1.0	3.3	5.3
1985	Quantity	4,133	503	2,574	--
	Over previous year	537.8	124.9	163.9	
	Amount	150,872	54,166	352,430	557,468
	Over previous year	331.0	113.6	227.5	224.6
	Component ratio to production of consumer electronic equipment	3.1	1.1	7.1	11.3

Rate of increase in quantity over previous year is in terms of units.
Source: MITI's Dynamic Statistics of Production

demand for new models will increase. Thus the central role of home video cassette recorders in the field of consumer electronics will remain unchanged.

Through world-famous product development, quality control, and mass production technology, our consumer electronic equipment industry has never slackened its pace in introducing leading products. There are hopes for the birth of new products that will assume a leading role in the decade from 1985 to 1994. Already, digital audio disk players, video disk players, and video cameras in unit with video cassette recorders are creating a market of their own at a pace much faster than expected. The production of digital audio disk players reached ¥150.9 billion, 331 percent of the previous year, that of video disk players was ¥54.2 billion, 113.6 percent of the previous year, and that of video cameras was ¥352.4 billion, 227.5 percent of the previous year. Without the growth recorded by these three items, the overall production of consumer electronic equipment would have receded.

The 1985 exports of consumer electronic equipment totaled ¥3.519 trillion, 106.4 percent of the previous year. Their sales records showed a downward trend in 1985, as did those of the electronics industry as a whole, with December registering a 20 percent decrease from the same month a year earlier.

With regard to destination, following the 1984 trend, the United States remained the largest recipient of exports, which amounted to ¥1.668 trillion, 108.3 percent of the previous year. Home video cassette recorders led the way, comprising 57 percent of exports to the United States. As in the previous year, exports to China also expanded considerably, reaching ¥303 billion, 281.4 percent of the previous year. Exports to China consisted mainly of color television sets, which occupied 85 percent of the total and numbered 6.42 million units, 277.6 percent of the previous year. This was the highest export total recorded for a single destination, greatly surpassing the past record of 2.97 million sets exported to the United States in 1976. This growth in color television exports to China regressed because of China's poor foreign exchange position: sets exported in December 1985 were down 53.4 percent from the same month the previous year, while sets exported in January 1986 were down 19.5 percent from the same month the previous year. Exports of consumer electronic equipment to other destinations were: ¥711.2 billion for Europe, 96.9 percent of the previous year; ¥59.6 billion for Africa, 69.1 percent of the previous year; ¥84 billion for Latin America, 120.7 percent of the previous year; and ¥97.3 billion, down 84.4 percent from the prior year.

Actual imports in 1985 amounted to ¥23.7 billion, 102.6 percent of the previous year. An estimate of domestic shipment from production and export results shows a leveling off with ¥1.440 billion, or 100.3 percent of the previous year. Japan's consumer electronic equipment industry depends heavily on sales in overseas markets, with an export/production ratio of 70 percent in simple arithmetic terms. Consequently, soaring yen rates since the end of 1985 have created an extremely serious situation. Furthermore, an even greater transfer of distribution systems overseas as a result of the trade imbalance and a stimulation of domestic demand are cited as major tasks for the future. Thus, 1985 can serve as a platform year from which to leap to new developments.

III. Industrial Electronic Equipment

Production of industrial electronic equipment in 1985 amounted to ¥6.926 trillion, 113.3 percent of the previous year, thus recording double-digit growth for 8 consecutive years since 1978. This growth rate exceeded increases in the other two fields of the electronic industry.

Of this figure, the ratio of computers and peripheral equipment (hereinafter referred to as computers) to the increase in the production of industrial equipment was 50.7 percent, indicating their leading role in the expansion of industrial electronic equipment. Although computer exports were slow because of a stagnant demand for computers in the United States, a brisk domestic demand contributed to increasing computer production that reached the ¥3 trillion level.

The placing of the Nippon Telegraph and Telephone Public Corporation under private management--which became effective in April 1985--and the introduction of competition into the field of telecommunications through a liberalization of telecommunications service, ushered in a new era for communications equipment. It is also anticipated that a new market will be formed as computers and communications equipment deepen their ties while coping with needs that will become increasingly varied and sophisticated as we move toward a high-level information society.

Exports of industrial electronic equipment in 1985 amounted to ¥2.721 trillion, 110.7 percent of the previous year, thus recording double-digit growth for 7 consecutive years since 1979. However, the ratio of industrial electronic equipment to the 1985 exports of the electronics industry was 29.5 percent lower than the levels of consumer electronic equipment (38.2 percent) and electronic components (32.3 percent). Since industrial electronic equipment was developed primarily to meet domestic demand, its export ratio was 39.3 percent in simple arithmetic, which was below that of consumer electronic equipment (71.3 percent) and electronic components (49.7 percent). In terms of areas, large increases were recorded in Asia (117.8 percent of the previous year), Europe (122.2 percent of the previous year), Latin America (130.6 percent of the previous year), and Oceania (132.1 percent of the previous year). But the overall figure decreased from the previous year's increase (139.4 percent) because exports to the United States, which comprise just under 50 percent of total exports, rose by only one digit (2 percent).

IV. Electronic Components

The production of electronic components in 1985 totaled ¥5.98 trillion, 98.6 percent of the previous year. This represents a decrease from a previous year for the first time in the past 10 years. The fact that total production dropped from the ¥6 trillion mark is thought to be attributable to two factors: functional parts, which occupy 51.2 percent of electronic components production, were adversely affected by the worldwide semiconductor recession; and demand for home video cassette recorders, the major userof general electronic parts, was stagnant.

The invention of the transistor after World War II and the birth of integrated circuits using transistors as the base technology provided a departure point for the semiconductor industry. If discussion is confined to integrated circuits, they represent a young industry with a history of only a quarter of a century, but they are already positioned as a leading sector of high-technology industry. With the introduction of microcomputers with arithmetic and control functions contained in a single chip together with other devices, semiconductors are now bringing about a microelectronic revolution in today's industrial world.

On the other hand, the demand for general electronic parts arises not only from the field of electronic equipment, including consumer electronic equipment, but also from every other industrial field. Further technological sophistication will be required, from now on, to cope with new media equipment.

(1) General Electronic Parts

Production of general electric parts in 1985 was ¥2.864 trillion, 100.4 percent of the previous year. The rate of increase was less than the large gain recorded the previous year (25.5 percent) as a result of a decrease in demand for parts for consumer electronic equipment.

Despite an increasing demand for industrial electronic equipment parts, general electric parts depend heavily on a demand for parts for consumer electronic

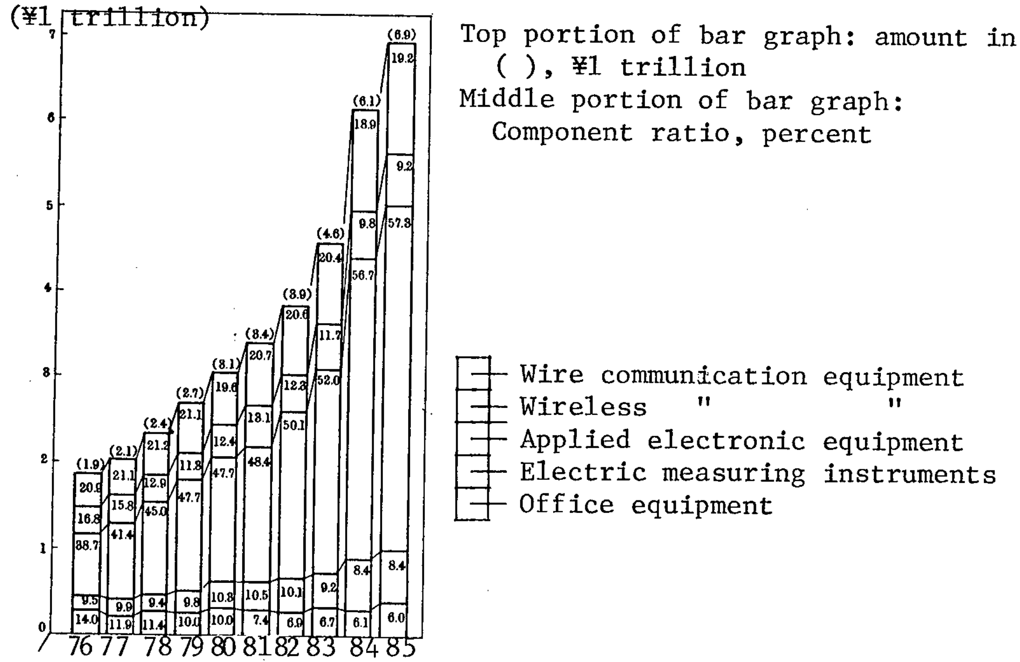

Figure 8. Production of Industrial Electronic Equipment

Source: Statistics are drawn primarily from MITI's Dynamic Statistics of Production and are partially rearranged.

equipment, thus demand for these parts is determined by trends in the consumer electronic equipment industry. Although a number of positive developments, such as brisk sales of color television sets due to an increase in exports to China and a large increase in digital audio disk players, characterized the 1985 production of parts for consumer electronic equipment, a lower rate of increase in home video cassette recorders, the leading consumer electronic product in the first half of the 1980's, was responsible for a slowdown in overall production. Also, higher yen and lower dollar rates that proceeded rapidly in the second half of 1985 had an adverse effect on the general electronic parts industry.

Exports of general electronic parts in 1985 amounted to ¥1.826 trillion, 98.4 percent of the previous year, showing a decrease for the first time in 10 years.

Backed by high quality and high reliability, general electronic parts have enjoyed solid user confidence that produced a double digit increase in Oceania (120 percent of the previous year) and Latin America (111.7 percent). Nevertheless, because of decreases in North America (97.8 percent of the previous year) and Asia (92.2 percent of the previous year), exports as a whole recorded a drop from the previous year. As a result, the export/production ratio was a high 63.8 percent in simple arithmetic terms though 1.3 percentage points less than the previous year (65.1 percent). However, industry sources view the actual export ratio as being a little under 20 percent. First, this is due to differences in the export items covered by the Ministry of Finance

Table 5. 1985 Exports of Industrial Electronic Equipment by Destination

Units: ¥1 million, percent

Classification / Destinations	Wire communication equipment	Wireless communication equipment	Applied electronic equipment	Computers as included in the electronic application equipment	Electric measuring instruments	Office equipment	Total
Asia	68,960	74,570	188,009	124,000	116,901	33,868	482,309
Over previous year	117.5	107.2	126.5	127.2	114.4	112.2	117.8
Europe	39,659	128,631	335,703	286,194	60,469	73,358	639,819
Over/down previous year	142.1	173.1	112.3	110.3	134.7	97.1	122.2
North America	175,215	322.922	706,262	619,069	76,769	103,451	1,384,619
Over/down previous year	117.5	123.0	93.3	93.0	109.4	93.9	102.7
Latin America	13,375	12,751	14,885	10,830	6,769	11,562	59,343
Over previous year	116.4	136.6	158.6	171.6	123.2	118.9	130.6
Africa	8,830	10,558	9,840	7,757	4,715	4,117	38,060
Over/down previous year	137.1	118.4	63.0	64.7	93.6	75.7	91.8
Oceania	22,809	16,149	64,489	57,772	7,142	6,578	117,166
Over/down previous year	196.1	114.6	127.0	126.5	130.7	98.2	132.1
Total	328,847	565,581	1,319,188	1,105,622	272,766	234,941	2,721,323
Over/down previous year	124.0	128.9	103.0	101.8	117.0	98.0	110.7

Note: Breakdown figures and the total may not match because of rounding to the nearest whole number.

Source: Customs Clearance Statistics, Ministry of Finance

Top of bar graph: amount in ( ), ¥100 million

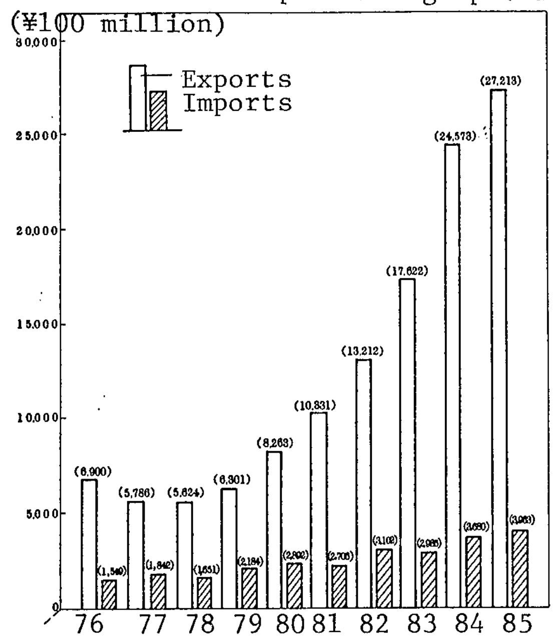

Figure 9. Exports and Imports of Industrial Electronic Equipment

Source: Customs Clearance Statistics, Ministry of Finance

Top portion of bar graph: amount in ( ), ¥100 million yen
Middle portion of bar graph: component ratio, percent

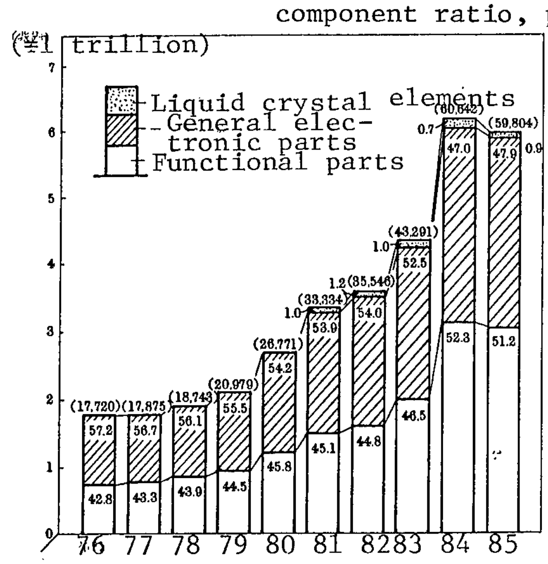

Figure 10. Production of Electronic Parts

Source: MITI's Dynamic Statistics of Production

Top of bar graph: Amount in ( ),
¥100 billion

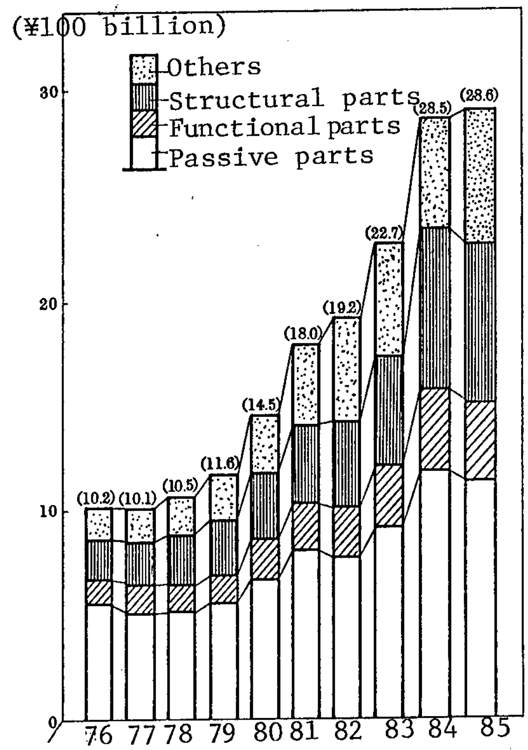

Figure 11. Production of General Electronic Parts

Source: MITI's Dynamic Statistics of Production

Customs Clearance Statistics and the range of items in MITI's Dynamic Statistics of Production, and second, because of a lack of production data from work places with less than 50 employees in MITI's Dynamic Statistics of Production. The number of work places producing general electronic parts that employ more than 4 but not more than 50 persons in 1983, and the shipment of products listed in MITI's Table of Industrial Statistics (Industrial Edition) total 5,736, occupying 82.2 percent of all places of work, producing ¥599.8 billion in products shipped, or 17 percent of the total exports.

On the other hand, imports registered ¥368.9 billion, 110.6 percent of the previous year, thus recording a double-digit, though modest, increase.

(2) Functional Parts

Production of functional parts in 1985 was ¥3.649 trillion, 96.7 percent of the previous year, thus showing a decrease for the first time in 10 years.

In 1984 functional parts showed a large gain of 157.4 percent of the previous year, but in 1985 they showed a rapid decline, recording a decrease in July (95.2 percent of the previous year) and receding drastically thereafter. This was due to a slowdown in demand for ICs, which comprise about 60 percent of the production of functional parts, as a result of the worldwide recession in the demand for semiconductors. IC market conditions in the United States shown in terms of the B/B ratio (ratio obtained by dividing an average monthly amount of orders received in the past 3 months by an average amount shipped in the same period: a value of over 1 indicating a brisk market) used by the World Semiconductor Shipment Statistics shows that it enjoyed prosperity, with the B/B ratio exceeding "1" in the first half of 1984, while the value dropped below "1" in September 1984 where it remained for 16 consecutive months until December 1985 (quick report values). However, the B/B ratio neared "1" in the second half of 1985, pointing to a U.S. market on its way to recovery. The IC market is subject to short-term change called the silicon cycle, but it is felt that, in the long run, it will maintain a high growth rate as the core of the development of the high-level information society.

As the staple "rice" or "oil" of industry, ICs will facilitate the development of smaller, lighter and better products not only in the electronics industry but also in general machinery, precision machinery, automobiles, and a wide range of other industrial machinery and equipment. It is a key factor indispensable to the product strategy of corporations and manufacturers.

A look at the trends of 12 major Japanese IC manufacturers (MITI survey) in order to see the status of IC-related R&D and spending for new plant and equipment shows that the annual average increase in the total of spending for IC-related research and spending for new plant and equipment in the past 10 years (FY 1975 to FY 1985, estimate for FY 1985) was 37 percent, exceeding the annual average increase (29.7 percent) of the total IC sales by 7.3 percentage points. Because of mass production effects and quality control, the annual average increase of spending for IC-related new plant and equipment showed a substantial increase of 46.3 percent. The annual average increase of spending for IC-related R&D was a double-digit gain of 28.1 percent. In this way, ICs demonstrate the characteristics of an innovative industry and of the equipment industry. As a result of a short life cycle, continuous spending on R&D is required. Nevertheless, spending in 1985 for IC-related new plant and equipment was ¥510.4 billion, down 66.9 percent from the previous year, because of the worldwide semiconductor recession. Its weight in the total IC sales of the 12 major IC manufacturers is expected to drop by 7.4 percentage points from prior year, to 35 percent.

Exports of functional parts in 1985 amounted to ¥1.145 trillion, 82.9 percent of the previous year. This is the result of a reduction in demand for semiconductor elements (¥114.8 billion, 95.3 percent of the previous year) and ICs (¥581.8 billion, 74.9 percent of the previous year) excluding electron tubes (¥244.1 billion, 103.2 percent of the previous year) due to the U.S. semiconductor recession.

Imports of functional parts, on the other hand, amounted to ¥244.4 billion, 79.7 percent of the previous year. In terms of items, semiconductor elements (¥34 billion, 70.8 percent of the previous year) and ICs (¥165.4 billion, 74.5 percent of the previous year) excluding electron tubes (¥31.7 billion, 131.8 percent of the previous year) decreased from the previous year.

Top of bar graph: Amount in ( ), ¥100 million
Inside bar graph: component ratio, percent

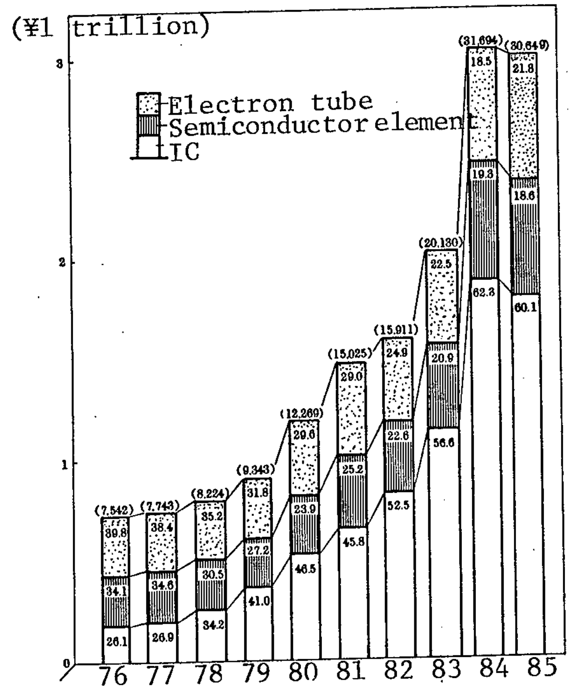

Figure 12. Production of Active Parts
Source: MITI's Dynamic Statistics of Production

Top of bar graph: Amount in ( ), ¥100 billion
Inside bar graph: component ratio, percent

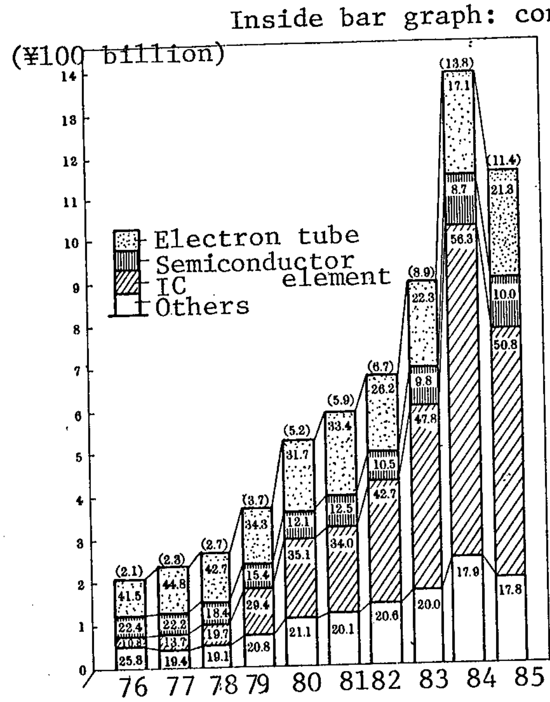

Figure 13. Exports of Active Parts
Source: Customs Clearance Statistics, Ministry of Finance

Table 6. Balance of IC Exports and Imports

Unit: ¥1 million

	1979	1983	1984	1985
Exports	108.298	423,836	776,775	581,801
Imports	98,465	152,602	222,176	165,439
(Exports-imports)	9,833	271,234	554,599	416,362

Source: Customs Clearance Statistics, Ministry of Finance

Consequently, the export and import balance of integrated circuits whose positive balance continued to increase after it first went into black in 1979 showed a decrease in the positive balance in 1985--¥138.2 billion less than the previous year--as both exports and imports were below the levels of the previous year.

Although the export and import balance continues to be in the black, reflecting the strong competitive power of the Japanese IC industry in international markets, attention must be paid to the fact that the IC industry has internationalized itself. In other words, Japanese manufacturers manufacture overseas or foreign makers expand or beef up their production in this country to make their Japanese operations into bases for supplying world markets. Local operations are mutually established both here and abroad for exporting or importing, and these cases are included in the export/import statistics.

Open markets are available in Japan and the United States as IC import duties were lifted in March 1985. However, developing the semiconductor field is an important task common to every country. The possibilities of policy friction are higher than trade friction due to quantitative problems. From now on, it is necessary for Japan and other advanced nations to deepen interchanges of trade, technology, and capital, and to assure international cooperation, including relationships with developing countries.

V. Technological Trends

(1) Items Related to Consumer Equipment

- Operations of the Emergency Alarm Broadcast System Inaugurated

When a state of emergency is announced due to, say, an earthquake in the Tokai Region, when a tidal wave warning is issued, or when an evacuation order is issued by the head of a local government, this system can relay an alarm automatically, even when everyone is asleep. Operation of the system is what concerned organizations reviewed on the basis of a technical method examined by the Radio Technical Council (currently Telecommunications Technical Council).

Revision and announcement of the related laws were put into effect on 1 June 1985, and operations commenced on Disaster Prevention Commemoration Day, 1 September.

Manufacturers are cautiously approaching the production and selling of receivers because of their connection to the protection of life and assets. It is expected that use of the receivers will gradually spread.

- TELETEXT by Coded Transmission (Hybrid)

Practical test broadcasts using patterns have been conducted by NHK since October 1983. In March 1985 the Radio Technical Council of the Ministry of Posts and Telecommunications submitted its final report on the technical standards for TELETEXT using coded transmissions. Accordingly, the Character Broadcast Experiment Liaison Conference was established to solve technical problems arising between TELETEXT and receivers, and technical development and operating rules were discussed by broadcasters and receiver manufacturers. Beginning in November 1985, full-scale TELETEXT operations were started by NHK and some commercial broadcasting firms. As a result, there is brisk production and sales of hybrid TELETEXT receivers. The rapid expansion of broadcast areas and better contents of the TELETEXT programs have generated great expectations for the spread and development of TELETEXT.

- Uniform Worldwide Standards of High Definition Television

Since last year, worldwide discussions have been held in Japan, the United States, Europe, and other venues, in connection with the activities of the Intermediate Work Sectional Meeting (IWP) 11/6 to determine the uniform technical studio standards by the CCIR. These in turn led to heated discussions at the final conference of the IWP 11/6 and SG11 from September to October 1985, where no agreement on recommendations was reached. Instead, an attachment entitled "Proposals for New Recommendations" was to be added to a report to be presented by the chairman to the CCIR convention. Final efforts will be made to institute uniform worldwide studio standards at the CCIR convention to be held in May 1986.

Studio-related equipment for high definition television broadcasting has already been developed in Japan to feasible levels ready for commercial production. Consequently, before the start of a broadcast, high definition television may be put to practical use for service television, ITV, printing, motion pictures, and other areas requiring high definition images by making use of the characteristics of high definition television.

- Full-Scale Satellite Broadcasting

Satellite broadcasting, which began on 12 May 1984, has been in operation via Channel 1 because of the BS2a breakdown. BS2b was launched in February 1986, and, if all goes well, NHK's Channel 2 is expected to start full-scale broadcasting sometime in the autumn. At the same time, the start of various new media experiments is anticipated, so the age of satellite broadcasting will pick up momentum.

Revitalizing Old Media

While new media are being started, 1985 saw activities aimed at revitalizing old media. Efforts to examine EDTV (image-quality improved television) in television and AM stereo broadcasting, FM multiplex broadcasting, PCM voice broadcasting, etc., commenced.

Research is continuing, on the otherhand, to provide conventional home video with high fidelity and high definition, and to make tape and heads of high density.

- Development of Digital Audio Taperecorder (DAT)

In July 1985, the DAT Social Meeting of 82 companies, including 21 foreign firms, outlined the technical specifications and its view on the two methods of S-DAT (fixed-heat DAT) and R-DAT (rotating head DAT). This completes the activities of the working groups for both methods, and a study meeting, comprising 49 companies, is now engaged in seeking to develop a practical system that will offer high-level recording and playback. The target date is March 1986.

To achieve international standardization of technical specifications, the details of past activities, outlines of technical specifications, and plans for the next activities of the DAT Social Meeting will be explained in the SC60A/WG18 conference of the IEC in November 1985, and it was promised that the specifications document would be presented in 1986.

(2) Items Related to Applied Electronic Equipment

- Making High-Performance Personal Computers

The personal computer is now further strengthening its position as a component of the total system, and its market continues to expand. In business use, there is a noticeable trend toward the manufacture of 16-bit high-performance computers and to develop 32-bit computers. A 16-bit FA personal computer equipped with a realtime OS and with environmental resistance has made its debut. Furthermore, in the field of CAS/CAM, with advances in image processing techniques, a 32-bit high-performance computer that can serve as an engineering workstation and includes multimedia processing with the personal computer as its key element has been introduced.

- Making a High-Performance Personal Computer

R&D of a disk memory using magnetism or light underway, and major advances have been made in data processing. Also, work to develop a CDROM is in progress.

- Development of Large-Capacity Computers

In the field of general-purpose, super large-capacity computers, one new model after another hasbeen introduced. Even though general trends are for distributed processing, the overall impression is one of stressing host computers as the core of the total system.

In super computers, what is conspicuous is an expanding variety of applications as a result of the introduction of economy models. Also, in the performance competition among top models, domestic manufacturers are demonstrating their advantages in every place.

- Sequencer (Programmable Controller)

With lower costs, sequencers are rapidly replacing conventional relay controls. In higher-performance models, the use of 16-bit and 32-bit processors is increasing, and a good lineup of software is being made available. Some sequencers act as master controllers of a small system.

- Higher-Performance of Various Controls

As the machine tool/equipment ratio approaches 73 percent, a diversity of numerical controls in terms of content and function are becoming available, from the high-grade, multispindle type with man machine interface to simple types exclusively for machine tools. In terms of control, all digital numerical controls fully using the newest motor control are now available.

For robot controllers, the trend is toward providing a direct drive and for making them clean, smaller, and high-performance. In terms of models, the market share of the intelligent, numerical control, playback type has increased to 80 percent of the total.

For motor controllers, the use of high-performance magnets is being followed by brisk activities to make AC motor controllers and to make them smaller. Also, as for drivers, improvements in devices to make all digital controls and to create highly precise sine wave pulse width modulation are proceeding at an accelerated rate.

- Higher-Level Medical Electronic Equipment

Through the introduction of IC and LSI, medical electronic equipment has spread rapidly. This is especially true of X-ray CT scanners and ultrasonic equipment. In diagnostic and testing equipment, equipment that makes full use of image processing, pattern recognition, and other data processing technniques has been developed. In therapeutic equipment, the development of the laser scalpel, hyperthermia (cancer thermotherapeutic device), fine ceramics, synthetic organs, and medical nursing robot devices using fine ceramics and other new materials is proceeding. As for home medical care equipment, the development of primary care equipment and equipment for chronic patients is making progress.

(3) Radio Related

- Enforcement of the Telecommunication Business Act

With the coming into force of the Telecommunication Business Act in April, restrictions on the telephone sets were lifted and related technical standards were relaxed to a very large degree. Also, the Telecommunications Technical Council, comprising 23 committees, began operations, and steps were taken to deal effectively with international organizations such as the CCIR, IMO, ICAO, and CISPR.

- Expanded Use of Radio

In line with the report on "Long-Term Perspectives for the Use of Radio" presented by the Radio Technical Council in FY 1984, many subjects have been examined and discussed at the Telecommunication Technical Council. Above all, as regards the car radio telephone, cordless telephone, and radio call-up service, the Council is examining new technical standards designed to eliminate obstacles to promoting further use of these products and services, and to liberating the domestic market. Early implementation of the Council's FY 1985 report is expected.

Also, the Council has already made its report on public radio communication from aircraft, and implementation at an early opportunity is scheduled.

- Efficient Use of Radio

The Radio System Development Center was established to review and develop new radio systems, andit is actively pursuing objectives. Its review of a low-speed data transfer system that uses comparatively low power, a private paging system, a telemeter/telecontrol system, mobile body identification equipment, etc., has been completed and a report has been drafted. Review of the tele-terminal system has also been completed.

Other systems such as various mobile radio systems, a satellite communications system, a semimicrowave mobile communications system, an integrated disaster prevention radio system, and LARN system are under review. It will become necessary to take further steps to cope with a multiplicity of radio systems.

- Status of the CCIR

In radio communications, mention must be made of the brisk activities toward standardizing the various types of digital communications and for making recommendations.

(4) Measuring Instruments

With the spread of 16-bit microprocessors, work on making measuring instruments with higher arithmetic functions or complex functions is in progress. Communication functions are also being enhanced as evidenced by the GP-1B, of course, and an increase in models equipped with a RS-232C interface that permits connection to the computer.

As for oscilloscopes, the reduced cost of the 100 MHz oscilloscope and a move to 150 to 200 MHz oscilloscopes can be pointed out. Also, there is a noticeable trend in digital oscilloscopes toward high-speed sampling (100M samples/s) and large capacity memories.

The FFT analyzer used for vibration and sound analysis has been expanded from the conventional 100 kHz to 1 MHz to a wide band, resulting in a more extensive application in such areas as communications and acoustic emissions.

Regarding support equipment for the development of microprocessors models capable of handling 16 bits of information are even more firmly established and debugging is possible with high-level languages such as C languages. Also, logic analyzers have been incorporated into high-speed, multichannel models. Products with 200 MHz and 95 channels have been announced.

In the LSI tester field, systems capable of simultaneously measuring 32 pieces in parallel have appeared to cope with high capacity, high-speed, multifunction memories such as 256K DRAM and 1M DRAM.

As for recorders, hybrid recorders that can perform digital recording at high speeds and at many points have become popular.

With the spread of Compact Disks (CDs), CD-related measuring instruments--such as jitter measuring devices and servo analyzers--have become noticeable. As for light communication measuring instruments, high functions, such as an expanded range of wavelength and high precision, are now featured by many optical spectrum analyzers.

(5) Electronic Devices

- High-Level and Multifaceted Memories

Production of 1M-bit silicon IC memories has reached the point where they are ready for mass production, and the development of 4M-bit memories is actively underway.

- Improved Semiconductor Laser Reliability

Smooth progress in CD and video disk equipment has helped to stabilize the motion of semiconductor lasers and has contributed to lengthening their life, thus producing a movement away from the gas laser.

- Improvement in Solid-State Image Sensing Devices

Solid-state image sensing devices are now in full-scale mass production. It serves primarily to make home television cameras smaller and lighter. Improvements in image quality have also been made.

- Development of Electronic Display Devices

With the progress of new media and the high-level electronic systems, improvements in the CRT, LED displays, fluorescent indicator tube displays (VFD), plasma displays (PDP), liquid crystal displays (LCD), electroluminescent displays (ELD), etc., are being pursued. As for the CRT, the dot trio pitch has been improved to 0.2 mm, and the horizontal scanning frequency has been raised to 60 kHz. Also, improvements in terms of human engineering have been made. There are also improvements in what is called recognition ability, such as improving "flickering" by developing a phosphor with a long period of afterglow and preventing the reflection of outdoor daylight through nonglare treatment of the panel surface.

As for the LED, work is underway to develop an LED that can be applied in areas such as traffic lights and automobile tail lamps, where until now light bulbs have been primarily used. Prospects are very good that this type of LED will be put to practical use in the near future. Also, research is in progress to improve the luminous efficiency of luminous bodies other than a red luminous body and to increase brightness.

In addition, as for the fluorescent indicator tube, plasma display, liquid crystal display, etc., their display capacity has been expanded by making them available in color and by enhancing the degree of fineness so that their usefulness in televisions and terminal displays can be improved in areas where the CRT is currently disadvantageous, such as the handy type and dry cell motion. Take, for instance, the liquid crystal display. It is forecast that in 4-5 years, the size of this market--for terminals, cars, and for imaging--will increase approximately 3 times, 5 times, and 19 times, respectively. The reason for such a huge increase in the market of the liquid crystal display image is that all the technical problems of its use for portable and wall-type televisions have generally been solved. Another use is being planned for passenger service in aircraft.

(6) Electronic Parts

- From High Density Packaging to Surface Mounting

To meet demands from high-technology fields such as smaller equipment and new media, R&D is being conducted to produce parts that are smaller and have higher performance, as well as higher reliability, than conventional models. In packaging technology, the trend is moving from high density packaging toward surface mount technology.

In the chip resistor, normally, type T electrode and type D electrode are used, but because of packaging requirements, type E electrode (five-sided electrode, top, bottom, left, right, and side) was incorporated. Its dimensions were reduced from 1.6 mm x 3.2 mm to 1.25 mm x 2 mm.

As for network resistors, the trend is moving away from the normal dual inline package to the small outline package for surface mounting.

In the ceramic capacitor, through improvements in laminating technology, even higher performance has been packed into chip parts. In the mica capacitor, research is underway to produce a chip shape that will prevent loss by high frequency waves. In the plastic film capacitor, films having a thickness of 4 μm to 2 μm are being used so that large capacity capacitors in excess of 0.22 μF are now available in small sizes. In the aluminum electrolytic capacitor, a cylindrical aluminum case of the same electrode directional shape is now available for surface mounting, and its quantity is improving. Also, despite great improvements in its high frequency characteristics, its operational life needs further research because the electrolyte is liquid.

In the high frequency coil, the small, thin 2-terminal type fixed inductors and surface mounting coils with multiterminal type inductance variable mechanisms are on the increase.

- Other High-Level Electronic Parts

In the transformer, excellent electric insulating materials have been developed. Also, for bobbin materials, engineering plastic materials of good moldability are being used, and the wire is now changing from the conventional enamel wire to polyurethane and polyester wire with good thermal resistance and insulation. The bobbin's structure has also changed from that of a paper-covered transformer to a fiberglass-covered transformer. The lead wire has changed to the pin terminal type to make the structure simple. This facilitates automation of the transformer production and inspection processes.

As equipment increasingly becomes electronic, there is a trend toward making microcurrent equipment and apparatus with requirements changing from the mA level to the μA level. As a result, the development of electronic switches is proceeding at a great rate. Recently, ultrasmall switches for surface mounting have become available.

New types of connectors are being developed for the EMC, light, ribbon cable (ID type), Eurocard, 8 mm video, home bus service, and many others.

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ELECTRIC POWER FACILITY PLAN FOR FY 1986 OUTLINED

Tokyo DENKI TO GASU in Japanese Jun 86 pp 3-10

[Article by Sadaumi Toyokawa]

[Excerpts] Introduction

A report of the Electric Power Facility Plan for FY 1986 drawn up by the 15 electric power companies designated was submitted to the Ministry of International Trade and Industry at the end of last March.

In addition to the facility plan of these 15 electric power companies, the report included that of public-owned power enterprises and nonpower companies jointly operating thermal electric power plants, etc., thus the report covered the facility plan of the total electric power enterprises for the fiscal year.

MITI is of the opinion that, in order to stabilize the medium- and long-range electric power supply-demand balance, systematic development of energy sources for power generation, of facilities for power generation and distribution is required.

I. Estimated Total Electric Power Demand, Peak Power Demand, and Annual Load Factor

Given in the sections below are the estimated total electric power demand, peak power demand, and annual load factor for FY 1995 on which the power facility plan was based. These estimates are not much different from the power demand figure and related figures predicted for FY 1995 indicated in the interim report prepared in November 1983 by the Supply-Demand Subcommittee of the Electric Power Enterprise Affairs Deliberative Council (see Table 1).

(1) Total Electric Power Demand

For the last 2 or 3 years, the total electric power demand has undergone high growth. This was because of the extremely severe summer and winter climates and business recovery having been faster than expected. In the near term, the demand for electric power is likely to see a rather slow increase in manufacturing industries, especially those depending on export, because such industries have become depressed due to the rapid rise in the yen. Then, in the long term, anticipated stable economic growth mainly due to market policy

Table 1. Estimated Electric Power Demand

(Material for comparison purpose) Estimate by the Supply-Demand Subcommittee of the Electric Power Enterprise Deliberative Council

FY		1984 (actual result)	1995	1995
Gross amount of electric power demanded (total power demand) (100 million kwh)		5,807	7,698 (2.6)	7,680
Electric power enterprises	Total electric power demand (100 million kwh)	5,245	7,052 (2.7)	7,080
	Peak power demand (10,000 kwh)	10,696	14,981 (3.1)	15,200
	Annual power load factor (percent)	59.3	57.1	56.5

Figures in ( ) indicate annual average increase (percent) from 1984 to 1995.

encouraged domestic demand for industrial products is expected to cause the electric power demand to grow steadily.

As regards the nonindustrial use electric power demand, there are causes for both increasing and decreasing it. Causes for saving such electric power are the progress of power-saving designed appliances and the spread of energy-saving type buildings. Causes for increasing demand are growth of power consumption stimulated by the elevated income level, new electric appliances spread due to a rapid expansion of tertiary industries, and growth of demand for office buildings and advancement of office automation. Thus, nonindustrial electric power demand, from FY 1984 to 1995, is expected to increase rather favorably, at a rate of 1.9 percent annually.

On the other hand, since the industrial structure tends to shift from the mass electric power consuming type to the small electric power consuming type, the industrial demand for electric power, from FY 1984 to 1995, is anticipated to continue increasing at a rate as low as 1.9 percent yearly.

In consequence, the total electric power demand for FY 1995 is estimated at 769.8 billion kwh (assuming the gross power demand annually increases 2.6 percent on the average).

Out of the above gross electric power demand for that fiscal year, the total power demand by the electric power enterprises will be approximately 705.2 billion kwh, and such demand, from FY 1984 to 1995, is supposed to increase annually 2.7 percent on the average.

(2) Maximum Electric Power Demanded

The maximum electric power demanded is expected to increase favorably mainly because the nonindustrial power demand is growing due to the spreading use of air conditioners. The change of the industrial structure expected to go on means that continuous production operation type industries such as steelmaking and aluminum production are getting smaller in scale, while noncontinuous operation type such as machinery industries are getting larger in size. Hence, the electric power demand by industries, is expected to increase. Accordingly, the maximum electric power demanded for industries is expected to grow at a rate exceeding that of the electric power demand for industries. In consequence, the peak demand is expected to grow to about 1.498 trillion kw for FY 1995 (about 1.4 times as much as FY 1984) as against 1.070 trillion kw for FY 1984. This increase amounts to about 3.1 percent yearly.

(3) Annual Load Factor

The annual load factor is declining year after year, because the use of air conditioners, etc., is spreading, and because the scale ratio of activities of daytime (noncontinuous) manufacturing operation industries is getting higher, as a phenomenon of industrial structure transformation. Though the decline of the annual load factor, to some extent, can be recovered by taking countermeasures such as urging supply-demand adjustment contracts and spreading heat pumps of heat storage type, yet the declining trend of the annual load factor will continue for some time. The percentage of the annual load factor is anticipated to fall to 57.1 percent for FY 1995, as against 59.3 percent for FY 1984. This declining trend of the annual load factor would certainly reduce utilization efficiency of electric power supplying facilities, bringing about a rise in power supply costs. Thus, for solution of the present low load percentage problem, it is necessary to carry on active measures to equalize the power load.

II. Development of Electric Power Sources and Keeping Power Supply and Demand Balanced

Electric power supply must be kept balanced all the time. In order to fulfill their responsibility for continued stable supply of electric power, the electric power enterprises should be prepared to fill such peak power demand as expected or should be prepared to cope with unforeseen occurrence of failure. Namely, they must have an ability to supply adequate extra power which is 8-10 percent of the peak power demand. Every electric power company is planning its power source development project taking these requirements into consideration.

Electric power companies are planning to build new power generation plants in the next 2 fiscal years, in order to maintain stable power supply; and they are going to submit their plan to the Electric Power Source Development Adjustment Deliberative Council. The plan for FY 1986 deliberation is for building 31 power plants generating 5.42 million kw (broken down into 140,000 kw by hydroelectric power generation, 2.18 million kw by thermal power generation, and 3.11 million kw by nuclear power generation). The next plan for FY 1987

Table 2. Development Plan of Electric Power Generation Sources (all electric power enterprises)

(Unit: 10,000 kw)

Type of power generation	Under construc-tion	Ready to start con-struction	FY 86 plan to be deliberated by Council*	FY 87 plan to be deliberated by Council*
Hydroelectric	640 (42)	254 (32)	14 (18)	12 (22)
Ordinary process	55 (34)	26 (29)	14 (18)	12 (22)
Pumping process	585 (8)	228 (3)	- (-)	- (-)
Thermal power	1,435 (26)	1,578 (32)	218 (9)	7 (6)
Coal-using process	361 (7)	1,020 (13)	210 (3)	- (-)
LNG-using process	793 (12)	450 (9)	- (-)	- (-)
Geothermal energy process	- (-)	- (-)	6 (1)	5 (1)
LPG-using process	- (-)	105 (2)	- (-)	- (-)
Oil-using process (except for facilities for internal oil combustion)	280 (7) 280 (6)	3 (8) - (-)	2 (5) - (-)	2 (5) - (-)
Nuclear power	990 (10)	628 (6)	311 (4)	853 (8)
Total	3,065 (78)	2,459 (70)	542 (31)	871 (36)

Figures in ( ) indicate number of electrical power generating units. But, as for hydroelectric process, it shows the number of proposed facility sites.
*Electric Power Generation Sources Development Adjustment Deliberative Council

deliberation is for building 36 power generation plants producing 8.71 million kw (broken down into 120,000 kw by hydroelectric power generation, 70,000 kw by thermal power generation, and 8.53 million kw by nuclear power generation) (see Table 2).

Apart from these planned power plants under submission for Council deliberation, there are 78 power generation plants still under construction. When completed, they will generate 30.65 million kw. Furthermore, there are projects of 70 more power plants, construction of which has not been started yet, although they have already passed the Electric Power Source Development Adjustment Deliberative Council. When completed, these 70 plants will produce 24.59 million kw. As for the construction of the mentioned plants now underway, smooth execution of the construction is to proceed further. As for the 70 plants having passed the Council, but not having started construction yet (ones under preparation for starting construction), construction will be started when the work schedule is made up.

Table 3. August-Time Electric Power Supply Reserve Rate Guessed, Assuming Power Source Development To Be Carried Out as Planned

(Unit: percent)

Area/company	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Eastern area power companies											
Hokkaido Electric	18.1	19.5	19.0	18.2	20.7	18.2	20.3	17.9	16.8	16.0	15.3
Tohoku Electric	6.1	9.9	10.5	8.7	9.3	9.1	8.3	8.7	9.2	8.2	10.6
Tokyo Electric	8.3	9.6	8.8	8.7	8.7	9.0	8.7	8.5	8.6	8.5	8.3
Central area power companies											
Chubu Electric	9.5	9.4	9.8	10.3	9.8	9.6	8.0	10.1	9.1	10.2	10.1
Hokuriku Electric	10.6	10.2	14.3	13.4	8.0	11.2	15.6	11.7	16.8	12.9	9.5
Kansai Electric	11.7	10.9	9.6	9.7	8.5	9.8	10.0	10.0	9.4	9.7	9.1
Western area power companies											
Chugoku Electric	9.6	11.1	11.8	11.0	11.9	11.6	12.4	10.2	11.1	11.9	12.8
Shikoku Electric	19.3	16.7	13.6	14.7	13.9	11.3	8.0	19.3	16.7	13.2	15.5
Kyushu Electric	16.6	14.0	14.8	11.5	10.9	10.3	11.3	11.2	12.3	10.8	12.3
Average power supply reserve rate in 9 leading electric power companies	10.5	10.9	10.6	10.1	9.7	10.0	9.8	10.2	10.1	9.9	10.0
Average power supply reserve rate in all electric power enterprises	11.2	11.4	11.1	10.7	10.7	10.8	10.7	11.0	11.0	10.7	10.8

When construction of all the plants, that is, ones now under construction, those to be started, and ones to be started after FY 1988 have been completed, capacity to supply extra electric power will be ensured, contributing to a stable supply of electricity.

However, should execution of the mentioned power plant projects be behind schedule, it is feared stable supply of electric power might be hindered depending on the demand situations. In order to secure stable supply of power in the future, power source development programs should be carried on, under properly developed plans.

Table 4. Constituent Ratios of Electric Power Sources Development at End of Fiscal Year

(Unit: 10,000 kw)

Electric power source \ FY	End FY 1985 (Actual results)	Percent	End FY 1990	Percent	End FY 1995	Percent	(Material for comparison purpose) Goal set by Supply-Demand Subcommittee of the Council: End of FY 1995	Percent
Hydroelectric	3,319	21.5	3,654	20.4	4,149	20.2	4,200	21
Ordinary process	1,884	12.2	1,954	10.9	2,110	10.3	2,250	11
Pumping process	1,436	9.3	1,701	9.5	2,039	9.9	1,950	10
Thermal power	9,654	62.6	11,117	62.0	11,748	57.2	11,500	56
Coal-using	1,034	6.7	1,424	7.9	2,261	11.0	2,100	10
LNG-using	2,855	18.5	3,868	21.6	4,285	20.9	4,350	21
Geothermal heat	18	0.1	24	0.1	79	0.4	150	0.7
LPG-using	220	1.4	325	1.8	325	1.6	4,900	24
Oil-using	5,526	35.8	5,476	30.6	4,798	23.4		
Nuclear power	2,452	15.9	3,148	17.6	4,648	22.6	4,800	23
Total	15,425	100	17,919	100	20,544	100	20,500	100

Notes: 1. Small family-owned power generation facilities excluded from the listing.
2. Listing of coal-using and LNG-using facilities includes such plants as those burning oil.
3. LNG used for power generation includes natural gas.

III. Development of Nonoil Thermal Power Generation Sources, Mainly of Nuclear Power Generation Sources Urged

After the referred programs have been completed, the structure of power generation ratios of the amount of generated power will be as shown in Figure 1.

MITI is guiding electric power enterprises so that power generation sources may be diversified, on the lines suggested in the interim report made up in November 1983 by the Electric Power Enterprises Affairs Deliberative Council. The mentioned programs to be proposed are observed to have been drawn up fundamentally on the lines suggested by the Council.

Development of the electric power generation sources intended to proceed under these programs, especially of nuclear and coal-using thermal power generation

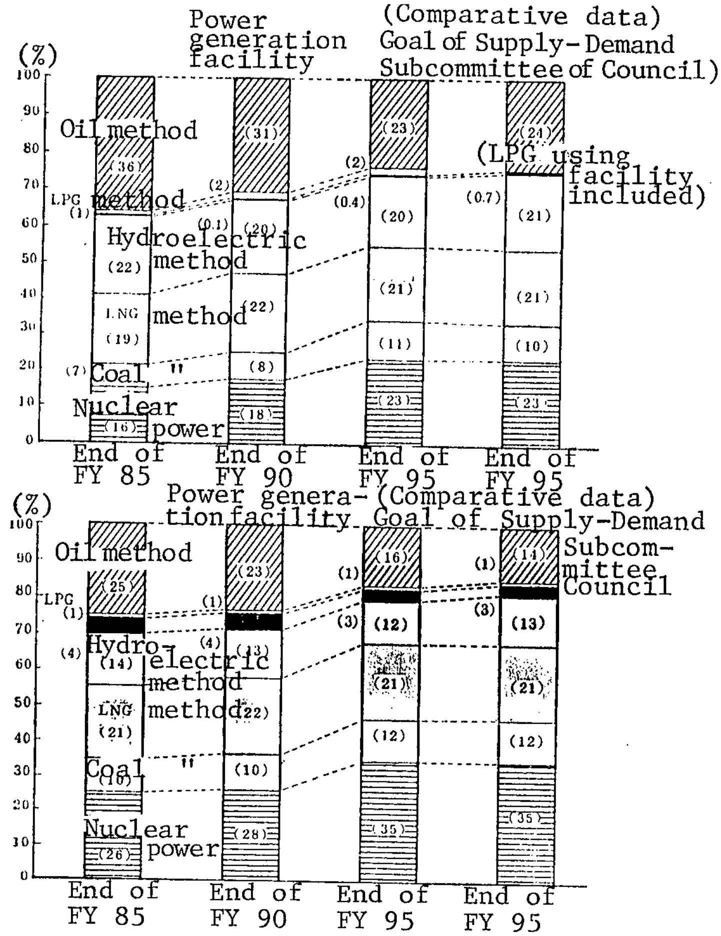

Figure 1. Constituent Ratios in Annual Total Power Generation--
(A) Facility size; (B) Amount of Power Generated

sources and other nonoil using power generation sources, should be enthusiastically promoted. For carrying on the development of power generation sources as planned, various measures must be taken, now and after. For taking such various measures, it is required that the nation's people understand the development well and extend their hearty cooperation.

IV. Reinforcement Plan for Power Transmission and Transforming Facilities

Power generation sources currently are being developed at increasingly remote sites, and on a larger scale in wider regions. Thus, all the more, power transmission and transforming facilities should be strengthened and extended. In order to cope with such power transmission and transforming situations, electric power enterprises intend to reinforce greatly power transmission and transforming facilities both in main and branch systems. The total length of aerial power transmission lines for working voltage of 500,000 V as of the end of FY 1986 is estimated at 3,747 km (see Table 5).

Table 5. Reinforcement Plan of Power Transmission and Transforming Facilities (additional plan to nine leading power companies' power generation source development)

(Unit: km•10,000 kVA)

		Facility (end FY 1985) (estimated from related actual results	Increase end FY 86	Facility (end FY 1986)
Total length of aerial cable	500,000 V	3,718	29	3,747
	187,000 to 275,000 V	12,820	279	13,099
Total length of underground circuit cable for 187,000 to 275,000 V		576	93	669
Capacity of transforming substation	500,000 V	10,547	167	10,714
	187,000 to 275,000 V	12,228	482	12,710

Note: Working voltage represented in table

Table 6. Electric Power Facility Investment Plan (by nine leading power companies)

(Unit: ¥100 million)

Division of investment	FY 85 (estimated from data)	FY 86
Power generation source	11,676	12,191 (4.4)
Investment carried over	11,673	11,670
New investment	3	521
Nonpower generation facility (supporting facility)	18,760	22,557 (20.2)
Total	30,436	34,748 (14.2)

Figures in ( ) indicate percentage of increase from the preceding fiscal year.

V. Facility Investment Plan

The facility investment fund which electric power enterprises are to expand for FY 1986, in the course of carrying on the mentioned programs, is estimated at ¥3.8 trillion. As shown in Table 6, the facility investment to be expended by nine principal electric power comapnies, out of the above amount, is estimated at ¥3.4748 trillion, a rapid increase of 14.2 percent from the amount for FY 1985 which was estimated at ¥3.436 trillion [figures as published].

The reason for this increase in the estimated facility investment costs for the nine enterprises, is that their FY 1986 facility investment includes additional costs for establishing systems to improve electric power supply reliability and for laying underground power distribution cables.

Table of Electric Power Demand Prospect

Fiscal year	Total electric power demand (100 million kwh)		August-time peak power demand (10,000 kw)	
	To be filled by all electric power enterprises	To be filled by 9 leading power companies	To be supplied by all electric power enterprises	To be supplied by 9 leading power companies
FY 1984 (actual data)	5,245	5,009	10,696	10,369
FY 1985 (estimated)	5,396	5,165	10,981	10,657
FY 1986	5,467	5,240	11,290	10,974
FY 1987	5,627	5,395	11,646	11,321
FY 1988	5,775	5,536	12,030	11,697
FY 1989	5,948	5,700	12,432	12,089
FY 1990	6,121	5,870	12,840	12,493
FY 1991	6,298	6,045	13,256	12,905
FY 1992	6,479	6,223	13,680	13,325
FY 1993	6,665	6,407	14,108	13,750
FY 1994	6,855	6,595	14,543	14,181
FY 1995	7,052	6,790	14,981	14,616
Average annual growth (increase) of power demand in FY 1984-FY 1995 (percent)	2.7	2.8	3.1	3.2

Table of Long-Term Balance Between Electric Power Supply and Demand--With Regard to August-Time Peak Demand

	FY	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Hokkaido Electric Power Co.	Peak electric power demand (10,000 kw)	298	306	310	320	330	341	351	362	374	387	400 [30]
	Reserve supply rate (percent)	18.1	19.5	19.0	18.2	20.7	18.2	20.3	17.9	16.8	16.0	15.3
	New principal power source (10,000 kw)	May 85 Tokachi (hydro-electric) 4	Oct 80 Toma-Higashi Atsuma No 2 (coal) 60	Jan 87 Tonosawa (hydro-electric)		Jun 89 Tomari No 1 (nuclear) 57.9		Jun 91 Tomari No 2 (nuclear) 57.9				Mar 95 Oma (ATR) 3.8/60.6
Tohoku Electric Power Co.	Peak electric power demand (10,000 kw)	802	803	829	852	879	903	936	965	995	1,026	1,058 [3.0)
	Reserve supply rate (percent)	6.1	9.9	10.5	8.7	9.3	9.1	8.3	8.7	9.2	8.2	10.6
	New principal power source (10,000 kw)	Dec 84 Higashi-Niigata No 3 (LNG) 109 x ½	May 86 Shin-Okawa (hydro-electric 2.1 Oct 85 Higashi-Niigata No 3 (LNG) 109 x ½		Apr 88 Shimosato (pumping) 50 x ¼	Oct 88 Hondoji (hydro-electric) 7.5 Aug 89 Tadami (hydro-electric) 6.5 x ¼		Oct 90 Daini Yamazato (hydro-electric) 2.29	Dec 91 Noshiro No 1 (coal) 60			Jul 95 Onnagawa No 2 (nuclear) 8.25 Mar 95 Oma (ATR) 6.1/60.6 Oct 94 Shinchi No 1 (coal) 100 x ½ Jul 95 Shimozato 50 x ¼
Tokyo Electric Power Co.	Peak electric power demand (10,000 kw)	3,503	3,612	3,772	3,838	3,949	4,061	4,176	4,295	4,413	4,529	4,642 [2.9]
	Reserve supply rate (percent)	8.3	9.6	8.8	8.7	8.7	9.0	8.7	8.5	8.6	8.5	8.3
	New principal power source (10,000 kw)	May 85 Fukushima two No 3 (nuclear) 110	Dec 85-Jul 86 Futtsu No 1 (LNG) 82.5 Jul 86 Tamahara (pumping) 60 Sep 85 Kashiwazaki-Kariwa (nuclear) 110	Sep-Nov 88 Futtsu No 1 (LNG) 17.5	Sep 87 Higashi-Ogijima (LNG) 100 Sep 87 Fukushima 2 No 4 (nuclear) 110 Feb 88-Aug 88 Futtsu No 2 (LNG) 82.5 Apr 88 Shimozato (pumping) 50 x 3/4 Jul 88 Imaichi (pumping)	Sep-Oct 88 Futtsu No 2 (LNG) 17.5 Jul 89 Hirono No 3 (gas) 100 Aug 89 Tadami (hydro-electric) 6.5 x 3/4	Apr 90 Kashiwazaki-Kariwa No 5 (nuclear) 110 Sep 89 Higashi-Ogishima No 2 (LNG) 100	Oct 90 Kashiwazaki-Kariwa No 2 (nuclear) 110		Jul 93 Kashiwazaki-Kariwa No 3 (nuclear) 110 Mar 93 Hirono No 4 (gas) 100	Jul 94 Kashiwazaki-Kariwa No 4 (nuclear) 110 Jul 94 Jaogawa (pumping) 30	Oct 94 Shinchi No 1 (coal) 100 x ½ Jul 2004 Shimozato (pumping) 50 x 3/4 Mar 95 Oma (ATR) 14.3/60.6

[Continuation of Table of Long-Term Balance...]

	FY	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Chubu Electric Power Co.	Peak electric power demand (10,000 kw)	1,600	1,650	1,710	1,770	1,834	1,901	1,970	2,040	2,111	2,182	2.253 [3.4]
	Reserve supply rate (percent)	9.5	9.4	9.8	10.3	9.8	9.6	8.0	10.1	9.1	10.2	10.1
	New principal power source (10,000 kw)			Jun 87 Owashi-sanden (oil) 50 Jul 87 Shin-kamiaso (hydro-electric) 6.14 Mar 87 Tsuruga No 2 (nuclear) 116 x 0.33	Sep 87 Hamaoka No 3 (nuclear) 110 Mar 88 Yokkaichi No 4 (LNG) 56	Jul 89 Kawagoshi No 1 (LNG) 70 Mar 89 Akashi (hydro-electric) 3.95	Jul 90 Kawagoshi No 2 (LNG) 70	Apr 91 Nikengoya (hydro-electric) 2.6 May 91 Kitamatado (hydro-electric) 2.42 May-Jul 66 Okumino (pumping) 50	Oct 92 Hekinan No 1 (coal) 70 Jun 92 Hekinan No 2 (coal) 70 Apr 92 Akaishi-zawa (hydro-electric) 1.9	Jun 93 Hekinan No 3 (coal) 70	Jul 94 Hamaoka No 4 (nuclear) 113.7	Mar 95 Oma (ATR) 8.3/60.6 Mar 95 Okumino (pumping) 50
Hokuriku Electric Power Co.	Peak electric power demand (10,000 kw)	340	350	362	376	390	405	420	435	451	467	484 [3.5]
	Reserve supply rate (percent)	10.6	10.2	14.3	13.4	8.0	11.2	15.6	11.7	16.8	12.9	9.4
	New principal power source (10,000 kw)			Feb 87 Asahi-Ogawa One (hydro-electric) 4.28 Mar 62 Tsuruga No 2 (nuclear) 116 x 0.34			Mar 90 Nanao-Ota No 1 (LPG) 55	Oct 91 Tsuruga No 1 (coal) 50		Mar 93 Noto No 1 (nuclear) 54		Mar 95 Oma (ATR) 35/60.6
Kansai Electric Power Co.	Peak electric power demand (10,000 kw)	2,128	2,209	2,282	2,372	2,467	2,565	2,664	2,763	2,862	2,963	3,067 [3.7]
	Reserve supply rate (percent)	11.7	10.9	9.6	9.7	8.5	9.8	10.0	10.1	9.4	9.7	9.1
	New principal power source (10,000 kw)	Sep-Nov 84 Mar 85 Gobo Nos 1, 2, 3 (oil)60x3 Jan-Jun 85 Takahama Nos 3,4 (nuclear) 87 x 2)	May 86 Inagawa Two (hydro-electric) 1.91	Aug 87 Akao No 1 (oil) 60 Mar 87 Tsuruga No 2 (nuclear) 116 x 0.33	Feb. 87 Akao No 2 (oil) 60	Aug 89 Miyazu Energy Laboratory (oil) 37.5	Nov 89 Nanko No 1 (LNG) 60 Dec 89 Miyazu Energy Research Laboratory No 2 (oil) 37.5 May 65 Nanko No 2 (LNG) 60	Aug 91 Oii No 3 (nuclear) 118 Nov 90 Nanko No 3 (LNG) 60 Jul 91 Okochi No 1 (pumping) 32	Jun 92 Oii No 4 (nuclear) 118 Dec 91 Okochi No 2 (pumping) 32	Jul 93 Okochi No 3 (pumping) 32	Nov 93 Sakaigawa (hydro-electric) 2.42 Oct 93 Okochi No 4 (pumping) 32	Mar 95 Oma (ATR) 9.6/60.6

[continued]

[Continuation of Table of Long-Term Balance...]

	FY	1985	1986	1987	1988	1989	1990	1991	1992	1983	1994	1995
Chugoku Electric Power Co.	Peak electric power demand (10,000 kw)	727	728	742	762	783	805	828	851	875	900	925 [2.4]
	Reserve supply rate (percent)	9.6	11.1	11.8	11.0	11.9	11.6	12.4	10.2	11.5	11.9	12.8
	New principal power source (10,000 kw)		Apr 86 Shin-Onoda (coal) 50	Feb 87 Shin-Onoda No 2 (coal) 50 Oct 86 Matanogawa (pumping) 30	Oct 87 Matanogawa (pumping) 30	Feb 89 Shimane No 2 (nuclear) 82	Mar 90 Osaki No 1 (LPG) 50 Jul 90 Matsuura No 1 (coal) 50	Sep 90 Yanai No 1 (LNG) 70		Mar 93 Yanai No 2 (LNG) 70	Apr 94 Misumi No 1 (coal) 70	Apr 95 Misumi No 2 (coal) 70 Mar 70 Oma (ATR) 5.2/60.6
Shikoku Electric Power Co.	Peak electric power demand (10,000 kw)	336	352	364	376	388	400	412	424	437	450	464 [2.9]
	Reserve supply rate (percent)	19.3	16.7	13.6	14.7	13.9	11.3	8.0	19.3	16.7	13.2	15.5
	New principal power source (10,000 kw)					Jul 89 Yanagiya (hydro-electric) 2.3	Jul 90 Matsuura No 1 (coal) .5		Mar 92 Igata No 3 (nuclear) 89			Mar 95 Ohma (ATR) 3.8/60.6
Kyushu Electric Power Co.	Peak electric power demand (10,000 kw)	924	964	995	1,031	1,069	1,108	1,148	1,190	1,232	1,277	1,323 [3.3]
	Reserve supply rate (percent)	16.6	14.0	14.8	11.5	10.9	10.3	11.3	11.2	12.3	10.8	12.3
	New principal power source (10,000 kw)	May 85 Oyodogawa 2d (expansion) (hydro-electric) 3.86	Oct 85 Kurokawa 1st (expansion work) (hydro-electric) 2.72 Nov 85 Kochi No 2 (nuclear) 89 Sep 85 Kochi No 2 (LPG) 50	Dec 86 Tenzan No 1 (pumping) 30 May 87 Tenzan No 2 (pumping) 30		Jul 89 Matsuura No 1 (coal) 70	Oct 89 Hattyobara No 2 (geothermal) 5.5 Jul 90 Matsuura No 1 (coal) 40	Jul 91 Reihoku No 1 (coal) 70 Jul 91 Shin-Ohita No 1 (LNG) 69	Dec 91 Shin-Ohita No 2 (LNG) 87/2	Mar 93 Reihoku No 2 (coal) 70 Jul 93 Genkai No 3 (nuclear) 118		Jul 95 Genkai No 4 (nuclear) 118 Mar 95 Ohma (ATR) 6.0/60.6
Totals of the nine companies	Peak electric power demand (10,000 kw)	10,657	10,974	11,321	11,697	12,089	12,493	12,905	13,325	13,750	14,181	14,616 [3.2]
	Supply reserve rate (percent)	10.5	10.9	10.6	10.1	9.7	10.0	9.8	10.2	10.1	9.9	10.0

Note:
1. The underlined electric power sources are those which passed the Electric Power Source Adjustment Deliberative Council.
2. Brackets showing peak electric power demand under FY 1995 indicate average growth rate (percent) FY 1984-FY 1995.
3. New principal power sources listed will start operation within the period from September of preceding year to August of referred fiscal year.
4. Planned power reception rate at Oma (ATR) in FY 1995 is provisional.

20,142/9365
CSO: 4306/2604

BRIEFS

ELECTRIC CHARGE BENDS CERAMIC--A new type of drive mechanism for piezoelectric motors has been developed by the Japanese Toyo Soda Manufacturing Co. It is a laminated ceramic which bends when electric charge is applied to it. The ceramic material consists of a mixture of barium titanate, aluminum, and silicon. Conventional drive mechanisms are usually made of a combination of metal and ceramic. The new material will make it possible to manufacture piezoelectric drive mechanisms for a third of the previous cost. The areas of application will be the regulation of piezoelectric fans and pumps, and the precision positioning of materials in manufacturing in manufacturing industry. [Text] [Stockholm NY TEKNIK in Swedish 15 Jan 87 p 8] /12232

CSO: 3698/241

MITI'S AGENCY OF INDUSTRIAL SCIENCE AND TECHNOLOGY DISCUSSED

Tokyo NIKKO MATERIALS in Japanese Sep 86 pp 10-11

[Interview with Kozo Iizuka, recently installed director of the Agency of Industrial Science and Technology, by Kazumi Otsu]

[Text] As one of our country's aims is to become a "nation of science and technology," the existence of the Agency of Industrial Science and Technology has become increasingly important. With its promotion of many projects, it has led Japan in industrial technology and has made contributions to our industries. Expectations for the agency are rising even higher now that we are moving into the age of high technology. Moreover, demands on the agency are not limited to Japan. Every Asian nation, beginning with the newly industrializing countries (NIC's), has asked the agency for technology transfers.

Despite these demands, the agency's budget increase has been zero for the past several years. An increase cannot be expected for the coming fiscal year either. We will speak with the newly installed agency head, Kozo Iizuka (former director of the National Research Institute of Metrology).

[Otsu] This is a rather banal question, but what are your aspirations as agency head?

[Iizuka] This appointment was really unexpected and I am really overwhelmed. Until now, I could say what I wanted, from the sidelines. Now I am in a position where I will have to relay diverse opinions to the government. I feel deeply the importance of my responsibility. Fortunately, MITI understands the need for research and development for our agency. Our budget demands are a priority issue within MITI.

Efforts Will Go Into Basic Research

[Otsu] What the people are expecting from the agency is the expansion of basic research, a field where we lag behind other countries.

[Iizuka] The importance of basic research is well recognized by MITI. At present, Japanese manufacturing technology is high-lighted throughout the world. We have even reached the point of upsetting the international balance in industry. However, we have only four Nobel Prize winners to our credit. We really have not had the time to develop basic research as we were engaged in a series of important projects which allowed us to catch up with the United States. I am happy that there is a new mood, both here and abroad, which encourages us to develop our own areas in our own way.

Our aim is not the Nobel Prize. However, it is our intention to make a concerted effort to push the development of new fields. We have 2,600 persons working in our 16 test laboratories. I want to try to create an environment conducive to challenging these fields.

[Otsu] Even in the United States, we can see a trend where Nobel Prize winners emerge during times of economic decline.

[Iizuka] I guess in this sense, there is hope for us (he laughs). Unlike the United States, Japan does not have many researchers. Further, as human resources are limited, we are facing a situation where industry and the government are fighting over the recruitment of college graduates. Ultimately, top-level personnel gravitate toward the government in times of economic depression.... (he laughs)

At present, there are 9,000 researchers working in national research institutes and about 15,000 more persons employed in related jobs. However, a reduction of personnel is being demanded. That this reduction is currently underway is a source of concern. A manpower shortage will mean that projects will have priority and basic research will suffer.

[Otsu] Some feel that it might be a good idea to firm up the authority of each government institute director.

[Iizuka] Rather than quibble about the authority of institute directors, I think that the problem can often be ascribed to the national budget and accounting system. For example, our budget for research requests from industry is only 2 million yen. As it concerns overseas traveling expenses for researchers, some feel that disbursements can be made at the discretion of the institute head, but we just cannot do that. We are asking the appropriate offices to refine their policies concerning such issues.

Budget Restrictions Are a Big Headache

[Otsu] Wouldn't this be a good time to reevaluate each project?

[Iizuka] I think that since many projects have reached the mid-point phase, the time has come to reevaluate them. However, we cannot ignore the difficult financial situation and we are really very concerned about how we should respond in the face of budget tightening. We will have to weigh new projects very carefully.

[Otsu] For example, will you be able to follow through with the Agency of Science and Technology's creative science projects?

[Iizuka] We will be able to participate in projects of the Research Development Corporation of Japan, but we will not be able to undertake projects ourselves.

[Otsu] Do you think it is necessary to strengthen cooperation on a fundamental level between the public and private sectors?

[Iizuka] I'd like this at all costs. This type of cooperation is developing steadily right now but I think it's time to take it a step further by considering such measures as a joint-research facilities center.

[Otsu] Quite a few private industrial laboratories are cropping up in Tsukuba.

[Iizuka] Information exchanges between different fields as well as joint research will no doubt become increasingly necessary. If there is usable space, every concern, whether private or governmental, should be allowed to use it.

[Otsu] We sometimes hear that it is difficult for small and mid-size companies to use government research agencies.

[Iizuka] The Agency of Industrial Science and Technology has regional technology centers which are linked to Tsukuba. It is a nationwide network which we would like everyone to take advantage of. Further, we are working toward the realization of industrial technology centers for each prefecture.

[Otsu] Tell us about technology exchanges with other Asian countries and the efforts to internationalize the Agency of Industrial Science and Technology.

[Iizuka] One of the agency's top priorities is international cooperation. International cooperation beginning with the energy problem has been going forward with measures involving international treaties or agreements between two countries. Henceforth, we would like to carry the burden of cooperation in the technology field.

Specifically, requests from newly industrializing nations including developing countries such as Korea are increasing and we would like to handle these requests in a constructive way. Although we have budget restrictions, there aren't many problems, especially where it concerns the basic-technology fields. We would like to start doing what we can. Last year, for example, we advocated a Human Frontier Program.

We Want To Continue Those Projects Presently in Progress

[Otsu] How do you want to develop human resources?

[Iizuka] We wish to start, first of all, by gathering top personnel. Among our research institute professionals, for example, we have many well-qualified people who became disillusioned after accepting jobs with top-level companies. However, students familiar with research institutes well advertised on television gravitate to those places (he laughs). We will work hard to get good personnel by publicizing institutes which are not in the limelight.

[Otsu] What about training after hiring?

[Iizuka] We want to go the route of on-the-job training such as encouraging our employees to take part in overseas' symposia. We have good material in our people and I, for one, am excited about the future.

[Otsu] Aren't there many recruiters from private industry interested in government personnel?

[Iizuka] I think that our human resources have to be good enough to be recruited on an individual basis by private industry (he laughs). A source of personnel is also good for government agencies. However, if recruiting is done mainly in specialized fields such as mechatronics and electronics, we would have a problem.

[Otsu] From 1983, there has been zero growth in the budget and prospects are not good for more allocations in the next fiscal year.

[Iizuka] Frankly, this is an issue which is troubling us day and night. Basically, we have tried to get the understanding of those involved with the budget and the people in general by speaking candidly about this situation. At the very least, we would like to have the zero ceiling on the technology development budget lifted. As for myself, I intend to work to continue those projects which are currently in progress.

12852/8309
CSO: 4306/3113

GOVERNMENT'S INDUSTRIAL STRUCTURAL REFORMS DISCUSSED

Tokyo TSUSAN JANARU in Japanese Dec 86 pp 32-37

[Article by Fukukawa Shingji, Deputy Minister of International Trade and Industry]

[Text] Introduction--Trends toward the 21st Century

As we have entered the 1980's, fundamental structural changes have been occuring in economic and industrial society. In the spring of last year, we challenged industry to clarify such issues as what the essence of these changes was, and what we should be doing to nourish the sprouts of these changes. The outcome of this is "The Basic Structure of the 21st Century Industrial Society," which was issued as a report of the Advisory Council on Industrial Structure.

We believe these changes fall into three general areas. The first is that we are entering into an age in which the support and management of the international economic order are being carried out by groups of principal countries and by concerted action; we have called this change a shift from Pax Americana to Pax Consortis. There are suggestions that Japan has used this international economic order as a kind of given, but now, changing this conception, we believe that Japan should share the responsibilities for the support of the international economic order and should contribute to common international resources. In view of Japan's external trade imbalance, Japan must strive to rectify this through cooperation with concerned countries.

The second change is that technological renewal and the information revolution, which are referred to as the third industrial revolution, are progressing, and industrial society is shifting to new systems. One characteristic of this is the transition from the so-called heavy, densely developed large-scale industries such as steel and chemicals to light, sparse and small-scale industries, such as semiconductors, new materials, and biotechnology. The appearance of new material and the emergence of shoots from these new materials today, as well as computers and communications technology of course, is unmistakeably the change from the large-volume production forms based on "economies of scale" representative of 20th Century industrial manufacturing systems to multi-product small-scale production systems for the 21st century, based on "economies of scope" and capable of production of a wide range of products. From this have sprung new technologies through fusing diverse technologies such as microelectronics, new materials and biotechnology, and this has become a period of the multiplication of new technolgies.

The third change is the birth of new lifestyles, i.e., new life and culture, through such environmental changes the spread of information systems, cultural directions of people, the strengthening of the desire for spiritual fulfillment, and the social advancement of women. I have pointed out that the recent hit products have provided esthetic recreation (beautiful designs, stimuli to the emotions, joy of the spirit of play, and novelty of creativity), and these are probably the expressions of such trends.

In view of these three changes, our principal interest is how we will fuse and develop such trends as we move into the 21st century.

II. The Trade Imbalance Problem and Paths to its Solution

1. The imbalances in international economic society

As we look at the present state of the world's economy, various imbalances exist.

The first of these is the current account imbalances among the industrialized nations. In the background of this, one can point to the fact that exchange rates have been largely controlled by capital transactions and were not able to have a sufficient effect on the adjustment of current account balance, and to the fact that there were such primary causes as imbalances in the savings and investment among the countries concerned and intimately related differences of macroeconomic policy. Since the G5 meeting of September 1985, exchange rates have been changing toward a cheaper dollar, and one of the conditions for the improvement of the trade imbalance has been worked out; but a comprehensive approach is required to rectify the imbalances.

The second imbalance is the widening of the gap in economic strength between the north and the south. In the 1970s, there was movement toward closing this gap, but a widening of the difference appeared again in the 1980s. In particular, the developing nations and the natural resource producing countries were forced into economic stagnation by the drop in the prices of primary products, especially petroleum.

The third area is the maldistribution of assets and debts symbolized by the expansion of the accumulated debt of the developing nations. In some of the developed nations, one sees a trend toward surplus funds, but in the regional developing nations there have been shortages of the funds necessary to make payments overseas.

Since the advent of GATT (General Agreement on Tariffs and Trade) and the IMF (International Monetary Fund), national borders in the economic field have been falling due to the efforts of the nations to free themselves across the various economic fields, such as trade, technology, capital, and finance; but we believe that these imbalances suggest that, at the same time we are working out the support and strengthening of the free trade system, supplementary measures have become vital to facilitate cooperation in macroeconomic policy and recycling of capital.

2. The problem of imbalances in the Japanese economy

If we next consider the problem of imbalances found in the Japanese economy, the first of these is the current account balance which has been criticized by the various foreign countries. In the background of this problem lie factors like industrial structure as well as causes such as the decline in the regulatory functions of exchange rates and the gap between supply and demand on the macro-economic side. This is because the Japanese industrial structure has developed a tendency to generate trade surpluses easily. According to the Trade and Commerce White Paper, an analysis of the period since 1973 shows that the elasticity of Japanese export income is 1.7, while the elasticity of import income is 0.7. On the other hand, the elasticity of U.S. export income is 1.1, while the elasticity of the import income is 2.3; these figures are 1.2 and 2.0 for West Germany. If we compare these, it is clear that the elasticity of Japanese imports and exports contrasts strikingly.

It has been suggested that, as a policy for ameliorating the trade imbalances, "the fundamental conception of 21st century industrial society" is the advance of imports into Japan and a general internationalization of the Japanese market; thus we need to make a structural response toward expansion of domestic demand simultaneously with a drive for an international division of production through such means as direct investment abroad.

The second issue is the current account imbalance and the intimately connected imbalance of savings and investment. If we can raise the yen rate by artificial means, then theoretically the imbalance of savings and investment ought to decrease, but of course there are undesirable aspects to such a deflationary solution both domestically and internationally. Accordingly, it is extremely important to respond by increasing investment. There are many ways of achieving this, such as providing for public facilities and residential conditions, which now lag behind other foreign countries, or providing new types of industrial facilities such as information linkages, international exchanges, research and development, leisure and new transportation systems.

The third element is the economic discrepancy between the central areas and the provinces. The 1970s were called the "age of the provinces," and the economic level of the provinces showed steady improvements; but since public investment has been curbed due to austerity measures for fiscal rebuilding, the gap has begun to widen again. As a consequence of the fundamental development of information systems, the accumulation of information in the major cities is relatively high, the concentration into the major cities becomes more pronounced, and land prices in Tokyo have exhibited an extraordinary jump. From a long-term point of view, in addition to the problem of redeveloping the major cities, it is important to grapple with the furthering of second industries and third industries in the rural areas.

Fourth is the relatively low level of basic research in research activities. Japan's outlays for research and development expenditures in 1984 totaled 9 trillion 893 billion 900 million yen (roughly one-third of the total in the United States), but if we examine the contents of this, the bulk of it was research and development for product applications, while the weight of basic research was 13.6 percent, a very low level in comparison with the various foreign countries. There is ever-stronger criticism that Japan does not contribute to basic academic research internationally; but if one considers the recent technological accumulation, it is time to devote more resources to basic research on fundamental technologies.

Fifth, there is a large gap between lifestyle and the level of economic activity in social activity. Despite the fact that the per capita national income calculated on the basis of the rise in the price of the yen has exceeded that of the United States, one can say that there is a deep conviction that the Japanese do not feel this in actuality. This is expressed in the length of time spent working and the fact that housing conditions are bad, and in the soaring land prices in the major cities as well as in the high cost of agricultural products in comparison with other countries. As a result of examining these sorts of phenomena, we feel it is necessary to try to locate the systemic causes.

III. Structural Adjustment and the Role of Trade and Industrial Policy

As we approach the 21st century, how can we solve the several structural imbalances we face in light of these three major changes? In order to grow into the 21st century, we should seek a way to solve our problems on the basis of an economic plus sum game; and it is important to respect free markets and market functions, to pursue creative economic growth through technological innovation, to achieve international cooperation concerning economic activity and policy implementation, and to contribute to the progress of international society.

At the end of August 1986, MITI pulled together the key policy issues for 1987 in a report entitled "Toward a Framework for a New Economic and Industrial Society Aimed at Creative Development;" let us now speak of the concrete policy details along the lines of the report.

1. Respecting Free Market Functions and Strengthening the Free Market

The basis of industrial policy lies in respecting the functions of the market. Of course this is premised on the exchange rate's accurately reflecting the fundamentals. For this reason, exchange policy obtained through international cooperation and the management of policies to regulate demand are indispensible, but these depend on the great expectations for policy coordination for the G7 administration through the agreements of the Tokyo Summit.

The recent rise in the yen has been intended to clearly change the trend of economic activity. Due to a rise in the price of the yen of nearly 100 points since the fall of 1985, the volume of exports has dropped below the level of last year; it has fallen by over 20 percent since last summer. Thus, although the export volume based to a dollar index has grown, which is consistent with the effects of the so-called J-curve, we believe that in the future the figures will decline on a dollar base as well. On a volume base, imports have continued the increase, primarily in the import of manufactured goods; the ratio of imports of manufactured items has recently climbed to 42 percent, and it is steadily approaching the roughly 50 percent in the EC and roughly 70 percent in the United States.

At the outset, in order that each nation can vitalize the market functions and continue efficient economic management, it is above all important to challenge protectionism and to support the free market system. From this standpoint, it was an epoch-making development in the GATT Soecial Ministerial Conference held recently to have been able to achieve a declaration calling for the beginning of a new round.

2. Industrial Structure and the Development of International Cooperation

a. Promotion of the International Division of Labor

In rectifying the foreign trade imbalances, it will be effective if we proceed with the international division of labor. For that purpose it is necessary to plan to promote imports of manufactured goods and to support of investment flows.

In order to plan to promote imports of manufactured items as early as next year, our policy is to promote such activities as import promotion operations such as import bazaars, the expansion of low interest financing for import of manufactured goods through the Export-Import Bank, the expansion by the Development Bank of financing to adjust the import system, and the building of import-related insurance.

Direct investment overseas has been accelerating in response to changes in the competitive conditions due to the rise of the yen, but direct investment overseas is effective in curbing exports from local production and in promoting imports of manufactured items suited to Japanese markets, as well as to contributing to the generation of employment opportunities of the other nation. While we consider such things as the effects in domestic employment over the next year, in order to further direct investment overseas, we will be arranging an expansion of the financial framework for funding for foreign investment through the Export Import Bank. In addition, with respect to an insurance system for transactions overseas, we are investigating business cooperation as a multi-national investment guarantee association (MIGA), the expansion of a foreign investment insurance system including an increase in compensation risk, as well as the creation of mediation trade insurance for export promotion for the developing countries.

At the same time, in order to further industrial cooperation with the EC, we will be trying to promote the establishment of Japan-EC Industrial Cooperation Center (tentative name) to carry out operations such as Japanese language training, and training in such areas as Japanese production administration, management of product quality, and Japanese management.

Toward the developing countries, particularly to aid the industrialization of the Asian nations, we will be trying to promote new comprehensive Asian regional industrialization plans that will comprehensively introduce cooperation in marketing, personnel cooperation in industrial technology, and cooperation in industrial technology, and cooperation in financing through yen loans.

b. Promoting a Revolution in Business

We have already noted that the exchange rate exercises a large influence on business operations and industrial structure. It is generally supposed that in structural changes of industry social costs such as the generation of unemployment increase, or else there is an increase in political activities seeking protectionism. Thus, in addition to structural responses to the expansion of domestic demand to be mentioned later, and the development of new fields for development, it is necessary to take supplementary measures to ensure that the business revolution comes off smoothly.

From among the fields thathave become indispensible, several have the capability to function in this way: a shift in employment within the firm to transfer the workers to growth sectors; the expansion of investment in new operational sectors for the purpose of absorbing unemployment; promotion of siting for new industries in locations that have high concentrations of unemployed; and debt guarantees for the purpose of eliminating facilities included in mortgates. To do these things, we would like to promote the establishment of an economic structural adjustment fund (provisional name) through government donations of 12 billion yen, and an operation that will further smooth structural adjustment.

Moreover, for small- and medium-sized industries the resources of the industries are meager at best, and trying to move forward with structural adjustment is accompanied by all the more difficulties. Therefore, in order to smooth out the transition of the enterprises from dependence on exports to dependence on internal demands, in addition to comprehensively promoting a thorough policy with regard to technological leadership, the nourishment of human talent, and finance, it is necessary to have thorough policies for the promotion of new type of industries, especially for special regions that are influenced by the structural adjustment. Such policy measures are not intended to preserve small- and medium-sized industries in the traditional form, but rather to contribute to making a more realistic correction of the foreign imbalance.

c. Structural responses to the expansion of domestic demand

In order to advance the structural revolution smoothly, it is necessary to increase the size of the domestic market.

If we examine recent domestic business trends, we see that a deflationary trend has been evident since around the summer of this year (1986), and major effects such as worsening of profitability and postponement of investment are appearing even in comparatively competitive processing and assembly industries such as automobiles and electrical machinery, basic materials industries and import-competitive industries that are highly dependent on exports. In order to control this sort of high-yen deflation and work out corrections to the foreign trade imbalances, it is absolutely indispensible that we expand domestic demand and achieve economic growth pegged at 4 percent. This past 9 September, the government decided on a comprehensive economic policy and began to grapple with various measures, including increases in public works, the completion of measures for housing, the promotion of investment in private equipment, promotion of the active application of private applications, restoration of profit margins under the high yen, the fulfillment of policies for small- and medium-sized industries, and the forceful operation of financial policies. The scale of operations for policies for the expansion of domestic demand has come to a total of over 3.6 trillion yen through an operation total of 3 trillion yen for public investment and residential construction and an operational scale of 600 billion yen due to increases in capital investment for the promotion of public activities, electric power and gas facilities. The Japanese national fiscal situation is currently precarious, and thus it is extremely important to provide inspiration for the total internal demand while a maximum private effort is made through the greatest possible cooperation between industry and the general public.

There are several points I would like to try to make concerning policies to increase domestic demand, and the first two of these are the problems of residential housing and urban reconstruction. Japan uses only 2.4 percent of its land for residences. Moreover, 34 percent of the land within citified areas is agricultural land. If we look at these figures, there is a large possiblity of increasing the supply of residential land, and if regulations governing construction are eased, then the demand for residences and construction materials should gradually expand; and if inducement policies are realized through tax reductions and other means, then I believe that the provision of residences and cities will accelerate. Through these means, demand will appear for related facilities and consumer durables. In this area, MITI has devoted efforts aimed at the rationalization of production through the prefabrication of housing, the development of residential construction materials that will lead to improvements in existing housing, and technological development intended to provide effective new types of mass housing; MITI has also established policies to promote operations and said to be aimed at providing facilities for office environments that are both pleasant and suited to intelligent production systems.

The second element in policies for increasing demand is the establishment of the infrastructure for a new type of industrial society. The institutions I want to consider are institutions for joint research, the training of technologists, and the accumulation and exchange of technical data; institutions for international exhibition cities and an international parliament; and institutions of community including new media. These all have a public character, but they can be provided by employing the strengths of the private sector. The scheme for accomplishing this was already enacted in May of this year (1986) with the "Public Activities Law" (Minkatsu-ho), and in this present policy we are working toward promotion and early execution through large incentives for arising from budget measures designed to promote the actualization of the operations in question, and from the expansion of financing and tax regulation measures. We are considering future expansions in the provision of world business zones (international business exchange zones) and facilities related to the development of leisure time.

The third point is the stimulation of provincial or regional economies. Our policy is to reverse the concentration of economic resources in centralized areas, to consider such concepts as revolutions in industrial structure, technological revolutions and information, and to promote the development in regional areas of industry and facilities related to modern life-styles.

Point four is to solidify consumer demand. In this regard it is indispensible first to improve residences and the living environment and to shorten work hours. Modern consumer needs have become increasingly varied, for health, sports, education, and creativity, and in response to these new service businesses are on the road to development. By realizing the hard and soft technologies for these, it is possible to unearth new consumer demands. There is also a large possibility that the impact of internationalization, deployment of information systems, and technological revolution will call new service fields into existence; the development of these new services will contribute to the opening of new industrial frontiers and to the shift to economic structures related to domestic demand. Thus we are working toward the comprehensive promotion of the establishment of debt guarantee systems and human resource promotion in information, finances and credit for these new businesses.

3. The Expansion of New Industrial Frontiers through Technological Development

Research and development of technological fields not only contributes to the expansion of new industrial frontiers, but also leads to the creative development of the world economy; similarly, it is important in that it supports Japan's activity in economics and society and offsets the reductions of employment opportunities caused by the international division of labor.

In the future, MITI will stress the development of basic research on fundamental technologies; it will aggressively support the development of technologies related to materials with new capabilities, the fifth generation computer, new materials such as fine ceramics, and biotechnology.

There are also active policies for joint international research and international research exchanges; as a part of these, Japan has announced to the world its large-scale international common research program (Human Frontier Science Program) in those areas of applied technology with vital functions thought to be the mainstream for the technologies of the 21st century, and the active pursuit of these goals is now being worked out. This project is basic research that will clarify the many extraordinary vital functions (replacement functions, motion functions, nervous functions, cognnitive functions) and apply these functions to the technology of fields of manufacturing; the project is both monumental and ambitious. MITI should publicize this program to the world, and the officials in charge have toured Western Europe and the United States, but this has aroused high costs and great expectations from many technical researchers abroad such as Nobel prize winners. Next year MITI plans to pursue a feasibility study on plans for this with the cooperation of both the concerned ministries and agencies and domestic and foreign research organizations.

IV. In Conclusion--The Significance of Policy Adjustment

Finally, I would like to emphasize the necessity for policy adjustment. Today the exchange rate has become so delicate that it fluctuates as a result of statements by influential people. In order to stabilize the exchange rate against speculators, it is necessary for the concerned countries to cooperate and to issue countermeasures early on. Moreover, even if the dollar rate slips vis-a-vis the yen or the mark, if the United States continues to ring up fiscal deficits that exceed each year's forecasts and to invest more than is saved, then the U.S. deficit will not be easily settled. And thus if such an influential country makes an abrupt policy change, it will inevitably cause chaos in the international economy.

Another point I wish to underline is that, whenever we consider policy coordination, we cannot ignore problems of industrial structure separate from exchange rate policy or macroeconomic policy. Industrial structure is of course heavily controlled by market functions, but it is also affected by technological strength, labor quality, and managerial capability. If the EC tried to reduce structural unemployment, it would have to consider providing investment and the environment for it to cause active development. If the United States were to try to call back the productive resources that have moved overseas, it would have to have a tax system and different investment conditions.

In order to plan the active development of today's industrial society, I believe it will be necessary to put together Adam Smith's "invisible hand" of the market and the "visible hand" of policy based on our insights, wisdom and judgment. I believe that international policy research will be even more important in the future, and from this point of view, in order to further theoretical research on macroeconomic policy and industrial policy with an international outlook, we are moving ahead with the preparations for the establishment of a Trade and Industry Research Center (tentative name) for next year. At the same time we plan to progress with joint international research and the convening of international symposia with mixtures of researchers and officials of the concerned policy offices.

Finally, to close my talk, I would like to stress that, for the sake of the creative development of the global society of the 21st century, it is necessary to construct a scheme for broad international policy cooperation.

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ALCOHOL ENGINE IN AUTOMOBILE RESEARCH INSTITUTE STUDIED

Technical Studies Review

Tokyo NAINEN KIKAN in Japanese Sep 86 pp 9-12

[Article by Kim Yongkil: "JARI Technical Studies Review on Alcohol Fuels Utilization in Automobiles"]

[Text] 1. Introduction

The studies of alcohol fuels conducted in the Japan Automobile Research Institute (JARI) can be categorized mainly into two parts. The first is the study of utilization technology of alcohol fuel, i.e., the research of an alcohol engine. The second is to study and investigate the feasibility of the application of alcohol fuel for an automobile.

The former is independent study for JARI; the latter is study requested to clarify feasibility by the Agency of National Resources and Energy, and the Ministry of International Trade and Industry (MITI), in cooperation with related industries such as automobile and oil. The study of oil-substitute energy technology application development, conducted under a grant-in-aid from the Agency of Industrial Science and Technology, is also included in the former.

The independent studies have been conducted by JARI since April 1973, preceding the First Oil Shock. The study of alcohol fuel over the past 13 years in this institute is outlined below.

2. Study of Utilization Technology of Alcohol Fuel

Table 1 shows the circumstances and summary of the study. In this table, the studies conducted by this institute since 1973 are classified and listed by year.

The classification of various studies is as follows:

--Experimental investigation study for conventional automobiles;
--Basic study with application of a single-cylinder engine regarding neat straight utilization;
--Study of the application of the result of a single-cylinder engine for

Table 1. Research Circumstances and Summary of Alcohol Fuel Utilization Techniques in JARI

Year \ Purpose and kinds of studies	Studies to clear possibility of alcohol fuel utilization techniques and potential for a future engine: Experimental investigation study	Basic research for neat straight utilization (single cylindered engine base)	Applicational research for neat straight utilization (research aiming at prototype of multiple cylindered engine system)	Developmental (basic) research for neat straight utilization (research aiming at prototype of vehicle system)	Comments (Note: No comments means that study or research activity carried out as independent work in JARI)
1973	[1] Study of low pollution neat utilization engine: oResearch targeted to clear Muskie levels of exhaust gas standards ① Study of engine for methanol-water automobile				
1974–1979	[2] Optimum study of oil-substitute, low-energy consumption rate and low-pollution engine and alcohol engine	2.1 Study of neat methanol spark ignition engine ① Influence of nonevaporation fuel under fuel supplying conditions ② Method to supply fuel, effect of cylinder injection ③ Optimum compression ratio ④ Fuel supply method, effect of boiling temperature with decrease of pressure by cylinder injection ⑤ Starting methods (method to add substances of low boiling temperature, supersonic fine graining method) ⑥ Stratified intake combustion method (single chamber type) utilizing reduced pressure boiling spray ⑦ Composition of exhaust gas, treatment of aldehyde ⑧ Investigation of high-compression ratio stratified intake combustion method (with subchamber) ⑨ Investigation of potential for neat methanol spark ignition engine			④ and ⑤ in [2]: Study conducted as supplementary enterprise from Japan Auto-Race Association ⑧ and ⑨ in [2]: Study conducted as trust research, "Study of Future Fuel"

[continued]

[Continuation of Table 1]

Purpose and kinds of studies / Year	Studies to clear possibility of alcohol fuel utilization techniques and potential for a future engine: Experimental investigation study	Basic research for neat straight utilization (single cylindered engine base)	Application research for neat straight utilization (research aiming at prototype of multiple cylindered engine system)	Developmental (basic) research for neat straight utilization (research aiming at prototype of vehicle system)	Comments (Note: No comments means that study or research activity carried out as independent work in JARI)
1980 1981 1982	[4] Subjected to present automobiles, mixture utilization feasibility investigation ① Compatibility investigation on application of alcohol mixture gasoline to present automobiles (period of 3 years) (subjected to M5-M20, E10-E20) ② Compatibility investigation on application of alcohol mixture gas oil to present automobiles (M5, M10, E5, E10)		[3.1] Gasoline-substitute dissociated methanol small-sized engine system ① Investigation of dissociation method, basic characteristics of dissociated engine system ② Design and trial manufacture of main components ③ Improvement of components, examination, and refining synthetic evaluation of engine system	[3.2] Vehicle system with gas oil-substitute methanol-gas oil dual fuel injection compression ignition middle-sized engine ① Combustion characteristics, selection of main engine specifications, selection of fuel-injection system specifications ② Refinement of engine system under all loading conditions regarding fuel consumption rate and exhaust emission ③ Refinement of vehicle system, including transitional condition	[3.1] and [3.2]: Study conducted under a grant-in-aid supported by Agency of Industrial Science and Technology, titled "Oil-substitute Energy-Related Technology Application Development" [4]: Study conducted in cooperation with the automobile industries (9 car makers, 4 motorcycle makers, 16 part suppliers), and the oil industry as trust enterprise from the Agency of Natural Resources and Energy
1983 1984 1985	[6] Same as the above ③ Compatibility investigation on application of low mixture rate, alcohol mixtured gasoline to present automobiles (M3) * M5: 5-percent methanol content, E10: 10-percent ethanol content			[5] Vehicle system with gas oil-substitute dissociated methanol large-sized engine ① Basic design of spark assist method and dissociated gas inhalation method, and trial manufacture of main components ② Component improvement, refinement, system evaluation and selection of both engine systems ③ Refining synthetic evaluation as vehicle system of selected engine	[5]: Study conducted under grant-in-aid supported by Agency of Industrial Science and Technology titled "Oil-Substitute Energy-Related Technology Application Development" in 1983 and 1984; this project is a 3-year plan [6]: Continuation of [4], it is expected to be continued in 1984

the multiple-cylinder engine system regarding neat straight utilization;
--Basic developmental study for the vehicle system based on extension of the multiple-cylinder engine system regarding neat straight utilization.

The original study conducted in 1973 was to determine the possibility of achieving the Muskie level--the target of the exhaust gas standards--under the guidance of Professor Hirao of Tokyo University, using a conventional gasoline automobile. It was the experimental investigation study about the possibility of a low-pollution neat utilized engine.

The results of the previous study indicated that the use of methanol-water fuel composed of methanol with 30 percent water had the possibility to achieve the Muskie level for NO_x, CO, and HC.

Soon after the study started, the First Oil Shock happened in October 1973. As supply and demand for oil became stringent, the request for elimination and reduction of energy became stronger. The study of low pollution gradually took over from the reduction of oil-substitute low energy consumption rate. A change in the point of the study was well observed. Under these circumstances, the study of an alcohol engine in this institute changed from step [1] to step [2] as indicated in Table 1.

Since 1974, basic study about neat straight utilization started putting emphasis on the reduction of oil consumption and low energy consumption rate. The study of fuel supply method, combustion, and compression ratio in order to utilize alcohol with the greatest efficiency was conducted by using a single-cylinder engine. In the beginning, the neat methanol spark ignition engine was the objective. After potential of this engine system was almost realized, the study of the application of alcohol in a diesel engine was carried out.

There were various methods to approach a diesel engine. However, based upon the judgment that success of a diesel engine system was stability of ignition combustion, the alcohol-gas oil dual fuel-injection method giving better stability was selected. Then, the basic study for ethanol had started.

From the results of basic studies ① to ⑨ of [2.1] listed in Table 1, it was concluded that the neat methanol spark ignition engine could satisfy the 1978 exhaust gas standards for a gasoline engine vehicle, as well as accomplish the same energy consumption ratio as that of a diesel engine with a subcombustion chamber by the use of lean mixture gas and the increase of compression ratio. It was also concluded that this engine could have potential as a practical engine in the future.

Regarding [2.2], it was concluded that the dual fuel-injection method showed cleaner exhaust gas than a diesel engine vehicle, and the same energy consumption ratio as that of a diesel engine vehicle. At the same time, this method allowed the drastic gas oil-substitute rate.

During the Second Oil Shock, originated from a political change of government in Iran, demand and supply for oil became extremely strained, and social needs for elimination and reduction of oil and energy became more serious. As a part of practical application development of oil-substitute energy-related technologies, methanol exchange technology was taken up as an important item to be studied by the Agency of Industrial Science and Technology in MITI.

Since it was impossible to clarify the possibility of neat straight utilization technology and its potential as a future engine within the area of conventional basic study, adoption of the study on utilization technology of methanol fuel proposed by JARI for methanol exchange studied in the Agency of Industrial Science and Technology brought a good opportunity to advance application R&D study.

In 1980, JARI started the following two approaches based on the past fundamental study under a grant-in-aid supported by the Agency of Industrial Science and Technology aiming at practical development of methanol fuel utilization technology:

[3.1]: Gasoline-substitute dissociated methanol small-sized spark ignition engine system.

[3.2]: Vehicle system with gas oil-substitute methanol-gas oil dual fuel middle-sized compression ignition engine.

The former is based on the basic study of [2.1], and the latter is based on that of [2.2].

[3.1] is the system aiming at an improvement in thermal efficiency of 20 percent by adding a dissociated methanol device with exhaust heat and a starting device of the catalytic method onto a neat methanol engine which is the outcome of this study; also by utilizing the improved starting characteristics of a conventional neat methanol engine, which was the basic subject and merit of dissociated methanol.

[3.2] views the possibility of drastic gas oil saving as a gas oil-substitute engine, and at the same time a vehicle with a low-pollution engine with less generation of particulates.

The studies described above were carried out between 1982 and 1985. The prototype of each system was developed. Through these, a part of the possibility of anticipated performance and technologies of the systems became clear.

With respect to the dissociated methanol engine system, the following points were discovered:

1) With preparation of a starting device of the catalytic method, it is possible to start an engine with only methanol, without using annexing fuel under the environmental conditions in Japan. The prospect to solve problems such as exhaust composition, fuel consumption rate, and driveability at a cold state just after engine starting can almost be seen.

2) With preparation of a dissociated exhaust heat device, an improvement in fuel consumption rate by 20 percent in terms of gasoline conversion can be achieved when compared with that of a gasoline engine.

3) A dissociated engine system and total dissociated methanol fuel under all conditions, from no-load to full-load, do not always give the best result with respect to thermal efficiency and output performance. This is because there is occurrence of negative factors such as abnormal combustion, such as back-fire originated from generated hydrogen gas, and a reduction in volume efficiency along with the increase of the amount of inspired gas. The optimum dissociation ratio exists depending on various loading conditions under appropriate balance with these negative factors.

4) Because of the reason described in 3), improvement of the performance of the dissociated engine system can be expected from improvement of the performance of the dissociated exhaust heat device.

Regarding the methanol-gas oil dual fuel-injection method compressive ignition engine for a vehicle system, it will be almost completed within the near future as the application of methanol to utilization technology for the compressive ignition engine. It was confirmed that drastic gas-oil saving and high thermal efficiency were achieved in avoiding the difficulty of compression ignition originated in methanol, and by utilizing stability of ignition and combustion due to gas-oil, and low-pollution combustion due to methanol, along with getting satisfaction for clean exhaust. However, regarding the disadvantage of adding the fuel-injection system, its synthetic evaluation has to wait until the stage where further advancement of utilization technology is completed.

From 1983 to 1985, JARI received a grant-in-aid from the Agency of Industrial Science and Technology. Practical application development study on the gas oil-substitute dissociated methanol large-sized diesel engine, i.e., item [5] listed in Table 1, was carried out. The purpose and objective of [5] is to apply the advantage of dissociated methanol to a large-sized diesel engine.

The developmental study was conducted under the following two steps:

1) Study for a direct-injection spark ignition method methanol large-sized engine;

2) Study for a spark-injection method dissociated methanol gas large-sized engine.

Through these studies, emphasis was placed on the development of a combustion system which enables injection of neat methanol directly, and to obtain stable ignition and combustion on the base of a large-sized engine in the case of 1). On the other hand, emphasis was placed on the development of a dissociated gas engine system which makes the most efficient use of dissociated gas by adding the newly developed dissociated exhaust heat device based on 1) in the case of 2).

The following results of the study [5] were obtained:

1) As utilization technology for the application of methanol fuel to the diesel type, it was determined to be one of the most prominent methods from the following respects:

--Gas oil-substitute rate;
--Thermal efficiency or heat consumption rate;
--Purity of exhaust gas;
--Easiness to start.

2) One feature of this dissociation method is the capability to change properly a fuel supply system and a combustion system depending on operational conditions. For instance, if liquefied methanol at starting, dissociated gas during partial-loading after warming up, and liquefied methanol during full-loading are applied, respectively, corresponding to the conditions, it is possible to accomplish cleaner exhaust gas than gasoline and better thermal efficiency than diesel.

3) A defect of the system described in 2) is the necessity of complicated control of a fuel supply system and combustion system. Success in improvement of the control system and exchange performance of the dissociated exhaust heat device holds a key to the practical application of this dissociated method in the future.

3. Feasibility Investigation for Utilization of Alcohol Fuel in Existing Automobiles

[4] and [6] in Table 1 are feasibility investigations on the so-called mixture utilization, i.e., the utilization of alcohol mixed with presently available fuels such as gasoline and gas oil for existing automobiles.

An investigation was carried out pursuant to a request from the Agency of Natural Resources and Energy in cooperation with related industries, such as the automobile industry and the oil industry.

Regarding [4], an investigation was made for middle density alcohol-gasoline blends (5-20 percent methanol-gasoline blend, 10-20 percent ethanol-gasoline blend) between 1980-1982.

The result of the investigation indicated that unqualified vehicles existed with regard to compatibility to exhaust gas standards, operation at normal and high temperature ranges, and parts being composed of a fuel system in the case for 15-percent methanol-gasoline blend (M15). It was also determined regarding 5-percent methanol (M5) and 10-percent ethanol (E10) blended gasoline that their influence decreased when compared with that of M15, but could not be ignored. In the case of alcohol blended gas oil, its compatibility was worse than M15.

[6] is a feasibility investigation on low density alcohol blended gasoline. An investigation on 3-percent methanol blended gasoline (M3) was started in

1983. Presently, a continuous investigation on the durability and reliability of parts for the fuel system is taking place.

In June 1985, reconsideration of energy and substituted-fuel policy was carried out by the Agency of Natural Resources and Energy of MITI, and future visions of new energy introduction were announced. The direction of developmental introduction of methanol fuel as a substitute for automobiles was indicated. As utilization technology of high-density methanol fuel, feasibility investigation of the Otto type and the diesel type has been started.

Henceforth, similar to [4] and [6], feasibility investigation will be conducted under the following steps in cooperation with the automobile industry and the oil industry:

--Study of fuel specification and engine specification;

--Development of utilization technology;

--Fleet test.

Recently, joint research on the utilization of alcohol fuel for automobiles was adopted in the International Energy Association (IEA). Under participation in planning from the United States, Sweden, Canada, New Zealand, and Japan (NEDO, JARI, and ATA), it can be considered that joint research for unknown subjects will be carried out in the future.

4. Conclusions

Presently, there is high expectation for methanol fuel for automobiles in Japan. The reasons for such expectation are as follows:

--possibility to eliminate and/or to reduce the amount of energy;
--pollution reduction.

The policy of the Ministry of Transport and Environment Energy stresses pollution reduction. Similar circumstances are seen in the CEC project of California in the United States.

The urgent situation with respect to energy reduction has become less important due mainly to a recent decrease in the price of crude oil.

In any event, both energy reduction and pollution reduction have close concern with each other. Steady feasibility study is indispensable in both respects. Developmental investigation is greatly expected in the future.

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Dissociated-Methanol Gas Vehicle

Tokyo NAINEN KIKAN in Japanese Sep 86 pp 13-20

[Article by Tadashi Ayusawa: "Development on Dissociated-Methanol Gas Vehicle"]

[Text] 1. Introduction

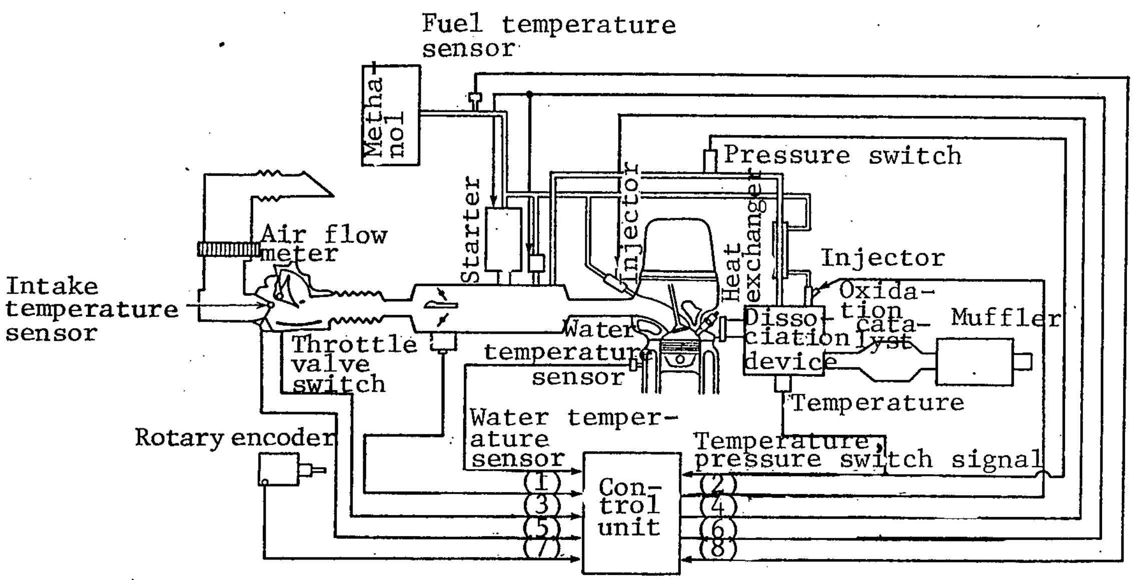
When methanol is used as fuel for an internal combustion engine, the technique to use dissociated methanol gas was studied and developed as being the utilization method which makes the most of its characteristics.

In this study, an engine of the premixed intake method for a passenger car was looked at. An improvement in the thermal efficiency was targeted by lean mixture gas operation with the effect of dissociated gas. At the same time, improvement in starting at low temperature and running at warming up, and utilization of heat from exhaust gas for generation of dissociated gas was aimed at.

The engine system having these functions was developed, designed, and manufactured as the device which could be actually installed in a vehicle. The original target was achieved, and improvement in the thermal efficiency of about 20 percent was accomplished when compared to a gasoline engine under the same compression ratio. The harmful composition of exhaust gas was reduced to that of gasoline. Its potential as an oil-substitute future engine was partially clarified.

2. Dissociated Methanol Gas Engine System

The combustion system is comprised of the 4-cycle, spark ignition method by premixtured intake. Its outline is shown in Figure 1.



Key:
1. Throttle valve switch signal
2. Injector output signal for dissociation
3. Intake amount of air signal
4. Injector output signal at intake port side
5. Intake temperature signal
6. Starter control signal
7. Rotation, crank angle signal
8. Fuel temperature signal

Figure 1. Dissociated Methanol Gas Engine System

Fuel supply is carried out by two systems: The intake port injection of liquefied methanol, and the intake manifold for dissociated gas from an exhaust heat dissociated device. The adequate amount of flowing fuel being supplied to the intake port and the exhaust-heat dissociated device is determined by a control unit corresponding to running conditions observing the amount of intake air, engine speed, intake temperature, position of the throttle valve, dissociated catalyst temperature, etc.

Fuel supply at starting is switched depending on atmospheric temperature and engine warming-up conditions. Under conditions of lower than 0°C, a starter is operated, and dissociated gas is supplied at the beginning of engine start. This essentially gives reliable and stable cold engine start and warming-up running. Under normal temperature starting, methanol sprayed by a common-chamber injection valve placed at the intake manifold assembly is supplied. Once an engine is warmed up, it can start the supply of liquefied methanol from an intake port. These are controlled from a control unit by selecting conditions.

An oxidation catalytic device for methanol is provided in order to process exhaust gas. Mixtured gas is fixed to fit the lean air-fuel ratio. The remaining fuel and carbon monoxide contained in the exhaust gas are then reacted with the oxygen remaining in the exhaust gas. The result is cleaner exhaust gas.

3. Starting and Warming-Up Performance by Starter

3.1 Generation Method of Dissociated Methanol Gas

When methanol vapor passes through a high-temperature catalyst, methanol is decomposed as seen in the following:

$$CH_3OH \rightarrow 2H_2 + CO$$

Reaction heat during this process is -2.8 KJ/g for gaseous methanol and -4.00 KJ/g for liquefied methanol. Since this process is an endothermic reaction, heating must be continuously provided in order to maintain the reaction. However, if a small amount of air is mixed with the gaseous methanol, an exothermic reaction takes place locally. Thus, without the external supply of heat, it is possible to dissociate methanol steadily. The low temperature starting method developed through this study is to achieve this reaction even at low temperature, and to start an engine with the generated gas.

Under the assumption that a part of the methanol achieves perfect combustion with the aid of air, and the rest is decomposed into H_2 and CO according to the above formula, the balance of the amount of endothermic and exothermic heat is shown in Figure 3. The air excess ratio λ which gives a well-balanced state between the amount of endothermic and exothermic heat is 0.167 in the case of the liquefied methanol base. λ becomes 0.117 in the case of the gaseous methanol base. It can be said that the mixture gas exhibits the nature of high fuel concentration. Under this condition, the ratio of methanol to be burned becomes equal to λ. For instance, $\lambda = 0.167$ brings 16.7 percent methanol to be burned.

In order to obtain mixture gas of high fuel concentration, the two methods of an exclusive carburetor and an injection valve which gives good spray were examined. Unfortunately, however, both methods resulted in problems associated with vaporization and mixture. Therefore, as the method to vaporize methanol completely and to obtain uniform mixture gas with air, the

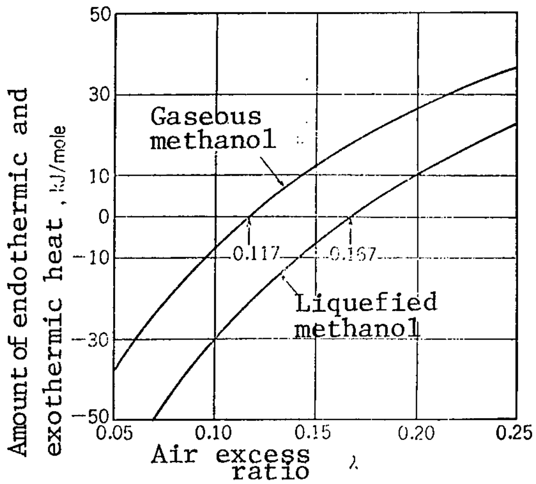


Figure 3. Balance Between Endothermic and Exothermic Heat Under Dissociated Methanol Oxidation Reaction

bubbling method was designed. This method flows fine air bubbles into liquefied methanol to get a mixture gas of high fuel concentration. In this method, air bubbles absorb vaporized methanol when passing through the liquefied methanol. This methanol vapor becomes saturated steam pressure which is influenced by the temperature of the liquefied methanol. Accordingly, temperature control of the liquefied methanol gives mixture gas of any value of λ.

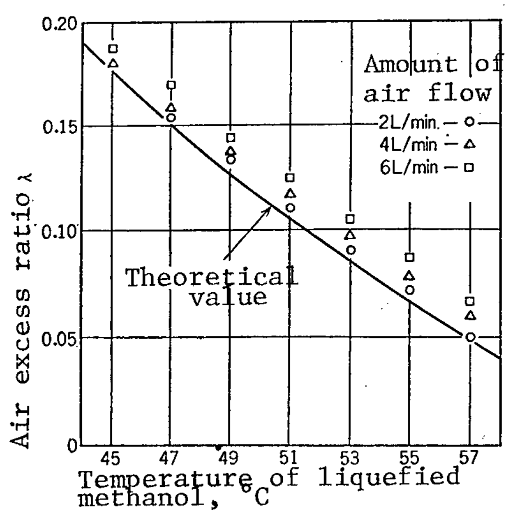


Figure 4. Air Excess Ratio by the Bubbling Method

Figure 4 shows corresponding λ of the mixture gas when the temperature of the liquefied methanol changes. The solid line in this figure is theoretical λ obtained from saturated steam pressure. It can be considered that the reason deviation from the theoretical value becomes more apparent as the amount of flowing air becomes larger, is an increase in air bubble diameter and/or a decrease in vaporization speed. From this result, in order to obtain a mixture gas ($\lambda \doteqdot 0.167$ for the case of liquefied methanol) which provides a well-balanced situation between the amount of endothermic and exothermic heat, it is necessary to maintain methanol temperature at 45-47°C.

3.2 Gas From Oxidation and Dissociated Reaction

When Pt catalyst is employed, among gas composition by oxidation and dissociated reaction of methanol, high density of noncondensable combustible gas becomes important for engine cold start. Thus, from generated gases, H_2, CO, CH_4, and C_2H_6O are judged to be combustible gases, and their total density is compared. The result is shown in Figure 5. From this figure, it can be seen that the density of combustible gases is not so influenced by catalyst, although relatively high density is obtained in the case of Pt catalyst. The temperature of catalyst during reaction is 360-550°C, and that of methanol 44-49°C.

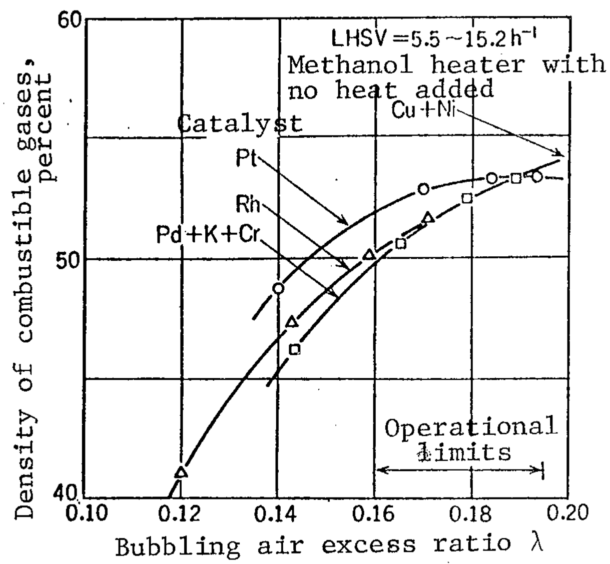


Figure 5. Comparison of Density of Combustible Gases by Catalyst

3.3 Starter and Starting Method

The outline of a small-sized starter placed on an engine which can be installed in an actual vehicle is shown in Figure 6. The starter has the structure in which a bubbling bath is arranged around catalyst. A heater for preheating of methanol and catalyst, and a thermal coupling for temperature control are provided. The control of the whole starter is carried out by a control unit.

The procedure to start an engine is as follows. When the ignition key is "ON," a solenoid valve is open, and an electric current is sent from a power unit to the methanol and catalyst heater. After the completion of preheating, engine cranking starts, and air passed through an air cleaner is inhaled into the starter because of intake negative pressure. Mixture gas of high fuel

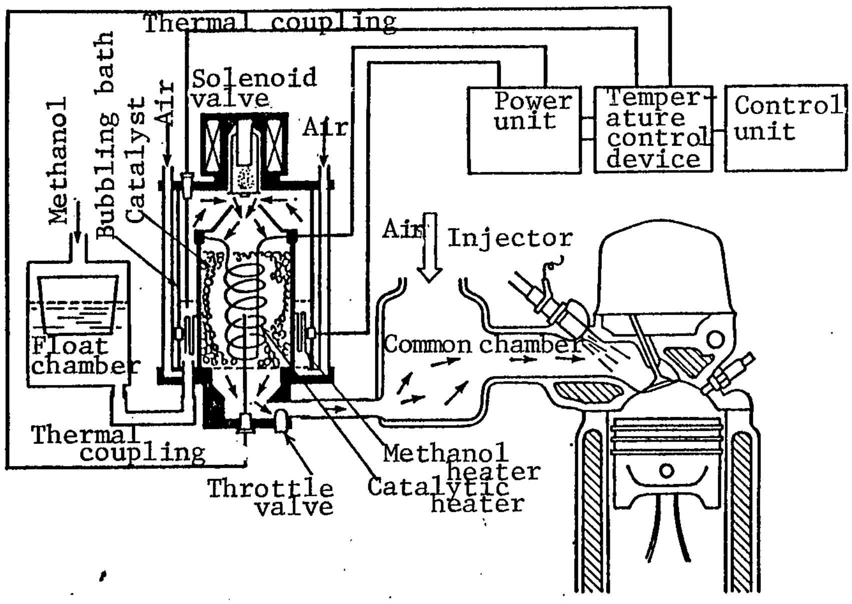


Figure 6. Composition of Starter

concentration is formed by bubbling. When this high density mixture gas is introduced into a catalytic floor, oxidization and dissociated reaction take place immediately. Due to reaction heat, the catalyst is heated higher than preheating temperature, and dissociated gas is generated. After this gas is measured by a throttle valve it is mixed with air. On the other hand, heat exchange takes place between the surface of the wall of the catalytic floor and methanol. The temperatures of catalyst and methanol reach equilibrium. Under this condition, the density of combustible gases such as H_2 and CO becomes higher, and mixture gas having the nature of easy ignition is formed.

The starter supplies only fuel, but it is designed to be used for warming-up running. There is a case, however, in which backfire may occur at engine starting. It is necessary to increase water temperature very rapidly during warming-up running, and also necessary to be fit for starting acceleration. Therefore, methanol is also supplied from an intake port injector. The amount of fuel supplied from the starter is about 50 percent of the total amount.

3.4 Starting Performance of Engine

An example of engine starting at a room temperature of -15°C is shown in Figure 7. Preheating temperatures of catalyst and methanol are 400°C and 47°C, respectively. After the completion of preheating, when cranking starts, the speed of engine rotations increases in about 7 seconds. At the same time, the amount of flowing air passing through the starter increases. From this fact, it can be judged that perfect combustion takes place inside the engine. When cranking stops 10 seconds later, the speed of engine rotations slightly decreases; after that, it increases again, and idling takes place continuously. When change in electric current for the starter is looked at,

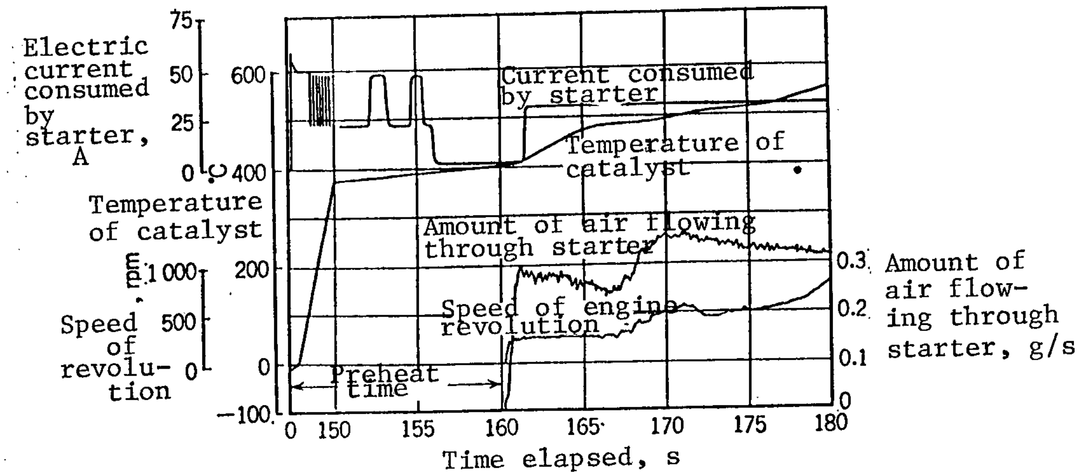


Figure 7. Engine Starting Characteristics of -15°C

which is shown in Figure 7, an electric current for the starter is small before cranking, but it becomes larger after cranking. This is due mainly to the functioning of a methanol heater, since the amount of heat transferred from the surface of a catalytic floor is still small.

3.5 Exhaust Gas During Warming-Up Running

Figure 8(a)(b) shows the comparison of unburned fuel (UBF) and carbon monoxide (CO) between a methanol engine with the prototype starter, and a gasoline engine. Figure 8(a) also shows the density of formaldehyde and exhaust gas temperature measured at the condition of which cooling water temperature is 0°C.

The result indicates that the densities of UBF, CO, and NO_x for a methanol engine with the prototype starter were less than those for a gasoline engine. In the case of a gasoline engine, it is necessary to correct the large increased amount of fuel during warming-up running. To the contrary, in the case of the methanol engine, an increase in the amount of fuel to be corrected should not be so large since the densities of noncombustible gas components are high. This contributes greatly to improvement in the fuel consumption rate at warming-up running. Although the density of formaldehyde for the methanol engine is higher than that of a gasoline engine, when compared with the density of formaldehyde at the normal operation of the methanol engine (150-250 ppm at the air excess ratio of an engine ≑ 1.0), it is still lower.

4. Exhaust Heat Dissociation Device

4.1 Exhaust Heat Dissociation Device and Dissociated Gas

An exhaust heat dissociation device is the device to obtain a mixture gas (dissociated gas) of hydrogen with carbon monoxide by dissolving methanol on

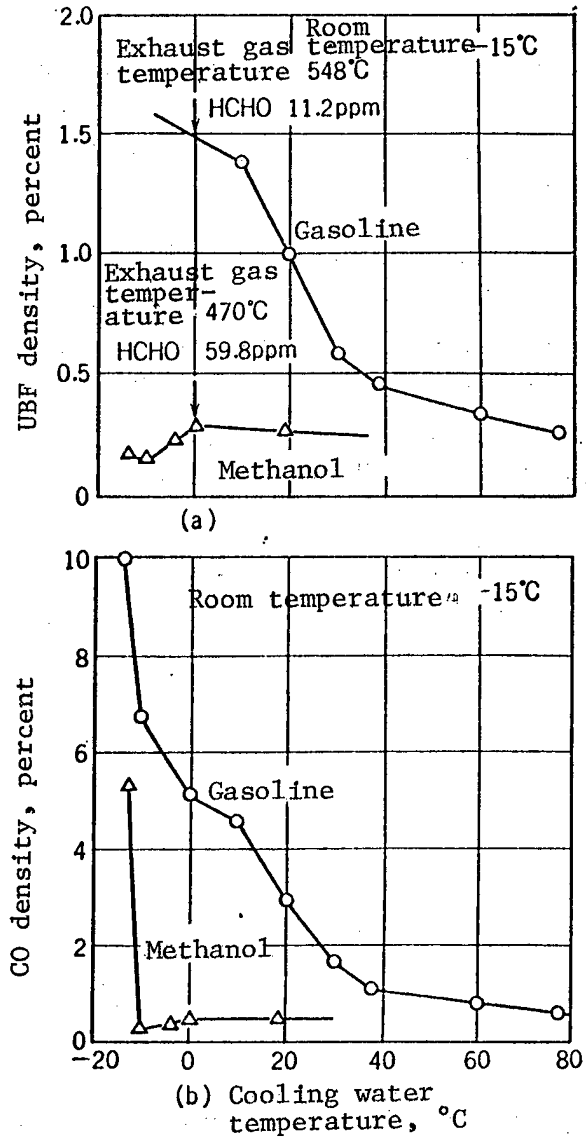


Figure 8. Exhaust Gas Characteristics at Warming-Up Running

the surface of a catalytic floor with the utilization of exhaust gas heat of an engine. Therefore, the performance of catalyst and heat exchanger are key in this device. However, in order to utilize exhaust heat effectively, it is necessary to install the device very close to an exhaust hole of an engine. There is a limitation on the size of the device. Its volume must be small.

The design of a heat exchanger was made pursuant to the following considerations: 1) large surface area of a heat exchanger; 2) longer stagnation time of exhaust gas; 3) large amount of catalyst; 4) uniform catalyst temperature; 5) reduction of radiant heat loss. Several prototypes were made and tested. As the result, as shown in Figure 9, the small-sized exhaust heat dissociation device having the capacity of being installed in a vehicle

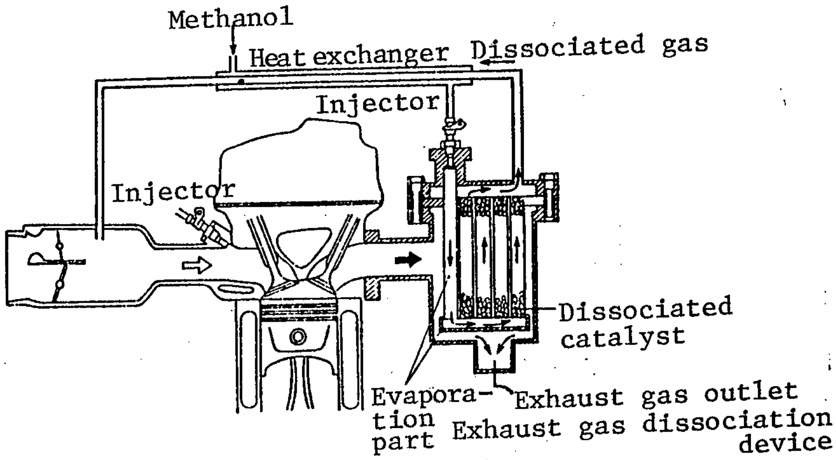


Figure 9. Configuration of Exhaust Gas Dissociation Device and Its Installation on an Engine

was developed. This device has a unified structure comprised of the evaporation part and the dissociation part.

During the development of a dissociated catalyst, among various catalysts such as Pt, Pd, Rh, Cr, Cu+Zn, Cu+Cr, and Cu+Cr+Ba, the ones exhibiting good performance were selected through basic experiments, and their practicality was investigated with the aid of an exhaust heat dissociation device. Cu+Zn and Cu+Ni are superior to others in activity performance at low temperature, but have less durability. Accordingly, among metals such as Pt and Pd systems, the Pd system was selected from the viewpoint of price and activity performance at low temperature. Dissociated gas composition by Pd system catalyst for which alumina is a carrier is shown in Figure 10. Since there is a defect of dimethyl ether and methane being generated as a secondary product, the catalyst having the additive of kalium was developed to control the generation of these. Thus, the composition of dissociated gas was improved.

The exhaust heat dissociation device developed at that time has to be improved to achieve high dissociation performance. There is yet room for improvement in this device; nevertheless, its specification is listed in Table 1.

Table 1. Specification of Exhaust Gas Dissociation Device of Vehicle Installed Type

Type	Multiple pipes typed heat exchanger
Volume of catalyst	970 cm^3
Catalyst	Pd+K system alumina carrier
Weight	22 kg
Dimension	305 mm x 170 mm x 250 mm

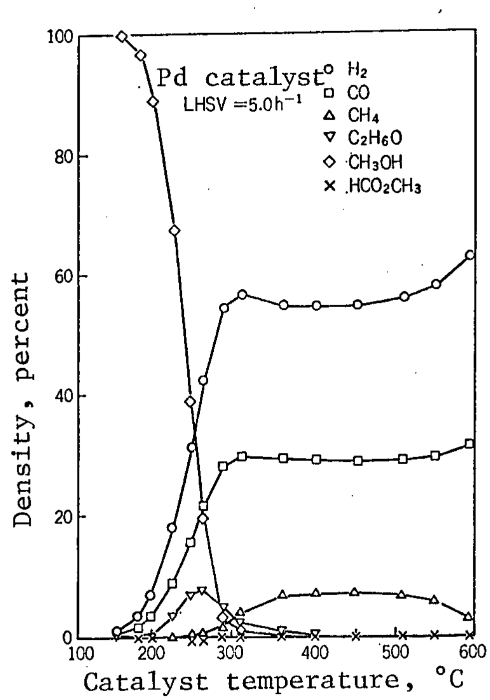


Figure 10. Composition of Dissociated Gas by PD Catalyst

4.2 Rate of Fuel Supply to Exhaust Heat Gas Dissociation Device

When methanol is to be dissolved completely by the exhaust heat dissociation device, liquid space velocity (LHVS) of methanol (the amount of flowing methanol/capacity of catalyst) must be small. In reality, however, when the exhaust heat dissociation device is installed in a vehicle, there is a limitation in its size. If all the necessary fuel is dissociated at once, LHSV becomes large, and its dissociation performance becomes poor. On the other hand, when all fuel is converted into dissociated gas, the ratio of H_2 to mixture gas sucked into an engine at heavy load becomes higher, and there may be the occurrence of premature ignition. Accordingly, instead of supplying the entire amount of methanol to the exhaust heat dissociation device, the fuel supply method having two different systems is adopted: one system prevents premature ignition by the cooling effect which utilizes evaporation latent heat of methanol by injecting methanol into an intake port at all times; the other system reduces LHSV by decreasing the amount of methanol supplied to the exhaust heat dissociation device.

Figure 11 shows the experimental result of the influence of net thermal efficiency when the fuel-supply ratio to the exhaust heat dissociation device and intake port is changed. Under the running condition in which the air excess ratio λ is close to 1.0, when the fuel ratio to the exhaust gas dissociation device becomes large at heavy load operation, premature ignition easily occurs. Therefore, the experiment was carried out under the condition of $\lambda = 1.5$. At this figure, an improvement in net thermal efficiency by dissociated gas supply at low and middle load operations is observed, but no

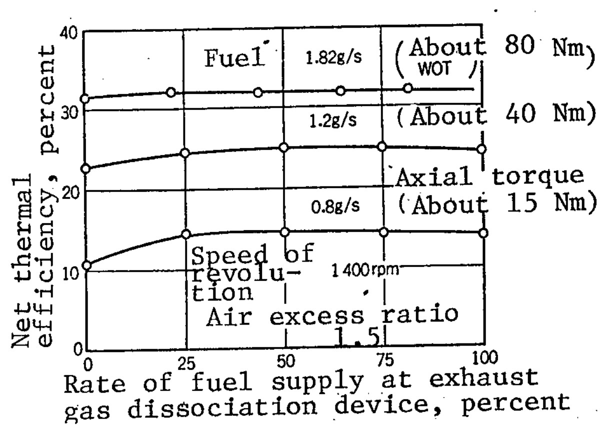


Figure 11. Influence of the Rate of Fuel Supply at Exhaust Heat Dissociation Device on Thermal Efficiency

apparent improvement can be seen at heavy load operation. In addition, even at low and middle load operations, the fuel supply ratio to exhaust heat dissociation device exceeds more than 50 percent; improvement in thermal efficiency cannot be seen.

In order to observe this cause, based on the composition analysis of the dissociated gas, the amount of heat generated from the dissociated gas was calculated; also, an increasing rate for the amount of heat generation was obtained provided both dissociated gas and methanol were in use together. An investigation indicated that dissociation performance of the exhaust heat dissociation device was not good enough.

It is considered that the change in the thermal efficiency shown in Figure 11 is due mainly to the improvement of combustion by dissociated gas, rather than to the increase of the amount of heat generated by dissociated gas. The fact that an improvement in the thermal efficiency is observed in the case of low load operation, instead of heavy load operation is also understandable.

Another fuel supply method making an influence on exhaust gas is shown in Figure 12. The measured values were obtained under the condition of no exhaust gas clearing oxidation catalyst. In this figure UBF means unburned fuel (alcohol). The measurement of formaldehyde was conducted by the deoxidation FLD (?) method. Because of the use of dissociated gas, if the fuel supply ratio to the exhaust heat dissociation device is more than 25 percent, there is a tendency to decreased CO, UBF, and formaldehyde, but not NO_x. Especially UBF and formaldehyde decrease more rapidly when compared with methanol fuel. This was because dissociated gas was used as fuel and the ratio of methanol to supplied fuel decreased. At the same time, there was the improvement of combustion due to dissociated gas.

On the above results, regarding the operation of the dissociated methanol gas engine, it was found that there was no merit in supplying the entire amount of fuel to the dissociation device. Instead, the fuel supply method in which methanol fuel was also in use simultaneously had an advantage of keeping

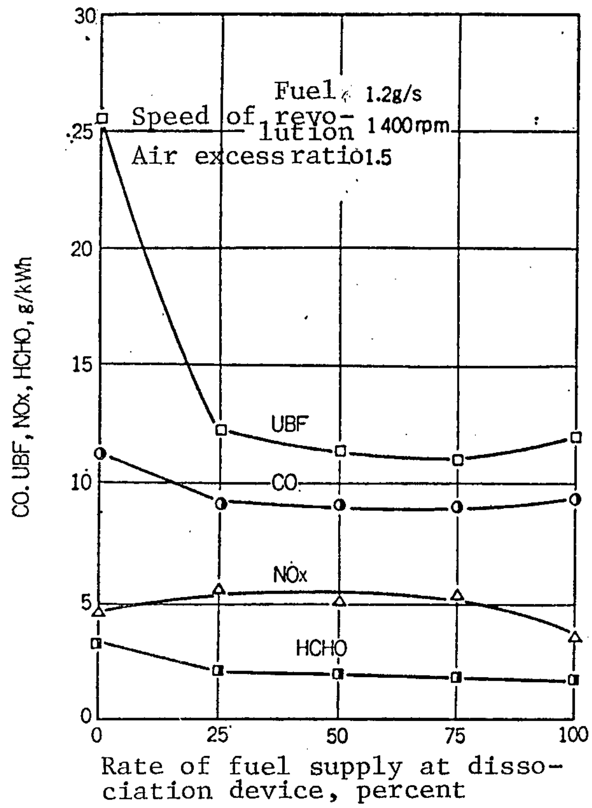


Figure 12. Influence of Rate of Fuel Supply at Dissociation Device on Exhaust Gas

small LSHV of the dissociation device. Accordingly, in the experiments with dissociated gas, to be described below, a 50-percent fuel supply ratio to the dissociation device was adopted, and its performance studied.

5. Performance of Dissociated Methanol Gas Engine

5.1 Influence of Air Excess Ratio

Since the main components of dissociated gas are H_2 and CO, its combustible limits are wider than methanol. It is possible to make the mixture gas lean. Figure 13 shows the result of the comparison of net thermal efficiency between the dissociated gas engine (50-percent fuel supply ratio to the dissociated device), and the liquefied methanol engine as a function of the air excess ratio λ. Under the condition of low loading, when λ becomes large, the thermal efficiency of dissociated gas is better than that of liquefied methanol. This is because the presence of dissociated gas prevents degradation in combustion even for a lean mixture ratio. It is possible to run even in the case of more than $\lambda = 1.8$ with the use of dissociated gas.

Figure 14 shows the influence of λ on the NO_x exhaust ratio of exhaust gas. The NO_x exhaust ratio of dissociated gas is larger than that of liquefied methanol for all values of λ under the same loading condition. However, the

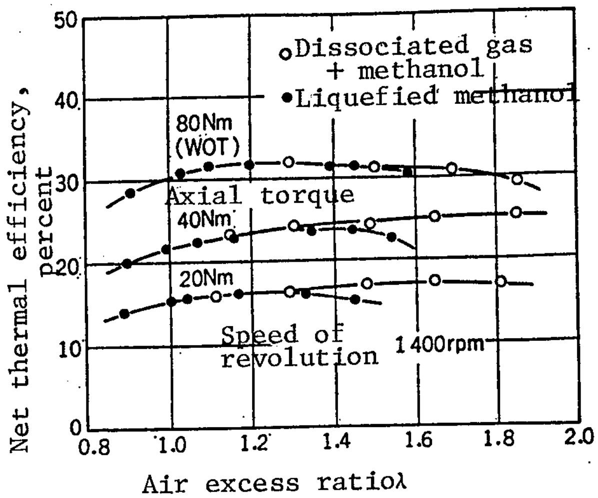


Figure 13. Comparison of Thermal Efficiency Between Dissociated Methanol Gas and Liquefied Methanol

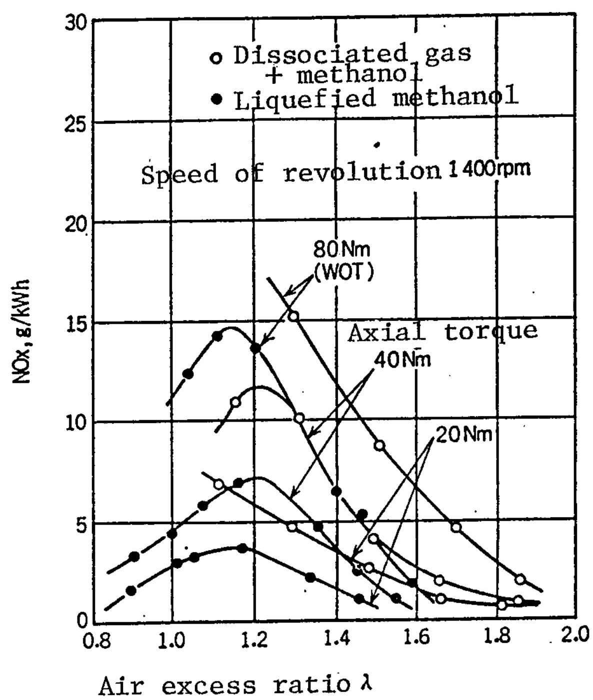


Figure 14. Comparison of NO_X Exhaust Between Dissociated Methanol Gas and Liquefied Methanol

large value of λ can be set up with the use of dissociated gas. This brings a low NO_X exhaust ratio, and it is possible to achieve exhaust gas standards.

There is no major difference between liquefied methanol and dissociated gas regarding the CO exhaust ratio. Dissociated gas has little effect on the reduction of CO.

The UBF exhaust ratio of dissociated gas is about half that of liquefied gas at the same value of λ under low loading conditions. Unfortunately, however, the dissociation performance of the exhaust heat dissociation device is not sufficient. When λ becomes larger, the UBF exhaust ratio increases even though dissociated gas is in use. It is difficult to expect to have large values of λ.

In order to reduce these ratios, four different kinds of prototype exhaust cleaning oxidation catalysts were tested: Pt, Pt+Pd, Rh+Pt, and Pd.

All catalysts were excellent in CO cleaning performance. But, for UBF cleaning performance, RH+Pt and Pt systems were superior. The result of the study of the influence on exhaust cleaning performance by λ for the case of Pt system oxidation catalyst indicated that the cleaning CO and UBF ratios became large as λ increased. It was possible to meet each corresponding exhaust gas standard with the use of exhaust cleaning catalyst.

As described above, based on the experimental results of exhaust gas, it was decided to set up λ to be 1.5 for engine operation by dissociation in this study.

5.2 Full Throttle Output Performance

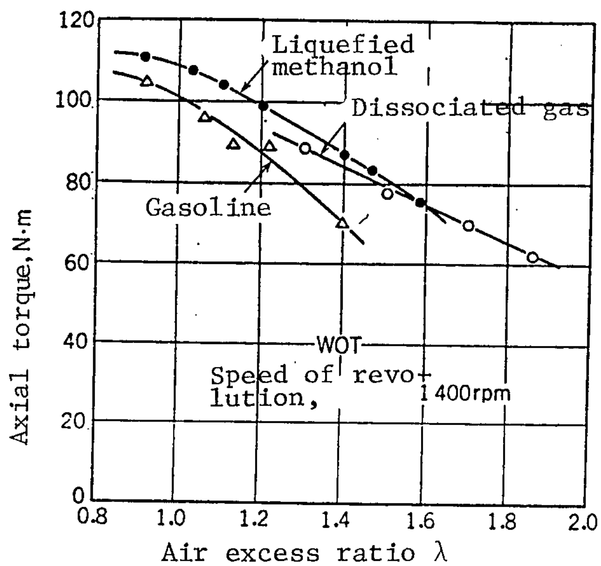


Figure 15. Comparison of Output at Full Throttle Between Dissociated Methanol Gas, Liquefied Methanol, and Gasoline

The influence of λ on axial torque at WOT running for dissociated gas, liquefied methanol, and gasoline is shown in Figure 15. When λ is close to 1.0, the output of every fuel becomes large. In the case of dissociated gas fuel, premature ignition occurs under the condition of λ = 1.2 or less, and operation fails. According to this figure, dissociated gas is superior to liquefied methanol with respect to operation under the lean condition. However, when λ is less than 1.6, the output of dissociated gas becomes lower when compared to that of liquefied methanol. Since the caloric value per unit volume of dissociated gas fuel-air mixture is almost the same as liquefied methanol fuel-air mixture, it can be considered that a decrease in the output of dissociated gas fuel is caused by a decrease of air filling up efficiency along with the increase of intake temperature and also a mole number of fuel due to the mixture of high-temperature dissociated gas. When looking for better output performance than gasoline at wide open throttle, the use of liquefied methanol gives better results than dissociated gas. Therefore, in order to increase output at high load operation, it is necessary to alter the fuel supply method. The method to increase the rate of fuel injected into an intake port, and to make λ 1.0 shows profitable results.

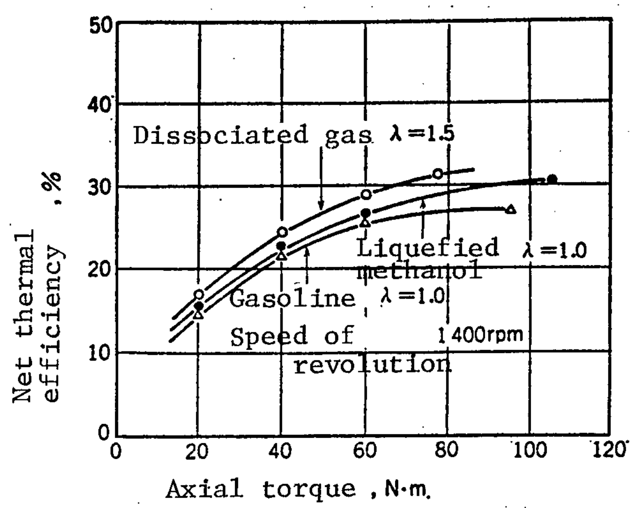


Figure 16. Comparison of Thermal Efficiency Between Dissociated Methanol Gas, Liquefied Methanol, and Gasoline

Figure 16 shows the results of comparison for the net thermal efficiency between dissociated gas (λ = 1.5), liquefied methanol engine (λ = 1.0), and gasoline engine (λ = 1.0). As seen from this figure, the dissociated gas engine is better than the liquefied methanol engine by about 12 percent, and the gasoline engine by about 20 percent in thermal efficiency at the same load condition.

5.3 Performance of Dissociated Methanol Gas Vehicle

This engine system is presently installed in a vehicle, and a tune-up is carried out so that it matches running conditions. Based on the fuel consumption rate (Figure 17) as a function of the number of rotations and load for the dissociated gas engine obtained through bench tests, and steady test data of the exhaust ratio for CO, UBF, and NO_x, the 10-mode running was simulated under the condition of vehicle installation. Table 2 shows the simulation result of the fuel consumption rate. The liquefied methanol engine

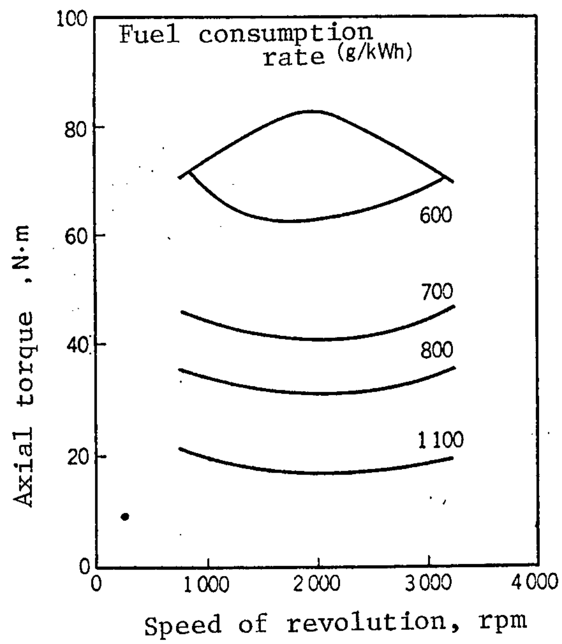


Figure 17. Fuel Consumption Ratio of Dissociated Gas Engine

Table 2. 10-Mode Fuel Consumption Rate (Calculation)

Conditions	Gasoline $\lambda = 1.0$	Methanol $\lambda = 1.0$	Dissociated gas $\lambda = 1.5$
Methanol fuel consumption rate	—	5.81	6.26
Fuel consumption rate equivalent to gasoline	10.53	11.71	12.62
Ratio	1	1.112	1.198

(Note 1) Fuel consumption rate equivalent to gasoline for methanol was corrected by the ratio of the amount of low heat generation for methanol and gasoline.

(Note 2) Unit: km/ℓ

($\lambda = 1.0$) is better than the gasoline engine by about 11 percent, and the dissociated gas engine ($\lambda = 1.5$) is better than the gasoline engine by about 20 percent. According to the calculation results for exhaust gases in Table 3, the NO_x and CO exhaust ratios of the dissociated gas engine meet the 1978 10-mode standards. Although the UBF exhaust ratio exceeds the requirement, it is possible to reduce the ratio, and to meet the standards because about 90 percent UBF can be absorbed by an exhaust-cleaning oxidation catalyst.

Table 3. 10-Mode Exhaust of Dissociated Methanol Engine (Calculation)

	NO_x	UBF	CO
Result of calculation	0.29	3.14	1.38
Standards (average)	0.48 (0.25)	0.39 (0.25)	2.70 (2.10)

(Note 1) No oxidation catalyst
(Note 2) Unit: g/km

6. Conclusion

The development status of the dissociated methanol gas engine has been described. Presently, it is still being continuously studied and tested as a vehicle system. In order to put this system to practical use, long-term efforts will be necessary. We would like to make preparations for the future by solving each problem step by step.

Finally, grateful appreciation is given to the Agency of Industrial Science and Technology of MITI for their financial support of this study.

Dual Fuel-Injection Engine

Tokyo NAINEN KIKAN in Japanese Sep 86 pp 21-27

[Article by Masahiko Hori: "Study on Dual Fuel-Injection Engine"]

[Text] 1. Introduction

Methanol is one of the fuels expected to be a promising oil-substitute fuel for automobiles. However, because of its low setane number and bad self-ignition characteristics, it is difficult to apply to a diesel engine without modification. As utilization techniques of methanol for a diesel engine, the following are proposed:

1) The forced ignition method (1-3): the method of using an auxiliary means such as an ignition plug or glow plug.

2) The dual fuel-injection method (4-6): the method of using gas oil having good ignition characteristics as an igniter.

Since the dual fuel-injection method enables control of methanol and gas oil independently, it is possible to obtain the same ignition and low-temperature starting characteristics as that of an ordinary diesel engine by injecting only gas oil at engine starting. In addition, this method has less difficulties from the viewpoint of combustion technology and fewer elements to be developed when compared to the forced ignition method (the spark assist method).

As the initial stage of application development regarding the utilization technique of methanol for a diesel engine, this study has an eye toward the methanol-gas oil dual fuel-injection which shows high probability for practical application. The purpose of this study is to develop the methanol-gas oil dual fuel-injection diesel engine which has the same or better power performance and exhaust gas characteristics than a current diesel vehicle under the conditions of the gas oil-substitute ratio more than 90 percent per volume at full load operation, and to establish its fundamental design data.

2. Combustion Characteristics of Dual Fuel-Injection Engine

2.1 Combustion Process and Heat Generation Ratio of Dual Fuel

Figure 1 shows Schlieren photographs for the processes of the mixture and combustion of the two fuels for the alcohol-gas oil dual fuel-injection diesel engine, and also shows the pressure at the inside of a cylinder and the heat generation ratio. The number of engine rotations is 1,100 rpm, and the amounts of gas oil and alcohol injection are 10 and 20 mm^3/cycle, respectively.

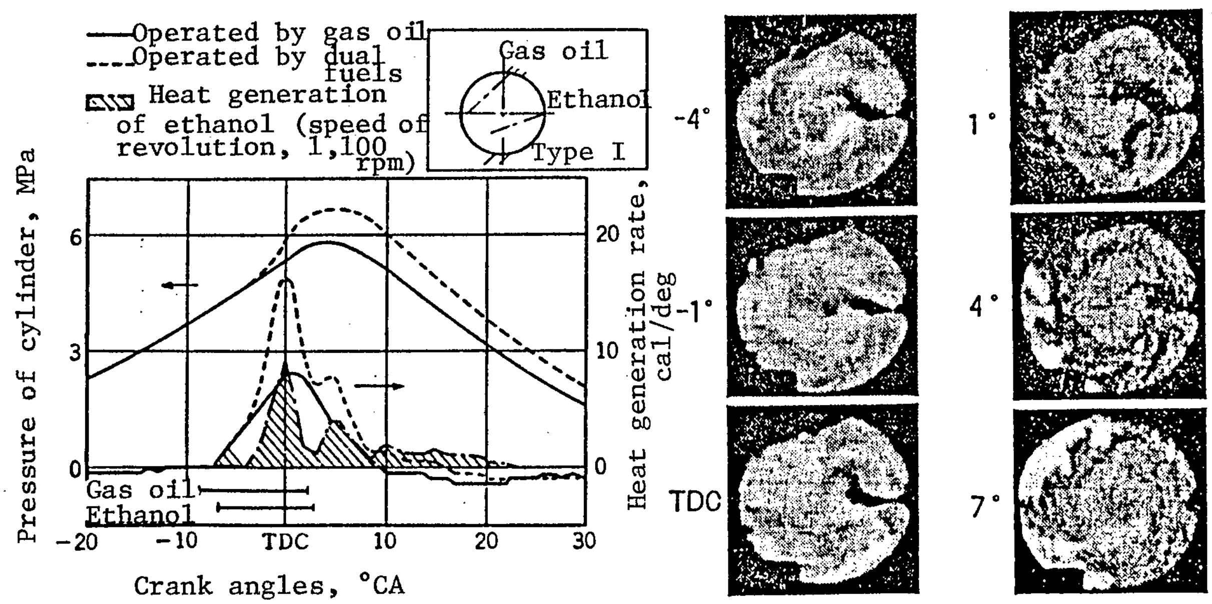


Figure 1. Mixture of Two Fuels in Fuel Injection Engine and Its Combustion Processes

The purpose of the formation of mixture gas and combustion for the dual fuel-injection method is as follows. A gas oil spray is inflected by swirl just after injection. The spray is formed closer to the wall of a combustion chamber than that of the designated injection direction. Immediately after injection, a fuel spray evaporates from its tip, and mixture gas is formed. This mixture gas flows along with the wall by swirl. When the evaporated gas reaches a connection hole between a main chamber and a subchamber, it is pushed toward the central portion of a combustion chamber by the amount of air which flows from a main chamber (TDC, Figure 1). Initial ignition of the dual fuel-injection method occurs at the mixture gas portion of gas oil formed along the wall of a combustion chamber. A gas oil flame spreads out along the wall. Combustible gas having lower density than air moves toward the center of the combustion chamber due to the centripetal force of swirl.

Alcohol is injected at an angle of 70 degrees to swirl under the condition of 2-degree delay from injection timing of gas oil. However, it is drifted by swirl, and forms a mixture gas of alcohol with air nearly at the center of the combustion chamber. At this moment, the tip of the gas oil spray is already formed along the wall. It is considered that alcohol spray does not cool down a gas oil flame, and does not deteriorate combustion. The alcohol mixture gas is ignited by a gas oil flame created along the wall of the combustion chamber. The Schlieren pictures may indicate that alcohol mixture gas does not ignite by itself; instead, combustion takes place by the propagation of a flame.

When the combustion process is looked at from the heat generation ratio diagram, the initial heat generation speed is slow. But, around an upper dead point of 5°CA, the heat generation speed becomes suddenly high. From this fact, it can be considered that two-staged combustion, a sudden increase in heat generation of alcohol followed by the combustion of gas oil, takes place in the case of dual fuel combustion.

2.2 Combustion Form of Alcohol

In the dual fuel-injection engine, an increase in the inside temperature of a combustion chamber due to the combustion of gas oil may cause self-ignition of the alcohol mixture gas. However, a phenomenon indicating self-ignition was not observed. Several reasons can be considered for this result. They are, for instance: 1) the small amount of supplied gas oil causes a small pressure increase rate at the inside of a cylinder, although pressure at the inside of the combustion chamber increases by adiabatic compression due to the combustion of gas oil; 2) it is difficult to increase the temperature of alcohol mixture gas by radiant heat from a gas oil flame because of the presence of an adiabatic layer of air; and 3) there is contact between the alcohol mixture gas and the gas oil flame. If there is no contact between the alcohol mixture gas and the gas oil flame, and also if there is a sufficient amount of heat supplied from gas oil, the possibility of self-ignition of alcohol spray cannot be denied. However, the combustion form of alcohol for a conventional dual fuel-injection diesel engine is considered to be mainly flame propagation.

3. Development of Methanol-Gas Oil Dual Fuel-Injection Diesel Engine

3.1 Research and Development Procedures

As the base development engine, a diesel engine for an automobile in the market (hereinafter referred to as the base engine) was used. In order to

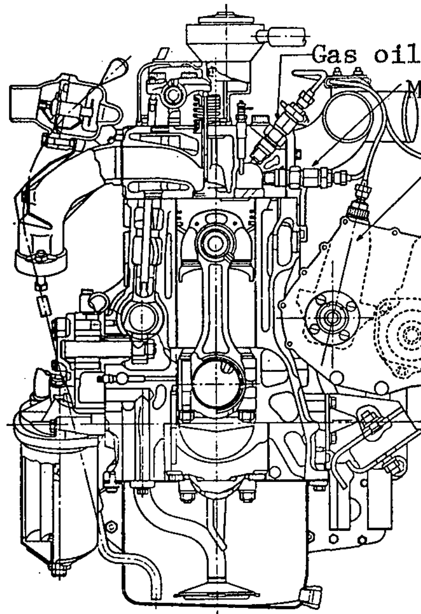


Figure 2. Cross-Sectional View of Development Engine

add a methanol injection pump and nozzle, the base engine was modified (hereinafter referred to as the development engine). A cross-sectional view of the development engine is shown in Figure 2. The two injection pumps were connected by a toothed wheel. The small-sized Bosch K-typed pump was used for a gas oil injection pump. The Bosch A-typed pump was used for a methanol injection pump. To prevent the methanol injection pump from corrosion by methanol, alumite was processed at the inside of the injection pump. The large-capacity SP-typed timer was adopted for common use between the two injection pumps. Table 1 shows the specifications of the base and development engines. Note that the specification of the development engine is the final one.

Table 1. Specifications of Base Engine and Development Engine

Type		Water cooling, 4 cycle, swirl chamber type	
Number of cylinders, bore x stroke		4-105 x 110 mm	
Displacement		.3298 cc	
Compression ratio		19.5:1	
		Development engine	Base engine
Injection pump	Gas oil	K type (PE4K70)	A type (PE4A75)
	Methanol	A type (PE4A95)	--
Injection nozzle	Gas oil	DNOSD	DN4SD
	Methanol	DN4SD	--
Governor	Gas oil	All speed	Minimax
	Methanol	All speed	--
Timer		External type (SP type)	Internal type (SCZ type)

The injection position of the two fuels was decided based on the combustion observations described before and the experimental results of a single-cylinder engine. Satisfactory output performance and exhaust gas characteristics were achieved by injecting methanol toward the center of the combustion chamber, allowing methanol to combust with gas oil flame generated along the wall of the combustion chamber as being the source of ignition. JIS second gas oil and industrial methanol (more than 99 percent purity, specific gravity 0.794) were used as test fuels.

3.2 Results and Consideration of R&D

(1) Fuel Injection Characteristics

The loading control of the development engine studied in this research was carried out by the amount of injected methanol. It was targeted to minimize the amount of injected gas oil as much as possible. However, when the amount of injected gas oil was reduced, injection did not occur at a low speed range even if the rack position of the injection pump was kept constant. The reason for this phenomenon could be considered that as the speed of revolution of the injection pump decreased, residual pressure at the inside of the injection pump decreased, residual pressure at the inside of the injection tube decreased, and fuel injection pressure did not reach valve opening pressure of an injection valve. Thus, a notch was placed on a discharge valve in order to reduce the amount of gas oil sucked back through the discharge valve at low speed, and to prevent the decrease of residual pressure at the inside of the injection tube. As a result, there was an improvement, and the amount of injection characterized by Figure 3 was obtained. The gas oil-substitute ratio by methanol (M/F) was more than 50 percent per volume except under the conditions of low speed and low loading. In the range of normal operation, it exceeded 70 percent per volume. Under full loading conditions, it was over 90 percent per volume except at low speeds.

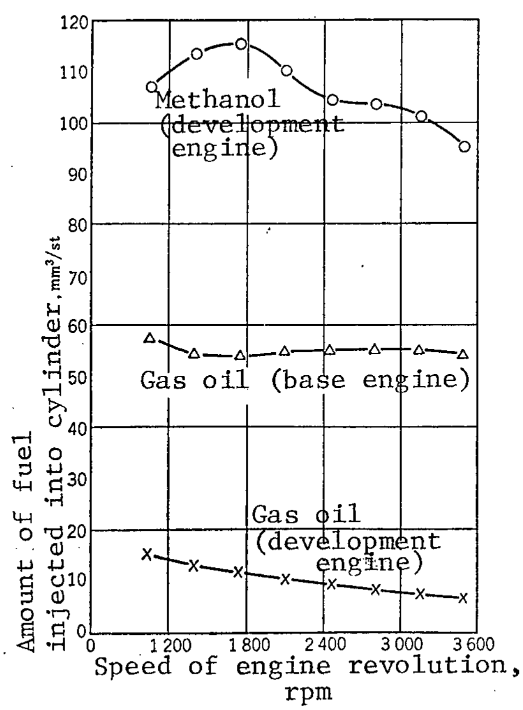


Figure 3. Characteristics of the Amount of Fuel Injected Into Cylinder

(2) Engine Performance

A. Comparison of Full Loading Performance

The full loading performance of the dual fuel-injection engine is shown in Figure 4. Injection timing of dual fuels is the fixed value of 2,800 rpm, decided by paying attention to the fuel consumption rate and CO. The value of M/F exceeded 90 percent per volume except at the low speed region.

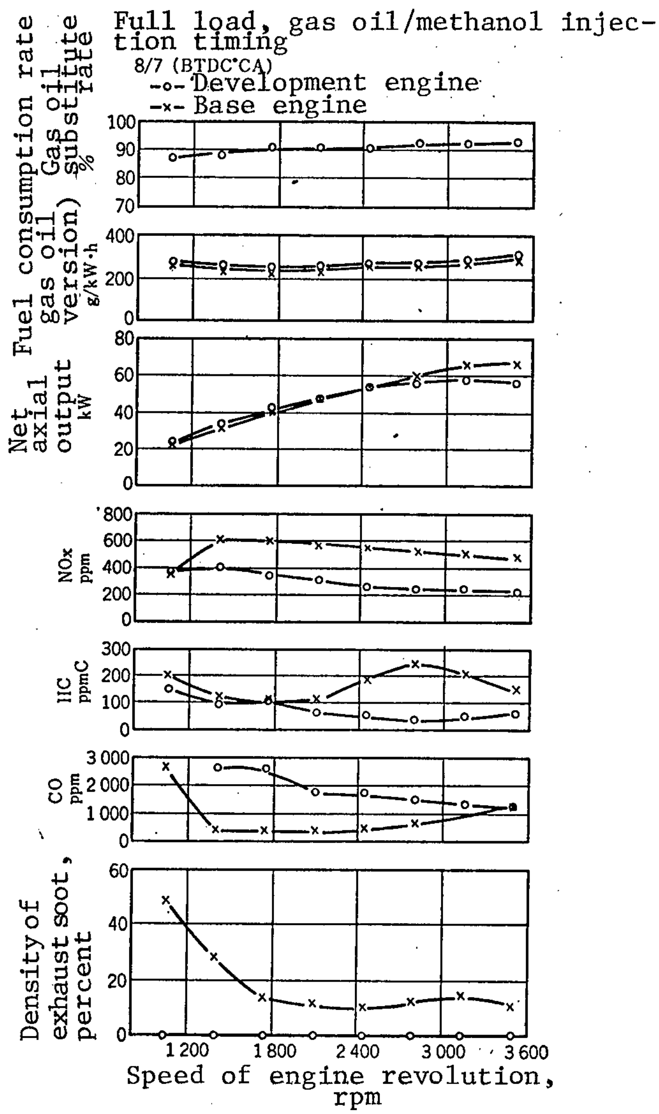


Figure 4. Full Loading Performance of Methanol-Gas Oil Dual Fuel-Injection Diesel Engine

The largest was 93.5 percent per volume. The fuel consumption rate of the dual fuel-injection engine was almost equivalent to the base engine at all speed ranges. Fuel consumption performance at full loading conditions was equal to a present diesel engine. Axle output became larger than that of the base engine in the low speed range, but it was reversed in the high-speed range. The main cause could be derived from a decrease in the amount of injected methanol in the high-speed range.

The amount of NO_x was reduced by half when compared with the base engine except at very low speeds. The reason for the reduction of NO_x, although the maximum pressure is high, can be considered that the temperature of a flame becomes lower than that of the base engine. The amount of HC was the same as the base engine in the low speed range, but it was cut in half in the middle and high-speed ranges. As speeds become higher, exhaust temperature increase. Uncombusted methanol, which is the main source of HC, could then react at the inside of an injection tube. The amount of CO exhausted was the same as the base engine at the high-speed range, but it increased at the middle and low speed ranges. The reasons for this phenomenon could be that CO generated by gas oil flame was cooled down by methanol spray, and discharged without reaction. At the same time, since the amount of injected methanol increased at the low speed range, the density of mixture gas became higher when compared to the base engine. The density of exhaust smoke was essentially zero pollution level in all speed ranges.

B. Comparison of Partial Loading Performance

Partial loading performance at an 80-percent rated revolution speed is shown in Figure 5. The value of M/F is more than 70-percent per volume even at low loading. It exceeds 90-percent per volume at 3/4 loading or more. The fuel consumption rate is almost equivalent to the base engine.

Regarding the amount of discharged NO_x, it decreased as loading increased when compared to the base engine. In the case of HC, its discharged amount remains the same as the base engine at low loading. When loading becomes larger, it decreases for the same reason described above. Regarding CO, its discharged density is almost equal to the base engine at low and middle loading, but it increases at high loading.

C. Compatibility To Exhaust Gas Standards

The test results applied by the diesel automobile exhaust gas testing methods (diesel 6-mode test) is shown in Table 2. The amounts of discharged NO_x and HC are decreased by 55 and 56 percent, respectively, when compared to the base engine. But there is an increase in CO by 75 percent. In either case, they satisfy the 1982 exhaust gas standards. The amount of discharged CO becomes three times larger than the base engine at full loading. If the injection characteristics of methanol are improved, and appropriate control of the maximum amount of injection is made at the low speed operation range, it could be possible to reduce the amount of discharged CO.

D. Discharged Characteristics of Materials Under No Control

(a) Uncombusted Methanol

The amounts of uncombusted methanol and HC at 40- and 80-percent rated revolution speeds, and the ratio of uncombusted methanol to HC are shown in

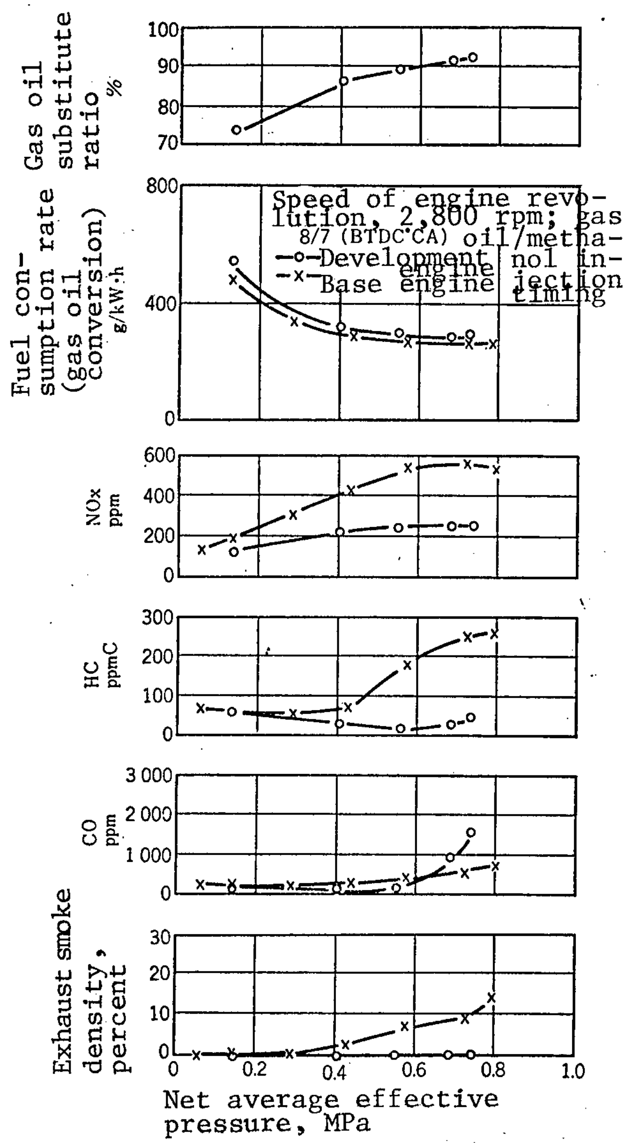


Figure 5. Partial Loading Performance of Methanol-Gas Oil Dual Fuel-Injection Diesel Engine

Table 2. Exhaust Gas Test Results (Diesel 6-Mode)

	CO	HC	NO_X
1982 exhaust gas standards*	790 ppm	510 ppmC	290 ppm
Development engine	472.4	43.7	206.6
Base engine	266	131.6	345.9

*Average

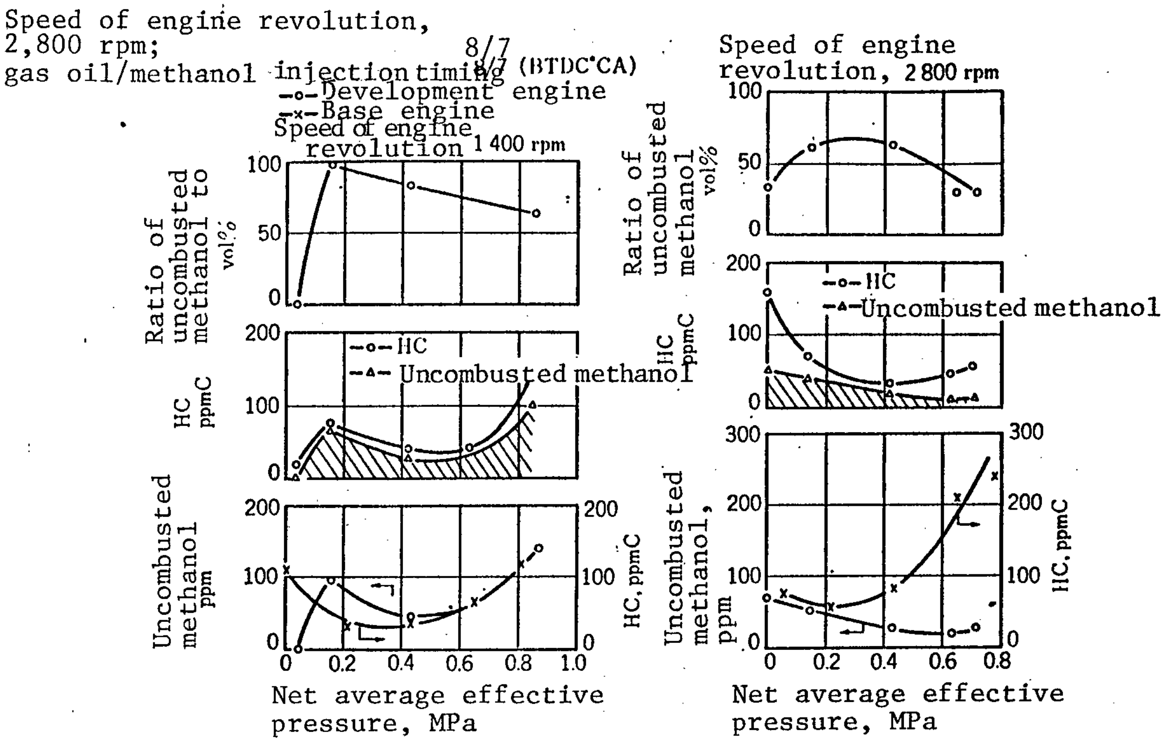


Figure 6. Exhaust Characteristics of Uncombusted Methanol

Figure 6. In this figure, the data for HC was the result of the correction made to the analyzer sensitivity for methanol. The amount of uncombusted methanol at 1,400 rpm is the same as the amount of HC of the base engine except at low loading. To the contrary, the amount of uncombusted methanol at 2,800 rpm decreases drastically as the increase of loading, when compared to the amount of HC. This may be due to the fact that exhaust temperature at high speed and high loading operation increases, and uncombusted methanol could be oxidized at the inside of the exhaust tube. It is considered that uncombusted methanol expelled from the dual fuel-injection engine has the same generation mechanism of HC exhausted by a diesel engine. Actually, it was found that its exhaust density varied remarkably on the inside temperature of the exhaust tube. HC generated by gas oil flame can react at the inside of a combustion chamber if there is enough stagnation time to mix with methanol flame. However, if stagnation time is short and reaction temperature is low, the amount of discharged uncombusted methanol is considered to increase.

(b) Formaldehyde

Exhaust characteristics of formaldehyde, HC, and CO at 40- and 80-percent rated revolution speeds are shown in Figure 7. The exhaust density of formaldehyde is the same as the base engine at middle loading, but it increases at low speed and high load, and high speed and low load. This tendency is similar to the exhaust characteristics of HC. An increase in

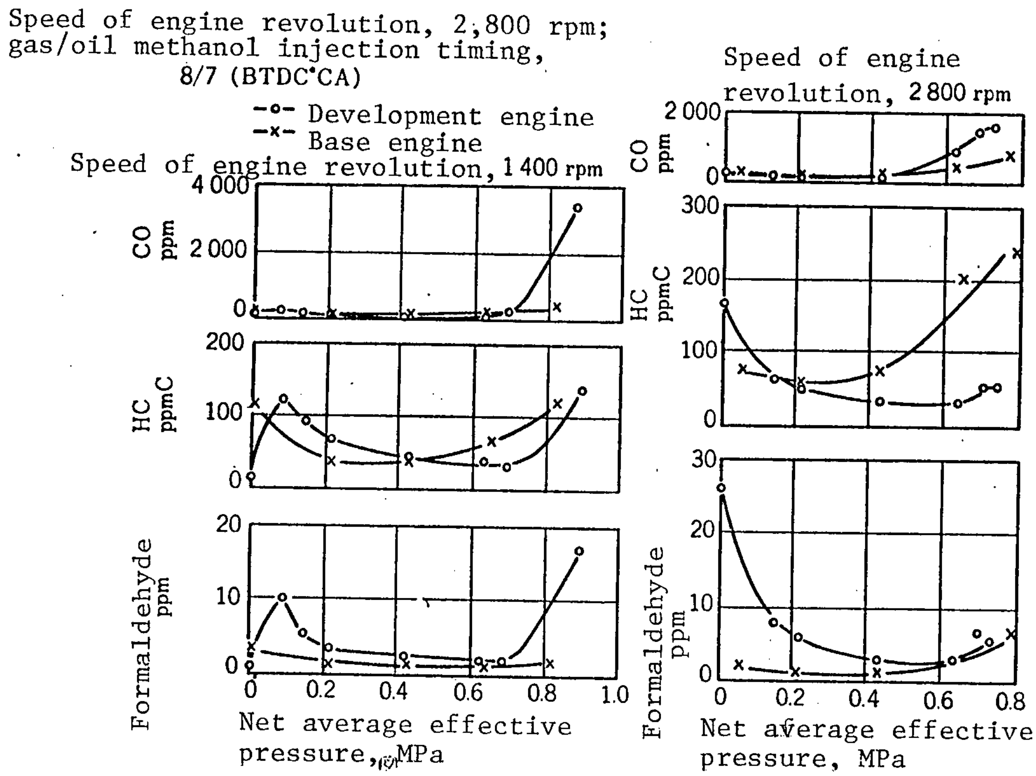


Figure 7. Exhaust Characteristics of Formaldehyde

low speed and high loading could be due to the excessive high density of mixture gas. The reason for the increase of formaldehyde might be a reduction in the injection ratio of gas oil and the degradation of methanol spray characteristics. Incidentally, the results of the examination of the composition of formaldehyde in exhaust gas indicated that the main component of formaldehyde was aldehyde.

The study on correlation between formaldehyde and HC indicated that the exhaust density of formaldehyde at the base engine was about 1/60 of HC exhaust density. But in the development engine, it was about one-seventh. A correlation factor for the development engine is higher than the base engine. It was judged that there was stronger correlation between formaldehyde and methanol.

(c) Particle State Substances

Figure 8 shows the exhaust density of particle state substances at 20-, 40-, and 80-percent rated revolution speeds. The data in this figure is at the conditions of 25°C and 101 KPa. It is known that the exhaust smoke density value of the dual fuel-injection engine is zero or very small. From this figure, it is seen that the exhaust density of particle state substances is also small. In the base engine, there is the same tendency between the

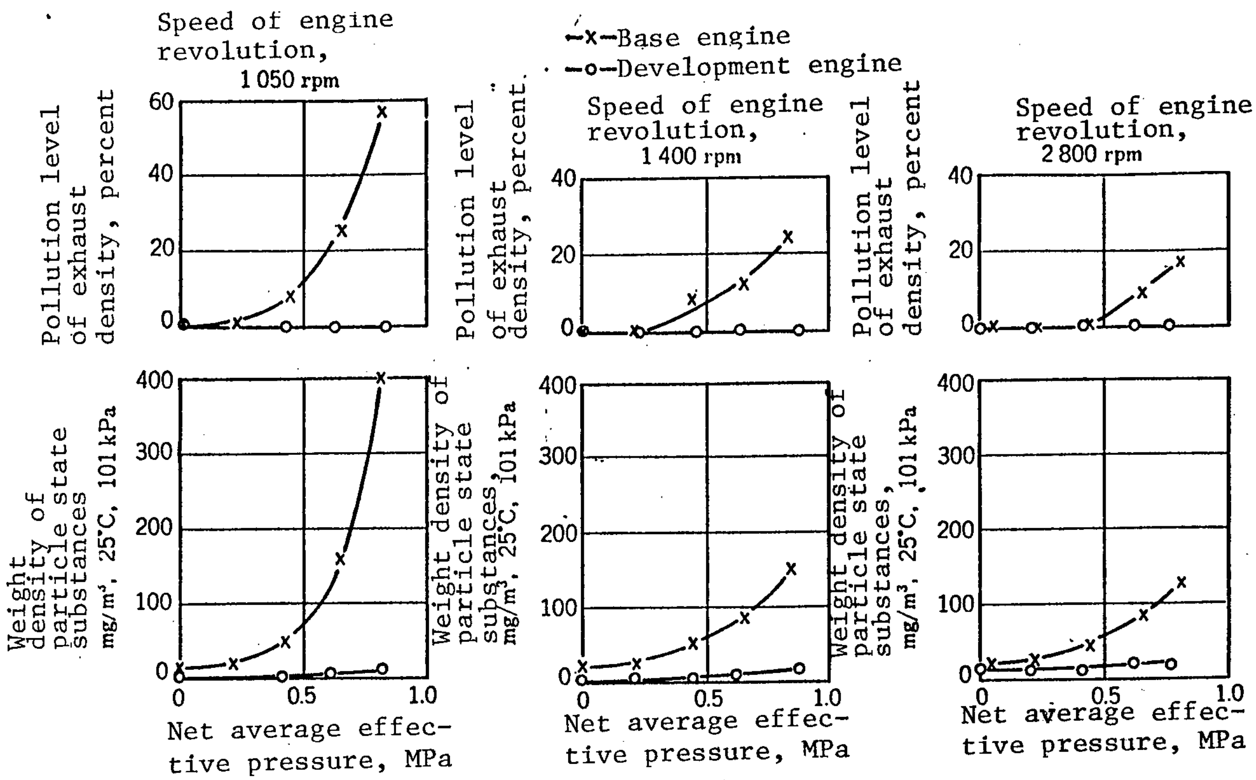


Figure 8. Exhaust Characteristics of Particle State Substances

particle state substances density and exhaust smoke density. To the contrary, however, in the development engine, although the exhaust smoke density is zero, a small amount of particle state substances are expelled.

(3) Durability and Reliability of Fuel System Parts

Since the viscosity of methanol is lower than that of gas oil, there is susceptibility to degrade the conditions of the parts designed to be lubricated by fuel injected from a fuel injection pump plunger or fuel injection nozzle. Furthermore, due to the strong corrosive nature of methanol, there is the possibility of damage to parts exposed to methanol. Thus, an injection pump durability testing machine was made on an experimental basis, and an 800-hour operation durability test was carried out. The prototype pump tested was the same as that used for the development engine. The operational conditions were a speed of injection pump revolution of 1,550 rpm, and the initial amount of injection of 64 mm^3/cycle. These correspond to full loading and maximum high-speed operation.

The degradation state of the parts tested is summarized in Table 3. In addition to nozzle burn out, there is evidence of burn out on a plunger barrel. If testing continued further, a plunger could be stuck. Although the surfaces of the aluminum-made parts of the pump housing were processed

Table 3. Degradation Observed in Test Parts

Places degradation observed	State of degradation
Pump housing	Holes on a gallery
Feed pump	Color change of Zn plating on a cap
Fuel filter	Holes on a cap
Delivery spring	Abrasion on an edge portion
Body nozzle	Evidence of abrasion of the circular shape at sheet portion
Valve needle	" "
Plunger	Evidence of burn out
Barrel	" "

by alumite, their corrosive damage was relatively large. The X-ray analysis of metals collected by a glass filter indicated that the main components of the metals were iron and aluminum. From these results, in order to apply methanol to a diesel engine, it is necessary to incorporate the methods to prevent abnormal plunger and nozzle friction and also to prevent corrosion of aluminum.

The vehicle installed with the methanol-gas oil dual fuel-injection diesel engine developed in this study is presently under the durability test program running since 1983. So far, by 1985 the vehicle has been tested the running distance of 20,000 km. There has been no serious problem observed in the fuel system parts.

4. Conclusion

In order to develop the methanol-gas oil dual fuel-injection engine, the amount of injection characteristics, combustion characteristics, engine performance, and low-temperature starting performance have been investigated with the use of the prototype engine.

The following are the results of the study:

1) Because the density and bulk modulus of elasticity of methanol are smaller than those of gas oil, there is a delay of injection starting timing and a reduction of injection pressure. Therefore, the amount of methanol injection is smaller than that of gas oil. The primary reason for this is considered to be that the speed of sound of methanol is slower than that of gas oil. Density has no major effect on injection characteristics.

2) The combustion of gas oil in the dual fuel-injection engine has an influence on not only the form of initial flame, but also exhaust gas characteristics. In order to obtain good output performance and exhaust gas characteristics, an improvement in the injection ratio of gas oil and the dispersion of gas oil spray before injection are necesary.

3) The value of M/F of the development engine at full loading operation exceeds 90-percent per volume except at the low speed range. The maximum value is 93.5-percent per volume. The amounts of HC and NO_X are reduced by half when compared to those of gas oil. However, the amount of CO doubles. The exhaust smoke density is essentially zero pollution level in all operation ranges. These values satisfy the 1982 exhaust gas standards for a diesel vehicle.

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Roundtable Discussion on Alcohol Engine

Tokyo NAINEN KIKAN in Japanese Sep 86 pp 28-34

[Discussion with the following persons on 26 May 1986 at JARI, under the topic of "Research and Future of Alcohol Engine in JARI": K. Yongkil, research manager of the Second Research Division (chairman); E. Kohno, director; T. Ayuzawa, head, I. Yamaguchi, and N. Iwai, Fourth Research Laboratory, Second Research Division; M. Hori, head, Y. Yoshida, S. Kobayashi, S. Seko, Fifth Research Laboratory, Second Research Division; and H. Kaji, head, Third Research Laboratory, First Research Division]

[Text] Chairman: JARI has been studying an alcohol engine for about 13 years. Today, we would like to discuss the subject of a view in the future by summarizing what we have done so far.

In the first place, since the Second Research Division of JARI studied an alcohol engine in the past, I will introduce the materials near at hand for the purpose of looking back over past circumstances. I propose to start discussion by recalling past experiences.

In April 1973, the study of alcohol fuel was first started in JARI. The First Oil Shock occurred in October of the same year, just a half year before that incident. At that time, there was a challenging but difficult subject for engine engineers. Namely, very severe exhaust gas standards had to be achieved. They were struggling agaisnt this subject even though various approaches from the engine side were studied.

At that time, there was nearly no hope to find techniques to meet the Muskie target of exhaust gas standards. Under those circumstances, an approach to study low pollution from now only the engine side but also the fuel side was proposed, and studies in low pollution of methanol fuel got started in April 1973.

This is the study of low pollution neat utilization engine shown in Table 1 (previously presented in "Technical Studies Reviews on Alcohol Fuels Utilization for Automobiles in JARI," September 1986 p 9).

Mr Iwai played a most active part in this study under the direction of Professor Hirao. The most difficult part was to reduce the amount of NO_X. The method to solve this problem was that the mixture of water by about 30 percent reduced combustion temperature, and it achieved the Muskie level. HC and CO were taken out by catalyst. This study showed a possibility to meet the Muskie level for these three components.

In the meantime, the First Oil Shock occurred. Since then, the situation did not allow emission study. Research emphasis on alcohol fuel shifted toward the viewpoint of energy saving.

To put it concretely, basic studies were carried out. They are for instance, which neat methanol is used for an automobile engine, what kind of combustion method and what kind of fuel supplying method is applicable, how to decide compression ratio, the processing method for exhaust gas, what kind of potential of the whole system is to be expected, etc.,

As seen in Table 1, between 1974 and 1978 the research subjects from ① to ⑨ in [2.1] correspond to the above basic studies. In a word, they are the optimization study of the oil-substitute low-energy consumption rate and low-pollution engine and alcohol engine. In [2.1], the items ⑧ and ⑨ are the summary of the whole study. These subjects are to investigate the potential of the neat methanol spark ignition engine.

The conclusion of the study of neat methanol applied to a spark ignition engine was such that exhaust emission generally met the Muskie levels and the 1978 standards. At the same time, the energy consumption rate of this engine was almost the same as a diesel engine with a subcombustion chamber. This was the final conclusion of the basic studies.

Along with the advancement of the above studies, not only the research of the spark ignition engine, but also the application of neat methanol to a diesel engine were judged to be necessary. From 1978, [2.2] in Table 1 got started. At first, the study of the ethanol-gas oil dual fuel-injection compression ignition engine was carried out. Under this subject three different methods, swirl chamber, prechamber, and direct injection were selected, and basic study such as obtaining the optimum combustion conditions was conducted.

Meanwhile, the Second Oil Shock occurred in 1979. At that time, there was indication that concrete study about substituted energy should be advanced in MITI with the Second Oil Shock as momentum. As seen from the comments in Table 1, the grant-in-aid system for "Oil Substituted Energy-Related Technological Application Development" was inaugurated in the Agency of Industrial Science and Technology. In addition, the feasibility study of the utilization of alcohol fuel mixture was started in the Agency of Natural Resources and Energy. In concrete terms, a scenario for new fuel oil was established. In particular, a feasibility study about the utilization of alcohol mixture was conducted.

Under those circumstances, from 1980, for the purpose of determining feasibility and potential of a methanol engine through the results of a prototype vehicle based on basic studies of [3.1] and [3.2], R&D of a more concrete engine system and vehicle system was undertaken. As a background for this R&D, there was a specific national demand, and also there was our own intention.

One of the studies was the dissociated-methanol small-sized engine system for gasoline-substitution listed in [3.1] of Table 1. Another was the methanol-gas oil dual fuel-injection method compression ignition engine vehicle system for gas oil-substitution. Since it was estimated that there might be many difficult elements to be developed in the case of the dissociated methanol engine, and the development of its vehicle was not achievable, the object was limited to the development of its engine system. To the contrary, in the case of the dual fuel-injection method, there were relatively few developmental elements. Therefore, the object was to develop the vehicle system. For the years 1980 to 1982, the original research object was almost accomplished regarding these systems.

As I mentioned before, we studied [3.1] and [3.2] with a grant-in-aid from the Agency of Industrial Science and Technology. An advantage of dissociated methanol could be observed for a large-sized diesel engine. Thus, it was judged that its possibility should be investigated. The application of dissociated methanol to a large-sized diesel engine was also studied on the technological results of the dissociated method described in [3.1].

That is associated with [5] in Table 1. The objective was to conduct R&D activity to obtain the vehicle system by placing a better engine system on an actual vehicle after two approaches, the dissociated methanol large-sized engine vehicle system for gas oil-substitution and the spark-assisted dissociated gas intake method, were examined. This development project started in 1983 and terminated in March 1986. The original development objective was achieved to a certain extent.

So far, we have been studying the possibility of utilization technique and the method to meet future potential for several kinds of systems.

Although at the request of MITI, various studies are presently carried out in JARI, I would like to start a discussion about the present status of alcohol fuel utilization techniques, their objectives, and its future by looking back to past studies. My introduction has been long, but based on those circumstances, I am going to proceed to a roundtable discussion.

First of all, as for the process of the study of alcohol fuel, the most important thing is the reason why the study of alcohol fuel is necessary. There is a problem associated with research needs. Secondly, is there a reason for JARI to conduct those studies? In this respect, I expect Mr Kohno to start.

Kohno: This study is to view the situation from a broader point of view. If the total amount of energy consumed in Japan is 100, half of it is used to generate heat; one-third is used for electricity; the rest of it, i.e., one-sixth, is used for power to rotate engines. This is not only for automobiles, but also for airplanes and ships. Transportation consumes about 17 percent of the total energy. Although it is said that automobiles make use of a lot of oil, in reality, automobiles consume only about 11-12 percent of the total energy.

When the First and Second Oil Shocks occurred, there was a proposal to reduce equally by 20 percent the energy used at that time by the various industries. Even if there was a reduction by 20 percent in the automobile industry, 20 percent of 11 percent could not have a big influence.

Apart from the above story, when fuel to be used for automobiles is considered, I think that oil fuel is still unsurpassable as automobile fuel. Automobile and airplane fuel which is essentially mobile should have three different characteristics. This idea was originated by myself, and recently many people are saying the same thing. They are: 1) probability or easiness to carry; 2) liquid under normal temperature and pressure, i.e., this is related to easiness to carry and simplicity to measure; and 3) large calorific value per unit volume or unit weight. This means that to run the same distance, it is possible to arrive at the destination with less weight. Presently, oil fuel satisfies the above three characteristics. Presently, oil fuel satisfies the above three characteristics. Therefore, I think there is no fuel available better than oil.

However, the First and Second Oil Shocks were caused by the problem associated with the fact that oil is limited. Oil will be gone in the future. We have to consider such an age. Under this situation, the development of oil-substitute fuel rose like a flood tide all over the world with the First Oil Shock as momentum.

When substitute fuel which satisfies the three conditions necessary for automobile fuel is considered, coal, for instance, is not liquid under normal temperature and pressure. The liquefaction of coal could become a different story. There is essentially no possibility to apply nuclear power to an automobile. Hydrogen is also not liquid under normal temperature and pressure. Under the above consideration, oil seems to be the best fuel, since it possesses the three characteristics which are essential for automobile fuel. Alcohol being characterized as an oxygen-containing fuel is considered to be very close to oil.

In this sense, we judged that without a drastic change in the reciprocating engine, which is the main current automobile engine, alcohol is the best oil-substitute fuel in use.

A little while ago, the chairman mentioned a historical story. Regarding cost, however, we cannot discuss inadvertently. That is to say that when the development of oil substitute fuel rose like a flood tide all over the world with the First Oil Shock was a turning point, the cost of oil substitute fuel such as liquefied coal was higher than that of oil.

In those days, the price of oil was about $3.00/barrel before the First Oil Shock. It rose to $17-$18/barrel after the incident. This was 4-5 times higher than the original price. Then, after the Second Oil Shock it jumped to $33/barrel. The price of oil increased approximately tenfold during that time. To the contrary, after the lapse of several years, by 1984 the power of OPEC became weaker, and the price dropped to $29/barrel. Since last fall (1985), surprisingly enough, it became close to $10/barrel.

Under this situation, at the occurrence of the First Oil Shock, if there was an idea to substitute for oil, provided the cost of liquefied coal was $50/barrel, the development of substitute fuel would have started all over the world. In reality, however, the cost of oil now becomes $10/barrel, and substitute fuel is no match for oil. I think that a forecast of cost will strongly depend on the political situation or economic situation at that moment. Thus, generally speaking, it is very difficult to predict.

Nevertheless, the fact is that oil is limited. On the other hand, there is also the fact that methanol is not unlimited. It is said that methanol is made from natural gas in a practical way. If the total amount of energy for natural gas reserves on the earth is estimated, it is lower than that of oil. Since it cannot be easily said which natural resources may be gone or which may remain, a meaning of JARI presently studying substitute fuel such as alcohol comes from our strong opinion that the automobile will not disappear no matter what kind of era comes. Under this assumption, we must consider countermeasures for the application of any kind of fuel.

As is often the case with people pushing methanol forward, many of them are considering to accomplish its practical application and to run a vehicle with methanol as soon as possible. My position is different from such an idea. No matter what kind of situation may come true, the accumulation of technologies which can correspond to any case seems to be a mission imposed on JARI. This is my thought.

Chairman: Recently, along with impetus from MITI, in conjunction with a NO_x problem in big cities to a certain extent, there is an idea to realize the diffusion of methanol vehicles. Do you have any opinion in this regard, Mr Kohno?

Kohno: For instance, if methanol is used, judging from the so-called pollution problem, a particular problem should be pointed out provided methanol is applied to a diesel engine. In the case of a diesel engine with gas oil, it is very difficult to take out particles. Under this subject, many researchers and scholars have tried to solve this problem spending several years. Unfortunately, however, it has been still unsolved. The fact is that when gas oil is changed into methanol, particles are very easily collected. In this respect, if the collection of particles is a serious problem for gas oil, there could be a movement toward the prompt utilization of methanol.

There seems to be less NO_x discharge in the case of methanol. But I think there is no difference in the amount of NO_x discharged between methanol and gas oil. When the motivation to utilize methanol as fuel is in terms of pollution, the greatest advantage seems to be the possibility of a reduction in the number of particles. Therefore, if the particles possess carcinogenic nature, and this causes a serious cancer problem to human beings, methanol should be utilized at all costs. This is my opinion.

Chairman: There are two different kinds of alcohol, methanol and ethanol. In addition, there could be composite alcohol. Generally speaking, I think we are able to talk about two different alcohols. Regarding ethanol, as you know, an ethanol vehicle was actually developed in Brazil, and the diffusion of such vehicles has already been completed in that country. Regarding methanol, the United States, Sweden, and West Germany are interested in the development of this fuel. There is a difference between countries, but except Brazil, most countries seem to put emphasis on methanol among various alcohol fuels.

If that is the case, a question may arise. Why do so many people pay attention to methanol? I think this is associated with supply of fuel and availability of resources. What is your opinion, Mr Kohno?

Kohno: As you know already, I went to Brazil to investigate because ethanol is actually utilized in that country. Before my trip to Brazil, I thought that since sugar cane is grown in such huge amounts and a large amount of ethanol can be made from sugar cane, Japan could import it. However, according to the Brazilian Petrobras, similar to the Japanese oil bureau, they said that they did not have a capability to export ethanol to Japan. They doubted whether they had enough ethanol for their internal consumption even at that time.

I made several field trips to the plants where ethanol was manufactured. They were very minor enterprises. It can be said that such small ethanol manufacturing operations was only realized because of Brazil. This country raises sugar cane by the slash-and-burn method of agriculture. The land is so huge that the production of sugar cane with the aid of chemical fertilizer is never profitable. This is my recognition through the investigation trip.

As you are aware, in the case of the slash-and-burn method of agriculture, a field is cleared and burned. This process provides fertilizer, and it is possible to grow sugar cane one time. Once a single harvest is completed, then people move into another field, and they grow sugar cane with the same process. There is no fertilizer placed. Since this agricultural method is unprofitable, the Brazilian Government helps their harvesting expenses, and ethanol is sold at a lower price than that of gasoline. That is why ethanol has come into wide use in that country. Due to this, Brazil is suffering from a large deficit. One of the reasons for an inflationary situation in that country may be the utilization of ethanol.

As I mentioned, the quantitative production of ethanol seems to be difficult. By the way, even in Japan, someone tried to determine the possibility to grow sweet potatoes in Japan in order to produce ethanol.

Chairman: Mr Iwai tried such an estimation in the past.

Kohno: What was the result of his estimation?

Iwai: It was impossible.

Kohno: I think so. Even in Brazil, it is nearly impossible. According to the latest information, the Brazilian Government is stumped by their financial problem. The government seems to have abandoned grant-in-aid.

In this meaning, there is no hope to get ethanol judging from its cost and quantity. Therefore, methanol is considered to be preferable as alcohol. Regarding methanol, as I mentioned before, it can be produced from natural gas and coal. The total amount of energy of coal deposits on the earth is so huge that it is considered a sufficient amount of methanol could be reserved. When people think about either ethanol or methanol, it will end in the victory of methanol from the viewpoint of its supply.

Chairman: When the combustive characteristics of methanol are looked at, methanol indicates different characteristics from that of conventional gasoline and gas oil. Judging from the characteristics of methanol, it shows both advantages and disadvantages. In this report, I would appreciate your discussion about advantages viewed from conditions being necessary for automobile fuel, and advantages and disadvantages from physical properties. In the beginning, how about advantages viewed from conditions being necessary for automobile fuel.

Kohno: Portability is very important for an unfixed engine. To be a liquid under normal temperature and pressure is a great advantage. Particularly, for instance, it is easy to carry. In the case of hydrogen, in order to carry it, it must be exposed to conditions of high pressure and low temperature. Additional weight is needed, and the cost of a container for liquid hydrogen is also added. A battery for an electric automobile presently causes a problem. This is associated with the lack of portability.

For the case of the present electric automobile, if the total weight of a vehicle is 100, for instance, 60-70 of the weight is batteries. After the oil shocks, under the subject of improvement in the fuel consumption rate of automobiles, three major countermeasures were considered. Among them, the most effective method is to make a reduction in vehicle weight. There is no better countermeasure for the improvement of fuel economy other than a reduction in vehicle weight. Due to this, various kinds of materials have been developed. High tensile steel is one example. In this respect, the installation of batteries opposes making a lightweight vehicle. Therefore, under the conditions of normal temperature and pressure, being a liquid does have a significant meaning. Methanol is certainly accepted from this viewpoint.

However, when calorific value per unit weight or unit volume, this is one of the conditions, is compared between gasoline and alcohol, the latter has smaller calorific value than the former. Actually, the calorific value of alcohol is almost half that of gasoline. In other words, when the same amounts of gasoline and alcohol contained in the same size fuel tank are compared to each other, cruising distance may become half in the case of alcohol. I think that is a disadvantage for alcohol. But this fuel satisfies the other two conditions. Therefore, this is better than other fuels. Small calorific value of alcohol may be a minor disadvantage when compared with that of gasoline.

Chairman: This is associated with the problem of making a large-sized fuel tank. Next, Mr Ayusawa, please give us your comment on advantages and disadvantages for physical properties of methanol in terms of high oxygen containing ratio (more than 50 percent), small calorific value, high octane number, large amount of vaporization heat, low cetane number, and so on.

Ayusawa: From the viewpoint of the physical properties of methanol, the improvement of engine efficiency can be expected from advantages such as high octane value and being combustible under lean mixture conditions. In fact, there is an improvement in efficiency. In addition, combustion with lean mixture makes it possible to reduce the amount of NO_x exhausted. In this respect, it can be said that there is positive influence.

Chairman: I think that containing oxygen leads to no smoke expelled. How about the disadvantages of methanol? What is your opinion regarding problems associated with half the calorific value and four times larger evaporation latent heat per unit volume when compared with those of gasoline.

Ayusawa: In the case of methanol, there is actually a problem associated with difficulty to start an engine during a cold start. Since vapor pressure of methanol is low, a flammable mixture is not easily formed below 7°C. In this respect, a cold start is a tough problem for methanol. Since evaporation latent heat of methanol is about four times larger than that of gasoline, it is difficult for methanol to get heat from its surroundings during warming-up operation after a cold start.

Similarly, it can be also considered that the increase of aldehydes contained in exhaust gas during warming-up operation at a cold start is a disadvantage of methanol.

Chairman: Gasoline is a well-balanced fuel for combustion at the low, middle, and high boiling points. Therefore, its composition well covers engine start at low and high temperatures and driverability at normal temperature. To the contrary, methanol is a simple substance; its boiling point is 64.5°C. There is no substance to cover low and high boiling points. In this regard, a cold start is a big problem for methanol. There is no chance to start an engine with methanol below 7°C. There is also a problem associated with operation under high temperature. Those problems are driven from the fact that methanol is a simple substance. What is your thought, Mr Iwai?

Iwai: I am going to discuss problems associated with the boiling point and evaporation latent heat of methanol since this fuel is a simple substance. In [2.1] of Table 1, there is the item of the stratified intake combustion method which utilizes decompression boiling injection. As the boiling point of methanol is 64.5°C, its relatively low boiling temperature is characterized as fuel of a simple substance.

Recompression boiling is described as follows. Methanol is kept under a high pressure condition, such as higher pressure than atmospheric pressure with higher temperature than saturation temperature of the atmospheric condition. Under these circumstances, fuel is injected so that its pressure becomes lower than atmospheric pressure. Then, liquefied methanol comes to a boil just after injection takes place. A spray composed of very fine particles is formed, and it helps the formation of mixture. I think this is the characteristic of methanol. Since this fuel has a relatively low boiling point, it is easy to be utilized.

Next, there is the problem of high evaporation latent heat. This may be solved by the application of the idea to get cool by utilizing high evaporation latent heat. Take for instance, in the case of injection into a cylinder, there might be a local spot in a combustion chamber where very high temperature condition is observed. The disadvantage to cool down compulsively by direct injection may turn out to be an advantage. This kind of a concept could be accepted, I think.

As one defect for methanol, there is the problem associated with easiness to cause surface ignition although its octane value is high. Surface ignition occurs because of high temperature at the wall of a combustion chamber. The reduction of the temperature at the wall should solve this problem. In this regard, if direct injection to cool down a hot spot enables prevention of surface ignition, there may be the approaching method to utilize a disadvantage as an advantage.

A problem of low calorific value is very often pointed out. This means that the amount of fuel supplied during one cycle is large. In particular, a small amount of metering is required for a small engine. For example, such metering is very difficult for a small engine of direct injection. When methanol is applied to a very small engine, twice the quantity of fuel supplied is necessary. In this respect, methanol is easy to be metered. Again, I think we could make the most of a disadvantage of methanol as an advantage. Methanol is the fuel having such characteristics.

Chairman: Moreover, methanol is suitable for the Otto type. But it is not easily applicable to the diesel type. There is a straight-out defect for methanol when it is used for the diesel type. Mr Hori, do you have an idea about this respect?

Hori: Since the octane value of methanol is naturally high, it is said this fuel is good for the Otto type and spark ignition engine. Therefore, some people consider this fuel should not be used for a diesel engine. Nevertheless, because of the possibility to reduce the amount of NO_X and the exhaust of black smoke, this fuel has been watched as a fuel to bring low pollution.

Judging from the physical properties of methanol, the most difficult problem for this fuel is nearly zero octane value when it is applied to a diesel engine. Namely, its self-ignitability is very bad. Gas oil being used for a diesel engine has the cetane number of 55-60. To the contrary, in the case of methanol, its number is nearly zero. When it is used for a diesel engine, it is necessary to improve its ignitability. For example, the method to use this fuel mixed with gas oil, the dual fuel-injection method, and the compulsive ignition method can be considered. A combustion technique to eliminate the disadvantage of the cetane number is necessary.

Another disadvantage of methanol is that its viscosity is very low. Both a plunger and a needle of an injection nozzle are lubricated by gas oil. When methanol is used, lubrication is degraded by its low viscosity, and the possibility of degradation by heat must be considered. In particular, in the case of an injection pump of the distribution type being in use for a passenger car diesel engine, it is considered that methanol cannot be applicable under the present situation.

In the case of a P-typed pump, lubrication of a plunger is expected to some extent because oil is compulsively circulated.

Regarding an injection nozzle, degradation by heat may also happen due to very high loading. To solve this problem, the use of new materials such as ceramics seems to be necessary. However, there are still problems associated with its practical application. The low cetane value and lubrication can be considered as serious disadvantages of methanol.

Chairman: Among the advantages of methanol, its easy reforming can be pointed out because of its simple substance. Mr Yamaguchi, please indicate your opinion.

Yamaguchi: Reforming of methanol is carried out so that methanol is changed into hydrogen and CO by utilizing exhaust heat with catalyst. In this case, if there is no oxygen, the recovery of exhaust heat is possible due to an endothermic reaction. This is the characteristic of reforming of methanol. There is an increase by 20 percent in the amount of heat based on a liquefied condition. Therefore, it is considered that an improvement corresponding to the amount of increased heat in terms of thermal efficiency could be achieved.

Chairman: Mr Kobayashi, you have conducted various studies about the octane value of methanol. How extensively can we utilize the advantage of the octane value on the practical base? Please give your comment to us on this respect.

Kobayashi: The octane value of methanol is considered to be very high. Actually, its value was measured with a CFR which is an engine to measure octane value. However, the exact value was not obtained in most cases.

The reason for this situation is considered to be as follows. Presently, a definition of octane value is for the purpose of the measurement of current gasoline. Since evaporation latent heat of methanol is so large, intake temperature decreases rapidly under the present measurement procedures. In other words, when intake temperature decreases, temperature at the inside of a cylinder also decreases. This leads to the increase of apparent octane value. Instead of actual chemical nature, influence is from a physical respect.

Therefore, in our study, in order to ascertain its chemical nature, intake temperature was increased. We then made a comparison with gasoline under the same intake conditions. As a result, its value was certainly higher than that of gasoline. Nevertheless, its measured value was not so high as the value we experienced through its actual usage. We obtained the result indicating the existence of considerable temperature influence. This says that if we utilize the nature of this fuel in a positive way, there could be the possibility to use this fuel at a high compression ratio.

In addition, methanol has the nature to be combusted under a lean condition. If both natures are well combined and utilized, the advantage to increase compression ratio considerably could be brought. This is my opinion.

Kohno: Strictly speaking, it cannot be said the octane value of methanol is high. In the final analysis, engine compression ratio can be increased.

Kobayashi: However, octane value itself is never low.

Kohno: I agree its value is not low, but there is not such a big difference as actually appeared. In this sense, an expression of high octane value seems to be saying too much. Take for instance, under the word of mechanical octane value, a different compression ratio used for the design of a combustion chamber. I believe an expression of the octane value of fuel seems to be strange.

Kobayashi: Thus, the octane value of methanol cannot be measured by equipment which is prescribed by JIS and ASTM. Those standards do not satisfy the conditions.

Kohno: In any case, the fact is such that it is possible to increase compression ratio. I think that such an expression is more appropriate.

Chairman: Do we miss any points regarding advantages and disadvantages of methanol?

Yoshida: Regarding an additional disadvantage of methanol, this fuel is originally a solvent. Accordingly, it possesses the nature to dissolve various kinds of materials. This intends to increase demand for materials such as rubber to a great extent with respect to durability to solvents.

Kohno: Moisture absorption is also a considerable disadvantage.

Chairman: As other advantages of methanol, a fuel with very high purity can be manufactured. There is less chance to contain various kinds of impurities.

Kohno: But water is contained.

Chairman: Of course, water is mixed, but other impurities such as S and N are not easily contained. In this respect, low pollution is one of the advantages of methanol.

Iwai: Talking about low pollution as one of the characteristics of methanol, the amount of aldehydes expelled from this fuel is about 10 times larger than that from gasoline. This is a serious problem. Aldehyde can be treated by oxidation catalyst. Unfortunately, however, under the condition of low temperature before catalyst is warmed up, this problem cannot be solved by present techniques.

The maximum allowable concentration of aldehyes at a working area regulated by the Ministry of Labor is 5 ppm. When the amount of aldehydes expelled from exhaust gas of a methanol engine at low temperature is measured, it is about several hundreds ppm. There is the strong smell of aldehydes from a vehicle with a methanol engine which is placed in the open air. Even in the case of a parking lot with no roof, people have a pain in their eyes. If a vehicle is parked in a garage, aldehydes become really intolerable to people. Relative to the aldehyde concentration at a working area, very high concentration of aldehydes is expelled before the catalyst is warmed up.

In the past, the problem associated with the possibility to eliminate methanol from exhaust gas by catalyst was studied. Methanol is reacted and decomposed into CO_2 and water through aldehyde. But if there is an incomplete reaction through catalyst, methanol will be expelled under the phase of aldehyde. The same thing can be said in the case of a thermal reactor. Generally speaking, in the case of catalyst for CO, the surface volume ratio of 40,000 is considered to be sufficient. When cleaning of formaldehyde was carried out with the utilization of catalyst which aimed at exhaust gas of an alcohol engine, not only for catalyst of formaldehyde, it was found that a surface-volume ratio of about 10,000 was necessary. In short, four times larger catalyst in size is necessary when compared with that for CO. This is also a disadvantage of methanol.

Chairman: This problem is very serious and important because the technique to solve this problem will take a very long time. I would like to discuss this problem again.

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