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.

subsequent commanding success of Ajinomoto Co.

Japan's remarkable achievements in the study of amino acids following the development of its modern chemicals technology were accelerated by its social and cultural climate and by the fact that the staple foodstuffs of the rice and vegetable centered traditional Japanese diet were short on amino acids, leading to recognition of the need to improve nutritional intake.

Today, amino acids are produced the world over, including L-glutaminate (2.07 million tons in 1979), and L-lysine (25,000 tons in 1979). Almost all this production is based on Japanese technology.

The population explosion poses a critical problem of how to ensure an adequate food supply for the people of the world. Japan, through its outstanding amino acid industry, is making a major contribution to meeting this great challenge.

At the same time, Japan has built a rich store of scientific knowledge and industrial know-how concerning fermentation that has worked to its decided advantage as a foundation for bioengineering and many other new industries in the life sciences. The use of recombinant DNA and other genetic engineering techniques for industrial purposes is a prerequisite for the massive culturing of useful varieties of microorganisms for extracting desirable new substances. Japan's sophisticated fermentation technology will play an important role in this area.

Developing original technology requires, above all, patient study, a social climate supportive of it both materially and spiritually, and a strongly entrepreneurial business climate that gives full rein to the exercise of that spirit. The Japanese have proved capable of responding swiftly to any new science or culture they encounter. They have a demonstrated ability to absorb and assimilate those elements suited to their own society. Japanese today are fully aware of their duty to exercise this national characteristic for the good of all mankind. ●

Moriya Uchida is a director and a consultant to the general manager of the Research and Development Division of Teijin Ltd. Uchida, 54, joined Teijin in 1953 after graduating from the Tokyo Institute of Technology. He became a director of the company in 1979 after serving successively as manager of the Patent Division, manager of the Research & Planning Department and manager of the Products Development Research Laboratories.

He has a doctorate in engineering.

The Opto-Electronics Industry

By Takanori Okoshi

Opto-electronics is now being lauded as a high-growth leading-edge industry with virtually unlimited latent growth potential. At the same time, the electronics industry—one of the parents of this powerful new industrial force—is numbered among Japan's top performers.

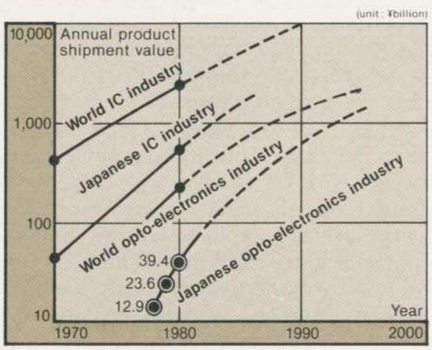
How do these impressions hold up under close statistical scrutiny? How high actually is "high-growth?" A study of recent statistics reveals that opto-electronics has finally begun to transcend the initial phase of vague expectations, and is beginning to evolve into a major industry ranking alongside the electronics—and especially the integrated circuit (IC) industry—that preceded it.

Government statistics on industrial shipment values divide the electronics industry into civilian electronic equipment, industrial electronic equipment, and electronic components. Shipment values in fiscal 1983 for these three sectors came out to ¥3,650 billion, ¥3,720 billion, and ¥3,220 billion respectively. Overall, electronics in Japan today is a ¥10,000-billion industry.*

Opto-electronics is still a border-line industry, and its boundaries are ill-defined. It is thus difficult to arrive at a clear statistical picture as can be done with integrated circuits. Nonetheless, the industry generally appears to be about 20 years behind the electronics industry, and is unlikely to reach the ¥10,000-billion level already posted by its parent in 1980 before the turn of the century.

*Growth projections for the IC and opto-electronics industries, 1970-95, are summarized in the chart.

Growth of IC and Opto-Electronics Industries



(Note) Based on records and projections for growth in annual IC and opto-electronics industry shipment values (global and Japanese).

Japan's Role in the Rise Of the Opto-Electronics Industry

Generally speaking, opto-electronics had its beginnings in the laser industry of the late 1960s, subsequently gaining in depth and breadth as optical fiber and fiber-optic communications technologies were developed in the second half of the 1970s. The subsequent appearance of optical memories and medical laser applications rounded out the field as it exists today.

How have Japan's own distinctive inventions and discoveries contributed to this process? In the late 1950s, Dr. Koichi Shimoda, then with the University of Tokyo and now at Keio University, made important contributions to theoretical work on lasers. Similarly, Dr. Iwao Hayashi, formely with the Bell Labs in the United States and now working at the Opto-Electronic Joint Research Laboratory in Kawasaki near Tokyo, played a key role in the development of semiconductor lasers capable of generating continuous laser light at room temperatures when he invented the double hetero junction structure used in these devices.

Japanese scientists have also been leaders in optical fiber work. Dr. Junichi Nishizawa of Tohoku University applied for a patent on optical fiber manufacture in 1964, two years before the publication by Kao and Hockham of what is often considered the seminal article on the topic. Nishizawa and Dr. Shojiro Kawakami subsequently (1968-69) came up with a theory on the optimal design of focusing-type optical fibers that set the standard for further work in the field, while Dr. Teiji Uchida of Nippon Electric Co. and Dr. Ichiro Kitano of Nippon Sheet Glass Co. paved the way for practical fiber-optic communications with their 1969 Selfoc fiber.

More recent Japanese innovations in optical fiber production include a VAD (vapor-phase axial deposition) process developed in 1977 by a team led by Dr. Tatsuo Izawa, then with the Nippon Telegraph & Telephone Public Corp. (NTT) Ibaraki Electrical Communication Laboratories and now at NTT's Musashino labs, and a buried double hetero structure devised by a team led by Dr. Toshihisa Tsukada of Hitachi's Central Research Laboratory. Japanese researchers have