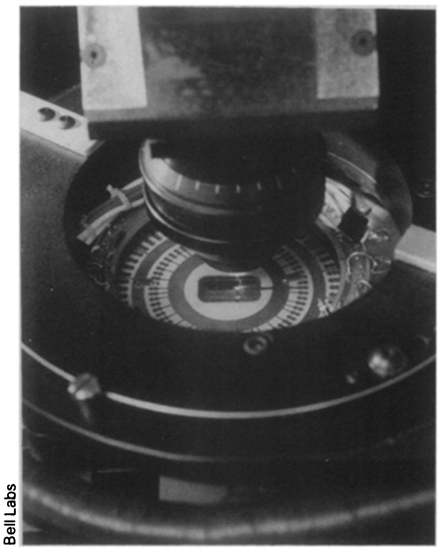
Nipponese Know-How

Japan's answer to Yankee ingenuity is generating panic in the hearts of America's high-technology leaders

By JANET RALOFF

To fear the worst oft cures the worst.
Shakespeare *(Troilus and Cressida, III)*



Bell Labs

America's business leaders are running scared. Whether or not their alarm is justified, an increasing number fear that the U.S. economy is being overrun with Japanese imports and being devastated by Japan's growing high-technology prowess. Market forecasters show America's technological leadership — particularly in solid-state electronics—being eclipsed by Japan within this decade. Not surprisingly, the ensuing fear has served to unite many research institutions in strategies for responding to this formidable challenge.

"Our perception of Japan and its development of technology has been strikingly and very suddenly transformed," noted Richard J. Samuels, director of the Massachusetts Institute of Technology-Japan Science and Technology Program. In kicking off a seminar last September titled High Technology and Japan's Industrial Future, he observed, "It really is a very curious combination of awe and admiration—in fact, dread — that now dominates discussions of this new, Japanese high-tech challenge."

And permeating those discussions is a pervasive ignorance, he claims. "But I would submit to you," Samuels adds, "that America's ignorance of Japan is largely America's own fault."

For 10 years, Samuels points out, Japan has been a net exporter of new technologies. "[It] now accounts for 10 percent of the world's economy as well as 10 percent of the world's R&D [research and development] expenditures," he reports. What's more, Japan makes no attempt to hide the fact that it is struggling vigorously to develop indigenous technologies as a means of freeing itself from foreign technological dependence, he says.

It has been estimated that this focus on technological progress will account for two-thirds of Japan's growth in the 1980s, Samuels says. "Japan conceives of its industry and technologies," he says, "as other nations — ours among them — conceive of their military, that is, as objects of national policy most likely to keep the nation strong."

Hidden strengths

Most Americans are already aware of Japan's strength in cars, trucks, televisions, motorcycles, watches and steel — industries for which Japan has already captured 25 to 30 percent of the trade among the free world's developed nations. "What we're not as aware of," says management consultant Ira Magaziner, "is that in a whole range of other industries — mainly mechanical engineering and electronics (ranging from motors to equipment for the construction, materials-handling, testing and electric-power industries)—the Japanese now have 10 percent or less of world trade, though they've been doubling their share every five years." As a result, notes Magaziner, co-author of *Japanese Industrial Policy* (Univ. of Calif., Institute of International Studies, 1981), Americans can expect to see the same pressures from Japanese imports on these industries that they witnessed developing over the past decade in steel and solid-state electronics.

Magaziner suggests that one should look at the programs being stressed in

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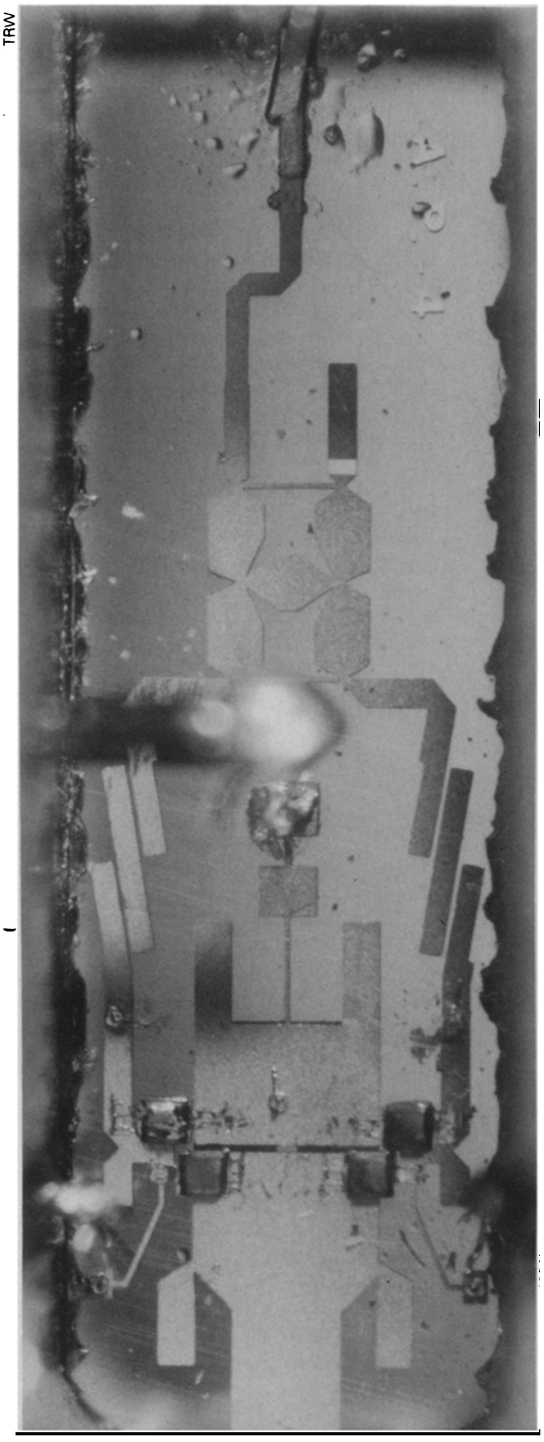
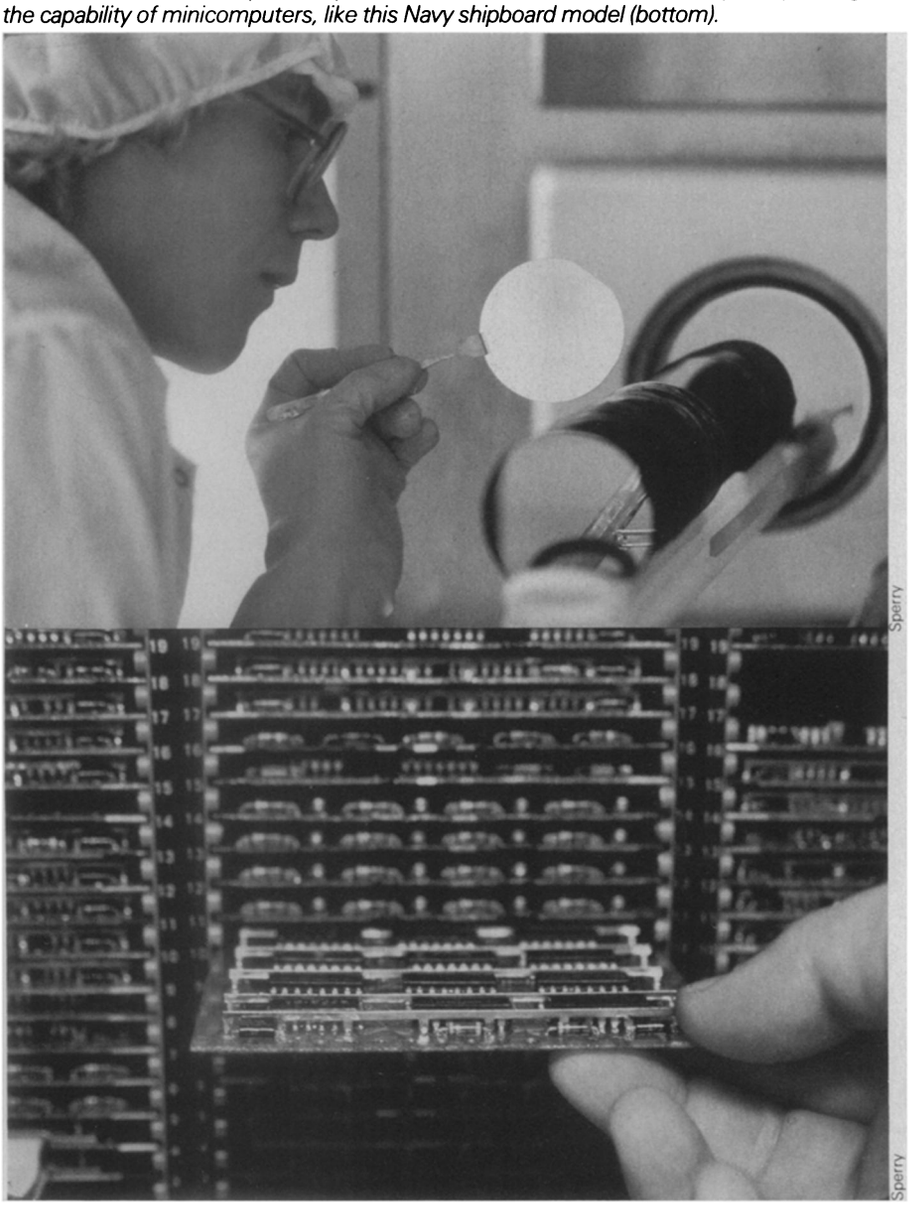


Japan today — namely flexible machine tools, measurement instruments, data communications, lasers and ultrasonics, telecommunications, and VLSI (very large scale integration) computer-chip miniaturizations — for clues as to which domestic industries will next be battling with Japan for major shares of the American market. Over the next 10 to 15 years, conventional basic industries like the steel and automotive industries will remain "as important or more important" than they are today, he predicts. But what will determine competitive success in these industries is who can adapt new technologies — electronics, lasers, ultrasonics and materials science, for example — to those basic industries for gains in productivity, quality or cost control. "I emphasize that point," Magaziner says, "because it's precisely in those kinds of areas that we in this country have been so weak — that is, in taking new inventions and applying them to existing industries for existing problems." By the early 1990s, recent work in Japan on advanced robotics (see p. 298) and composite materials "is going to come to fruition," he says.

"Probably, Japan's most hidden strength," he says, is its active personnel-training programs. "In some companies I've worked for," Magaziner says, "you may find between 20 and 40 percent of all engineers at any given time will be abroad for periods of a couple years — working for foreign companies, attending foreign universities, doing independent studies about foreign technologies." This "feeds back" into the companies and universities, he says, directing the areas in which they specialize and the research that they pursue.

This approach developed not out of great foresight so much as necessity, Magaziner believes. "Because they were behind technologically, they were constantly looking outward and set up elaborate programs for sending Japanese scientists and engineers abroad to learn. We have really very little that would be comparable in this country."

Computer-controlled laser activates spare memory cells on an integrated-circuit chip (photo at far left) to transform an otherwise defective chip into a reliable one. At 0.7 inch long, 0.003 inch thick, the 60-gigahertz integrated receiver (near left) illustrates how small electronics components are becoming. Researcher checks silicon-substrate blanks (below), from which computer chips will be fashioned. Such microcircuitry is expanding the capability of minicomputers, like this Navy shipboard model (bottom).



Intelligence gathering

"The thing that always strikes me," Magaziner told the September symposium in Boston (sponsored by MIT and the Japan Society of Boston) is that when Japanese come to tour U.S. research or manufacturing plants, they "will have a full list of who they want to talk to, down to the names of the individual engineers on the plant floor. They know exactly what parts of the process they want to talk about."

"It's not industrial espionage," he points out, because they're being given the same kind of plant tour which they extend to visiting Americans. "But [the Japanese] take better notes." Magaziner chalks up America's problem to "a real disorganization in terms of its technology intelligence." Some Americans who take foreign plant tours go home and are transferred to a division of their company that has no use for the data they collected, he says. Others return and misplace their notes before briefing colleagues in detail. And few, he contends, do sufficient homework to know before arriving what to focus their attention on. Finally, without a conversant knowledge of Japanese, they lack the opportunity to direct specific follow-up questions to those plant engineers who understand the industrial processes best.

Leonard Lynn, another MIT symposium speaker, shored up the contention with an anecdote. Lynn, a Carnegie-Mellon professor and author of *How Japan Innovates* (Westview Press, Boulder, Colo., 1982), related how a major Pittsburgh steel company with which he had been dealing decided to exchange scientists for a year with a Japanese firm. The day after the agreement was signed, the Japanese had their representative on a plane to Pittsburgh. As a Carnegie-Mellon graduate, the Japanese scientist not only spoke English, but he also knew Pittsburgh. Lynn recalls the researcher telling him, when his year's stay was up, how the American company had still not found someone to send to Japan. "It wasn't a matter of just finding someone who could speak Japanese," Lynn said, "because that was out of the

question." It was that the company couldn't figure out what their representative should be sent to learn, since it wasn't sure what that person would be expected to do once he returned.

Financial tools

Unquestionably one of the most important factors propelling Japan's drive for technological leadership has been development of its "policy instruments" — financial and other institutional mechanisms for aiding those industries the government deems strategic to its long-term economic and political security. Magaziner notes that Japan has carefully targeted business incentives — such as low-interest federal loans, loan guarantees, R&D grants and purchase subsidies — to the needs of a particular industry as determined through discussions with industry leaders.

Among the more unusual of the incentive programs coordinated by Japan's Ministry of International Trade and Industry is one Julian Gresser described as an attempt "to learn how to clone future Mr. Hondas [the founder of the motorcycle and auto company]." The idea is to identify promising young entrepreneurs and provide them with capital. In fact, noted Gresser, a visiting professor at Harvard's law school, MITI has the real Mr. Honda on the board of the Venture Enterprise Corp. surveying companies not yet large enough to be listed on the Tokyo stock exchange, and ranking them on the basis of perceived promise for purposes of awarding loan guarantees.

While the Japanese government offers outright subsidies to strategic industries, Magaziner points out "the level [of subsidy] is not so important" because if the government shows interest in helping a particular industry, "the private banking system will follow suit." What's more, because of the way Japan's banking system is structured, banks often hold "a large portion of the equity" in strategic companies, he says. With the banks standing to gain from a company's ultimate, long-range success, there is more "patience," Magaziner asserts — the banks are not expecting a three-year payback on these investments. Coupled with the availability of high-risk public capital and Japan's developing venture-capital market, Magaziner contends "the whole system makes one very secure about [obtaining] capital," even during recessions.

America's response

What can America do to meet the Japanese high-technology challenge? Learn more about Japan, for starters, Samuels says. The program he directs at MIT attempts to offer researchers an opportunity to do just that. Set up last year, it offers courses in Japanese science, culture, economics, politics, history and language (no student will be sent to Japan under the program's auspices without the equivalent of three years' training in the language). A cooperative-research association with Tokyo University and several Japanese research laboratories has been set up, Samuels says, with the expectation that their collaboration will eventually focus on energy policy, innovation, communications, materials science and transportation. The program also intends to continue symposia and workshops, like its September seminar in Boston, as an outreach program to the business and research community.

Northwestern University's engineering school signed a cooperative agreement this fall with its counterpart at Osaka University to exchange scholars, faculty and students (perhaps even undergraduates). According to Mike Meshii, a materials-science engineer on the program's advisory board, perhaps 20 to 30 faculty members, and an even larger number of graduate

Robots: Japan's answer to guest workers

Not only are the Japanese adept at gathering intelligence, but also at applying it. And few places is this better exemplified than in the development of industrial robots. Leonard Lynn of Carnegie-Mellon University, who is studying the industry, offers some contrasts in how the United States and Japan have attempted to create markets for their automatons.

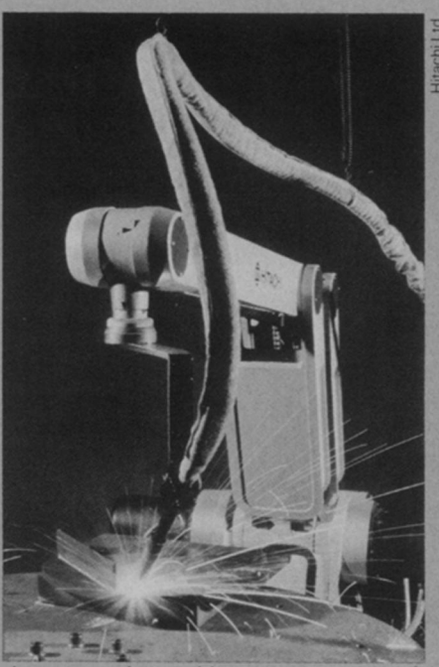
Though it would be virtually impossible to credit any one person as solely responsible for invention of the robot, American ingenuity clearly made programmable versions commercially attractive. In fact, most industrial-robot patents were filed in the United States around 1954. An industrial prototype, created by Unimation of Danbury, Conn., made its debut in 1960. Within two years, a commercial version was sold to Ford Motor Co. Shortly thereafter, General Motors invested in a few.

But the robot market didn't really get off the ground until roughly a decade ago. (Lynn says, "I understand that Unimation, the leading American firm in this industry, didn't make any money off its robots until 1974, some 20 years after the patents were initially accepted.") And it was only at this time that the Japanese began to seriously investigate the robot's potential.

In December 1967, Toyota bought Japan's first commercial robot. A year later, Kawasaki Heavy Industries signed with Unimation to begin developing robots under a license agreement. Several other Japanese companies, such as Mitsubishi, also began developing robots that, Lynn notes, "looked a lot like the Unimation robot."

While Americans still claim to lead in development of robot technology, the Japanese are widely considered experts in its application. As of December 1981, Japan had roughly 14,000 industrial robots operating (perhaps 70,000 if one doesn't limit the census to programmable machines), created by some 150 different manufacturers. The United States, by way of contrast, had a mere 3,500 to 4,000 robots — and six companies accounting for virtually all the sales (the largest U.S. manufacturer built 40 percent of the total, the second largest produced 30 percent).

Perhaps more important, "Some of the major American firms that are now entering the industry, and that we might have thought would have been strongly interested in it at an earlier date, are linking up with the Japanese," Lynn says. General Motors will produce robots in the United States through a joint venture with Fanuc. IBM signed an agreement with Sankyo Seiki, a small Japanese movie-camera company, to sell its robots. General Electric is selling Hitachi robots, while Westinghouse is bringing in models designed by Mitsubishi and Komatsu (one of the world's leading tractor manufacturers).


Hitachi Ltd.

Japanese robot welder at work.

Lynn says the Japanese appear to be getting three times as many robot-related patents as Americans are, and are spending three times as much money on robotics research. "You have to be careful when comparing numbers," he says, "because their definition of robots differs a bit. But the impression, at least, is that they're spending strongly, have more people working on robots, and are doing more."

What fostered Japan's growing dominance of the industry? "Linkage," says Lynn, using economic jargon that refers to

students, will visit Osaka in the first five years. Japanese language training is not a prerequisite, though NU established a Center for U.S.-Japan studies last year that offers classes in both language and culture.

Michael Radnor, at NU's Center for the Interdisciplinary Study of Science and Technology, notes that the university also has a U.S.-Japan Economic Relations Program. "We have all the same things as MIT," he says, "probably more in this area, but we don't package it in the same way." Not only is NU actively collaborating with Japanese companies such as Mitsushita and Toshiba, but also with schools and laboratories, including Keio University, Tskuba University and the Kobe University of Commerce. And, Radnor notes, his center, CISST, is in the process of setting up a U.S.-Japan program for executives on R&D management.

Thomas Coulter has another solution. He's offering a fellowship program through Northwestern to send graduate students to work in Japanese companies. Coulter, a director of the Chicago-Tokyo Bank and executive vice president of the Lester B. Knight and Associates management-consulting firm, has been involved with U.S.-Japan economic-trade issues since the State Department sent him to Japan in 1958 to run productivity seminars for local businessmen. Having watched the way Japan has sent its best and brightest to absorb American "know-how" for application to its domestic issues, he thinks it's time someone began offering programs to motivate Americans to reciprocate.

But most businessmen, Coulter included, note that the structure of America's tax and financial systems makes it hard for new high-technology firms to acquire the capital needed to invest in the research and manufacturing of conceptually new products. Gresser says the modified free-market system and laissez-faire attitude of American finance "is inadequate to foster the development of these industries." Therefore, he says, "some sort of remedy for market distortion is essential." Although the U.S. Congress considered several bills addressing this issue, none of these bills showed signs of passing this year.

Michael Dertouzos, director of MIT's Laboratory for Computer Science, has been following plans for Japan's development of a "fifth generation computer"—a super brain to harness the information revolution. He suggests that American firms had better "take more creative approaches to cooperative ventures" with their domestic competitors. And he sees the Japanese-style collaboration being proposed by the Semiconductor Research Cooperative (SN: 4/24/82, p. 277) and the Microelectronics and Computer Technology Corp. (SN:10/16/82, p. 247) as steps in the right direction.

"In the 19th century, we had lots of skilled labor migrating to the U.S. and we came up with something called Yankee ingenuity," Lynn says, "which meant copying ideas from Europe and doing things a little better." From those humble beginnings, America ascended to a position of world technological supremacy.

Japan today stands in much the same position America did a century ago, borrowing foreign technology that it then adapts with vigor and ingenuity. Might not Japan play out the role a step further, itself ascending to world technological supremacy? With Japan embarking on such ambitious cutting-edge research as its fifth-generation computer project, Dertouzos warns that U.S. supremacy in semiconductors and computer science could be on the wane. And, he adds, "I believe that whoever has a controlling hand in the information revolution has a controlling hand on geopolitical influences." □

the dual role so many Japanese robotics leaders play as both manufacturer and user of industrial automatons. Among the more notable advantages of this dual function, the robot maker has a guaranteed market for its initial prototype machines (whatever their cost), it has intimate knowledge of the precise performance criteria demanded of the machine to be commercially significant, it has the opportunity to feed back design changes into new models fairly efficiently and quickly, and it has an impressive if not compelling showcase for selling potential buyers on the merits of its robots by merely offering tours of its robot-assisted operations.

Kawasaki Heavy Industries, shortly after signing an agreement to produce Unimation robots under license, put robots on its motorcycle assembly line. Mitsubishi Heavy Industries, another robot maker, is also a major partner/owner of the Mitsubishi automobile operation where Mitsubishi robots are used. Yamaha is installing 145 arc-welding robots on one of its motorcycle-assembly lines. Yamaha made the robots, which are not yet generally for sale. Toyota, too, is making robots for in-house use. Seiko makes robots that put watches together. Pentel makes robots that assemble felt tip pens. Okamura makes robots to assemble office furniture. And the list goes on.

American robot makers tend to make only robots, and often general-purpose machines at that. Not so with many of their Japanese counterparts who, in fact, are best known for more conventional industrial products, like cars, steel or machine tools. Not only do many of the Japanese robotics leaders produce robots as a side line, but they also tend to focus on developing specialty robots—generally for use in manufacturing their primary products. Kawasaki, for example, is one of Japan's leaders, but for a single sector only—spot welding. It doesn't rank even second or third in arc welding; Yaskawa Electric leads the field there. Kobe Steel leads in spray-painting robots. Fanuc commands the assembly-robot field. And the small, 800-employee Aida Engineering, which made its reputation in hydraulic presses, now leads the industry in robots for use with those presses.

Having established the utility of robots in their own industry, these manufacturer/users have a relatively easy time selling other members of their industry on them also, Lynn says. As generalists, the American robot makers have little that is so comparably compelling with which to win new industries over to their product. And Lynn suspects that may partially explain why American robot sales have not kept pace with the Japanese.

Thomas Eagar, a materials engineer at MIT, sees another drawback. The attitude of U.S. robot buyers has been that automatons are best justified in high-technology and high value-added industries. Though Americans are willing to pay more for quality, Eagar says they fail to realize that robots cannot yet match the performance of our "best workers." Therefore, when quality is paramount — as in the welding of nuclear-plant pressure vessels —Eagar would rule out using robots. And it's because the Japanese share this view, he says, that most have married their automatons to low-technology applications, where the performance and speed of robots will surpass that of careless or tired production workers.

Finally, Lynn notes a cultural factor that he believes has been critical in fostering Japan's apparent love affair with robotics. Following World War II, Japan's birth rate dropped sharply, leading demographers to predict that a critical worker shortage would commence around the late 1960s. Being a closed society—unwilling to "contaminate" its culture with immigrants — Japan looked for alternatives to Germany's guest workers (Turks, Moroccans and others invited in as temporary laborers for the rebuilding of its auto and other industries). Synthetic workers appeared the perfect solution for maintaining Japan's productivity gains and economic growth. In sharp contrast to the United States, Japan even today has startlingly low unemployment (at 2.7 percent, this summer's figure was a 20-year high).

But things are changing. "Robots are replacing many more workers than the shortage," Lynn says, adding that he read an estimate by one Japanese academic suggesting Japanese unemployment could hit 12 percent by 1990. He says a technology-assessment project, begun a few months ago, is examining the potential effects. And last year trade unions began raising the issue of job protection in the wake of robot automation as a clause for new contracts.