R&D In Japan

Tsuneo Asai of the Nihon Keizai Shimbun reports on trends in Japanese R&D from a macroeconomic perspective, focusing on patent applications. He also reports on activities at the forefront of electronics and software development. This is followed by Dr. Moriya Uchida's report on chemical technology, including biotechnology and new materials. Dr. Takanori Okoshi closes out our special section with a discussion of the present state of opto-electronics. Both Uchida and Okoshi are first-line researchers.

A Report From The Front

By Tsuneo Asai

The race to develop high technology has become more intense than ever, while the successive development of new techniques is rapidly expanding the high-tech frontier. All the advanced nations are vying for supremacy in this critical area. Creative and revolutionary techniques are the key to successful technology development, and Japanese scientists and engineers are striving hard in that direction.

Recently, I visited the front lines of R&D in Japan to find out how these creative techniques are being developed. Here I would like to report the views of those involved on the present state of Japan's R&D efforts.

Joining the Front Runners

The number of patent applications is considered a yardstick for technological development. Applications for patent rights in Japan more than doubled between 1966 and 1980 from 86,000 to 191,000. The number of patent applications in the United States increased only slightly in that time from 89,000 to 104,000, while in West Germany it declined from 51,000 in 1966 to 49,000 in 1980.

Japanese applications for foreign patent rights more than tripled during the same period from 10,000 to 35,000, while those filed by U.S. and Western European applicants decreased. The list of foreign applicants for U.S. patent rights in 1966 was headed by West Germany, followed by Britain, France, and Japan in that order. Ten years later Japan outstripped West Germany to top the list. Similar trends distinguish Japanese applications for patent rights in other foreign countries, including West Germany, France and Britain.

Koshiro Matsuoka, Patent Department director at Fujitsu Limited.

Increased applications for patent rights reflect the development of new technology. In particular, a steady rise in applications for overseas patent rights indicates the development of technology of considerable quality.

According to Koshiro Matsuoka, Patent Department director at Fujitsu Limited, Japanese enterprises depended on imported technology from about 1955 to 1964. During the period 1965-1974, the concept gained ground that they must independently develop their own techniques. Notes Matsuoka: "The big change this touched off has been clearly reflected in patent application statistics. The trend has given birth to many new techniques in rapid succession. And although some people would say that Japan depends heavily on imported technology and has no techniques of its own, the drive to develop independent technology has been in progress for more than 10 years."

The upward trend in Japanese patent applications is unlikely to wane in coming years. By the same token, development of new technology in Japan is expected to accelerate further.

Electronics R&D

Next, let us take a look at the front lines of R&D in electronics, which has displayed marked progress in high technology development. Electronics has given many industrial products new value added and expanded their industries as a whole. Atsuyoshi Ouchi, vice-president of Nippon Electric Co. (NEC), has been designing electronic circuits for many years and, through his wide experience with semiconductors and other electronics products, is considered a leader in private-sector R&D. He described the present situation as follows: "Electronics has made progress in every area. Large scale integration (LSI) has advanced rapidly, and is expected to continue to show steady progress in the years ahead. This is because LSI microprocessors—initially used in computers, personal computers, and microcomputers—have spread to television sets, air-conditioners, microwave ovens, and other electric home appliances. They are now finding new applications in sewing machines, robots

Atsuyoshi Ouchi, vice-president of Nippon Electric Co. (NEC)

and other machinery. While popularization has been slow outside electric or electronic applications, microcomputers are now transforming the primary and tertiary industries. They are employed in poultry and hog raising, horticulture, arcade games and toys. Through the use of microcomputers, it has become easy to get chickens to lay more eggs or make dolls talk.

On the other hand, progress in electronics has also given rise to a number of problems. Only by dealing with these wisely can we open the path to further development. What are the new problems facing researchers? Ouchi described them as follows, while stressing that all can eventually be overcome.

"The term 'mechatronics' has been coined to bridge the gap between electronics and mechanics caused by the inability of mechanics to keep pace with electronics technology. The age of electronics requires high-quality mechanical experts to cater to its needs, and increased importance is being attached to developing quality mechanisms. At the same time, the delay in the development of sensors is becoming a worldwide problem. Further progress in robotics will soon make it impossible to move robots with microchips alone, necessitating machines and sensors operated by man and his brain. Precision machines are also needed for manufacturing LSIs. People talk about Japan as a country where things are made tiny, but when robots are shrunk they will need to be more precise than at present.

"At one stage," continues Ouchi, "there was apprehension that progress in robotics might increase unemployment. However, it is possible to reallocate middle- and high-aged workers by retraining them for more advanced and intellectual jobs. If jobs are made 30% easier, increased efficiency should lead to 30% higher productivity and shorter working hours. Automated factory operation also has its merits. This is possible in Japan, where many unions are intra-company."

Software R&D

Progress in electronics technology has touched off an information revolution. However, while there has been steady progress in hardware, software has lagged behind. Japan is said to be particularly weak in this area, and there have been calls for improved software development.

Norihisa Suzuki, associate professor at Tokyo University, recently returned to Japan after many years of research at U.S. universities and enterprises. Now engaged in the development of fifth-generation computers, and a key figure in Japanese software development, Suzuki describes the situation in Japan at present as follows:

"We are in the midst of an information revolution. This has two aspects: quantitative change caused by hardware, and qualitative change caused by software. While inexpensive, compact and high-speed hardware has made great progress, software has been slow to develop. Big changes are expected in coming years. Present hardware is considered capable of meeting the needs of an information-centered age for the next decade or two, but adequate software has yet to be developed.

Norihisa Suzuki, associate professor at Tokyo University

"Despite the microcomputer craze among Japanese youths, there are still only a few people who can teach them about software. Software engineers are considered less important than hardware engineers at universities, where fewer professors are engaged in software research. However, software departments have more students, apparently because young people are increasingly aware that software has huge potential. The great popularity of information equipment—such as microelectronics, microprocessors, and personal computers—has created increased demand for programmers and other software technicians. This is why there should be more emphasis on education which can form the basis for the technology. I think universities should be more aware of this factor and take appropriate steps in that direction.

"Fifth-generation computers are being developed in Japan as thinking computers with high-speed, high-performance characteristics. In the same way, we will also see the development of unique software. Computer memory capacity will increase both quantitatively and qualitatively, requiring the development of unique software to make full use of the hardware."

NEC's Ouchi also stressed the importance of software, noting: "The emergence of personal computers has led to increased recognition of the value of software. Prior to this its value had not been recognized in Japan, because it has no visible form. Computer makers produce basic software, but this is like the record-player business, leaving room for other makers to produce records. As a result, software technicians are now in short supply. In recent years, the graduates of university science departments have found themselves very much in demand, especially women. Female graduates of liberal arts departments are also given aptitude tests for assignment to software development. Training software experts has thus become an important task. People talk about turning Japan into a technology-oriented nation, and give priority to science students. However, in an office automation (OA) age in which personal computers and microcomputers are used in the office, liberal arts students will also play an important role. Reading, writing, and arithmetic are considered the basics of education, but utilization of microcomputers should also be counted among the fundamentals and taught to young boys and girls. The younger the child, the easier it is to start learning software, which is in a sense a cultural achievement.

"Since differences between Japanese and Western software can be traced to different language structures, it is possible that uniquely Japanese software may eventually emerge here. This is why we have such great hopes for future software development."

Suzuki also addressed the software issue, observing: "Japan has displayed great creativity in the application of techniques. Software in Japan, however, differs substantially from Western software. This is because it is based on the Japanese language, which is the product of a distinctive culture. In Western countries, where typewriters have been used for many years, input and output between computers and human beings could be achieved easily through a natural extrapolation from the typewriter. By contrast, typewriters have only been popular in Japan for a decade or so, and have presented many problems in terms of processing the Japanese language. Different language skills have necessitated research on computer input and output methods that circumvent these obstacles via voice input and output, pattern recognition, letter recognition, 'kanji' (Chinese character) input and output, and other systems.

"I hope that Japan will also contribute to the world in musical software—which is truly creative software—as well as in literary and artistic software. Translating machines may be described as an artistic engineering product, and many other tasks also still remain to be tackled, including processing pictures and linking the arts with computers." •

Tsuneo Asai is a science writer with the economic daily Nihon Keizai Shimbun. Asai, 48, began his career with the Sangyo Keizai Shimbun in 1959 after graduating from Kanagawa University and joined his present newspaper in 1971. A noted science writer in Japan, he has authored many books on science and technology.

Original Chemicals Technology

By Moriya Uchida

The Japanese fermentation industry has a long history reaching back hundreds of years. Alongside Japan's silk-centered natural fiber industry and rice-centered agriculture, the fermentation industry has taken root throughout the country, spurred by the brewing of *sake* (rice wine) and such fermented foodstuffs as *miso* (soybean paste) and *shoyu* (soy sauce). These industries are an inseparable part of the everyday life of the Japanese, and have evolved as an integral part of Japan's social and cultural milieu.

Similarly, ceramics—originally imported from China—have developed alongside indigenous earthenware. Japanese ceramics early on reached such a peak of perfection that they were exported to as far away as Western Europe, and won international acclaim. In addition, Japan has sophisticated traditional pharmaceutical and medical skills built upon oriental medicine.

The spectacular growth of Japanese chemicals technology owes much to this firm foundation of traditional skills. But it also is due to the nation's tremendous efforts to absorb and assimilate the advanced Western technology that was introduced with the opening of Japan to the West in the second half of the 18th century.

By the early 1960s, Japan had begun to turn out many outstanding specialists in chemicals technology the equal of those in the West.

The Rise of Japan's Chemical Fiber Industry

It was in 1891 that Count Hiraire Bernigaud de Chardonnet built the world's first artificial silk (rayon) factory at Besançon in eastern France and started producing the new textile at a rate of 100 lbs. a day. The following year, Naokichi Kaneko, a Japanese businessman, became interested in the fledgling industry, and in 1907, a Japanese chemist-businessman, Seita Kumura, began his research into commercializing the manufacture of viscose rayon. With the cooperation of Dr. Itsuzo Hata of Yonezawa Technical School (now part of Yamagata University), he inaugurated Japan's first rayon factory in the northwestern Japanese city of Yonezawa in 1916. In 1918 this mill became the starting point of Teikoku Jinzo Kenshi K.K., forerunner of today's Teijin Limited.

By 1937, Japan was the world's leading producer of rayon with an annual output of 336 million lbs., surpassing America's 320 million lbs. Teijin alone was producing 60 million lbs. a year, equal to the entire output of the pioneering French rayon industry.

Indeed, rayon proved the prototype for Japan's subsequent efforts to build modern industries, and established the tradition among Japanese companies of welcoming the challenge of innovative new technologies.

World War II, however, dealt a stunning blow to Japanese industry.

Annual rayon and staple fiber yarn production in 1945 plunged to 5.6 million and 22 million lbs. respectively, 1/60th and 1/17th of the prewar peak output.

This was the situation when Kurashiki Rayon Co. (today's Kuraray Co.) launched its all-or-nothing drive to commercialize polyvinyl alcohol (PVA) fiber, invented in 1939 by Dr. Ichiro Sakurada of Kyoto University. At the same time, Toyo Rayon Co., predecessor of today's Toray Industries, Inc., purchased patent rights to nylon from Du Pont Co. of the United States for a staggering sum exceeding its own capital, and devoted itself to refining the technology and paying for the hard-won prize. Polyester fiber production also developed from a basic production process acquired from Imperial Chemical Industries Ltd. (ICI) of Britain.

As for acrylic (acrylonitrilic) fibers, now also manufactured in quantity in Japan, Du Pont and West Germany's Bayer A.G. originally used their patent rights for the dry-type spinning process to retain oligopolistic control over world production. But Japanese synthetic fiber makers successfully countered the American-West German challenge by developing their own wet-type acrylic fiber spinning process, previously considered too difficult to apply to the production of good acrylic fiber. Today, Asahi Chemical Co., Japan's top acrylic fiber producer, is enjoying outstanding success with its own nitric acid solvent method. This unique achievement is attributable to a combination of Japan's long-nurtured rayon production technology and Asahi's own ammonia production and application technology, for which its research staff is well known.

It was again this pattern of dynamic industrial development and strenuous scientific promotion that enabled Japan to devise its unique carbon fiber technology.

In 1959, a researcher at the Government Industrial Research Institute, Osaka, of the Ministry of International Trade and Industry's Agency of Industrial Science and Technology discovered that carbon fiber can be produced by baking polyacrylonitrilic fiber.

From that basic discovery, Toray has developed a complete set of commercially viable industrial processes including methods for producing acrylic filaments, accelerating the carbonizing reaction and baking of such fibers. The company has also joined hands with Union Carbide Corp. of the U.S. to start developing dif-

Asahi Chemical's ammonia plant in Mizushima, Okayama Pref.