Behind the Scenes of Technology Development in Japan

By Masanori Moritani

Japanese industry's ability to develop technology has improved greatly in the past 10 years or so. Products have become more competitive internationally, not only in high technology but in other fields as well. One result is a rapidly swelling trade surplus.

On the other hand, there is a wide gap between Japan and the United States in space development and aeronautics. Moreover, it is clearly lagging behind the U.S. in basic research. Some critics say Japanese industry has fostered almost no epoch-making new technology. But while this was true in the past, it no longer is today.

How high are Japan's technological standards? And what are the characteristics of its technological development?

One striking feature is its demonstrated strengths in production, improvement and modification, and applications. Recently, it has begun to show its force in high technology. How will it change and develop in the future?

An important point to remember about Japanese technology is that it demonstrates its strength only in the household and industrial sectors. This is only natural. Almost all the money and human resources necessary for technical development are poured into these two sectors. The United States invests huge sums of money in military and space R&D, and assigns an extremely large number of its most able people to these areas. The same is true in Britain, France and other EC countries.

In Japan, high-level technological development capability is mostly confined to big enterprises which tend to focus their efforts on areas with promise of creating major new markets. This concentration is one of the striking features of Japanese technological development.

Next, Japanese enterprises excel at improving, step by step, technologies which have already been commercialized. They make vigorous efforts to improve within a short time a product's function and reliability and to reduce its size, weight and cost.

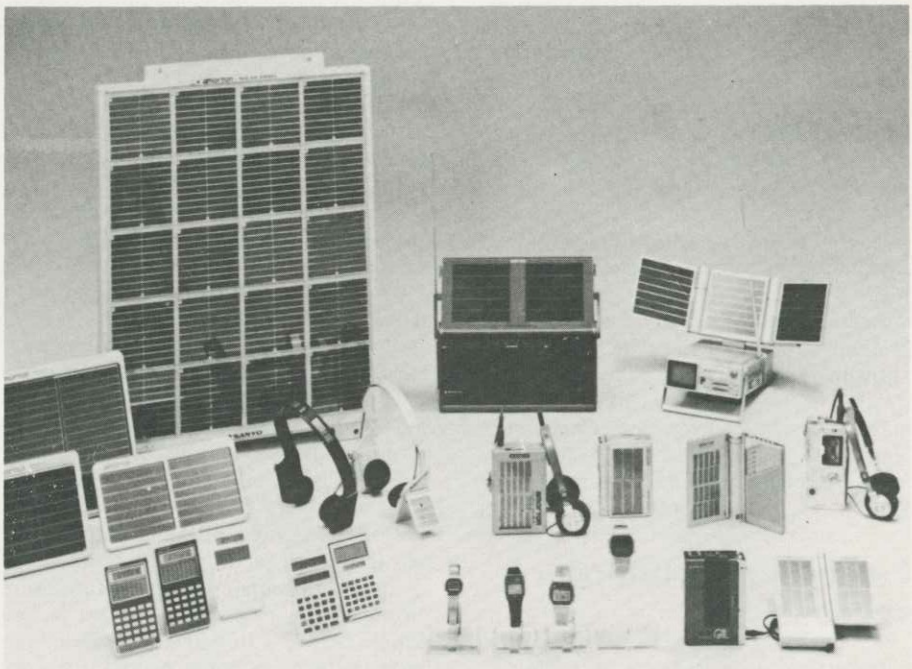
Home video, which has grown into a giant market in the past few years, is a case in point. Japanese enterprises took the huge VTR machines used by broadcasting stations and after many years of experiments reduced their size and cost without greatly changing the structure of the original machine. RCA of the U.S. launched a major drive to incorporate such revolutionary technologies as lasers and holography into VTRs, but failed.

VLSIs (very large scale integrations) are another example. Technological development in this case involves increasing the integration of transistors on a single chip. In order to do this, the printed circuit must be made smaller and smaller. This, too, is an example of continuous, step-by-step technological development.

No time is wasted

Once given a clear-cut, concrete target, Japanese technical engineers rush headlong into research and waste no time on circuitous bypaths. Thus, they can achieve excellent results in a short time. The development of optical fibers was a project well suited to Japanese engineers. The target was simple: to minimize the loss of light, make the fibers longer, and cut production costs.

This cumulative-style of technical development is most effective in reducing a product's size. Japan has often demonstrated its technological superiority in reducing size, weight and cost. Representative cases are desk-top calculators, printers, photocopiers, and facsimile machines, not to mention VTRs. Even in the case of computer tomography and laser



Sanyo products incorporating amorphous solar cells

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printers—all requiring sophisticated technology—Japanese products are strongly competitive as a result of miniaturization.

Cumulative technological development was, until very recently, the foundation of Japan's progress. It involves the improvement of already commercialized technology through step-by-step development. In the past few years, however, there have been a growing number of cases in which Japanese enterprises are the first to industrialize an entirely new technology.

A good example is the amorphous solar cell. This was developed by a team of engineers led by Dr. Yukinori Kuwano of Sanyo Electric Co. For more than a decade, Dr. Kuwano had been researching amorphous semiconductors. Around 1975, the possibility of using them in a solar cell began to draw the attention of researchers in this field. Professor W. E. Spear of Dundee University published a paper on the amorphous solar cell. But, as often happens with development of a new technology, the theory was announced first in Europe and the product developed first in Japan.

The biggest problem with amorphous solar cells was how to raise the efficiency with which they converted solar energy into electricity, while drastically reducing the cost. Unless this could be cut by a double-digit percentage, it would be impossible for ordinary households to use solar cells as a power source. Nor would they be practical for commercial power generation. In order to raise the conversion ratio and lower costs, Dr. Kuwano finally hit on the idea of "integration." Instead of linking the elements of the solar battery in a line, he piled one on top of another to form an integrated structure of elements. He also developed a continuous production process to open the way for industrializing the product. Although the idea was spawned in Britain, Japan was the first country to give the amorphous solar cell industrial shape.

There are several other fields in which Japan has outcompeted or is competing with other countries in developing and industrializing technology whose theory, principle, idea and concept are already known. These include the electronic watch, CCD (charge coupled device), magnetic bubble memories, GaAs FET (gallium arsenide field effect transistor), HEMT (high electron mobility transistor), and the post-Neumann computer.

Perseverance brings success

Once they see clearly the possibility of industrializing a certain technology, Japanese engineers work untiringly and usually successfully. It may be, as is often said, that Japanese engineers lack originality. But they can exhibit impressive creative ability in the process of attaining the development target assigned them.

It is very difficult to state categorically that the Japanese people lack originality. The Japanese have demonstrated recently that they are fully capable of producing innovative ideas, such as the vertical magnetic recording developed by Dr. Shunichi Iwasaki of Tohoku University and the Bloch line memory developed jointly by NEC Corp. and Dr. Susumu Konishi of Kyushu University. Also falling under this category is the SIT (static induction transistor), invented by Dr. Junichi Nishizawa of Tohoku University. Dr. Nishizawa conceived, at a very early date, the idea of industrializing optical communication.

Japanese researchers have taken the lead in start-up development of the fifth-generation computer, which is still mostly in the realm of the unknown. In nuclear fusion, too, Japan, along with America and European countries, is carrying out a major R&D project.

How do Japanese industry, enterprises, engineers and researchers approach R&D? Its purpose is largely the same in every country. However, each has its own way of promoting it. Compared with America and Europe, Japan's approach is certainly distinctive.

One outstanding feature of Japanese industry is fierce competition among enterprises. When a certain technology or product is regarded as promising, a host of enterprises will go for it at the same time. Only a few years ago, about 30 companies were engaged in life-or-death competition to develop and manufacture desktop calculators. The majority fell behind and withdrew. Today, 20 to 30 companies are competing in FDD (floppy disc drives), Japanese-language word processors, and personal computers. It is estimated that as many as 200 companies are currently producing industrial robots.

Each enterprise strives to improve the function and convenience of its product, reduce the size and weight, and bring down the cost. This is essential in order to distinguish a product even slightly from similar ones made by other companies. The improvements made by each company may be minor, but they accumulate, and within a short time the product in question has been entirely made over.

Generally speaking, Japanese enterprises keep very close tabs on their competitors. They are constantly watching for new technology and products. This results in quick dissemination of information throughout the industry. There is no doubt that cut-throat competition has been the driving force behind the very rapid, continuous and cumulative technical development activities of Japanese companies.

The second most outstanding feature of Japanese industry is the close cooperation seen in technical development, both within and among companies.

The employees of a Japanese company cooperate extensively with one another to achieve corporate targets. This is seen also in technical development. First, there is close contact between a company's R&D and production divisions. Traditionally, many competent engineers are assigned to the production division, where they enjoy a high reputation for their skills and therefore have a strong voice within the company. They exert great influence on technical development. From the standpoint of facilitating smooth production, their advice is taken into account whenever detailed steps to implement the project are decided.

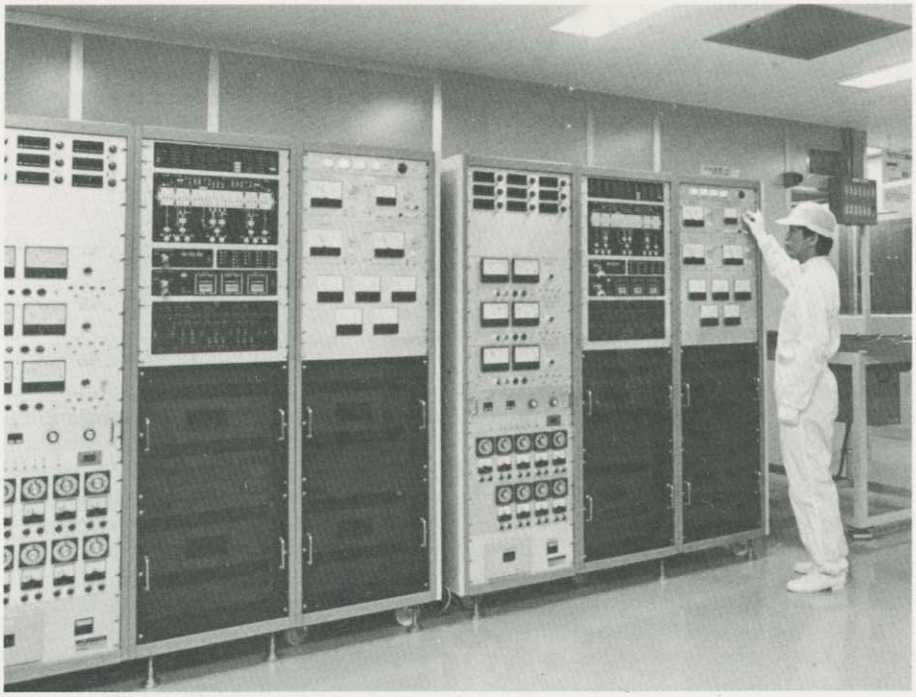
No divisional fences

In many cases, the researchers who develop a new product or technology are transferred to the production division when commercialization stage is reached. Similarly, production engineers may join researchers in R&D. In a Japanese company, unlike in their European and American counterparts, there is almost no barrier between the R&D and production divisions, nor any differences in their abilities.

Often, the supply or procurement division gives its views regarding the procurement of parts, while the sales division voices its opinions from the user side. These views are taken into account in the development process.

A Japanese company does not single out an employee for a high position only on the basis of ability. Even if a worker's performance is exceptional, the Japanese company does not reward him generously immediately. Credit is shared by all the members of the group or division to which he belongs. However, because supervisors and board directors carefully observe the ability and performance of each employee, outstanding individuals will eventually be promoted when the appropriate time comes. Group activities thus contribute greatly to establishing close cooperation among employees without each thinking about winning personal credit.

Another striking feature of Japanese industry is the close cooperation that is established and maintained between different companies. A good example was the development of VLSIs. A number of corporations that were competing hotly to develop and produce ICs (integrated circuits) and LSIs (large scale integrations) nonetheless combined forces in the basic research and development of the next generation VLSIs. The development project was undertaken jointly by six computer and semiconductor companies from 1976 to 1980 with satisfactory results.



An amorphous solar cell production line

In passing, it should be noted that all six companies develop and produce both computers and semiconductors. This, too, is common practice in Japan. Companies become involved in a wide range of products without limiting themselves to a single item. A semiconductor maker, for instance, will try to branch out into office computers, facsimiles and word processors. This tendency is a major cause of the tough competition in Japan.

But joint development among Japanese enterprises is a relatively new practice. It emerged because the VLSI project scored such remarkable success that similar arrangements were made to develop supercomputers and the fifth generation computer. Yet even while competing furiously, Japanese companies have a long tradition of cooperating on matters of common concern within their respective industries. This background has facilitated the smooth execution of joint projects.

Despite close cooperation within and between companies, the abilities of individual workers are not necessarily buried deep within the corporate organization. Obviously, successful technical development requires that each worker give complete rein to his abilities.

Japanese corporate managers usually make special efforts to draw out and adopt the opinions of their subordinates, instead of handing down absolute orders. Managerial ability is judged in Japan by how well a manager motivates people by providing them with a pleasant working environment and stimulating jobs.

Under competent managers, researchers and engineers use their ability. Yet it cannot be denied that this rarely exceeds the framework of a company-wide target. Japanese researchers and engineers strive hard to achieve the targets assigned them, but the environment is such that it is difficult to go beyond the given terms of reference and produce innovative and original ideas. This helps explain the effectiveness of Japanese corporations in developing VLSIs, optical fiber solar cells and other technologies with clearly defined development targets. The challenge now facing Japanese companies is how to engage in more original R&D.

Under-the-table research

Efforts in this direction are already under way, and corporate managers are aggressively seeking ways to develop innovative technologies. One top corporation tacitly approves "under-the-table" research projects. Researchers and engineers are allowed to pursue discreetly any research theme they think promising, even if it is not directly related to corporate goals. In this case "discreetly" simply means the work is not officially recognized as a company project. Actually, the researcher's superiors handle all the arrangements to facilitate the work. The Japanese-language word processor was the offspring of such "secret" research efforts.

Japanese enterprises, needless to say, give top priority to attaining their corporate targets. Yet, the target itself is not necessarily thoroughly planned nor rigid. There is considerable flexibility and even some irrational aspects.

Typical of this was the development of home VTRs by Victor Co. of Japan (JVC), which started development around 1955. In those days, work on VTRs was the province of RCA of America and Japan's biggest companies. JVC had to travel a long, long road to develop and perfect a small, low-priced VTR for home use. The members of the R&D team had not the faintest idea when they would succeed, but they persevered anyway. Many fellow employees were skeptical. Management, however, allowed the efforts to continue. "The project team was like a prodigal son," explains an official, "but all its members were devoting themselves so enthusiastically to the project that it would have been cruel to stop them. We decided to allow them a little more time."

Management's sympathetic understanding bore fruit 20 years later in 1975, when the company developed a home VTR machine at about the same time as Sony Corp.

RCA of America, on the other hand, kicked off its home VTR development project about 20 years ago by drawing up a detailed plan and investing huge sums of money. But as soon as RCA realized there was no immediate prospect of commercializing the invention, it abandoned the project. JVC is an example of irrationality winning over rationality. Clearly, Japanese corporate managers tend to respect the enthusiasm and devotion with which their researchers and engineers tackle projects.

The majority of Japanese corporate executives are not professional managers trained in graduate business schools. They have risen to the top through the ranks after a long career in the company. More than 30% of the presidents and more than 40% of the directors on the boards of leading Japanese enterprises are science and engineering majors with long experience in R&D and/or production. Their background leaves them favorably inclined toward the R&D and production divisions.

Many of the outstanding features of Japanese technological development will remain unchanged in the future. However, there are signs of major transformations in some areas. Although Japanese corporations offer lifetime employment, the number of researchers and engineers who resign from their first company in search of better opportunities has increased significantly. This trend is expected to encourage the development of unique technology.

Another point is the emergence of many venture businesses armed with technical development skills. Venture businesses find it much easier than big enterprises to integrate corporate targets and the research themes favored by individual researchers. This style suits the nature of the Japanese people. Japan's new venture businesses will eventually evolve into organizations which give their members a sense of shared fulfillment rather than pursuing wealth and fame on the strength of the technology developed by their founders. ●