Superconductivity Drive Sparks New Policy Debates

Key need is coordinated federal government program involving universities and business, together with a policy that integrates government/industrial research relations with Japan

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Superconductivity by now is a term familiar to anyone who reads the daily newspapers or watches the evening news. The discovery of ceramic copper oxide materials that can conduct electricity without resistance at temperatures within or above that of liquid nitrogen has touched off unprecedented excitement in the scientific and technological communities, and an extraordinary amount of "hype" in the Reagan Administration.

What has also been touched off is an apparently new focus for debate about U.S. technology policy. The debate consists of two related parts. One is an attempted harnessing of government, industry, and universities into a single big effort to exploit a major breakthrough. The other is to throw a challenge to the country's top technological and economic competitor, Japan. Superconductivity is the symbol around which the U.S. aims to prove it can "compete" in global high technology. Naturally, not everyone sees the picture the same way.

In late July, the White House Office of Science & Technology Policy with the Department of Energy sponsored a two-day meeting on commercial applications in the field (C&EN, Aug. 3, page 4). President Reagan spoke and announced an 11-point federal initiative. About 1100 attended.

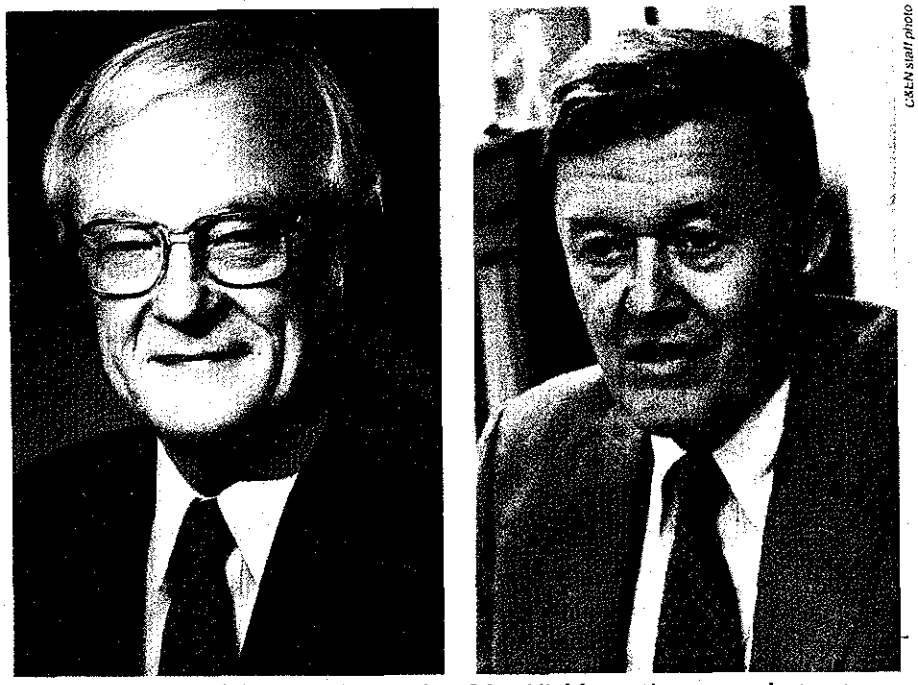
At the meeting, organized by Reagan's science adviser William R. Graham, Energy Secretary John S. Herrington sounded the tone of urgency. "The race to commercialize superconductivity is on," he said. "And the economic prizes await the nation that first discovers a viable, marketable technology. We will face unprecedented international competition. Although we have the jump on our competitors in basic research, we must marshall all our resources and tap our ingenuity to the fullest to compete effectively in the marketplace."

Herrington was aiming his rhetoric mostly at Japan.

Superconductivity initiatives feature $150 million for Defense Department

During July's federal conference on superconductivity, President Reagan outlined several government programs to spur developments in superconductivity and other technologies. He spelled out a total of 11 initiatives to:

- Expand antitrust laws to allow corporations to enter joint manufacturing ventures.
- Amend patent laws so that U.S. owners of process patents can sue foreign manufacturers when they export to the U.S. a technology that infringes the U.S. patent.
- Tighten Freedom of Information Act rules to prevent commercially valuable technical information generated in government laboratories from being disclosed to foreigners.
- Establish expert Superconductivity Advisory Group to advise the Administration on research and commercialization policies.
- Establish Superconductivity Research Centers at Argonne, Lawrence Berkeley, and Ames national laboratories, and at the National Bureau of Standards' Boulder, Colo., laboratory. Allocate $150 million to the Department of Defense for a three-year program of superconductivity research for military systems. Expand National Science Foundation superconductivity research and engineering by transfer of funds from other programs.
- Accelerate federal, university, and industry cooperation in research.
- Accelerate patent procedures for superconductivity uses and court suits.
- Accelerate standards work for superconductors and related devices and materials.
- Expand reallocation of agency funds into superconductivity research.
- Speed up sensor and electronic work at NBS and DOD.
- Seek more U.S. involvement in Japanese superconductivity research.



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Schmitt (left): no life or death situation. Merrifield: wasting research structure

A later speech by U.S. Trade Representative Clayton Yeutter also was directed at Japanese competition. Even National Academy of Sciences president Frank Press, known for his measured prose, was drawn into the all-or-nothing rhetoric. Herrington quoted Press as saying, "Superconductivity has become the test case of whether the U.S. has a technological future."

Rudy Pariser, director of advanced materials science at Du Pont's Central Research Laboratories, attended the conference and recalls, "I personally was put off by the day-after-Pearl-Harbor mood of the meeting on the part of the politicians there."

Individual voices are counseling a balanced view. Says Donna Fitzpatrick, assistant secretary of Energy for conservation and renewable energy, "Some people [might be led to believe] we have a near monopoly [in superconductivity] but I don't think it's the way the world works anymore." Adds Roland Schmitt, General Electric's corporate vice president for science and technology, "I would not like to see this superconductivity situation characterized as a life or death situation. I would suspect there will be lots of deals struck between U.S. and Japanese companies."

Meanwhile, government agencies, heeding President Reagan's mandate, are gearing up for expanded work. About $55 million is currently being spent, much of it in funds redeployed from other programs. More is expected to be asked for in Congress next year. The Pentagon alone is slated to receive $150 million over the next three years.

The immediate goal of superconductivity research is disarmingly straightforward. What's involved is nothing more than developing a piece of ceramic copper oxide wire and a strip of film based on something nature, not any scientist, has produced. In a sense, it is up to science to improve on nature's provision. The wire would be used for coil in magnets, the film for electronic circuits. DOE is taking the lead in funding the former, the Department of Defense the latter. The National Science Foundation and the National Bureau of Standards will be working on the fundamental science and the basic engineering.

There are many, however, especially in DOD, who feel that the time to push applications is right away, anticipating the emergence of test materials a few months hence.

Much of DOD's work will be concentrated in the Defense Advanced Research Projects Agency (DARPA). "We have decided to concentrate our efforts to develop as quickly as possible an industrial technology base for the processing, fabrication, and manufacturing of these new superconducting ceramics," says Craig I. Fields, deputy director for research at DARPA. "We expect to develop small-scale pilot production lines, or 'boutique' factories, as we did with gallium arsenide. We hope to see some concept demonstrations in three or four years. We are relying on other organizations to do the work to establish a solid intellectual basis for understanding the properties of the new materials. We feel this is a situation where engineering must parallel or even precede science."

There are those, however, who believe the Administration should have used the conference to make a case for strengthening the country's scientific base.

William O. Baker, former president of Bell Laboratories and a long time insider in national science policy issues, is one who believes so. "The way the government has gone about establishing a superconductivity policy has been backward," he says. "We don't need commercial razzle dazzle when the fundamentals are a mystery. It was naive to assume that science would automatically be pulled along or that it already existed. We have a severe knowledge deficiency in this country. The lack of scientific and technological literacy is going to hurt us. The universities need additional wisdom. We need to have more scientists. That's what the emphasis should have been on."

Baker also believes the conference should have tweaked chemistry for its lack of imagination and its failure to be more interdisciplinary. "The chemistry departments have been reluctant to do much work in solid state science," he says. "Chemistry, metallurgy, and physics are still backward with regard to collaborative research. It's a challenge to theoretical chemistry and the universities are just not with it."

The Baker argument forms the nub of the technical debate. It is U.S. science that is in crisis, he argues, and the superconductivity campaign diverts the country from a more fundamental science policy agenda—building a more solid foundation by attracting young people to science in the volume Japan and West Germany do. Yet, even a Baker ally in criticizing Administration hype over superconductivity thinks applications should be given strong emphasis. He is Rustum

Argonne gets major role in national superconductivity effort

Argonne National Laboratory near Chicago has been tabbed by the Administration to take the federal lead in catalyzing the transfer of commercial uses of superconductivity from the public sector to business. The laboratory has been doing research on superconductivity and on ceramic materials for 20 years and has established under Gregory Besio a superconductivity applications office within its Technology Transfer Center. In June it held a meeting outlining Argonne's capabilities to almost 200 repesentatives of industry.

The center itself was set up some years ago to seek out promising Argonne research for licensing to the private sector. Proprietary aspects will be handled through a nonprofit entity known as ARCH Development Corp. ARCH is an acronym combining Argonne and the University of Chicago, which manages Argonne under a Department of Energy contract. As manager, the university is the automatic owner of Argonne inventions and, through ARCH, licenses inventions to interested corporations. Half the royalties, however, will be contributed to Argonne's research budget.

The centerpiece of the superconductivity outreach effort at Argonne will be an industrial affiliates program modeled after many that already exist in the country's major technical universities. Besio says the program, costing companies with fewer than 500 employees $15,000 a year and larger companies $25,000 annually, will organize yearly meetings that will review progress in the field, publish a newsletter for members, and provide preprints and reprints of research plus market analyses of new commercial ventures. In addition, Besio says the center will provide affiliates—who will be from R&D, manufacturing, and financial fields—one consulting day per year at Argonne and it will send out experts to provide seminars at affiliate sites.



C&EN staff photo

Schriesheim: Argonne will be a player

To protect proprietary information, affiliates will have to sign nondisclosure agreements to ensure that important findings are kept within ARCH. In addition, Besio says Japanese firms will not be eligible for affiliate membership. Whether U.S. companies that engage in joint ventures with Japanese firms will be allowed membership has not been determined.

Through its economic development activities, the state of Illinois is also hoping to cash in on the enthusiasm for superconductivity. So an equally significant move at Argonne is a planned Illinois Superconductivity Institute that would draw upon superconductivity work at Illinois Institute of Technology, Northwestern University, University of Chicago, University of Illinois, Argonne, and Fermilab. Illinois believes it has the best concentration of superconductivity research and applications talent in the Western World and is hoping to build a "Superconductivity Valley" on the plains of northern Illinois.

Looking down at it all with considerable pride is Argonne director Alan Schriesheim. "In superconductivity," he says, "Argonne has the largest nonindustrial basic program in the country. And with our work in basic ceramics, too, we can easily mesh a basic and applied program. We also have the facilities to examine structure. If there is a game to be played here, Argonne will certainly always be a player."

Roy, materials scientist at Pennsylvania State University.

"The science will happen in any case," Roy contends. "Remember, we are talking about materials nature already has made. I would fund the people with ideas on bringing the product to applications. They will adapt as the ideas come along."

The government is hoping that many ideas will come out of the federal laboratories, mainly DOE's big national laboratories, such as Argonne, Lawrence Berkeley, and Brookhaven. The national laboratories at present have a total superconductivity budget of around $11 million. But the keys to their potential are their resources and equipment, and some provisions of the Technology Transfer Act passed last year. That act allows the labs to collaborate with private industry and involves transfer of patent rights to companies provided they try to commercialize the developments. DOE has great hope that the facilities will pay off for industry.

One skeptic, however, is GE's Schmitt. He believes the national laboratories serve small entrepreneurial firms better than large corporations like GE.

"To work in corporate regimes," says Schmitt, "requires big investments in linkages and communications. We have 600 Ph.D.s in our labs and 1200 technical people at the bench. And those people get 12,000 to 15,000 visits a year from the corporate marketing side. When I look outside General Electric, I see adequate linkage opportunities not with the national laboratories but with universities. Right now I don't have anything in place with the national labs. But I think the labs working in a mode of spinning off technology and licensing would be the way to go."

But universities need a revival, too. Says D. Bruce Merrifield, assistant secretary of Commerce for productivity, technology, and innovation, "We're doing $15 billion a year in basic research in universities, 10 times more than any other nation does or can do. I'd like to see the amount doubled. No one else has [such

a basic research structure] in place or can replicate it. And we're largely wasting it.

"The trouble with the universities," he adds, "is that they don't know that there is a marketplace. They have a gold mine in the research they do and they are only beginning to build the patenting and licensing structures to take advantage of the knowledge they are producing."

Merrifield has one initiative he is trying to promote. "We're taking some of our most experienced industrial people—retired executives, vice presidents and technical managers of various corporations—and offering them to colleges and universities to help the institutions identify the potential of their research. These are people on the leading edge of technology who know what the score is." About $1 million is available for that activity through the Technology Transfer Act. In charge of that program is consultant Lee Rivers, formerly of Allied-Signal Corp. and a recent visiting fellow at OSTP.

To Penn State's Roy, collaboration is necessary but he doubts whether NSF in its programs is equipped to force such collaboration. NSF, he says, is still too wedded to the disciplines, despite the emergence of its engineering research centers in the universities. "It must force recipients to form interdisciplinary teams within the university itself and with industry," he points out.

"Also," he says, "there should be no peer review because peer review discourages a scientist from revealing his best work. He's afraid it will be stolen by the 'peers.' " Roy says the lack of outside peer review by such DOD agencies as the Office of Naval Research makes these agencies models of research support in the field of materials science.

A further belief among senior policy figures in Washington is that Graham's OSTP should be given the power to manage the superconductivity effort. That Graham was able to convince the White House to approve of a conference and even have President Reagan attend speaks for Graham's influence with the President's inner circle of advisers. Where Graham needs to improve, observers say, is in relations with peers and with other agencies.

"Graham didn't even clear the idea of the conference with his own White House Science Council," says one critic. "Nor did Graham consult with the President's own Critical Materials Council." The latter council, chaired by Interior Secretary Donald P. Hodel, was established to assess policy problems around critical material needs for a high-technology era. Nor was NSF director Erich Bloch brought into the planning. "Many are concerned that Bloch's role was too small in discussing the scientific and manpower issues," one critic says. "What will go on are turf wars," he says, "and OSTP must fight against these."

Perhaps the major element missing from the Administration's war-drum rhetoric on superconductivity appears to be recognition of the importance of collaboration with Japan in the field, a development that is more a sign of hope than of despair.

Joint ventures between U.S. and Japanese companies are increasing. In the past year and a half, the Commerce Department's Merrifield points out, 400 joint ventures were set up between U.S. and Japanese companies. The number the year before was half that. Next year, he says, the figure could be 800. "The only way the Japanese can access our technology," says Merrifield, "is going to be through joint ventures—something that expands the economy rather than carving it up into small pieces."

Du Pont, reports Pariser, already has several joint ventures with Japanese companies. It has ventures in fluoropolymers, Kevlar, and Capton, and last year opened up an electrochemical development laboratory in Tokyo. "We've made no joint venture decisions yet on superconductivity," says Pariser. "On our list of things to consider right now is exploring some type of synergism with our colleagues in U.S. companies. Our strength is in materials, less so in forward integrated applications."

Du Pont, he says, established early this year a business development group for superconductivity, much as several other companies have done. "They're looking at various market segments and trying to assess opportunities," he says. "For example, they're asking what the market opportunities would be for a material with superconducting properties at 95 K. We have not been in touch yet with the Japanese, but we have exchanged scientific information with them at open meetings. I certainly don't want to see a big wall built between us and the Japanese, or else we'll both go down the drain."

GE's Schmitt says GE already has a joint venture going in a small area of the superconductivity field through a partnership with Yokagawa Medical Systems involving manufacture of a computer tomography scanner. "This case was interesting in that they started out as our distributor and decided they wanted to license the technology," he recounts. "We said no dice. We wanted a joint venture instead. So we own 51% of the company. It's a good example where American and Japanese skills can match. In this case, we provide the technology, Japan provides the design. One of the nice aspects of teaming up with the Japanese is that we get a nice percentage of the Japanese market."

Revamped government-to-government science and technology relations with Japan are a top item at Graham's OSTP. The action centers around renewal of the Presidential-level science and technology agreement between the U.S. and Japan. Signed originally by President Carter and Prime Minister Masayoshi Ohira in 1980, the agreement is up for renewal now and Graham hopes to make this the official policy framework between the countries in science and technology.

Graham traveled to Japan last February in an effort to lay the groundwork for his position. In one speech he told a group of Japanese science and technology leaders that the U.S. wanted to see "American graduate students, postdoctoral fellows, and senior researchers working in such centers of excellence [in Japan] as the Institute of High Energy Physics in Tsukuba, In-

stitute of Molecular Sciences in Okazaki, Institute for Physical & Chemical Research in Wako, and the Electrotechnical Laboratory in Tsukuba."

A Graham aide put it in blunter terms. "It's time for the U.S. and Japan to work together in sharing risks, costs, and benefits of science and technology. The U.S. and its partners have shared responsibilities. And no one nation should bear a disproportionate burden in maintaining the science and technology enterprise we all need. At any one time we have 100 people in Japan. There are 14,000 Japanese students in the U.S."

The aide says OSTP is pressing Japan to come up with more in the way of sharing their knowledge. The science and technology goals recently announced by Japan involving a more international thrust in their R&D—such as their Human Frontiers Program—are considered at OSTP "a cheap way of buying future access to centers of excellence in the West.

"It looked like they were just intending to drop their people off here and there. So we proposed to them that they set up a world class institute for Third World scientists. They wouldn't hear of it. So they lost credibility by not doing something totally selfless. Japan is awash with capital. Industry could have given millions of dollars to set up this facility.

"And the complaint that more Americans would be invited if they knew Japanese is a smoke screen. The Japanese have no problem functioning in both languages. The issues that are more important involve how people are received."

The OSTP attitude, shared by the Department of Commerce, is not popular in the State Department, however. State is important because it actually drafts all scientific and technological agreements between countries and sees to it that the language has the appropriate diplomatic nuances.

A State Department official with long experience in Japan criticizes Graham's use of the word "reciprocity" in dealing with Japan because he feels the term implies barriers between the two countries. He says Japanese government laboratories are as open as those in America. "It's true that more Japanese visit the U.S. than we visit there," he says. "But the Japanese government invests heavily in teaching people English. Very few American companies make the same kind of investment."

The official claims that the debate has been "poorly managed" and claims that OSTP is taking an "amateurish" approach toward foreign policy. "Trying to educate people who don't know the situation is a painful process," he says. "The living standards in Japan are not the same as in America. Very few Americans would want to go to Japan and live like the Japanese do. OSTP is misunderstanding realities when they want to include in the agreement that visiting Americans must live in Japan without any reduction in their standard of living. Western-style houses or apartments run up to $8000 a month in Japan.

"Another myth is that Japanese are awash with money. OSTP wanted Japan to put more money into the Superconducting Super Collider and the space station. They didn't know the Japanese government has a more serious deficit problem than we have. Their trade surplus does not go into the coffers of government. Their percentage of total outstanding debt as a percentage of gross national product is higher than ours. And their fiscal policy over the past six years under Prime Minister Yasuhiro Nakasone has been zero growth. We in the State Department don't want to go to foreign countries and rattle the tin cup. We are not going to have an agreement that involves the Japanese spending more money here."

And so it goes. With superconductivity, both the U.S. and Japan seem to have arrived at a new playing turf in their science and technology policies. Remnants of the "America must be first" mentality still persist in the U.S., whereas many Japanese still believe that theirs is a poor island nation. Neither myth truly sustains either society.

Superconductivity brings national and international science and technology into one context. By focusing on one thing, all things must be considered, from understanding why GE's 1200 bench scientists can no longer do long-range research in this era of corporate bottom line frenzy, to solving the modest but crucial energy needs of a South Asian village. The dissonance of the dialogue only demonstrates how few really seek to understand its scope. □

Science adviser Graham boosts Keyworth's new venture

As a direct result of the current superconductivity hoopla, various consulting groups are forming to advise industry of trends and opportunities in the fast-moving field. But during July's federal conference on superconductivity, science adviser William R. Graham singled out only one for a plug—that formed by his predecessor, George A. Keyworth II.

Graham announced before his largely industrial audience that Keyworth, now a Washington consultant, was setting up a nonprofit "Council on Superconductivity for American Competitiveness." Keyworth will be chairman; Roland Schmitt, vice president for corporate science and technology for General Electric and chairman of the National Science Board, will be vice chairman.

Members of the council board are yet to be announced, but, according to Keyworth assistant Bruce Abell, the new organization will "bring together knowledgeable people to share insight with members and get first-hand information on things that are going on and where they are heading." Keyworth was working on the idea before the conference began, Abell says, and the council will try especially hard to attract members who are not "first line" companies in the field.

The big distinguishing feature of Keyworth's council, says Abell, is that it "focuses on a technology that cuts across a whole range of industries and government areas." Japanese corporations will be excluded from purchasing membership.