office sector that the domestic computers were able to make inroads. It can easily be understood that the Japanese manufacturers were fighting a desperate battle in the domestic market to halt the foreign penetration on their citadel especially after the liberalization of imports in 1975. Generally speaking, customers tend to upgrade their current models, partly because of the wealth of software capability they have accumulated for the model they are using and partly from habit rather than switch to other manufacturers. Naturally, new customers are subject to intense sales campaign. I would like to point out that foreign computers are now gradually finding their way into Japanese Government and public offices as a result of stepped-up sales promotion efforts.

It is difficult to make an objective assessment of the Japanese computers' competitive edge. Judgement will be passed by the market.

By developing large computer models, Japanese computer manufacturers somehow narrowed the gap with IBM. They are, however, being outstriped by IBM again as a result of the latter's recent development of new models. Model 3981 of the new H Series announed by IBM in October 1980, said to be the harbinger of the fourth-generation computer, and the 3081 K Series announed in October 1981 have, in fact, had great impact on the Japanese market.

According to the October 30, 1981, issue of the *Nihon Keizai Shimbun*, IBM Japan had by then sold 150 of its 3081 Model computers in Japan, whereas Fujitsu, Hitachi, and Nippon Electric had sold only about 10 to 30 competitive models each. Although not even MITI has accurate sales figures, I think that the figures given by the *Nihon Keizai Shimbun* are correct. The new software technology incidental to the 3081 K Series eludes all attempts at imitation even by those Japanese manufacturers who approximate IBM in hardware technology. It is said that IBM has demonstrated its supremacy in software technology with its 3081 K Series, far outdistancing Japanese makers.

Unlike other manufacturing industries, the computer industry is one in which there is continuous technological innovation. The ratio of research and development expenditures to sales is a very high 9.2% in the computer industry. Technological development capability controls the market in computers. And technological development capacity, in the long run, derives from the overall strength of each company.

It hardly needs to be noted that 80% of the world computer market is controlled by American makers. IBM alone has about 60% of the world market. Even combined, Japanese manufacturers have only about 7%. IBM's computer sales are six times the combined sales of all Japanese computer makers by value. IBM's sales reflect its competitive edge and its superb research and development capability. The gap between IBM and the Japanese computer makers is still extremely wide.

The six Japanese computer manufacturers made communication equipment or electric machinery before they branched out into the manufacture of computers. The ratios of computer sales to overall sales for the six computer makers are as shown in the attached table.

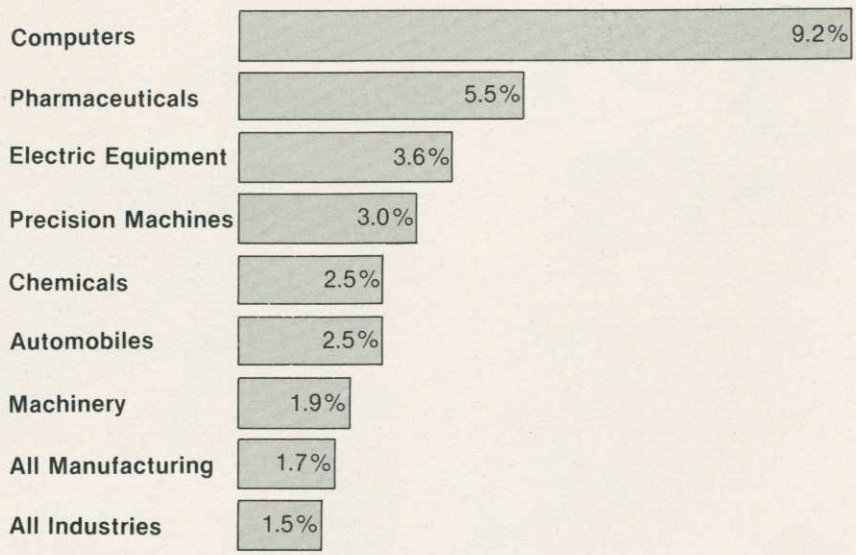
Some people have counted this small ratio of computer sales to total sales as one of the strengths of the Japanese computer manufacturers. However, the truth is that almost all the Japanese computer makers are presently financing their computer divisions with profits from other divisions, pinning their expectations on future sales and on technological advances.

How have Japanese computer manufacturers done overseas?

According to 1980 statistics, the ratio of exports to total computer production was slightly less than 10% by value. (The ratio drops to about 5% when IBM Japan's figures are excluded.) At present, each computer maker follows its own export strategy. When I went to New York on business last year, I heard directly from Japanese computer company sales managers stationed in the United States that it takes more capital, more time, and more people to develop computer markets than it does to develop markets for other industrial products. In the case of large-capacity computers, it is necessary to train software support personnel and computer operators in order to sell hardware. Moreover, it is necessary to provide maintenance for the hardware. Unlike automobiles and electric appliances, which do not require salesmen to maintain after-sale contacts with customers, the computers are extremely complex machines which require elaborate post-sale customer service. Moreover, it takes considerable time to organize a sales network. In electric appliances and automobiles, both of which are known as full-fledged export industries, the ratios of exports to output are about 70% and 55% respectively. It took these industries about 15 years to raise their export ratios from 10% to 50%. The recent sharp increase in the exports of small computers (office computers and personal computers) has caused some people to think that the computer industry will become a "second automobile industry" in less than five years. However, judging from the histories of the electric appliance and automobile industries, I personally think it will be 10 to 15 years before the computer industry develops into a full-fledged export industry with an export ratio of 50% or more.

MITI has not set any long-term export target for computers. Nor does it have an overseas sales strategy. What MITI has is a policy intent to make the computer industry the nucleus of Japanese industry. Needless to say, when the computer industry establishes itself as the nucleus of Japanese industry, it will have acquired international competitiveness and made in-

Percentage of Total Sales Used for Research and Development By Industry (as of 1980)



Source: "Report on Scientific and Technical Research" of the Statistics Bureau, Prime Minister's Office)

roads into overseas markets. At such a time, the computer industry, like other industries that have advanced overseas, will be exporting finished products and components and providing technical guidance, stepping up technical tie-ups and joint development, constructing plants overseas, and establishing joint venture companies —the same pattern as followed by other industries that have developed into export industries. Yet the path taken by each Japanese computer manufacturing company in its attempt to advance overseas will probably differ greatly according to technical level, manufacturing capacity, and business management, as well as in response to overseas trends and the international market situation. It is important that each computer company learns from the experiences of other industries and other products in order to respond appropriately to the situation overseas and to try to avert friction in overseas markets. MITI will provide guidance to computer manufacturers with these points fully in mind.

Problems Faced by the Japanese Computer Industry

The Japanese computer industry will have to overcome a great variety of difficulties and resolve many problems in order to evolve into a leading Japanese industry.

First, the Japanese computer industry has lagged seriously behind its counterparts in the other industrialized countries, and has therefore been trying to catch up. Japanese technology development projects were aimed at catching up with advanced foreign technology, and this technology served as the development target for the Japanese computer industry. From now on, however, the Japanese computer industry has to try to become less dependent on technology developed overseas and develop its own advanced computer technology. Unless the Japanese computer industry becomes fully independent of overseas technology, it will not be able to stand truly on its own feet.

Secondly, the demand for computers is expanding and becoming more diverse as society and the people's lives become increasingly information-oriented. This means the range of computers will expand, from ultra-large to mini, and from all-purpose universal models to special-purpose models. At the same time, terminal equipment will become increasingly intelligent. To cope with this trend, computer makers will most probably split into a number of categories, such as total-range computer makers manufacturing all models and speciality model makers dealing exclusively in a few models and types. It is also anticipated that companies in other industries will start manufacturing computers. At any rate, it is essential for the entire Japanese computer industry to respond appropriately to increasingly diverse market demand.

Thirdly, it is necessary for the computer industry to position itself internationally. Diversification of domestic computer needs will inevitably invite foreign computers into the Japanese market, while prompting overseas advances by Japanese computers.

Government Policy for the Computer Industry: Technological Development

The next problem is what policy measures the Japanese Government should take in order to resolve the problems confronting the computer industry.

To begin with, the fundamental purpose of industrial promotion policy measures is to enhance the vitality of the private sector. The basic thinking underlying Government policy for the promotion of a specific industry is to extend a helping hand on areas which cannot be accomplished by market mechanism alone. The computer industry promotion policy is also premised on such thinking. The policy today emphasizes supplementing industry's ability to develop new technology. We intend to augment this policy stance.

On this basis, the Japanese Government will help the computer industry in developing technology in the following three fields.

First are fields in which commercialization will take a long time even though far-reaching ripple effects can be expected for the economy, society, and technology.

Second are fields in which development is beyond the means of the private sector because the risks involved are great and the financial burden is enormous.

Third are fields in which the economic and social needs are extremely great and a prompt response is urgently required.

In sum, this means that the Govern-

International Symposium on the Fifth-Generation Computer held in Tokyo in Oct., 1981 was participated in by scores of leading computer scientists from the world.

ment will help the industry in those fields where it is unreasonable to hope for the development of urgently needed technology in response to price mechanisms alone.

Concretely, this assistance can take either of two forms. One is Government assistance (subsidies) to technical development projects being undertaken by the private sector, and the other is Government initiative in organizing a technical development project and promoting it with the cooperation of universities and private firms. The amount of money which the Government invests annually in both types of assistance for the development of information-related technologies totals approximately ¥10 billion. This is not much compared with the amounts of money being spent by the other industrialized countries. Nor is it much in comparison with the private sector's investment, since the annual research and development budgets of the private companies themselves amount to approximately ¥90 billion, making the Government's contribution only about 10% of the total.

Subsidies are granted, in the first place, to basic research. They are not granted to help product commercialization.

Prof. T. Moto-oka of Tokyo Univ., top leader in MITI's Fifth-Generation Computer Project.

Secondly, if a private corporation should profit from the use of a technology developed with subsidies it is obliged to pay the state back from that profit.

Thirdly, the Government encourages private firms to make patents obtained as a result of technology developed with Government subsidies available to foreign countries.

The VLSI project, one of the technology development projects that has attracted the greatest attention recently, is an excellent example. It is worth noting that access to the patents obtained for VLSI as a result of this development project has been granted to rival foreign VLSI makers, such as IBM, Western Electric, Fairchild, and Texas Instruments.

All patents obtained in connection with technology developed in State-initiated projects belong to the State. All patents owned by the State are open to anyone, Japanese and foreign, for proper compensation. There will be no change in this Government policy in the future.

In Government-initiated projects in the 1980s, MITI will positively promote the development of software technology, in which Japan lags seriously behind. In addition, three major projects to develop hardware technology are now underway:

(1) Project to develop a high-speed-electronic computer for science and technology computation (Super-Computer)

The project was started in January 1982, with approximately ¥20-25 billion to be invested over a period of nine years.

The project aims at developing a high-speed computer to make scientific and technological computations. The target is to develop a computer exclusively for science and technology that will be able to compute about 1,000 times faster than the universal computer currently available.

Technical problems involved in this project include the design of a parallel operation system that will make such high-speed computation possible as well as the development of a new high-speed element. Among the new high-speed element candidates are the Josephson junction element, the gallium arsenic element, and the HEMT (high electronic mobility transistor). Research and development will be conducted on these new high-speed elements.

If such a high-speed computer can be developed, it will be possible to do test simulations of nuclear fusion and of advanced reactors. Because a high-speed computer will have a high-speed picture and image analyzing ability of far greater resolution, this will greatly improve the accuracy of weather forecasts and of resource exploration by satellite, as well as making it possible to design simulations for wind tunnel tests. Accordingly, this project is attracting international attention.

(2) Project to develop the fifth-generation computer

This is a project to develop an epoch-making computer based on a new design concept and completely free of the defects of computers currently in use. This computer is expected to become a reality in the 1990s.

Research has been going on now for over three years. The concept of this revolutionary computer was announced at the *International Symposium on the Fifth-Generation Computer* held in Tokyo in October 1981. This project is therefore attracting global attention. It has been decided to begin full-scale research in 1982. This development project will be undertaken by a major team of researchers from universities, Government research institutes, and computer manufacturers.

There are three main technical problems involved in the development of the fifth-generation computer: the inference function, the data base, and the intelligence interface. Under the present plan, a prototype will be developed in about 10 years. About ¥10 billion in State funds will be invested in the first phase of this project for the three years from 1982 through 1984. In the second phase (1985-1988), the sub-system will be completed; while in the third-phase (1989-1991), the total system is scheduled to be completed.

Joint efforts on an international scale are now being contemplated for the research and development on the fifth-generation computer. The Japanese Government has discussed the feasibility of international joint research with the British, French, and West German Government delegates to the International Symposium, and discussions are to continue in the future.

(3) New Function Elements (project to develop next-generation industrial infrastructure technology)

This is a Government-initiated 10-year project begun in 1981 for the purpose of developing the industrial infrastructure technology for the 1990s. The development of elements with new functions will be taken up as computer-related technology in connection with this project.

The elements with new functions are (1) super-lattice elements, (2) three-dimensional elements, and (3) environment-proof elements. The first and second are epochal elements with integration levels much higher than today's VLSI, and they are still in the idea stage in even the most advanced countries. The third is for elements able to function at temperature extremes and to withstand radioactivity. If environment-proof elements can be developed, this will lead to the development of sensor elements that can be loaded in satellites or used in exceptional environments.

By promoting these three major projects, Japan will be able to develop truly original and highly advanced computer-related technology. At the same time, Japan will be able to make international contributions befitting its economic superpower status by weaving international cooperation into the development of these projects.

Information technology is opening up a new future for mankind, and we must work today to build the information-oriented society in preparation for the 21st Century.

It is MITI's wish to develop the information industry for human progress and to contribute to the international community through the development of this industry. ●