Japan Is Racing to Commercialize New Superconductors

Discover[illegible] Prompts Frantic Research Effort; U.S. Response Is Measured

Norm Lalker MAR 26 1987

Norm – this is designed as a "briefing" document upstairs. Would much appreciate your corrections, additions etc. . . .

Bill

By STEPHEN KREIDER YODER
Staff Reporter of THE WALL STREET JO[illegible]

TOKYO—In the corner of Prof. S[illegible] Uchida's laboratory at the Unive[illegible] Tokyo, across from the bottles [illegible] nitrogen, stands a bunk bed.

Until recently it was little [illegible] on Feb. 15, a University of H[illegible] conference announced the [illegible] through in the science of s[illegible]vity, a development with p[illegible]mous commercial applica[illegible]

The lab and its bunks h[illegible] been empty since.

For three weeks Pr[illegible] searcher team worked [illegible] seven days a week to [illegible]ton results. Sleeping [illegible] their meals in a t[illegible] their latest batch of exper[illegible] pellets baked in the lab's kiln.

In other labs, in company board ro[illegible] and in the offices of the powerful Ministry of Trade and Industry, or MITI, the Houston breakthrough has galvanized Japan. Scientists, industrialists and government officials have responded frantically, convinced they can, and must, walk away with the commercial applications. "When it comes time to make something out of it," predicts Prof. Shoji Tanaka, who is Prof. Uchida's boss, "the Japanese will have the upper hand."

In the U.S., by contrast, the reaction has been more measured. Labs are busy, but there isn't any nationally coordinated drive for commercialization. Leaders in superconductivity research caution that much science remains to be done first. "You must keep in mind that the scientific scene is changing so rapidly that to decide (on specific applications) on the basis of what is known today would be a mistake," says John Armstrong, director of the research division at International Business Machines Corp. It would also be wrong, he thinks, "to turn this into a race between East and West."

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te[illegible] [illegible]als make economic[illegible] [illegible], superfast computers, ma[illegible] [illegible]ting trains, long-distance power li[illegible] [illegible]t don't waste electricity and even appliances that use almost no power.

The discovery meshes with technologies Japan has refined for years. Japan has a train using superconductivity that is almost ready for commercial use. It travels at more than 250 miles an hour while hovering five inches above a track on a magnetic cushion created by superconducting coils. Japan's shipbuilders, meanwhile, have spent $23 million to build a fast ship propelled by superconducting magnets.

NEC Corp. and others already have produced prototypes of superconducting computer chips; the West gave up trying to do so four years ago. Such giant electronics concerns as Hitachi Ltd. are supplying the West with millions of dollars of superconducting equipment. And Japan's leading role in industrial ceramics will help it develop ceramic superconductors. "A lot of revolutionary things are going to come up and a lot of it is going to come from Japan," says David L. Keller, a technology analyst with James Capel & Co., a British [se]curities firm. "The Japanese will dra[m]atically lead the rest of the world."

The Japanese government already is organizing that. Four days after the Houston bombshell, Japan's Science and Technology Agency announced its intent to form a research consortium of Japanese companies, universities and government labs. A week later, the consortium was in place, including such industrial giants as NEC, Toshiba Corp., Nippon Steel Corp. and Mitsubishi Electric Corp. "We've gathered all the leading-edge researchers in superconductivity in Japan," says Koji Yamaguchi, the agency official overseeing research. "We need to get everybody together to share information and decide how to move."

> [illegible]E,' says Japan's leading [illegible]aper, 'is to organize industry [illegible]e West in applications and for a huge new market.'

MITI, the agency that picks and funds national projects like the one that helped Japanese makers dominate the memory chip business, began moving on the day of the announcement. It already is polishing up an existing feasibility study on a superconducting power plant and plans to have a working model built by 1992.

"The objective is to organize industry to get the jump on the West in applications and commercialization for a huge new market," says Nihon Keizai Shimbun, Japan's leading business daily. The earliest application, researchers say, could be superconducting computer chips that would enable creation of a shoe box-sized supercomputer. IBM and most other U.S. companies abandoned research in 1983 on the chips, called Josephson Junction devices, partly because of the complications of cooling with helium. That left NEC, Hitachi and a MITI lab to refine the technology with little foreign competition.

For all the government-inspired organization, Japan's research labs didn't wait for government orders when they heard the news from Houston last month.

Elements of Surprise

At the University of Tokyo, Mr. Uchida sat his researchers down in front of a large periodic table of the elements. For hours they debated which elements Houston could possibly have used. While they were still guessing, a rumor came over the phone that the material was fluoric. Students ran out and bought fluorinated chemicals. For three days they tried out hundreds of combinations until they found the rumor was false.

Acting on another tip that the Houston material was dark green, the researchers mixed all the plausible chemicals that would become green when fired, again with no success. (The material needs to be fired further until it is black, they found later.) Then a news report said a Chinese lab had achieved superconductivity at 100 degrees Kelvin (minus 173 degrees Celsius) using a ceramic with ytterbium in it and researchers attacked that. The report proved wrong—the element was yttrium. (Ironically, the University of Tokyo lab later found, by coincidence, that ytterbium works. The lab patented the discovery.)

Finally at 2 a.m. March 1, they got superconductivity. "It was an other-worldly experience," says Prof. Uchida. They drank a toast and launched back into another week of experiments, this time to refine the resulting ceramic. On March 8 they announced a purified form. On Wednesday the lab finally took a holiday.

Meanwhile, labs at Tohoko University, Hokkaido University and a government research facility in Tokyo have burst forth with rapid-fire announcements of their advances in superconductivity. They and other labs have been snatching up the ingredients for superconductors so fast that there are shortages. Suppliers have run out

of yttrium, for example, and labs must wait three weeks for orders to be filled.

'The Real Thing'

Prof. Uchida's lab has been flooded by calls and visits from companies. Sumitomo Electric Industries Ltd. researchers brought in some rudimentary wire made from superconducting ceramic. Engineers from Toshiba, Fujitsu Ltd. and Hitachi have visited the lab to keep watch on developments. "Company people have the conviction that this is finally the real thing. A lot are starting to pick it up. . . . They see that superconductivity is a sure thing and they want to get on to application," says Prof. Uchida.

Of course, there is scientific and commercial excitement in the U.S., too, but it's less frenetic and isn't centrally controlled. Scientists say indications of an incipient breakthrough came as early as April 1986, when researchers at IBM's laboratory in Zurich, Switzerland, reported they had achieved superconductivity in a new class of materials, the metal oxide ceramics. This galvanized researchers throughout the world. By November, the Japanese and Chinese had confirmed the IBM discovery and by December, scientists in Houston and at American Telephone & Telegraph Co.'s Bell Laboratories were reporting important advances with the new materials.

About 5,000 physicists jammed the ballroom of the Hilton Hotel in New York Wednesday night for an unprecedented special session on superconductors at the annual meeting of the American Physical Society. They listened to the presentation of 60 papers on superconductivity research done largely within the last two to three months. Although scientists from U.S. universities dominated the program, there were reports from IBM, Bell Labs, Westinghouse Electric Corp. and Exxon Corp. as well as from Japanese, Chinese and Canadian scientists.

The breakthrough generated tremendous excitement among Bell Labs scientists, says Robert A. Laudise, director of the laboratories' inorganic chemistry branch. "Usually, research managers are coaching people to do this or that," Mr. Laudise notes. "But in this case we had people coming around from all different disciplines wanting to know if there was anything in this for their area," he says.

Too Soon for Applications

"We've had a lot of people going without sleep," Mr. Laudise says. But he agrees with IBM's Mr. Armstrong that it's still too soon for anyone to settle on specific applications of the superconductors. "We're not trying to make any specific devices or systems," he says.

Bell Labs researchers are, however, trying to fabricate various superconducting materials into experimental devices. At Wednesday's APS meeting they displayed a superconductor in the form of a flexible ceramic tape that can be formed and then hardened into a shape to fit a superconducting device.

Researchers at General Electric Co.'s big research and development center in Schnectady, N.Y., agree that it's too soon to jump into an industrial competition with anyone, including the Japanese.

Jury Is Still Out

"In the materials field, the events of the last several weeks have been quite spectacular, but in the applications sense, the jury is still very much out," says Michael Jefferies, manager in the center's engineering physics laboratory.

Until recently, the GE lab didn't have a group of scientists working on superconducting materials. "But we're now trying to confirm and duplicate the results that are being reported," Mr. Jefferies says.

Guy Donaruma, vice president for research at the University of Alabama in Huntsville, says governmental agencies and private concerns have shown a keen interest in the university's superconductivity research, which duplicated the Houston breakthrough.

"Wherever I go around town somebody buttonholes me and asks how we're coming along or when can we use this," Mr. Donaruma says. Some inquiries have come from the space and defense related agencies in the area, including the Marshall Space Flight Center and the U.S. Army Missile Command, he says.

In Palo Alto, Calif., where Stanford University recently announced a breakthrough in fabricating a superconducting thin film, useful in electronic devices, a news conference last week was packed with industry people. Several other scientists have called for more information for use in making a superpowerful magnet used by geological researchers. Niels Reimers, director of Stanford's technology licensing office, said, however, that he hasn't been fielding many industry inquiries.

Crash Programs

In Japan, however, companies that already sell conventional superconducting wire to the U.S. have begun crash programs to commercialize the new discovery. Fujikura Ltd. and Sumitomo Electric, for example, say they have developed rudimentary wire out of the new ceramic, despite skepticism among some scientists that the material won't lend itself to wire-making.

Like their U.S. counterparts, Japanese makers temper their euphoria with warnings that too little is known about the new ceramic superconductor to tell when and how the material will be commercialized.

Aside from possible problems in forming brittle ceramic into wire, the new superconductor still can't handle enough current to be used in heavy applications such as power plants. Superconductors also don't work well with alternating current, the type of electricity used in most of the world's power equipment.

But Japanese labs are convinced they can solve the problems over the next several years. Now that the West has made the basic breakthrough, they say, the ball is in their court. "It will be difficult and will take time," says Kasumasa Togano, a government scientist. "But that's precisely where Japan's labs and makers have the edge."

Still, he and other researchers admit to a twinge of hurt pride. "To be honest, we're following in the footsteps of the U.S.," Mr. Togano says. "Here, again, the originality is coming from the West. We have a measure of sadness about that."

JERRY E. BISHOP IN NEW YORK
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The Super(conductor) Bowl

JAPAN AND the United States are spending similar amounts of money on research into superconductors, the new materials that conduct electricity without resistance. But the Japanese are much likelier to dominate the markets for the commercial applications of this technology. Why? Because in this country most of the research money is being distributed by the Department of Defense and other agencies with no real interest in the commercial possibilities. Currently American manufacturers seem to be losing the semiconductor market to their Japanese competitors. How can the United States prevent that from happening to the future products based on superconductors?

The White House put that question to a committee of scientists and industrialists headed by Ralph E. Gomory of IBM, and the committee has now given an answer with implications far beyond this one technology. It recommends setting up several consortia centered on universities and bringing in experts from both government laboratories and private industry to work on research programs on which they all agree. Companies would contribute to the cost, in return for which they would take part in directing the research.

Superconductivity is only one of many new fields in which the United States is moving much faster in basic science than in its applications. The competitive pressures on manufacturing companies discourage all but an unusual few of them from doing much serious research of their own. There are several missing links in the chain that leads from the academic labs doing pure science to the kind of short-term product design that is the limit of most companies' R&D. The concept of the consortium is very much worth exploring.

It's not quite the departure from American tradition that it might seem at first glance. Government has always played a powerful role in American technological progress. One spectacularly successful example over the past century and a quarter has been in agriculture, where the government operates the system that brings the universities' research to the farm. Two of this country's most prominent manufactured exports, the computer and the jet airliner, were originally developed with military money. But that source is under tight constraint these days, and there's a clear need for surer ways to direct the research and development that is going to be crucial to the economy in the next century. There have always been partnerships among the universities, government and industry. Now it's becoming necessary to make them stronger and more systematic.