Japan (III): Industrial Research Struggles to Close the "Gap"

In January, the Americans announce a new invention.

In February, the Russians claim they made the same discovery 20 years ago.

In March, the Japanese start exporting the invention to the United States.

—A joke currently making the rounds in Tokyo.

Just 25 years ago Japan lay defeated after World War II, its major cities in ruins, much of its industrial capacity destroyed, its merchant marine on the bottom of the seas, and its people destitute and demoralized. Yet, in the decades since, as was noted in the first article in this series, Japan has achieved the highest sustained real economic growth rate ever recorded by any great nation. Japan now ranks first in ship production, second in automobiles, and third in steel and chemicals.

Japan's growth has been particularly impressive in the "high-technology" or "research-intensive" industries that are traditionally regarded as the strong point of the West. Michael Boretsky, a specialist on "technology gap" studies with the U.S. Department of Commerce, has compared the growth rates of advanced nations in five such industries, namely, chemicals, electrical machinery, nonelectrical machinery, scientific instruments, and transportation equipment. Though his figures are not yet in final form, Boretsky told *Science* they indicate that Japan "really took off" between 1955 and 1965, achieving a 22.5 percent average annual growth rate in those five sectors, compared with 3.9 percent for the United States, 4.1 percent for Britain, 6.8 percent for France, and 8.4 percent for West Germany.

Boretsky acknowledges that Japan started from a relatively low base, but he says Japan has moved ahead so rapidly it now almost certainly ranks third in production value in these five sectors—well behind the United States and the Soviet Union, but ahead of such technically-oriented European powers as West Germany, Britain, and France. The "Made in Japan" label may once have stood for shoddy goods, but it now signifies technical quality in a number of products, including cameras, watches, scientific instruments, consumer electronics, electric turbines, and high-speed trains.

A host of experts have sought to discover the secret of Japan's dynamic growth, but unfortunately there are almost as many explanations as there are experts. Various analysts have stressed Japan's capacity for hard work; its high educational level; its flair for production engineering and organization; and its peculiar "team spirit" in which government, industry, and, to some extent, the entire population work for the greater good. The opportunity to build a new industrial plant largely from scratch after the devastation of World War II was also clearly important, as were a number of factors related to the peculiar organization of Japanese society and industry.

How Much of a Threat?

Almost all analysts agree that research and development have played some role in promoting Japan's economic growth, and most agree that it will have an important bearing on Japan's future economic progress. But there is sharp disagreement over how good Japanese technology is and over how much of a "threat" it poses. One prominent member of the U.S. National Academy of Sciences recently expressed alarm over America's "diminishing ability to compete" with Japanese industry "in areas in which great scientific and technical skill is involved." Similarly, an authority in Europe has warned that, "If the last 20 years have been those of the American challenge in Europe, the coming 20 years promise to be the years of the Japanese challenge." Yet an American scientist who has studied the Japanese for many years believes they have formidable obstacles to overcome before they can hope to close the "technology gap" with the West. "My biggest headache," he gripes, "is the stream of American scientists who come to Japan for a week, take a ride on one of the fast trains, inspect one of the modern shipyards, and then go home exclaiming that Japanese technology is superior to American. It just isn't so."

The Japanese themselves, in characteristic self-effacing fashion, seem more concerned than impressed with their achievements thus far. On a recent reporting trip to Japan, I found some industrial scientists talking modestly about filling their "technological niche" and others grappling with a host of problems that are said to stifle innovation and impede the application of research findings to industrial products. In the first two articles of this series (*Science*, 2 and 9 January) I discussed Japan's problems and prospects in the areas of "big science" and university science. This final article will focus on industrial research and on certain common problems that are confronting all sectors of Japanese science.

Several attempts have been made to define the precise role of R & D in promoting Japan's economic growth, but none of them has been wholly satisfactory. The most widely quoted estimate, published by the Japanese Science and Technology Agency, suggests that technological progress accounted for about 40 percent of the production increases in manufacturing during the 1956–1966 decade, with capital and labor inputs accounting for the rest. But when I talked to officials of the agency this fall, they said that the 40 percent figure is derived from an econometrics equation and is actually the value of a variable which represents such factors as management skill and education as well as technology. "We have no way to estimate the actual contribution of technological progress," said Hiroshi Ando, head of the research division in the agency's planning bureau.

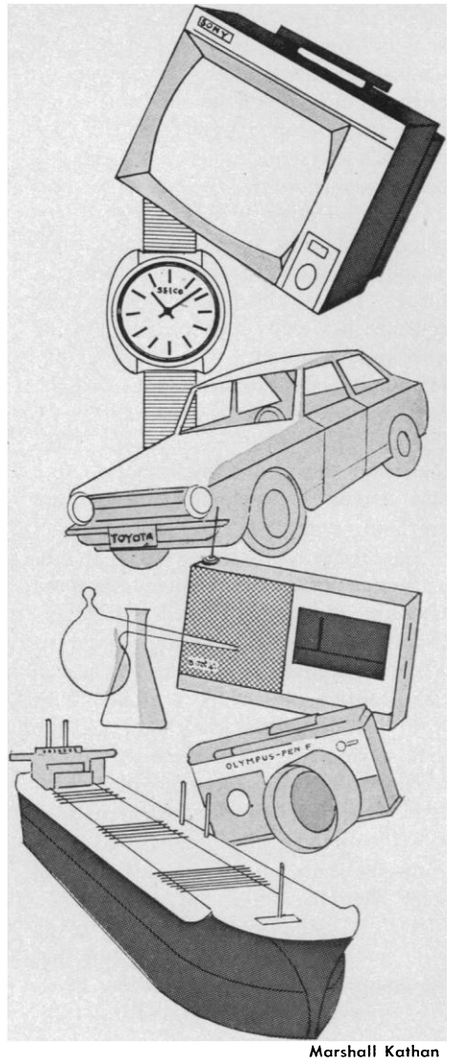
The Japanese are popularly regarded as technological "copycats" or "imitators," and while the designation is to some extent true, it is also misleading. The Japanese have seldom come up with the kind of fundamental breakthroughs (such as the transistor or integrated circuits or nylon) that spawn whole new lines of businesses. Moreover, Japanese industry still relies heavily on imported technology. In the fiscal year ending 31 March 1969, Japan paid about $314 million for technology imports, while earning only $33.9 million from selling its own technology to other countries, a far poorer ratio than the West European countries achieved.

But the Japanese are not mere slavish imitators. They are extraordinarily nimble at taking a foreign development and then improving it and disseminating it so rapidly that they end up beating out the brains of the originator of the development. "You can sell them a process package and they'll end up doing better with it than our own people would," says Raymond J. Kenard, president of the Power Gas Company of America, which has interests in Japan.

A technology gap study published by the Organization for Economic Co-Operation and Development in 1968 concluded that while American firms have led the world in original innovation over the past 15 or 20 years, Japanese firms have been the most successful at adopting and diffusing new techniques and products. Interestingly enough, the study concluded that performance in originating inventions did not seem to affect a nation's overall economic growth, but performance in the diffusion of technological innovations did seem to be associated with economic growth.

The Japanese business world is so different from the American that analysis of its strengths and weaknesses is difficult. Most Japanese companies, for example, would be considered bankrupt by American standards. The big companies typically get 70 or 80 percent of their growth capital from bank loans and only 20 to 30 percent from sale of stock. Such a high debt-equity ratio would be unthinkable and dangerous in our own economy, but the Japanese firms get away with it because the commercial banks seldom call the loans, and the Bank of Japan stands behind the commercial banks. The system allows Japanese companies to grow without having to finance their growth out of retained earnings, and it makes for an unusually close business-government relationship in Japan. It also illustrates the hazards of trying to judge Japan by Western standards.

I had heard numerous complaints from American businessmen suggesting that the Japanese government simply *must* be subsidizing much of Japan's export trade, otherwise how could Japanese companies undersell their competitors so consistently around the world. So I asked Robert J. Ballon, director of finance at Sophia University in Tokyo and author of numerous books on Japanese business, whether subsidies play an important role in Japan. "You're thinking like an American," he chided. "Don't worry about whether there are subsidies. The debt-equity ratio is 80 to 20 here. In a sense, there are no individual firms in Japan. There is only Japan, Incorporated. The cost of a business operation is shared by the entire nation." Father Ballon said Japanese companies involved in joint operations with Westerners often keep two sets of books, one for themselves and one to satisfy the panicky Westerners. "They'll keep as many sets of books as you want," says Ballon, "but it doesn't change a thing."



Marshall Kathan

Before the Second World War, much of Japan's commerce and industry was controlled by a few great families under the so-called *zaibatsu* system. The analogous situation in American terms, according to Edwin O. Reischauer, a leading expert on Japan, would be if "United States Steel, General Motors, General Electric, Standard Oil, the Du Pont interests, several of our major banks, a few of the major shipping and export firms, and a host of less well-known but equally important companies in less prominent fields were all owned and controlled by a single American family." After the war, the *zaibatsu* were broken up, but lingering traces of the old system remain. There are big groupings of Japanese banks and companies that bear at least superficial resemblance to the old groupings, and some of these "ex-*zaibatsu*" even carry the old names, like Mitsubishi, Mitsui, and Sumitomo. Some observers detect intense competition between the big groupings and, indeed, throughout the entire Japanese economy. Others believe the competition is "unreal" because Japanese companies, with government encouragement, will often make an industry-wide agreement on production, sales, and prices to curb "excessive competition."

The great bulk of industrial research in Japan, as is true in this country, is concentrated in the largest companies. Firms such as Hitachi, Toshiba, Sony, Matsushita, Mitsubishi, Toyo Rayon, and a number of others have research laboratories that compare well with those found in this country.

Harold R. Mighton, manager of technical liaison for Du Pont's Far East office, says the central laboratory at one leading Japanese chemical company "is as well equipped as any we have at Du Pont—they've got electron microscopes falling out of their ears."

But industrial research in Japan is poorly financed by American standards. In the fiscal year ending 31 March 1968 Japanese companies spent somewhat more than $1 billion on research and development, a hefty 30 percent boost over the previous year but still well below the more than $17 billion spent on industrial research in the United States. Japanese industry, according to a 1968 government White Paper, was recently devoting only 1.04 percent of sales to research expenditures, compared with 4.3 percent for the United States and 3.8 percent for France.

Almost half of Japan's industrial R & D expenditures are concentrated in just two industries, chemicals and electrical machinery, but even these two industries are not lavish in their research spending. A survey published by the *Oriental Economist* in February 1968 concluded that a single American Company—IBM—was spending more than twice as much for research operations as the entire Japanese electronics industry (though a research dollar buys more in Japan, of course).

Japanese industry does remarkably little "exploratory" research of the kind that is said to have given American industry its technological lead in many areas. Research-minded American companies—such as General Electric, Du Pont, and the Bell system—will often allow dozens of scientists to tinker away at whatever interests them in hopes that the tinkering will eventually lead to a breakthrough of commercial importance. But most of the Japanese companies keep their scientists focused on rather narrow practical problems.

Even Sony, the electronics manufacturer whose products have come to signify technical excellence throughout the world, relies remarkably little on its own basic research. George M. Hatoyama, president of a Sony affiliate and former head of its research operations, told me that while Sony scientists had come up with a few "basic" advances—such as the well-publicized Esaki diode—these advances had contributed almost nothing to the company's product lines. "Up to now, science has had nothing to do with Sony's success," Hatoyama said. "We succeeded mostly with the transistor radio. The transistor was not new. The radio was not new. Basic science at Sony didn't have anything to do with developing the transistor radio."

Sony's Secret

The secret of Sony's success, Hatoyama believes, lay in the company's ability to make "process improvements" that greatly reduced the cost of transistors and related components, and in the foresight of top management in recognizing that transistors could be made cheaply enough to be used in commercial products.

Sony spends about 6 percent of its annual sales (which totaled $198 million in the year ending 31 October 1968) on research and development, and about 10 percent of that 6 percent is devoted to "basic research." But almost all of the basic work is aimed at solving very practical production problems. As Hatoyama explains it: "We go towards a certain product and then there is trouble between us and the final product, so we analyze the trouble and we extract some basic problems to work on."

As an example, Hatoyama said Sony had been trying to break into the color TV market using a system developed by the late E. O. Lawrence, but manufacturing difficulties made the price too high to be competitive. So Sony performed some basic studies on the behavior of electron beams in electrical fields and discovered an unexpected phenomenon which enabled the company to develop a new color TV system. The system, which is currently being advertised in this country, uses a single electron gun instead of the usual three guns, a development which is said to allow sharper, brighter pictures. "This is the first time our basic research has really had something to do with our products," Hatoyama exults. Hatoyama said Japanese industry can't hope to compete across-the-board with the vast American research establishment, but he said Sony hopes to find and exploit technological niches that are being overlooked by others.

One industrial scientist with an unusual perspective on the American and Japanese research efforts is Michiyuki Uenohara, assistant general manager of Nippon Electric Co.'s Central Research Laboratories, who worked at Bell Labs from 1957 to 1967. Uenohara told me that while Bell scientists do a lot of research "just for the sake of knowledge," Nippon Electric's research is almost entirely "purpose-oriented." In much the same language Hatoyama had used, Uenohara told me that Nippon Electric's basic research effort had made little impact on product lines, but that his company had made numerous process improvements which gave it a technological jump on foreign companies. "For some parameters, our semiconductor crystals are better than Bell's," he said.

The only company I visited that claimed to be doing a substantial amount of undirected basic research was Hitachi Ltd., the big manufacturer of electrical machinery and electronic equipment. Some Western scientists regard Hitachi's Central Research Laboratory, located on the outskirts of Tokyo, as the finest industrial laboratory in Japan. The laboratory was founded in 1942 with a mandate to perform research that might prove important 10 to 20 years in the future. I was told by the laboratory's management that about 20 scientists are free to decide what they want to work on, and that about 30 percent of the laboratory's budget supports basic research. The laboratory managers cited several instances where their basic research had led to product improvements. But the developments they mentioned as the laboratory's greatest achievements—namely, the electron microscope, mass spectrometer, low-temperature passivation transistor, high-power laser television, and hybrid computer—all seem to represent clever improvements of fundamental breakthroughs made elsewhere.

The Japanese are struggling to solve a number of problems that hamper the progress of research, not only in industry but throughout the entire scientific establishment. "Perhaps the weakest point in Japanese science and technology," according to Kankuro Kaneshige, one of Japan's leading statesmen of science, "is the lack of real strength in originality or creativity." Even in basic university research, Kaneshige says, there have not been "very many original ideas or creative types of work."

I heard numerous theories as to *why* the Japanese supposedly lack creative ability. Some suggest it is a racial characteristic; others blame an educational system that stresses rote memory; still others cite a "group approach" to problems that supposedly stifle individual initiative; and some even blame Japan's "confining" island geography which supposedly limits grandiose visions. But the most likely explanation is that Japan has frantically been trying to catch up with the West for a century now, and thus the main problem has been to "absorb" existing knowledge rather than to create new knowledge.

Is Creativity Necessary?

In view of Japan's fantastic economic success, one might question whether any supposedly higher level of creativity is really necessary. But the Japanese themselves, in formal reports and private conversations, seem to have no doubt that it is. They note that much of their industrial technology is already equal to or superior to world levels, and that it is becoming increasingly difficult to buy new technology from foreign companies. They also fear that, as Japan opens its doors to more foreign capital, sophisticated foreign enterprises may dominate the Japanese market and may cause a "virtual brain drain" by enticing away Japanese scientists. Thus far Japan has not suffered much of a brain drain, at least partly because of the language and cultural barrier.

A second major problem afflicting Japanese science is the unusually high barriers between the academic, industrial, and governmental research sectors, a situation which hampers the free flow of funds, personnel, and ideas to areas where they are most critically needed. There is relatively little use of

contract research in Japan. Professors at the national universities are forbidden by law to accept contracts from industry, and while there seem to be numerous ways to get around this prohibition, it seems safe to say that Japanese industry gets much less mileage out of the academic community than does American industry. Japanese industry pays almost entirely for its own research efforts, in sharp contrast to the situation in this country where roughly half of all industrial R & D is paid for with government funds. And there is relatively less "job hopping" by scientists in Japan than in this country. The usual practice is to go to one company and stay there until retirement.

Even the flow of ideas seems limited, not only between the industrial and academic sectors, but within them as well. One high-ranking industrial scientist told me he learns more about what Japanese companies are doing when he comes to the United States than he does in Japan. And an American scientist who spends most of his time visiting Japanese laboratories told me he is continually surprised to find that separate research groups on a single campus are often unaware of each other's work, even though they are physically close and are working in the same general area.

A third problem that has traditionally hampered Japanese science is the language barrier. Most Japanese scientists seem to read English well enough to keep up with the literature, and they can often understand spoken English fairly well, but they generally have difficulty speaking the language themselves. They are thus at a tremendous disadvantage at international conferences. I made the acquaintance of one Japanese scientist who delivered a paper at last fall's meeting of the American Chemical Society. He was barely able to ask directions to his hotel, and was clearly in no position to participate in sophisticated discussion. Japanese papers in some disciplines are published in English, but in other disciplines they are published primarily in Japanese, and thus their authors cannot benefit from the critical scrutiny of the world scientific community.

The Japanese are making numerous efforts to improve the effectiveness of their research establishment. Expenditures for R & D, though still relatively low, have been increasing rapidly; the government, through tax incentives and other policies, has been encouraging more industrial research; and the government is specifically pushing research in several high-priority areas, including atomic energy, high-performance computers, jet engines, ocean bottom digging machines, and olefin manufacture, among others. Moreover, some of Japan's organizational rigidities seem to be lessening. Joint research institutes have facilitated cooperation between scientists from different universities. And the traditional system of basing pay and promotions on seniority is slowly being supplemented by more emphasis on merit. Hitachi's Central Research Laboratory, for example, has a 38-year-old manager for its 80-man telecommunications department. "Ability counts most here," I was told. "He's the youngest manager in the whole Hitachi company."

Whether Japan will ultimately become a leading scientific power as well as a top-rank industrial power remains to be seen. But some Westerners with long experience in Japan profess an almost mystical belief in Japan's ability to do just about anything it sets out to do. One night I had dinner with Father Ballon, the university administrator and author mentioned earlier, who firmly believes that Japan will become a technological innovator. "I believe more in the spirit than in material resources," he said. "Japan has the will, but we in the West have lost our spirit." Ballon particularly noted that Japanese at all levels of society have a driving ambition to make their country great. "GE stands for GE and to hell with the United States," he said. "But Hitachi is primarily and fundamentally Japan. That makes all the difference."

Later that same night I was sitting in a coffee house, reading the notes I had scribbled while talking with Ballon, when I was accosted by a young man with beer on his breath who subsequently identified himself as a parking lot manager. What, the young man asked, did I think of Herman Kahn's prediction that Japan might be the leading nation in the world in the 21st century? I expressed some skepticism, pointing out that Japan was perched on a precarious physical base, with very little in the way of natural resources. But the young man countered: "We Japanese work hard and study hard because that's what our parents and our grandparents did." As I paid my bill and left for bed, I couldn't help thinking: My God, if the parking lot managers are working to make Japan number one, they just might do it.

—PHILIP M. BOFFEY

NEWS IN BRIEF

● **INVESTIGATIONS OF THE PILL:** Oral contraceptives are under increasing scrutiny in Congress and in federal agencies. The subcommittee on monopoly of the Select Committee on Small Business began a series of hearings this week to examine whether users of the pill are warned adequately about possibly dangerous side effects. Senator Gaylord Nelson (D–Wis.) invited 18 doctors and researchers to testify. Also, scientists at the Food and Drug Administration will begin shortly to review data which convinced British medical authorities to ban certain oral contraceptives. The pills in question contain comparatively large amounts of estrogen; the British study found that women using them ran a greater risk of serious and sometimes fatal bloodclotting. If the FDA confirms the British findings, it may set new standards for the pill in this country.

● **BIOSATELLITE PROGRAM:** The space agency should prepare for long-duration manned flights by a series of medical experiments conducted on orbiting animals, a House subcommittee urged recently. The biosatellite program, which cost $150 million over 4 years, was scrapped last year when a monkey died after a 30-day flight in orbit. The Space Science and Applications Subcommittee of the House space committee urged the space agency to reinstate the program with the idea that man should not be used as a test animal. Emphasis should be put on bioscience programs which offer immediate return to the taxpayers; men and animals on flights should be tested more extensively than at present to determine the biological consequences of space flights.

● **PEACEFUL USES OF THE SEABED:** The United Nations General Assembly passed several resolutions on international exploration of the ocean floor before adjourning for Christmas. One resolution declared that states and individuals should refrain from all exploitation of seabed resources beyond territorial lines, pending the establishment of an international regime for the seabed. The United States opposed this resolution. The Assembly also resolved to ask the Secretary-General to survey the views of member states on convening an ocean law conference with a view to redefining territorial limits.