Japan's Potential Strength in Science and Technology

By Yamane Kazuma

In December 2002, two Japanese citizens received the Nobel Prize. Theoretical physicist Koshiba Masatoshi (1926-), Professor Emeritus at the University of Tokyo, received the prize in physics, and Tanaka Koichi (1959-), a technical employee at Shimadzu Corp., received the prize in chemistry. Both were joint recipients with other researchers working in the same fields.

Koshiba created the Kamiokande (Kamioka Nucleon Decay Experiment), a giant device for observing elementary particles, deep inside a former zinc mine in Kamioka, Gifu Prefecture in mountainous central Japan. In 1987, he became the first person in the world to succeed in observing neutrinos, elementary particles that fly through space, using this device. Dr. Totsuka Yoji, Koshiba's successor, and his team went further to prove that the neutrino, which was previously thought to have no mass, actually had mass. Both of these were major discoveries in the field of theoretical physics, providing one answer to the eternal question regarding the definition of matter. I heard the news in Bern, the capital city of Switzerland, which I was visiting on business, and was very excited because I had been covering Kamiokande for several years as a science and technology writer.

I heard the news about Tanaka receiving the prize in chemistry the next day in a phone call from a newspaper company in Tokyo while traveling on an autobahn from Munich to Frankfurt Airport. This was the first time I had heard of Tanaka. I have been publishing the "*Metalcollar no Jidai* – The Spirit of 'Made in Japan'" interviews with the scientists and technologists who have supported Japan's cutting-edge industries in *The Weekly Post* (published by Shogakukan), Japan's biggest mass circulation magazine. The sixth volume of collected interviews will be published shortly. This series, which began in 1991, will soon see its 600^{th} interview, and many of the people I have spoken to have developed technology at Japanese manufacturing companies. However, I had never heard of Tanaka. In 1985, two years after joining Shimadzu, Tanaka developed a revolutionary technique for determining the structure of protein molecules using lasers. This technique has made a significant contribution to the development of the life sciences field. However, I believe that there are probably 100,000 creative people developing technology in Japan who rank with Tanaka.

In 2001, Dr. Noyori Ryoji of Nagoya University received the prize in chemistry for a method of synthesizing chemicals and Dr. Shirakawa Hideki of the University of Tsukuba received the same prize in 2000 for the development of conductive plastics. Japan has world class industry, but it has been rated inferior in basic research and outstanding only in the application of technology. The Japanese people themselves have also tended to take this assessment for granted. However, at the front lines of cutting-edge science and technology, there are many people doing world-class creative work. Without these basic research and technology development capabilities, Japan is unlikely to have developed as an industrial power. The fact that four Japanese people have received Nobel Prizes in the science and technology field in the space of a mere three years means the time has finally arrived when Japan's science and technology capabilities are being assessed fairly.

Kamiokande, which Koshiba constructed in 1983, is a giant cylindrical sensor.[1] It holds 3,000 tons of pure water and is 15.6m in diameter and 16m high. About 1,000 photomultiplier tubes inside it capture the faint light (Cherenkov light) emitted by the neutrinos that pass through it. At present the even larger Super Kamiokande is in operation. It holds 50,000 tons of pure water and is 39.3m in diameter and 41.4m high with about 11,200 photomultiplier tubes. Installed 1,000m underground, it overwhelms the observer. A Hyper Kamiokande, 20 times larger than the Super Kamiokande, is being planned.

Koshiba's major discovery was also helped by the strength of Japanese industry, which built the device. Hamamatsu Photonics[2] made a particularly significant contribution in developing and manufacturing photomultiplier tubes which were unprecedented in size. At a time when photomultiplier tubes with an eight-inch diameter had yet to be achieved anywhere in the world, Hamamatsu Photonics developed, manufactured and supplied large tubes with a diameter of 20 inches for Kamiokande.

Hamamatsu Photonics is a world-class photosensor company, and it was founded in the spirit of Dr. Takayanagi Kenjiro, who was the first to invent the modern electronic television set. It was a Japanese scientist who invented the television of today. Hiruma Teruo, Representative Director and President of Hamamatsu Photonics, is a close friend of Koshiba's, and his aim is the development of original technologies. I conducted an interview with Hiruma, and this is the gist of what he spoke about. "According to the book of *Genesis* at the beginning of the *Old Testament*, the beginning of the world was in chaotic darkness. Then God said 'Let there be light.' In other words, everything in the world is based on light. This is why our company pursues the science and technology of light." Phototechnology has made major advances. Lasers have developed appli-

Photo: THE YOMIURI SHIMBUN

Japanese Nobel Prize winners; Koshiba Masatoshi (left – physics) and Tanaka Koichi (chemistry)

cations in many fields, including precision machinery processing, medical treatment and telecommunications. The work of Tanaka was also based on lasers. As such, Japan has no rivals in the world in this field as well.

Phototechnology is the nucleus of current telecommunications. The Internet is made up of an optical communications network that covers the entire world. Perceiving the potential of optical communications in the 1950s, Dr. Nishizawa Jun-ichi, President of Iwate Prefectural University, invented the technologies of optical semiconductors and optic fibers that today's global optical communications network is based on. Nishizawa is considered the leading Nobel Prize candidate among the inventors of IT technology. It is precisely because manufacturers joined with scientists to produce advanced industrial products that Japan became one of the world's top industrialized nations.

A team led by Dr. Yamanaka Tatsuhiko at Osaka University's Institute of Laser Engineering recently succeeded in instantaneously generating 1,000 trillion watts of energy using an original laser device that they had designed and developed. This amount of energy is equivalent to about 600 times the world's electric power. According to this basic research, Yamanaka's team is aiming to commence the operation of a trial nuclear fusion reactor in five years time. These efforts are also supported by the sophisticated technology of Japan's phototechnology manufacturers.

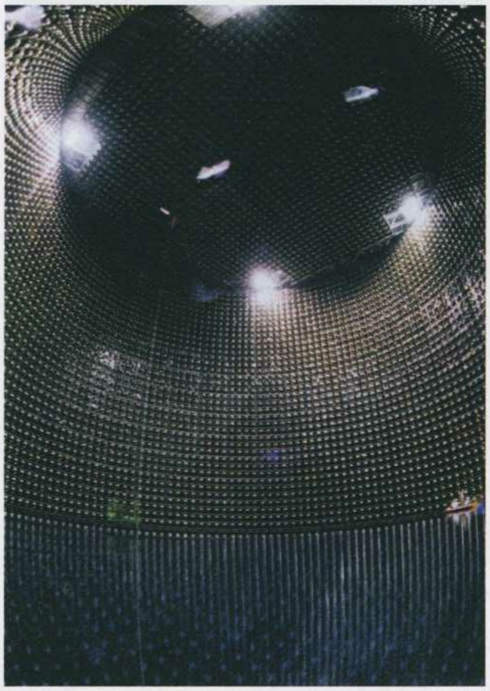
Japan is a small island nation with a population of 130 million people. However, together with the eastern half of the United States and Western Europe, the Japanese archipelago appears particularly bright in night images of the earth taken by satellites. This is because the plentiful supply of electricity, which is the cornerstone of society, reaches into every corner of the nation. However, about 70% of Japan's huge primary energy consumption depends on the natural resources of petroleum and coal, which are virtually all imported. In order to free itself from this dependence on imported energy resources, Japan has pressed ahead with the construction of nuclear power plants, and ranks third in the world in the number of such installations. However, in recent years, there has been a series of accidents and management scandals at nuclear power facilities. This has created the strong impression that Japanese nuclear energy policy is approaching a crossroads. At the beginning of 2003, the Tokyo Electric Power Co., which mainly supplies electricity to the Tokyo metropolitan area, shut down operations at 13 of its 17 reactors and carried out a general inspection to restore confidence.

Japan's serious energy concerns have coincided with the growth of global environmental issues, spurring research and development (R&D), and the production of new energy. I recently visited Freiburg in Germany as a reporter for a major environmental program of Nippon Hoso Kyokai (NHK; Japan Broadcasting Corp.), one of the largest TV stations in Japan. Freiburg is considered an advanced city in the diffusion of solar power generating panels. However, at the place where I gathered news materials, I was asked "Why are you collecting data in Freiburg despite the fact that Japan leads the world in generating solar power?" Japan certainly topped the world in the production of solar power panels in 1999. In terms of installation, it also led the world with 133,000kW in 1998. The Agency for Natural Resources and Energy has forecast that the volume of solar power generated in Japan in 2010 will be 2.53 million kW, but it is likely to far exceed that.

Japan covers an area of 378,000km^2, which is virtually the same size as Germany, but mountainous land that cannot be used for residential purposes or industrial production accounts for 61% of this area. Moreover, Japan lacks energy resources such as coal and petroleum and is almost totally dependent on imports. Japan is also 100% import dependent on mineral resources such as steel, copper and bauxite, which are essential for industrial production. It has been 135 years since Japan created a Western-style state through the Meiji Restoration of 1868. The past 135 years have witnessed a continual series of crises regarding resources and energy.

In the past, Japan experienced the error and misery of causing a major war in an attempt to resolve this crisis. This war was brought to an end with the United States dropping two atomic bombs on Hiroshima and Nagasaki. After Japan's tragic experience of losing the lives of nearly 500,000 of its citizens to the atomic bombs, it has deeply learnt the folly of trying to secure resources and energy and achieving

Photo : Kamioka Observatory, ICRR (Institute for Cosmic Ray Research), The University of Tokyo



The Super Kamiokande holds 50,000 tons of pure water and has about 11,200 photomultiplier tubes

political influence over other countries through war. Since 1945, Japan has aimed for national development using methods that do not employ military might or the exercise of political force against other countries. The development of advanced science and technology and the resolute promotion of industrial production based on them are due to this.

From the second half of the 1950s until the first half of the 1970s, Japan sustained high growth with an annual average gross national product (GNP) growth rate of 10%, until it had attained the second highest GNP in the world. Japan is currently experiencing economic recession, but its national strength is still greater than Germany and France combined.

After the end of the war, Japan was placed under U.S. control. Its aviation industry, which was connected to an increase in military power, was completely shut down. As a result, while Japan is the world's leading industrial nation, it is markedly lagging behind the United States in the aerospace sector. After losing the war in 1945, Japan professed itself to be a peaceful nation and renounced war in its new Constitution. Japan does possess ground, maritime and air forces which are restricted to activities for the self defense of the nation. U.S. military expenditure is $380 billion while Japan's military expenditure is $32 billion (2000 figures), which is less than one-tenth of the U.S. figure and lower than that of Germany, France and Britain. Unlike the United States, which has been able to develop its aerospace industry with the help of a large military budget, Japan has concentrated its energies on industrial production in the private sector that does not depend on the military budget. However, this has led to great private industrial power for Japan. Japan has concluded a security treaty with the United States and provides bases for U.S. military use within Japan, but it has not waged war itself even once in the last 58 years. Of course, the number of citizens of other countries that the Self-Defense Forces have killed in the 50 years since they were established in 1953 is zero. It seems that this fact has assisted Japan in importing resources from countries all around the world and in selling Japanese products in every corner of globe.

Japanese people have weak presentation skills compared with people from English-speaking areas of Europe and America, ethnic Chinese, ethnic Indians and also South Koreans. This is because Japan is an island nation, and it composed of virtually one ethnic group. Moreover, nearly 100% of its citizens use only Japanese as their everyday language. In such a country, smooth communication can be achieved even without particularly strong self-assertion. This becomes an advantage when the people are directed toward a single purpose. In the past, they were directed toward war. After it resolved to renounce war, however, Japan united to move toward a new objective of industrial development. Moreover, the absence of significant ethnic problems, little crime, high levels of education and a developed media using a single language were favorable to the thoroughgoing promotion of highly efficient industrial production. Japan managed to grow and develop industry precisely because everyone shared the common awareness that, for a Japan lacking energy, resources and land, it would be diligence, hard work and earnest R&D that would become the sole path to survival for the Japanese people.

The *Kanban* system, or the "just-in-time" system, is an efficient method of procuring automobile parts. This is one of the production systems at Toyota Motor Corp., which is the world's top automobile manufacturer, and this was also born from Japan's national circumstances that do not allow waste. Mass production of automobiles began at the beginning of the 20th century with Ford Motor Co. of the United States. Japanese automobile manufacturing got underway 60 years later. While learning from U.S. industry, the Japanese automobile industry, focused on producing the high-quality, low cost small cars that suited Japan's small land area, gradually became a threat to the U.S. automobile industry.

The strength of the Japanese product has also been spurred by environmental technology. Since the 1970s, Japan has acquired even greater product strength through the development of engines with low pollution and low fuel consumption. Furthermore, as measures to counter global warming were recognized as the greatest challenge for human beings, in 1997 Toyota developed and launched the hybrid car, an eco-car fitted with two motors: a gasoline engine and an electric motor. I bought a Prius hybrid car, and found that the fuel consumption was about the same as a small motorcycle. A passenger car with fuel consumption of 30km to the liter (70 miles to the gallon) depending on running conditions is a miracle in itself. In December 2002, the fuel cell-powered car, a next-generation clean energy car, was delivered simultaneously in the United States and Japan by Toyota and Honda Motor Co. The debut of the Japanese eco-car is a stimulus for the world's automobile manufacturers, and a new battle over automobile technology has commenced. "Made in Japan" has become a primer for new industries in the era of environmental protection.

Even in the steel industry, which is regarded as an old industry, Japan still continues to make major technological advances. Extremely high-quality, long-life steel is required for the axles of steam turbines in electric power generation, but Japanese steel manufacturers have maintained the technological skills to keep providing it. The development of technology for the strength of steel cables also continues unabated. The Akashi Kaikyo Bridge, the world's biggest suspension bridge, constructed between Kobe and Awaji-shima island (both are in Hyogo Prefecture) in 1999, is 4,000m long, and four main cables would have been required using conventional steel technology. However, steel manufacturers developed high tensile cables, so only two main cables were needed. The cables are almost twice as strong as those on New York's Brooklyn Bridge.

Steel twice as strong and durable as the currently available type is being developed at a Japanese government-related materials R&D institute, and trial products have already been completed. The special feature of the manufacturing method is just a change in the order of the production line. If the production technology for this "ultra-steel" comes to be widely used, it will halve the volume of steel used in buildings, automobiles, ships and bridges. Moreover, with twice the durability of the new steel, it will also lead to marked cost reductions as well as being in harmony with the environmentally conscious age. Steel is a typical recyclable resource, and "ultra-steel," which can be produced simply by changing the production line, will perform the magic of doubling or quadrupling the resources of scrap iron.

The 20th century model of the industrial revolution is considered to have begun at Britain's Coalbrookdale Ironworks. Ironbridge was built with iron produced at the first modern ironworks. In spring 2001, I went on a world tour following in the steps of industrial technology starting at this historic bridge built in 1779. My tour finished at the Akashi Kaikyo Bridge. Standing atop the 300-meter high main tower looking back on day after day of observing science and technology around the world, I pondered various thoughts. In particular, I was convinced that the opinion that Japanese science and technology is an imitation of Europe and the United States is a mistake. Without creative technological capabilities, Japan would not have been able to construct such a colossal bridge with greater precision than a watch just 220 years after Ironbridge was built.

Japan's advanced science and technology have been developed not simply because "Japanese people are dexterous." Nara, popular with foreign tourists, is even older than Kyoto, and is symbolized by the Great Buddha of Todai-ji temple (Rushana Buddha). It is 16m high, 12m wide and weighs 112.5 tons. The Great Buddha was built in 752. Molten copper was poured into a huge mold and it was finished with baking gold plate. The gold has lost its shine today, but even now after 1,200 years there is no corrosion due to the advanced finishing technique. A total of more than 2.5 million people were involved in the work, and the completion of the world's biggest Buddha statue took 11 years.

The technology to build the Great Buddha came to Japan from China via the Korean peninsula, but Japan improved the technology to create the world's biggest Buddha statue. When I once talked to a South Korean journalist, he said; "Although we transmitted the technology needed to produce the Great Buddha, we were not able to create such a big Buddha statue. Japan's tradition of grand technological capability begins in the era of the Great Buddha." In the past, only the creativity and progressiveness of people who have the original idea has been valued in the world of science and technology. However, ideas are meaningless without the ability to realize them in concrete form. Japan's scientists and technicians display original ideas and creativity, and excel in making ideas that have been left incomplete by others into reality. I believe that this valuable creativity can be of equal importance to invention.

Japanese industry is now suffering from an assault by extremely inexpensive Chinese products. However, this is the same thing that Japan did to the United States in the past. The United States has led the world in new industrial fields, including the aerospace industry backed by the military budget, biotechnology based on molecular biology research and the IT industry. But Japan will further open up the coming world of science and technology in the future. The tide of anti-U.S. sentiment spreading around the world before and during the war in Iraq has accelerated a long-term global distancing from the United States. Japan is commencing a battle against environmental problems, the biggest challenge confronting the earth, using its science and technology capabilities rather than military power. The majority of business managers firmly believe that it is science and technology which will bring about a new industrial revolution. I have named this phenomenon the "eco-industrial revolution" and am writing a book with the title *Eco-Industrial Revolution* that will form a statement of resolution for Japan's new industrial era. It is reported that the reason why a succession of Nobel Prize recipients in the science and technology field has appeared is because a review of Japan's potential in this eco-industrial area has begun. Japan also has a great wealth of human resources for the coming era. JJTI

Notes:

1 http://www-sk.icrr.u-tokyo.ac.jp/index.html

2 http://www. hpk.co.jp/Eng/main.htm

Yamane Kazuma is a non-fiction writer. His work covers a wide range of fields, including wildlife and environmental problems, regional development, disaster prevention and the history of development in the Amazon.