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CONGRESSIONAL ACTION ON TAX INCENTIVES FOR R&D

Innovation, according to Edward Dennison of the Brookings Institution in Washington, DC, was responsible for 64 percent of the gains in the United States labor market productivity between 1929 and 1982. Further, because research intensive companies have established themselves as the most promising segment of our economy, our hopes for reducing the national deficit, now over $140 billion, rest heavily on them. Thus the research and development tax incentive issue is provoking intense interest in the business office, the ivory tower and among policy planners.

This interest was reflected in the political arena on April 3 when the Senate Finance Committee's Subcommittee on Taxation and Debt Management held its hearings on R&D tax provisions. The large hearing room contained no empty seats as a diversity of participants testified before the subcommittee including university professors and administrators, executives from the industry, and members of the Council on Research and Technology (CORETECH).

CORETECH is of particular interest because of its unique representation of both the academic and industrial sectors of the R&D community. Its constituency includes corporations such as Control Data Corporation, IBM,Hewlett-Packard, and Procter and Gamble; and universities such as Caltech, MIT, Cornell, Dartmouth, Harvard, Princeton, and Purdue. (For more information, see **RDM Digest**, March 1987.)

The primary topics under debate were the possible removal of research and development disincentives such as Treasury regulation section 1.861-8, and the two credits available to corporations for applied as well as basic research and development.

1.861-regulations

Under 1.861-8 regulations United States corporations with foreign operations must allocate a percentage of their research and development expenses as if they were incurred abroad. The net effect of Section 861 is to deny companies full tax benefits for a portion of their domestic R&D expenses. Since most of these companies operate in foreign countries almost exclusively through foreign subsidiaries with the U.S. parent performing R&D in the United States, many foreign governments do not permit these allocated funds to be deducted from foreign taxes as a part of research and development expenses. Thus companies subject to section 1.861-8 regulations obtain no tax benefit from R&D expenditure anywhere in the world.

Tax technicians, however, believe that Section 1.861-8 is appropriate because the new products and processes resulting from such R&D activities are utilized not only in the United States, but abroad as well. Theoretically, the adverse effects of the regulations are balanced by excess foreign tax credits.

Issued in 1977, the regulations have been under a series of temporary moratoriums since 1981. They are due to become effective August 1, 1987. The uncertainty surrounding the 861 issue has frustrated long-range R&D planners, but recently two bills that would permanently and completely repeal section 861 as it applies to company research and development expenditures were sponsored in the House and Senate. Through the work of the Senate Subcommittee on Taxation and Debt Management, a tentative compromise has been hammered out between Congressional R&D proponents, the Treasury department, and

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industry, allowing 67% of U.S. incurred R& D expenses to be allocated to U.S. income.

Dean Morton, executive vice-president and chief operating officer of Hewlett-Packard, addressed the Subcommittee about the regulations. He expressed the concern of many people that the net effect of the regulations is to encourage **multi-nationals** to establish their R&D facilities in countries where tax benefits will be more available, Mr. Morton said. "One key point to understand in this regard is that manufacturing activity seems to follow R&D . . .it is typically easier to manufacture at the same facility or nearby, than to transfer manufacturing responsibility for the product to another country. This is why it is critical for the U.S. tax laws to provide incentives and not to provide disincentives to conducting R&D in the United States. Much more than the R&D activity is at stake." In concluding, Mr. Morton endorsed the compromise proposal reached by the Congressional sponsors of the 100 percent moratorium legislation, saying, "When enacted on a permanent basis, it will provide needed stability to U.S. R&D tax policy."

R&D AND BASIC RESEARCH TAX CREDITS

In addition to the debate on the Treasury regulation, the R&D Tax Credit and the Basic Research Credit were discussed. The R&D Tax Credit, first adopted in 1981 as part of the Economic Recovery Tax Act, provided a 25% credit for any increase in company R&D spending above the company's average R&D spending for the prior three-year period. The original credit expired on December 31, 1985 but was extended as a 20% credit until December 31, 1988 as part of the Tax Reform Act of 1986. Congress also adopted a new tax credit for company support of basic research under the 1986 Tax Reform Act. The new Basic Research Credit can be claimed at a fixed rate of 20% of total contract research payments over a company's average spending for basic research during the fixed period of 1981-1983. Under the new regulations,contract payments and grants to universities and other non-profit organizations for basic research qualify for the new credit. It is to be in effect for a period of two years from January 1, 1987 to December 31, 1988.

CORETECH'S ENDORSEMENT

Industrialist Dr. Joseph A.Saloom, Chairman of CORETECH, stressed the need not only to remove R&D disincentives (the 861 regulation), but also to ensure that the most effective incentives are in effect. Speaking for CORETECH, he said, "The Research and Development Tax Credit and the new Basic Research Tax Credit form and core of our nation's effort to stimulate private support of research. Both of these tax credits work to correct the underinvestment that would occur if the market were left to its own devices." Saloom also urged that Congress make the credits permanent although he said he realized there were economic reasons behind the initial temporary status of the credits.

UNIVERSITIES AND THE BASIC RESEARCH CREDIT

Dr. Hans Mark, Chancellor of the University of Texas System, addressed the flat credit granted by the Basic Research Tax Credit to companies sponsoring basic research at universities and nonprofit research institutions beyond a threshold amount. "The new tax credit will encourage our industries to work more closely with universities in all the important areas of research. . .(it) provides an incentive for corporations to spend a portion of their research budget on expanding the basic knowledge on which they ultimately depend for the creation of a new product," he stated.

THE R&D CREDIT AND EMERGING COMPANIES

Mr. Ron Pherigo, President of Applied Computing Technology, a start-up computer engineering firm, discussed drawbacks of the credit provisions for new companies. As the law is presently written, a companies research and development expenses are not eligible for the R&D credit until its products are being sold. "Just as the company starts to take-off with an innovative product the tax law puts on the brakes," Pherigo told the Subcommittee. Hundreds of firms disappear every year due to acquisitions, mergers, failures and bankruptcies. Pherigo stated that "often the acquisition takes place because the original owner of the business has no other alternative: he's out of capital; he's shipping product, but the after-tax earnings will be insufficient to fund the new R&D necessary to keep the product's technology progressing at the same pace as the rest of the industry. That's the point where the company can best use the lift of a tax credit of offset taxes on new income earned as product is being shipped and sold. That's what the credit ought to do, but it doesn't.

PROSPECTS

Whether any new legislation will be enacted by Congress this year remains to be seen, but CORETECH is very hopeful, especially about the 67% compromise on Treasury regulation 1.861-8. Stephanie Becker, CORETECH spokesperson, said that the widespread feeling is that the compromise is a fair one and CORETECH is "pretty optimistic" that a resolution will be reached before the 861 regulation is due to take effect in August. Of the R&D tax credits, Becker said the hearings on April 3 were "more of a beginning than a debate.... They are an opportunity to examine the credit and to look at suggestions to make it more effective,, particularly in the context of competitiveness." Scot Williams, press secretary to Subcommittee Chairman, for Senator Max Baucus, reports the one sticking point of the credits is that they cost money, and the financing to make them permanent has not yet been nailed down. He said if for this reason the bills die they will probably be reintroduced next year because competitiveness is of great importance in today's market.

As Senator Baucus said, "Research and development tax incentives are basic to this country's economy because research and development is basic to this country's growth.

NEWS

FEDERAL ELECTROTECHNOLOGY R&D BUDGETS FOR FISCAL YEAR 1988 ANALYZED IN IEEE DOCUMENT

More than $67 billion in Federal electrotechnology research and development funding for fiscal year (FY) 1988 is analyzed in a document released by The Institute of Electrical and Electronics Engineers, Inc. (IEEE): **Electrotechnology in the FY 1988 Federal R&D Budget.**

Conclusions reached in the IEEE document about R&D budget requests in the electrical and electronics are:

- o The Defense Department's Research, Development, Test and Evaluation (RDT&E) request is $43.719 billion during FY 1988, approximately 18.3 percent above the amount appropriated in FY 1987.

- o Air Force RDT&E is budgeted at $18.623 billion for FY 1988, a 20.8 percent increase. Navy has requested a total of $10.49 billion in RDT&E funding. Army is seeking $5.1 billion, a 15.9 percent increase.

- o The Strategic Defense Initiative Organization (SDIO) requested $5.22 billion, a 39.5 percent increase.

- o NASA is seeking $9.5 billion for FY 88, R&D would exceed $3.6 billion, a 16.8 percent increase. Most of the funds are designated for the Space Station, a total of $767 million, or an 83 percent increase.

- o Funding for the National Science Foundation (NSF) is proposed at $1.89 billion, a 17 percent boost. The total for R&D activities could rise to $1.635 billion, a 16 percent boost. The NSF Engineering Directorate could receive the largest increase with $205 million or 26 percent. The Directorate for Engineering, created in 1986, could receive the second largest increase of $143 million or 23 percent.

- o Total Department of Energy funding for R&D could rise from about $4.5 billion in FY 1987 to $5.5 billion in FY 1988. According to the IEEE document, "within DOE, funding more than 30 years in the U.S., the U.S.S.R. and other countries, but the outcome of these field tests was poorly recorded, according to Thomas E. Burchfield of the National Institute for Petroleum and Energy Research (NIPER), a Government-funded facility based in Bartlesville, Okla. Now investigators from NIPER, the U.S. Department of Energy and two private companies—Microbial Systems Corporation and INJECTECH, Inc.—are seeking to gather definitive data by testing the technique in an old, water-flooded oil field near Bartlesville.

The investigators have selected four bacteria: three of them grow in the absence of oxygen (two from the genus *Bacillus* and one from the genus *Clostridium*), and one is a so-called facultative anaerobe, which can grow with or without oxygen (the genus has not been disclosed). In March the bacteria were mixed with molasses, which serves as a nutrient, and were injected into a five-acre field that has 15 wells. Although under the right conditions the microbes can reproduce rapidly—doubling in number every half hour—they are expected to diffuse only slowly through the sandstone that underlies the test site. Some preliminary data should be available within six months, but it will be more than a year before all the results are in, according to Burchfield.

Even if the technique boosts recovery only slightly, he says, its low cost could make it economical for both large oil companies and smaller independent ones. Molasses is very inexpensive and the bacteria under consideration can be cultured at low cost. Moreover, Burchfield points out, once the bacteria have been established in the reservoir, simply feeding them additional molasses should keep them thriving—and working.

Technology for Sale

The Cummins Engine Company, Inc., recently started developing a new diesel engine that employs a ductile form of nickel aluminide, an alloy that has an unusual property: it gets harder as it gets hotter. Cummins was granted an exclusive license to incorporate the new material in heavy-duty diesel engines by the Oak Ridge National Laboratory, which did the original research. Such direct arrangements are currently unusual, but now that economic competitiveness has been sanctioned by President Reagan as the political watchword of 1987 they may become standard.

Federal funds account for about half of the $110 billion spent on research and development each year in the U.S., and yet only one-fortieth of the 120,000 patents issued annually stem from Federal research. This statistic "suggests that we could get more from the Federal investment," Norman J. Latker, director of Federal technology-management policy at the Department of Commerce, told a Senate subcommittee in February. Furthermore, the proportion of Federal patents that find their way to commercial application—about 5 percent—is much less than the equivalent figure for industry patents.

Until recently legal obstacles made it hard for private industry to commercialize research carried out in Federal laboratories. The Government usually owns inventions arising from work it supports. Although an agency may waive title to an invention if a private company is interested in developing it, agencies have not always been prompt to do so.

For example, between October of 1977 and December of 1985, 135 waiver requests were made to the Department of Energy for patent rights to inventions made at contractor-operated facilities. Yet as of December 24, 1985, the department had completed action on only 55 of them; five had awaited a decision for more than two years. Representative John D. Dingell, chairman of the House Committee on Energy and Commerce, wrote in February to Secretary of Energy John S. Herrington that he considered such delays "irresponsible." Ronald W. Hart, director of the National Center for Toxicological Research, says the Public Health Service's inability in the past to grant exclusive patent rights has meant that research "was everybody's property and so nobody's product." Hart says that "many inventions that could have improved public health simply languished."

All of this may be changed by the Federal Technology Transfer Act of 1986, signed into law last year and now being implemented. The statute encourages industry to make better use of Federal research by providing new incentives: for the first time all 700-odd Federal laboratories will be able to enter into collaborative research agreements with private industry and to grant companies exclusive development rights. Individual Federal employees whose inventions are taken up commercially will be awarded not less than 15 percent of the royalties, to a maximum of $100,000 per year. President Reagan is to issue an executive order instructing all Federal agencies to comply with the new act, which extends and clarifies earlier legislation.

The president has also proposed a doubling of the National Science Foundation's budget in the course of the next five years and the establishment of university-based centers for "fundamental science that directly contributes to our nation's economic competitiveness," which are to be funded through the NSF and perhaps through other agencies. Other proposals would accelerate exchanges of personnel among private companies, Federal laboratories and universities, as well as joint projects.

Latker says there is "a lot of pride and turf" that could impede the implementation of the new technology-transfer act. Still, it was only in 1984 that Oak Ridge was designated as a guinea-pig laboratory to see how incentives such as those in the new law might work. According to the laboratory's Jon Soderstrom, the number of patent applications sought by laboratory employees increased by more than 30 percent in two years.

Squeeze Me

Stretch a block of material and its girth contracts; push its ends together and its girth expands. Such behavior would seem to be predictable and universal. Yet Roderic S. Lakes of the University of Iowa has transformed foamy materials that behave as expected under deformation into foams that distend when they are under tension and become thinner when they are compressed.

Lakes reports in *Science* that the process by which he accomplished the transformation is rather straightforward: a specimen of conventional low-density polymer foam is compressed and placed in a mold, where it is heated. The foam that is then extracted from the cooled mold no longer behaves normally; its dimensions change under strain in a way contrary to what one would expect. By means of a similar procedure that involves sequential plastic deformation along each of three perpendicular axes, Lakes also invested normal metal foams with the same peculiar property.

Microscopic examination of the foams reveals the cause of their anomalous behavior: whereas the ribs of the cells constituting normal open-celled foams bulge outward, the cell ribs in Lakes's treated foams protrude inward, forming what Lakes calls reentrant structures. Under tension the reentrant-cell ribs are drawn out and unfolded, thus causing the cell to expand. Conversely, under compression the ribs collapse farther inward, resulting in an overall shrinkage of the cell's volume.

Lakes has found that his reentrant

Does the Fear Of Litigation Dampen the Drive To Innovate?

By WILLIAM J. BROAD

SOME scientists and legal experts are beginning to argue that fear of safety-related litigation is holding back technical innovation in a variety of fields.

Although the dimensions of the problem are unknown and probably unknowable, experts say the blizzard of liability suits in the past decade has sent a chill through fields as diverse as computer science, food processing and nuclear engineering.

"The legal system's current message to scientists and engineers is: Don't innovate, don't experiment, don't be venturesome, don't go out on a limb," said Peter W. Huber, an attorney and engineer who has written about the problem.

However, some groups concerned with consumer issues question the severity of the problem, saying its new visibility seems part of campaign to weaken liability laws so corporations will have to worry less about public safety and be able to make higher profits.

> 'It's becoming difficult to get venture capital for new ideas,' said one physicist.

As the debate heats up, legal experts are trying to probe the extent of the problem even though its symptoms — foregone innovations — are by nature difficult to document. The National Academy of Engineering, a branch of the Government-chartered, private National Academy of Sciences in Washington, D.C., recently held a symposium on the subject, and the Rand Corporation in California is organizing a large study.

"There's clearly a chilling effect," said Stephen M. Matthews, a physicist at the Lawrence Livermore National Laboratory in California who has worked on establishing new commercial ventures. "It's becoming difficult to get venture capital for new ideas. People are afraid of potential liability."

Experts have long agreed that risky products and dangerous procedures should be banned from the marketplace. Recently, however, some have begun to argue that increased technical regulation and litigation designed to

Continued on Page C9

ART: A burst of growth in Chic

BOOKS: 'The Poems of Lincoln K

Does the Fear of Litigation Inhibit Innovation?

Continued From Page C1

promote safety can have hidden costs in the form of stifled creativity and abandoned ideas. The upshot, these experts say, is that products, processes and large-scale technologies may fail to be made as good, cheap and safe as possible. They say innovation can be deterred when either inventors or developers have inordinate fears of being sued over new products and technologies.

"A lot of people are interested in the phenomenon, but no one has hard data on its extent," said Deborah R. Hensler, research director of Rand's Institute for Civil Justice. One example involves researchers who are slowing efforts to test and market computers with artificial intelligence because of potential lawsuits. Their fear is that new types of liability will emerge for computers that diagnose patients, run factories, and perform other complex tasks. "Some of the state-of-the-art applications are not going forward," she said.

Dr. Matthews of the Livermore lab said one of his own efforts to develop an invention with commercial potential had recently failed at least in part because of fears of liability suits.

His idea centered on a powerful particle accelerator that is only about six feet long. Livermore uses a similar device for developing beam weapons. Dr. Matthews proposed modifying the accelerator so it could irradiate food products, killing insects, larvae and parasites that infest freshly harvested fruit and vegetables. Such irradiation could replace the chemicals used on many crops, thus eliminating the chance that poisonous fumigants might cling to produce.

But lawyers told potential investors its development was too risky, he said. "One of the factors they cited was liability," Dr. Matthews recalled. "It was too new, with no precedent to follow in a broad area of technology. They were afraid we might build in a liability that no one was aware of." In this case, liability concern was only one factor; the more general controversy over food irradiation, for example, also played a role.

Worry for Universities

A different kind of chill has been felt in universities across the country, according to Howard W. Bremer, patent counsel for the University of Wisconsin at Madison, which last year devoted about $230 million in private and Federal funds to scientific research. The fear, he said, focuses on small businesses that want to buy licenses to university patents. If such companies should be sued, plaintiffs might turn to the "deep pockets" of the university that spawned the idea. Mr. Bremer said such fears were causing universities to shy away from licensing patents to small companies. The trend is especially troublesome, he said, since small businesses are usually better than large ones at nurturing innovation.

"There's some sincere questioning of whether we should license to small businesses at all," he said.

Product liability has forced companies to be more careful, Ralph Nader says.

Yet another problem can occur, some experts assert, when public safety regulations create incentives to keep bad technologies in the marketplace, hindering innovation. The reason for this, they say, is that the adoption of a new, safer technology implicitly involves acknowledgment that the previous technology was not as safe as possible.

Nuclear reactors provide an example of "encouraged inferiority," some experts assert. For instance, engineers at the University of Texas invented a simple and effective solution for the problem of leaky welds in the pipes of some reactors. It involved a new welding technique in which powerful bursts of electricity are directed into steel pipes that abut one another, fusing them with extremely strong and uniform seams.

But the idea, little known outside of engineering circles, has been ignored by the industry in the three or so years since it was developed.

"If you admit you have a solution, then the regulatory agencies might force you to go back and retrofit," said an engineer familiar with the new technique, who spoke on condition that his name not be used.

Judging Technology

According to Dr. Huber, who holds a doctorate in engineering from the Massachusetts Institute of Technology and a degree from Harvard University Law School, the current clash of law and science boils down to a fight between technological optimists and pessimists.

"The technical community usually judges that new technologies are safer, cheaper and better for the consumer," he said. "But when you shift into Federal regulation and the law, you get suspicion of change, of innovation, of departures from the status quo. Lawyers tend to see risks, not benefits. The law is basically hostile to change and innovation."

Dr. Huber, a fellow of the Manhattan Institute for Policy Research in New York, a non-profit, private group that conducts economic research, told the conference of the National Academy of Engineering that the clash had been engendered by new interpretations of liability law and new regulatory statutes over the past two decades. "Under the old regime, which prevailed in this country for about a hundred years, the regulator's charter was that of an exorcist," Dr. Huber said. "He identified established hazards and rooted them out. Now the regulator acts as gatekeeper, charged with blocking new technologies not known to be safe and with protecting us from the ominous technological unknown."

To many public-interest groups and activists, this new role for regulators is good since the technological risks of modern life are seen as greater than in the past. Almost everywhere, they say, lurk invisible killers, from radiation to asbestos. They say tragedies such the chemical disaster at Bhopal, India, and nuclear reactor fire at Chernobyl in the Soviet Union must be avoided.

Rise in Liability Suits

"It's clearly in the corporate interest to limit liability," said Mike Johnson, an analyist for Public Citizen, a comsummer rights organization in Washington, D.C., founded by Ralph Nader. "The principal impact of product liability has been to force companies to be more careful in their products, not to limit innovation."

Indeed, the number of product liability cases filed in Federal courts, for instance, has risen to 13,554 in 1985 from 1,579 in 1975. Although most cases are settled before trial, the number of jury awards has risen over the past decade, and the cost of liability insurance has surged.

Experts have differing ideas about what steps, if any, should be taken to solve the problem. Consumer advocates say that the current system should be kept largely intact, with the possible addition of special regulatory incentives to help move safety-related innovations into the marketplace.

Dr. Huber suggested that Federal regulatory agencies, not the courts, were the right place to weigh risks and benefits of new technologies. "And these agencies should be encouraged to exercise this responsibility through good hindsight, rather than through bad foresight," he said.

David G. Owen, professor of law at the University of South Carolina, told the National Academy of Engineering that one issue will linger no matter what changes take place. "The engineer must now and hereafter give proper respect to safety," he said. "The current problems of product liability law and insurance will in the long run prove manageable for engineers and enterprises who treat safety not as a nuisance, but as an important engineering goal."

MANAGEMENT OF GOVERNMENT-OWNED TECHNOLOGY PRODUCED IN FEDERAL LABORATORIES

The Packard, the Business-Higher Education, and the Energy Research Advisory Board (ERAB) Reports all recommend sweeping improvements in the way Federal laboratories and universities cooperate and collaborate with industry. All reports call for increased transfer of technology resulting from laboratory efforts.

It is Commerce's view that enhanced transfer of technology must begin with establishment of focal points at laboratories with the authority to make "deals" with industry to fund the continued development of new products and processes they have evaluated to have commercial potential.

The optimum laboratory authority should include at least the ability to:

- Identify, evaluate, and protect new technologies,
- Promote commercial use of the new technologies laboratories produce,
- Initiate research and develop limited partnerships,
- Seek venture capital,
- Enter into collaborative research projects,
- Establish policies encouraging employee-inventor startups,
- Share royalties with inventors,
- Assess potential conflicts of interest, and
- Grant patent licenses <u>or</u> assign invention ownership rights as a quid pro quo for private sector guarantees to develop, participate in, or contribute cresouces to further development.

To the extent that the Government has some of these authorities, they have not been delegated to the laboratory management most knowledgeable with the new technology. The centralization of existing authorities have acted as a substantial disincentive to optimum technology transfer.

How Japan Inc. is cashing in on free U.S. R&D

Technology transfer between federally funded labs and Japanese firms is flowing only one way — Eastward

It's a familiar scene. Japanese scientists tour U.S. laboratories to visit with their American counterparts and share information. In many cases, however, U.S. industrialists and government officials argue, the sharing is strictly one-sided. The Japanese, they contend, often walk off with innovative technology — for free — and offer little in return. "They recognized early that the U.S. is funding the entire world's basic research," says Norman Latker, director for federal technology management policy in the U.S. Department of Commerce's Office of Productivity, Technology and Innovation.

There is nothing illegal about this. Information on nonclassified research and development at national laboratories has been readily available. So it's no surprise that the Japanese and others have launched concerted efforts to cash in for free R&D. "They would be nuts to pay for research they can get for nothing," says one government official. "And the Japanese are anything but dumb."

What is perhaps more of a surprise is that few U.S. companies have followed suit. Some companies, such as Harris Corp. and Intel Corp., have technology transfer agreements with national laboratories, but U.S. industry in general has kept its distance from federal labs. One reason might be that U.S. companies want guarantees in the form of patents before they will invest heavily to adapt basic research for commercial applications. Until recently, this has been a difficult procedure.

Representatives of Japanese firms, however, point out that there is nothing illegal about picking up technology that is in the public domain. "It is a mistake to single out the Japanese for cleverly taking technology that is freely available to everybody on a nondiscriminatory basis," says H. William Tanaka, an attorney with the Washington, D.C., firm Tanaka-Walders-Rigter, which represents the Electronic Industry Association of Japan.

Furthermore, Tanaka contends, the technology transfer legislation goes against the current trend for companies from different countries to link up to share enormous R&D costs. "It is highly questionable whether this legislation will help American companies develop technology out of federally funded laboratories in the face of structural changes that are forcing companies and countries to pool their resources."

> U.S. companies want guarantees in the form of patents

Nevertheless, new legislation could change the often asymmetrical nature of technology transfer. At the very least, its proponents hope the Federal Technology Transfer Act of 1986 will give U.S. companies a beat on foreign competitors in making the most of U.S.-developed basic research. At best, supporters predict this new method of exploiting technological breakthroughs will give birth to creative Silicon Valley-like communities around many of the labs. "Our economic future depends on encouraging the efficient dissemination of skills and information within our communities," says Senator Patrick J. Leahy (D-Vt.).

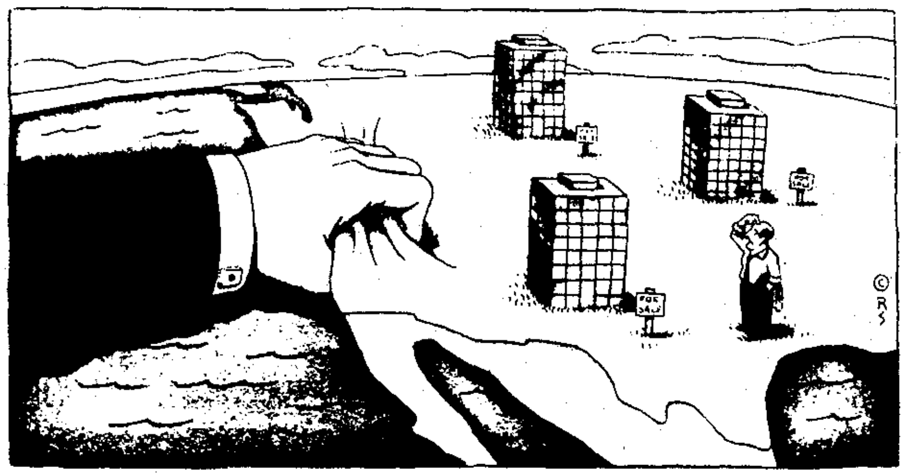
Under the new law, national labs will decide how best to disseminate internally developed technology. They can cut their own deals with interested companies and share the profits. "To improve technology transfer, the federal laboratories need clear authority to do cooperative research and they need to be able to exercise that authority at the laboratory level," states a Commerce Department report. Until recently, such information was routinely published and available to anyone — from the United States or abroad. Now, American companies will get first crack. The law:

- Allows labs to enter into cooperative research agreements with industry, universities and others, and to negotiate patent licensing agreements
- Directs heads of agencies with large labs to institute cash award programs to reward scientific, engineering and technical personnel
- Requires agencies to give at least 15% of royalties received from licensing an invention to the inventor and distribute the balance of any royalties among its labs
- Creates the Federal Laboratory Consortium for Technology Transfer at the National Bureau of Standards.

Publish and perish

The need to make federal labs more responsive to national needs was outlined in a 1983 report by the Packard Panel, headed by David Packard, cofounder of Hewlett-Packard Co. and former deputy secretary of the Defense Department. "The national interest demands that the federal laboratories collaborate with universities and industry to ensure continued advances in scientific knowledge and its translation into useful technology," the report states.

Although the legislation encouraging such interaction was approved late



Rob Saunders

CRITICS CONTEND the Japanese are too aggressive in acquiring U.S. technology last year, it will be some time before the provisions are routinely enforced, according to Latker. "We're now trying to implement the law," he says. "But first we have to change a significant cultural bias away from the idea of publishing everything."

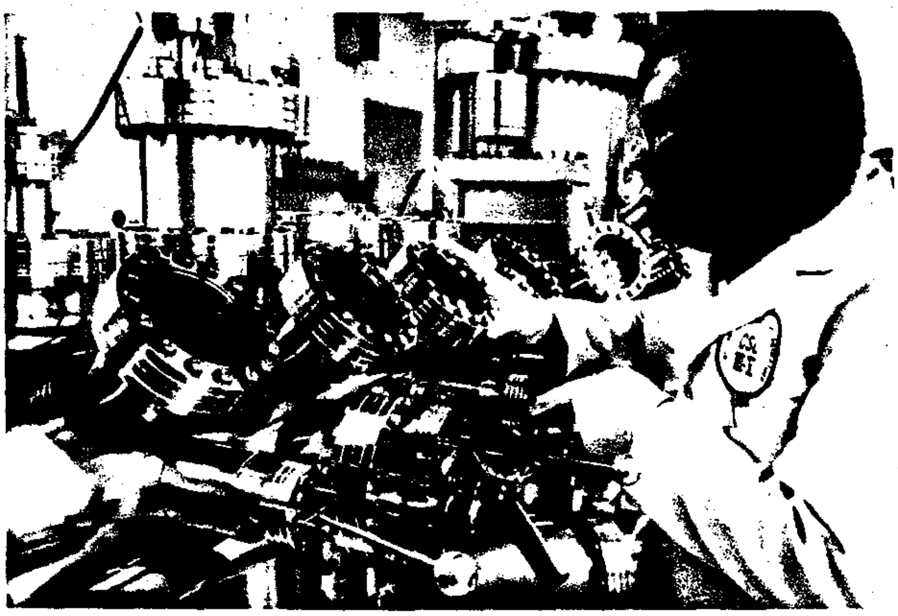
It might seem naive to some that inventions funded by taxpayers were made equally available to everybody, but that policy reflects the democratic attitude that no individual or company should get preferential treatment. And federal researchers have felt uncomfortable coming down from their ivory towers and hooking up with private companies in commercial ventures. The financial incentives could help change these attitudes. "It [will be] interesting to see the response when the first researcher pulls up in a red Ferrari," says Joseph Allen, technology policy liaison in the Commerce's Office of Productivity, Technology and Innovation.

Lab officials are learning the benefits of licensing and cost-sharing arrangements from universities, which lately have expanded their ties with industry. Some particularly aggressive institutions like Stanford University and the University of Wisconsin reportedly have made more than $5 million a year in profits by licensing technology and sharing research costs.

By contrast, the U.S. Treasury made only $2 million on patents in 1985 even though it spent $18 billion — a third of all R&D spending — at about 400 federal labs. The labs do research on everything from thin film and optoelectronics technology to boll weevils, with the heaviest funding going to the relatively large labs for weapons, space science and energy research, medical programs, and physics experiments.

The labs, which employ a total of 185,000, including one-sixth of the country's scientists, have produced 28,000 patents. Only 5% of those patents have been licensed. "This statistic is a reflection both of the fact that many government patents have little or no commercial value and that agencies have made little effort to seek private sector users for even their most important commercial inventions," says E. Jonathan Soderstrom, director of technology applications for Oak Ridge National Laboratory at Martin Marietta Energy Systems in Tennessee.

It is difficult to track the evolution of basic research, so there are no clear-cut examples of U.S. technology that the Japanese have exploited for com-



SEMICONDUCTOR RESEARCH at Sandia Labs, where scientists no longer allow routine visits by foreign scientists

mercial products. But no one denies that there has been a concerted effort by aggressive foreign companies (and country-sponsored initiatives) to acquire technology from America. In 1983, for example, the Japan Economic Institute reports that the United States transferred to Japan six times as much electronics technology and almost eight times as much machine-tool technology as it acquired from Japan.

In all, 70% of Japan's worldwide technology imports that year came from the United States, according to Senator J.D. Rockefeller IV (D-W. Va.) "This asymmetry in the international flow of knowledge has real repercussions for our country's competitiveness in world markets," says Rockefeller. "If our cutting-edge technology is made fully available to our rival in international trade . . . we stand to lose not only foreign markets but also jobs and income at home."

Lab officials are learning the benefits of licensing

It's not that Rockefeller and others want to totally stop technology exchange programs with foreign countries. Rather, they want to guarantee that technology swaps are equal. "It's time we started bartering a little more," says Robert Stromberg, technology transfer officer at Sandia Laboratories in New Mexico. "We want a fair, equal exchange on a tough Yankee-trade basis." Stromberg cites, for example, that Sandia no longer allows routine visits by foreign scientists unless "we are sure they are as good as ours and that any exchange of technology goes both ways."

Allen of the Commerce Department points to the lopsided international scientist exchange programs as one of the most obvious inequities. "The Japanese have been able to place a lot of people in labs here," he says. "But we have a hard time placing them over there." At the National Institute of Health, for example, some 397 Japanese scientists were working in U.S. facilities in fiscal 1985, while only three U.S. NIH scientists were assigned to Japanese labs.

Even without their aggressive attempts to acquire U.S. technology, industry sources contend, the Japanese have a significant R&D advantage. Even though U.S. R&D spending has leveled off at about 2.7% of the gross national product, the Japanese project that, by 1990, R&D expenditures will rise to 3.2% of GNP.

"We're stagnating at 2.7%, much of it for the military, while they keep increasing spending for commercially exploitable R&D," says Ralph Thomson, senior vice president of the American Electronics Association. "Our one remaining competitive advantage was innovation, but we're wrong to believe the Japanese are just copiers. Their emphasis on commercial R&D has got them to the point where they are better than the U.S. in many products."

BETH KARLIN

Joe Allen

Cover Story

AT&T'S JOHNSON EXAMINES THE SUPERCONDUCTING TAPE DEVELOPED WITH TEAM MEMBER BATLOGG

LAWRENCE BARNS

'OUR LIFE HAS CHANGED'

THE LIGHTBULB, THE TRANSISTOR—NOW THE SUPERCONDUCTOR REVOLUTION

With the poise of Harry Houdini, Bertram Batlogg reaches into his coat pocket. Slowly, he draws out a piece of flexible green tape and holds it aloft. There is silence. Then gasps and exclamations ripple through the crowd. "I think our life has changed," says Batlogg, who heads solid-state materials research at AT&T Bell Laboratories. The 3,500 physicists jamming the ballroom and surrounding hallways at the New York Hilton burst into shouts and applause.

The simple tape that Batlogg brandished at the annual meeting of the American Physical Society on Mar. 18 was indeed the pennant of a technological revolution. Because it can conduct electricity with no power losses to resistance, the tape material promises to have an enormous technological—and economic—impact. Such so-called superconductors could speed the way to a quantum leap in both electrical and electronic technology.

A torrent of developments is pointing to applications ranging from superfast computers to trains that float on magnetic fields, from less costly power generation and transmission to fusion energy. Although it may take 20 years before the full potential of these laboratory discoveries is realized, the economic impact could be enormous. Some scientists compare the importance of these advances in superconductors to the invention of the transistor. But to Jack S. Kilby, co-inventor of the integrated circuit, that's an understatement. "This is much broader," he says. "It could impact almost everything."

The normally staid physicists at the New York meeting apparently agreed. Like rock music fans waiting to get into a concert, the crowd began gathering for what they dubbed the "Woodstock of physics" 2½ hours ahead of time. When the doors opened for a hastily scheduled 7:30 p.m. session on superconductivity, scientists shoved and jostled each other for the 1,150 seats. The rest craned to hear from the hallways or watched on video monitors outside. "I came to see history," declared one scientist as he elbowed his way to a seat. He wasn't disappointed. More than 50 researchers reported brand-new experimental results. Several revealed information phoned in from their laboratories just hours earlier. With only five minutes allotted to each, the session ran until 3 a.m.

The advances have been a long time coming. In 1911, Dutch scientist Heike Onnes first observed that some metals became superconductive when cooled to almost absolute zero—the point at which all motion of atoms ceases. That opened tantalizing prospects for huge markets. But the only way to get near that ultracold temperature of –459F—or zero on the Kelvin scale that scientists prefer—was cooling with costly liquid helium.

CHASING THE GRAIL. So the search began for materials that would exhibit superconductivity at warmer temperatures. The effort, however, was slow and discouraging. In 1941, scientists discovered alloys of niobium that became superconductive at 15K. By 1973 the best superconductor operated at 23K—warm enough to make a few applications, such as magnets for medical imaging, economical. But this was far from the physicists' Holy Grail of "room temperature" superconductors. Many despaired that such materials were even possible.

In just the last four months, however, researchers in the U. S., Europe, Japan, and China churned out a stunning set of discoveries. They created a group of materials that become superconductors at temperatures that can be achieved with inexpensive liquid nitrogen. That made frigid superconductors red-hot. "It's the most exciting development in physics for decades," declares Neil W. Ashcroft, director of the Laboratory of Atomic & Solid State Physics at Cornell University. "The pace of discoveries can hardly be matched." And the dream of room-temperature materials is no longer unthinkable. "We've knocked down barriers and removed our blinders about what's possible," says Paul A. Fleury, director of the physical research lab at AT&T Bell Labs.

No one, least of all K. Alex Müller, a physicist from International Business Machines Corp.'s Zurich research laboratories, expected the barriers to higher-temperature superconductors to tumble so quickly. It was Müller who set off the current research rush a little more than a year ago with the discovery of a superconducting oxide of copper. Hunched in a chair during a lull in the New York meeting, the 59-year-old Müller seems ill at ease with the attention he is getting. "It was so unexpected," he says quietly, stroking his beard.

Müller holds the prestigious post of IBM Fellow, which frees the company's distinguished scientists to pursue projects of their own choosing. With the freedom to explore, Müller took a cue from research in the U. S. and France to examine a little-known group of oxides containing copper and nickel. Normally insulators, the materials had displayed some intriguing metallic properties. So for nearly three years, Müller and his colleague, J. Georg Bednorz, mixed hundreds of compounds and tested them for signs of superconductivity. In January, 1986, they measured superconductivity at a record-breaking 30K in an oxide containing lanthanum, barium, and copper. Müller, who expected a rise of several degrees at best, was incredulous.

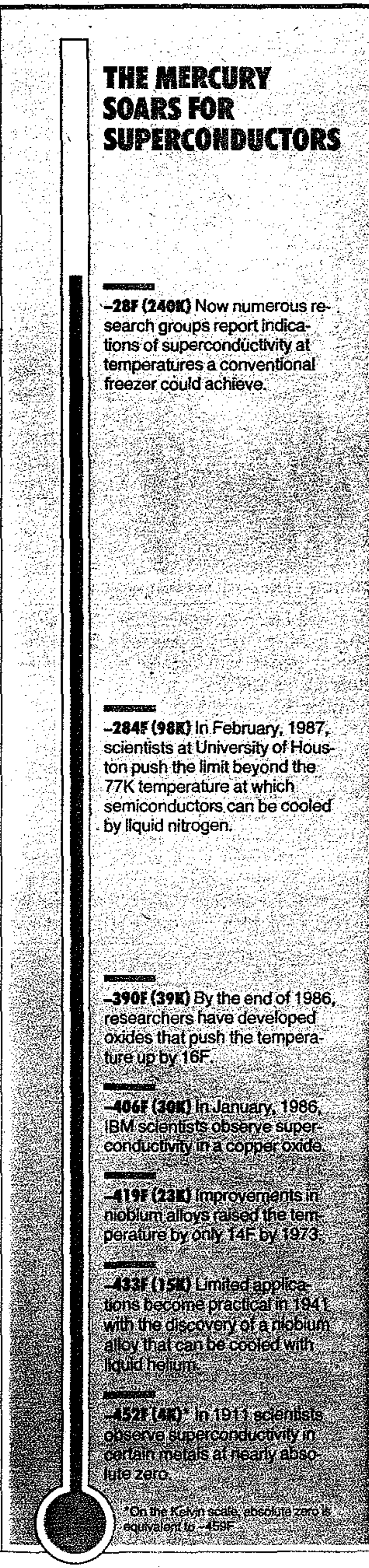
Bednorz, a former student of Müller's, was so excited he wanted to report the results immediately. But Müller refused. The history of superconductor research is littered with unsubstantiated claims and the tarnished reputations of the scientists who made them. Fearful that his peers would denounce the results, he insisted on additional tests. "I didn't want to ridiculize myself," he recalls.

Only after they had confirmed their findings did Müller and Bednorz publish a paper. And then many U. S. scientists missed the paper when it was published last April because Müller chose a German journal not widely read in the U. S. Some who did read it doubted the findings. "I just couldn't take the claims seriously," says one physicist who now regrets his skepticism.

THE COLD RUSH. By fall, however, a handful of research teams was experimenting with Müller's compound. In December, reports discussed at a Boston scientific meeting created a sensation. Müller's work had been confirmed by a Tokyo University research team led by Shoji Tanaka and another group at the University of Houston headed by physics professor Ching-Wu "Paul" Chu. Immediately, scientists at more than a dozen labs, including AT&T, Argonne National Laboratory, and the University of California at Berkeley, began experiments on the substance.

It was easy to jump on the research bandwagon: The promising oxides can be whipped up in the chemistry lab of any junior college. Simply grind the chemicals with a mortar and pestle and heat them in a furnace. Regrind the result, press it into pellets, and heat it again with oxygen. So by the end of December, researchers at AT&T, the University of Tokyo, the Institute of Physics, Academia Sinica in Beijing, and the University of Houston announced they had cooked up oxides that smashed Müller's record.

The scientists have been at it ever since. Chu and his close-knit team of six pushed the temperature of Müller's ox-



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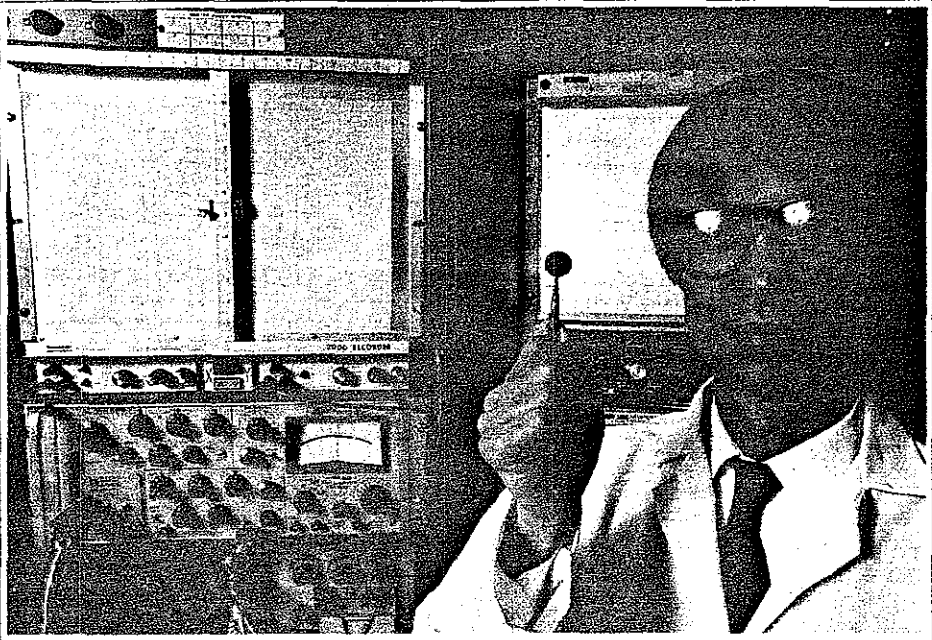


YOU'RE GETTING WARMER: THE UNIVERSITY OF HOUSTON'S CHU WITH SUPERCONDUCTOR

ide to 52.2K. "But I knew we wouldn't go higher unless we found a new material," Chu says.

So he decided to substitute another element, called yttrium, for the lanthanum in Müller's oxide. Working with University of Alabama scientists under Wu-Maw Kuen, the researchers soon recorded signs of superconductivity at a torrid 100K in that oxide. "But we came back the next day, and it had disappeared," recalls the 45-year-old Chu. The researchers began an intense cat-and-mouse game with the material, trying to stabilize the superconducting properties at that high temperature.

The team tested dozens of recipes with little success, but Chu's optimism never flagged. "He always looks on the bright side," says Pei-Herng Hor, one of his Taiwanese-born colleagues. By early February the team scored: The researchers found a stable compound that was superconductive at 98K, well above the temperature at which inexpensive liquid nitrogen could be used for cooling.

'SCIENCE SUPERSTAR.' Chu kept mum for two weeks, but rumors quickly lifted the veil of secrecy. Researchers at IBM, AT&T, and the University of California at Berkeley immediately set out to discover the secret ingredient. "Chu ran the four-minute mile in superconductivity," declares James E. Shirber, manager of solid-state physics at Sandia National Laboratory. "He broke the barrier to liquid nitrogen." When the news got out, Chu earned the nickname "Science Superstar" from his staff.

That could prove to be an elusive title. Within weeks Tanaka, Z. X. Zhao from the Institute of Physics in Beijing, AT&T, and IBM were pacing Chu. By substituting still other elements such as calcium and lutetium, they concocted a dozen different oxides that become superconductors above 90K.

With so many teams after the ultimate superconductor and the prizes it might bring—perhaps even a Nobel—the tension among key researchers is becoming almost palpable. At the Physical Society meeting in New York, the scientists assiduously noted the dates when they observed high temperatures, developed compounds, or completed other ground-breaking work. "Everyone is writing history to make themselves look better," observes one physicist.

IBM'S K. ALEX MÜLLER: HIS DISCOVERIES A YEAR AGO KICKED OFF THE RESEARCH FRENZY

At a press conference during the meeting, Tanaka claimed the Japanese were first to experiment on certain compounds. Chu jumped up to add that his lab, too, was working on the same compounds at that date. Such incidents are "just the tip of the iceberg," says Chu. Although Chu and Tanaka used to compare work, the communication stopped once Chu began experiments on yttrium.

"It's frantic, mass hysteria," says Paul M. Grant, manager of magnetism and collective phenomena at IBM's Almaden Research Center in San Jose, Calif. "Everyone's exhausted." Grant, whose weeks of midnight research sessions resulted in the identification of the structure of one of the oxides, has the dark circles under his eyes to prove it. And the research is progressing so rapidly that it has outstripped the usual channels of scientific communication. At *Physical Review Letters*, the leading physics journal, more than 50 superconducting research papers await publication. " 'Recently' in this field now means two days ago," says M. Brian Maple, professor of physics at the University of California at San Diego.

GETTING PRACTICAL. The race to push superconducting materials out of the lab has barely begun, however. Just because a substance loses its electrical resistance when it's dipped in a cold, liquefied gas does not mean it will be much good in the real world. To be practical, superconductors have to be fashioned into wires, cores of magnets, and the thin coatings that form the foundation of computer circuits. And the materials, which are basically ceramics, are brittle—and fragile. "It is a long road between discovery and use of the devices," says Robert J. Cava, a chemist at Bell Labs.

But scientists already are pulling off the basic developments that lay the foundation for commercial applications. One key finding is that the materials may make possible the most powerful electromagnets ever built. Tests at Westinghouse and AT&T indicate that the new superconductors can withstand magnetic fields up to 10 times greater than those possible with such materials as niobium. That could open the way to such applications as tiny but extremely powerful electrical motors and higher-resolution medical imaging machines.

By March, both IBM and Stanford University had used techniques common in the semiconductor industry to produce a superconducting thin film that could be used in computers. At Stanford, Theodore H. Geballe, a professor of applied physics, fashioned a film into a prototype device that might be an ultrahigh-speed data pathway between computer

(TOP) CONNOLLY/PICTURE GROUP; (BOTTOM) WALTER P. CALAHAN chips. An AT&T team that included Bertram Batlogg and ceramist David Johnson used ceramic processing technology to make its tape and small donut-shaped magnets. Japan's Fujikura Ltd. and Sumitomo Electric Industries Ltd. have made prototype superconducting wires.

The prospect of high-temperature superconductors shooting out of the laboratory has scientists lusting nearly as much after potential profits as scientific prizes. Just as semiconductor technology created Silicon Valley, the new superconductors may well create an "Oxide Valley." Already, some researchers are talking about starting companies. And Henry Kolm, who left Massachusetts Insititute of Technology to found a company to develop superconductivity applications a decade ago, believes the new oxides will open the door to venture capital. "People didn't consider helium practical," he says. Liquid nitrogen cooling, however, "is not far from frozen-food technology."

But just who owns the rights to the new technology promises to be a major muddle. The U.S. Patent Office is already sifting through dozens of applications on everything from the structure of oxides to manufacturing processes and devices. IBM and AT&T both contend they have claims for broad patent protection, but "it may be some time before we find out who has what rights," admits George Indig, a patent attorney at AT&T. Observers are predicting messy shootouts in the courts.

The rush of discoveries also leaves physicists with some loose ends. For one thing, they can't fully explain why the oxides are such superior superconductors. "It may be several years before we know what's going on, but there may be no theoretical limit to how high the temperature can go," says Robert Schreiffer, a professor at the University of California at Santa Barbara who won a Nobel for developing a theory of superconductivity. Indeed, by the time the New York meeting broke up, labs in the U.S. and Europe had reported signs of superconductivity well above 100K.

Such reports are spurring a frenzy of activity in Chu's Houston laboratory. Shoes are scattered under desks, and jackets and shirts are hung in corners, as the researchers work around the clock. The full-sized refrigerator is crammed with Chinese take-out food. "When you are No. 1, you always have to work to keep it," says Hor. "You hardly sleep." And Chu has his sights clearly on another record—125K. By mid-March rumors were circulating that he might be close. "Will history repeat itself? Who can tell," says Chu grinning.

By Emily T. Smith in New York, with Jo Ellen Davis in Houston and bureau reports

THE U.S. HAS THE ADVANCES, BUT JAPAN MAY HAVE THE ADVANTAGE

When a Houston laboratory announced a major advance in superconductivity research in February, Japan Inc. wasted no time. Its Ministry of International Trade & Industry immediately began assembling a consortium of government, industry, and university researchers. A MITI official describes the ministry's goal with missionary zeal: to exploit the "fantastic world of future industries" promised by new materials that conduct electricity with virtually no loss of power.

Both leading U.S. universities and major industrial companies such as International Business Machines Corp. and American Telephone & Telegraph Co. are playing a pioneering role in the spectacular scientific advances. But some experts fear that the Japanese ability to organize their research into a program with strong commercial goals could give them the edge in moving the research out of the laboratory.

At the moment, declaring a winner in the superconductivity race is premature. But leaders of the nation's science Establishment marvel at the speed of MITI's action. "I wouldn't call what they have done ominous, but it certainly is a sign of intensifying aggressiveness," says Roland W. Schmitt, General Electric Co.'s chief scientist and chairman of the National Science Board. Adds Carl H. Rosner, president of Intermagnetics General Corp.: "The Japanese have long recognized the tremendous potential of superconductivity, whereas the people in this country have been very short-sighted."

HEAD-SCRATCHING. No one government agency coordinates U.S. attempts to exploit the new science. Nor does anyone know precisely how much the U.S. spends on superconductivity research. But the National Science Foundation, which funded much of the recent U.S. research, estimates that federal agencies are funneling at least $8 million a year to universities.

American scientists and industrialists share the assumption that, as in the past, the U.S. system doesn't need a push from the government to bring innovative technologies to market. "The discoveries have been so spectacular that the level of activity is enormous in every laboratory in the U.S. with any capability in superconductivity," argues Schmitt. And Frank Press, president of the National Academy of Sciences, notes that a surprising amount of the academic work is aimed at applications of the new knowledge, such as thin superconducting films for computer chips.

But not everyone is satisfied. Ching-Wu "Paul" Chu, the University of Houston physicist who is the leading U.S. superconductivity researcher at the moment, thinks more action is needed to meet the combined weight of Japan's governmental, financial, and industrial resources. "We cannot afford not to move the same way as the Japanese," he says. "We really have to have a coordinated effort this time." In between those standing pat and the activists, there are a lot of people just scratching their heads. "Maybe," says one official half-jokingly, "what we ought to do is have some kind of conference to see what we ought to do."

'FIRST WIDGET.' But one aggressive government science administrator is not waiting. James A. Ionson, the astrophysicist who heads the Office of Innovative Science & Technology for the Pentagon's Strategic Defense Initiative Organization, is already busy forming his own consortium. He has lined up an unnamed university, a federal research laboratory, and a handful of small companies. Ionson's consortium will have a specific target: vastly improved space-based infrared sensors for detecting enemy missiles."My concern is that if we don't pull the science into a technology fast, we're going to be beaten to the punch," says Ionson. "I think we've got to build the first widget."

Early proof that the science can be converted into a product might, as Ionson hopes, be enough to spur vigorous development. But there are no guarantees. Even in the basic science, the international competiton is fierce, and other nations are already scrambling hard for products because the potential payoffs appear to be so great. Furthermore, there are signs that the time from discovery to application may be exceptionally short.

Superconductivity is likely to be a severe test of the highly individualistic American system. Even as basic findings are still pouring out of the laboratories, the stark reality of the competitive marketplace looms. And Ionson's embryonic consortium is no match for MITI's directed Japanese effort. In this case, the U.S. may have to consider imitating Japan for a change.

By Evert Clark in Washington

THE NEW WORLD OF SUPERCONDUCTIVITY

Technologies and products once only dreamed of are suddenly coming within reach

Inexhaustible, cheap energy from fusion, desktop computers as powerful as today's number-crunchers, trains that fly above their rails at airplane speeds—all suddenly have taken a giant step closer to reality. But while scientists developing a new breed of "warm" superconductors are planting the seeds of an almost Utopian tomorrow, it will be up to engineers to reap the harvest.

That won't happen overnight. The novel materials that researchers are churning out in laboratories still have to be transferred to the factory floor. Significant hurdles must be cleared before an experimental circuit for a superconducting computer can be turned into mass-produced chips. A small sample of wire is a long way from cables that will span the nation.

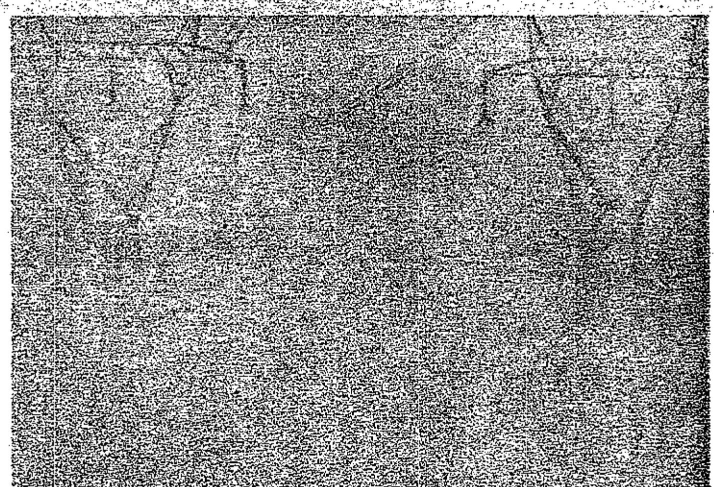
Even in the fleet-footed electronics business, it will probably be 1990 before full-fledged products show up. For electrical utilities, it could take 10 to 20 years before the revolutionary new superconductors make a meaningful impact on power distribution. The challenge of scaling up lab results "could be formidable," cautions Paul M. Grant, manager of magnetics research for International Business Machines Corp.

SCOTCH AND WATER. Until now, superconductivity has been limited to a few applications because the materials available had to be cooled to extraordinarily frigid temperatures with expensive liquid helium. "Liquid helium costs about the same as Scotch," says Walter L. Robb, senior vice-president for corporate research and development at General Electric Co. Liquid nitrogen is 10% as costly—roughly on a par with bottled water. And even with complicated and very expensive insulation systems, liquid helium escapes far more rapidly than liquid nitrogen, which can be protected with simple plastic-foam insulation.

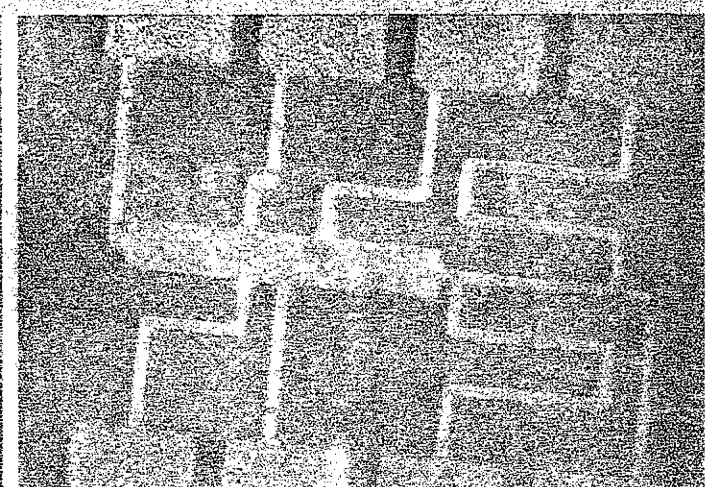
The idea that it may soon be economically feasible to put superconductivity to work in myriad uses is sparking development projects at hundreds of companies worldwide. The payoffs would be enormous. And if room-temperature superconductors are ultimately discovered, the world could be transformed. Such "hot" materials could provide new tools for every technology related to electricity. But just the prospect of superconductivity at liquid-nitrogen temperatures is enough to excite most industrial engineers.

Practical nitrogen-cooled superconductors could save the utilities billions—

FOUR TECHNOLOGIES THAT WILL BE



POWER SYSTEMS If electricity can be transmitted vast distances without loss, the country's electrical demands could be met by burning less fuel. As it is, copper wires waste enough power to light up the West Coast. Power plants will become more efficient by using generators made with superconducting electromagnets. And giant electromagnets could even be used to store electricity for use during peak hours. Smaller and more powerful superconducting electric motors will cut industrial power bills.



ELECTRONICS Nothing since the transistor promises to overhaul computer science as drastically as superconductivity. The experimental microcircuit above, produced by International Business Machines Corp., heralds the dawn of a new age in electronics. Tomorrow's electronic systems will pack 100 or more times as much information-crunching power in smaller boxes. With powerful magnets and more sensitive detectors, medical imaging systems will give doctors dramatically sharper pictures.

and save enough energy to put 50 or more power plants in mothballs. Copper wires may be the conductor of choice now, but they lose a lot of power. The copper soaks up 5% to 15% of the electricity flowing through long-haul transmission lines, and still more disappears in local distribution lines. For Pacific Gas & Electric Co., these losses amount to $200 million a year—"plenty of incentive to use a new conductor," says Virgil G. Rose, PG&E's vice-president for operations.

With so much at stake, there has been interest in developing transmission lines and power generators even with existing superconducting technology. Research began in the late 1960s but eventually ground to a halt as the energy crisis faded and the cost of cooling with liquid helium stayed stubbornly high. One line was actually built in the U. S., a 300-ft.-long test installation at Brookhaven National Laboratory. It showed that the technology could not compete with a conventional system unless all the power needs of a city were fed through one line to minimize cooling costs, says Carl H. Rosner, president of Intermagnetics General Corp. But because of the inherent unreliability of such a system, no city would dream of putting all of its watts into one cable. If the new superconducting carriers can be fashioned into cable that can stand up to high power loads and alternating current, 10 or 12 "feeder" lines might be affordable.

Interest in using powerful superconducting magnets to build high-speed trains that levitate above their tracks has also flagged in the U. S., because of high capital costs. That interest, too, could be reviving. But the eventual builders of these so-called maglev trains are more likely to be in either West Germany or Japan, which have continued to fund serious research, or Canada, which still supports a modest effort.

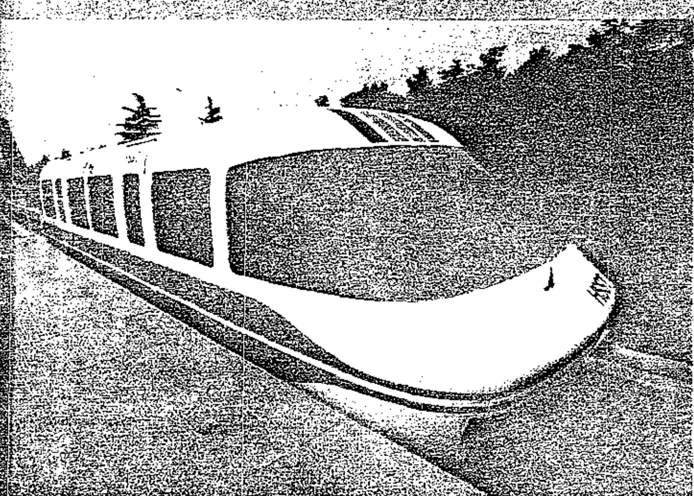
William F. Hayes, a senior research officer with Canada's National Research Council and a maglev believer, bubbles over with anticipation. The new superconductors will have "a tremendous impact on maglev," says Hayes. "The major problems were refrigerating units and reliability. All that's eliminated now." And trains aren't the only vehicles that could benefit. Hayes predicts that superconducting motors one-half to one-third the size of normal motors will one day power ships. They could also help eliminate urban air pollution by making electric cars practical.

America's best shot at exploiting the new technology is probably in electronics. There, superconductivity will usher in what Sadeg M. Faris calls "the third age of electronics," after vacuum tubes and transistors. Faris worked on superconducting microchip devices known as Josephson junctions at IBM. When Big Blue decided in 1983, after 14 years of work, that the technology was a no-go, Faris left and founded Hypres Inc. In February, less than four years later, Hypres unveiled the first system based on Josephson junctions. Now, Faris asserts that Hypres will be the first to build chips using the new materials, because "no one else in the world has a manufacturing line producing JJ chips."

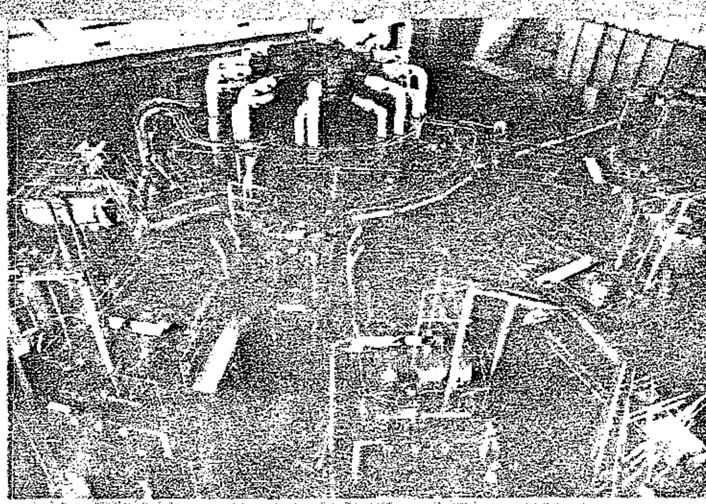
SUPERCHIPS. That distinction isn't likely to last long. Major electronics companies, from IBM to Varian Associates, are racing to explore the new superconductors. "Guys are working like maniacs," says John K. Hulm, director of corporate research at Westinghouse Electric Corp. "I haven't seen anything like this in years." Westinghouse wants to use Josephson junctions, which are up to 1,000 times faster than conventional silicon transistors, to build radar systems it believes would outperform any now available. At Varian, a leading maker of equipment used in semiconductor fabrication, a crash effort is under way to verify the work on superconducting thin films being done at nearby Stanford University. Such films could be the starting point for tomorrow's superchips.

Health care is another area where su-

THE FIRST TO FEEL THE IMPACT



TRANSPORTATION [illegible] trains would get a big lift from [illegible] [illegible] could power ships and electric cars.



SCIENCE In their never-ending quest for knowledge, physicists want to smash atomic particles into smaller smithereens or, conversely, to fuse atoms together and mimic the energy-generating furnace inside the sun. To "bottle" an ultrahot fusion reaction in a so-called tokamak device such as the one at Princeton University, magnets more powerful than any now available will be needed. Magnets made with the new materials could also boost the power of future atom-smashers.

Chip Sense and Nonsense

By George Gilder

This is the economic landscape that stares at Malcolm Baldrige through his window at the Commerce Department: The U.S. has created 14.4 million jobs over the past five years with rising per capita incomes. We have been increasing employment far faster than any other major industrial country, including Japan. We have enjoyed the second-longest economic recovery of the postwar period.

In 1986, U.S. companies produced some $188 billion of electronics goods, more than twice that produced in all of Asia. American companies hold about 70% of the world computer market and produce about 57% of the world's semiconductors when you consider the huge output for in-house use at a handful of major U.S. firms. Value added in the computer industry is shifting toward small computers that are now about 90 times more cost effective than mainframes and toward software. The U.S. lead is largest in desk-top computers, and over the past decade we have increased our market share in software from under two-thirds to more than three-quarters.

The U.S. government has become the chief obstacle to American competitiveness in electronics.

For the past five years the U.S. has enjoyed a surge of microchip imports from Japan. The resulting trade gap resulted chiefly from a key strategic decision by the world's largest chip maker, IBM, which produced about $3 billion of advanced semiconductors in 1986. Faced with an unexpectedly large but unpredictable market for its personal computers, IBM resolved to import huge volumes of basic memory chips from Japan rather than invest in special plants to build these commodity items in the U.S.

Driving Down the Prices

The IBM decision was a brilliant success. The Japanese plus Texas Instruments' Miho facility produced huge volumes of chips and within two years drove down the price from about $8 to around 50 cents for 64K Dynamic Random Access Memories; then they proceeded to launch production of 256K (four times the memory capacity) and one megabit (four times again the memory) generations. Since memory chips constitute about a third of the manufacturing cost of personal computers, the Japanese chips allowed IBM and other U.S. firms to drive the price of computers to new lows and expand the market at a pace of about 30% a year.

Nonetheless, the U.S. did not fall behind in memory-chip technology. According to McKinsey & Co., Texas Instruments became the most profitable semiconductor producer in Japan and introduced a prototype 4-megabit DRAM at about the same time as the Japanese producers. (The 4-megabit design would permit all the working memory in a typical personal computer to be put on one chip.) Most significant of all, IBM probably became the world leader in the technology. Today, in Essex Junction, Vt., it is pioneering the production of very fast one-megabit chips on eight-inch wafers (increasing the chip yield nearly 40% over Japan's best six-inch wafers), and at the recent International Solid States Circuits Conference, IBM introduced an impressively manufacturable 4-megabit design. The company thus is poised to reenter mass production of basic chips should that be strategically desirable in the future.

Because IBM decided not to mass produce 64K or 256K DRAMs, the company—and the U.S.—may have increased its lead in semiconductor technology over the past four years. While the Japanese chip revenues are puffed with money-losing commodity semiconductors, U.S. production totals, including IBM, are dominated by more complex and ambitious designs.

Here's the rub. The figures constantly cited by the Semiconductor Industry Association and by U.S. government officials do not include IBM, AT&T and a few other big in-house producers. To the Japanese, these numbers resemble auto market-share figures that leave out Toyota and Nissan.

In any case, reacting to a catastrophe theory of American semiconductor market share that left out IBM, U.S. trade officials imposed a pricing agreement on Japan. In an act of stupidity unparalleled since Smoot-Hawley, the U.S. forced Japan to more than double the price of its commodity memories. According to a concept of "fair market value" apparently cribbed from some primitive East European pricing guide, the Commerce Department declared war on the U.S. computer industry, effectively excepting IBM. According to the pact with Japan, U.S. computer firms would have to pay twice as much for memory chips as their Japanese competitors that make the chips in-house.

The computer industry is what the contest is all about. The Japanese do not make chips for their health; they make them for their computers and other electronic products. To attack the U.S. computer industry in order to save the U.S. semiconductor industy is simply crazy. Obviously, the U.S. computer firms rushed to circumvent the agreement any way they could, resorting to the gray market and Korea, and making plans to move manufacture of U.S. computers offshore as fast as possible.

Therefore, the agreement broke down. In the interests of U.S. competitiveness, it had to break down. Even the various provisions about increasing the U.S. share of the Japanese chip market became unenforceable because of a recession in the computer industry and because U.S. companies do not supply the chips needed by still thriving Japanese producers of consumer electronics.

Meanwhile, the three U.S. semiconductor companies that may have benefited in the short run from the agreement began to complain of Japanese "violations." Democratic politicians, who lacked telling objections to economic conditions under the Reagan administration, began carping about the "trade gap." Spurning advice from economists who could refute the mercantilist superstitions of trade balance and lacking advisers who understood the technological complexities, the Reagan administration collapsed.

Jeopardizing thousands of relationships between U.S. and Japanese electronics firms, the administration has made it far more difficult for U.S. semiconductor firms to penetrate the Japanese market except possibly on the basis of forced quotas. But semiconductors, critical to the production of end products, can be purchased in the long run only on a basis of trust and predictability, with just-in-time delivery and fail-safe reliability. By constantly imposing special export controls for nonsensical national security concerns and changing policy from month to month in response to utterly spurious emergencies, the U.S. government has become the chief obstacle to U.S. competitiveness in electronics.

Herbert Stein on this page recently stripped away the layers of illusion and superstition surrounding the theory of the balance of payments. In a world with global money markets on line 24 hours a day, there is no more reason for a trade balance between any two countries than between any two American states or companies. The U.S. currently is dominating world electronics markets because it is following a global strategy consistent with the increasing integration of world information technology.

This means that like every other major nation we will have to be dependent on foreign producers for many critical parts and materials. As long as we teach more students sex education and cooking than physics and calculus, we must depend on immigration for key technical personnel. The alternative is a real decline in U.S. competitiveness. We cannot do it alone.

Although the Japanese need to reform their increasingly restrictive tax rates and monetary policies, Japan is not a problem for the U.S. It is a supreme and precious asset of world capitalism. Not only do superb Japanese manufacturers supply the U.S. with crucial goods and technologies, but they supply the U.S. economy with an indispensable flow of investments. Not only did Japan save the U.S. economy by tripling auto gas mileage when OPEC tripled the price of oil, Japan also has spurred tremendous creativity and resourcefulness in U.S. electronics.

Some analysts believe the U.S. is becoming excessively dependent on Japan for vital supplies of capital equipment. This is a minor problem that can be quickly solved by IBM and the Pentagon, if they insist, without wrecking the international trade system. But the key ingredients in electronics are not machinery or materials, but ideas and inventions. To imagine the Japanese will dominate the age of information because they have the purest silicon and industrial gases is like predicting the Canadians will dominate world literature because they have the tallest trees.

Useful Roles for Government

If the government wants something to do, there are plenty of useful roles. It could begin with a defense education act that helps the schools teach math and science. (Opening a DRAM plant in North Carolina, Mitsubishi discovered that it had to use graduate students to perform statistical quality control work done by line workers in Japan.) Then the government could reform immigration law to allow admission of workers to support our increasingly gargantuan entitlement-state, and technical personnel to man our high-tech and defense industries. Finally, the government could expend its trade powers defending U.S. patents, copyrights and other intellectual property against Asian nations that let their citizens steal it. Thus the government could reward U.S. achievement rather than protect U.S. sloth.

With recent breakthroughs in superconductivity, bioengineering, computerized chip design, parallel processing, and artificial intelligence, we are entering an era of limitless opportunities. The politicians, however, continue to live in a 19th-century fog of territorial fears and mercantilist fantasies. Peter Drucker tells us, "Don't solve problems, pursue opportunities." That is the supreme message of the day in electronics.

Mr. Gilder is finishing a book on the computer industry for Simon & Schuster.

For Many Criminals, Incarceration Is Not the Answer

By Latique A. Jamel

Prisons are bursting at the seams. New York and other states are spending millions to expand existing facilities and build new ones. The number of men and women being put in cells each month far exceeds the number released. But need this be done in order to maintain public safety?

State prisons, for both moral and economic reasons, should house not marginal, nonviolent criminals, but only those felons who pose a genuine threat to the community. The evidence in New York, at least, is that a wider net is being cast.

Not all of these felons should have gone to prison, and many of them would be better off in community rehabilitative pro- fined totals a staggering $468 million. Take the annual cost of confinement for each prisoner (a figure identified by both the New York studies as $26,000 a person) and multiply it by 4,680 and you come up with an additional $121.7 million a year.

(Some might argue that a home burglar, armed or not, is the sort of person society would want confined. Even removing all burglars from the total above and cutting the number of inmates to be released to 6%, however, would still permit a saving in New York state alone of $234 million in construction costs and $60.8 million a year in confinement costs.)

But there is a more important noneconomic reason for committing fewer felons tence of prisons, some criminologists believe time in prison tends to increase the level of violence perpetrated by a repeat offender and increases his propensity to commit criminal acts. The number of inmates who undergo marked character improvement during imprisonment is low; this is borne out by recent studies of recidivism rates among released criminals.

Younger inmates often have committed such crimes as car theft and possession of stolen property. In some cases, being sent to prison serves to deter young criminals from committing new, more severe crimes upon release. However, in an alarming number of instances, prison is a graduate school, with older, more hardened crimi-

Those who would have us believe that the best, if not only, response to crime is to "get tough" on all criminals ought to consider that according to the Bureau of Justice Statistics, at least 20% of all inmates in New York state are released within three years, and more than 90% of all prisoners return to the communities in which they lived before incarceration, and often this means returning to the community in which they committed their original crimes.

One would hope that citizens would prefer to have nonviolent criminals—who will come back to their communities and share their schools and work places—punished in a manner that will reinforce respect for co-

The Rise and Fall of the Blue-Collar Worker

By Peter F. Drucker

Whether high-paying jobs are growing or declining in the American economy is being hotly debated. But as important as the numbers is the fact that the new high-paying jobs are not where the old ones used to be.

For 30 years, from the end of World War II to the mid-1970s, high-paying jobs in all developed countries were concentrated in unskilled blue-collar work. Now a majority of the new high-paying jobs are in knowledge work: technicians, professionals, specialists of all kinds, managers. The qualification for the high-paying jobs of 20 years ago was a union card. Now it is formal schooling. The long and steep rise of the "working man"—in numbers, in social standing, in income—has turned overnight into fast decline.

There is no parallel in history to the rise of the working man in the developed countries during this century. Eighty years ago American blue-collar workers, toiling 60 hours a week, made $250 a year at most, or one-third the price of that "low-priced miracle," Henry Ford's Model T. And they had no "fringes," no seniority, no unemployment insurance, no Social Security, no paid holidays, no overtime, no pension—nothing but a cash wage of less than one dollar a day. Today's employed blue-collar worker in a unionized mass-production industry (steel, automotive, electrical machinery, paper, rubber, petroleum) working 40 hours a week earns about $50,000 a year—half in cash wages, half in benefits. Even after taxes, this equals seven or eight new small cars, such as the South Korean Excel, or 25 times the worker's 1907 real income (if food were used as the yardstick, the increase would be even larger). And the rise in social standing, and especially in political power, has been greater still.

Society's Stepchildren

And now it is suddenly all over. There also is no parallel in history to the abrupt decline of the blue-collar worker during the past 15 years. As a proportion of the working population, blue-collar workers in manufacturing have already decreased to less than a fifth of the American labor force from more than a third. By the year 2010—less than 25 years away—they will constitute no larger a proportion of the labor force of every developed country than farmers do today—that is, a 20th of the total. The decline will be greatest precisely where the highest-paid jobs are. Blue-collar automobile employment in the U.S., 15 or 20 years hence, will hardly be more than half of what it now is, even if there are no imports at all—and automobile blue-collar employment is already down 40% from its peak, less than 10 years ago. No wonder the unions do not regard the fast growth of high-paying knowledge jobs as a compensation for the steady decline in the numbers, power, prestige and income of their constituents. Yesterday's blue-collar workers in manufacturing were society's darlings; they are fast becoming stepchildren.

This transformation was not caused by a decline in production. U.S. manufacturing output is steadily expanding, growing as fast as gross national product or a little faster. The decline of the blue-collar worker is not a matter of "competitiveness," of "government policies," of the "business cycle," or even of "imports." It is structural and irreversible.

There are two major causes. First is the steady shift from labor-intensive to knowledge-intensive industries—e.g., a drop in pouring steel and a steady rise in making pharmaceuticals. All the growth in U.S. manufacturing output in the past two decades—and it has about doubled—has been in knowledge-intensive industries. Equally important is the world-wide spread in the past 40 years of two American inventions (or discoveries), "training" and "management." In a complete reversal of all that economic history and theory had taught, these two methods enable a country with the labor costs of an "underdeveloped" economy to attain, within a very short period, the productivity of a fully "developed" one.

The first to understand this were the Japanese after World War II. By now everybody does—the South Koreans, for instance, or the Brazilians. The most telling example are the "maquiladoras," the plants on the Mexican side of the U.S.-Mexican border, where unskilled and often illiterate people produce labor-intensive parts and goods for the U.S. market. It takes three years at most for a maquiladora to attain the labor productivity of a well-run American or Japanese plant even in turning out highly sophisticated products—and it pays workers less than $2 an hour.

This means that manufacturing industry in developed countries can survive only if it shifts from being labor-intensive to being knowledge-intensive. Machine operators getting high wages for doing unskilled, repetitive work are being replaced by knowledge-workers getting high wages for designing, controlling and servicing process and product, or for managing information. This shift also fits in with demographics. In every developed country more and more young people, and especially young males, stay in school beyond the secondary level and are no longer available for blue-collar jobs, even for well-paying ones.

These are changes so sharp and so sudden as, for once, to deserve being called "revolutionary." Yet their impact is different from what everyone expected, and different also from what economic and political theory had taught.

This applies particularly to U.S. unemployment. In Britain and Western Europe the decline in blue-collar jobs in manufacturing has indeed, as unions predicted, resulted in stubborn unemployment. But in the U.S. the decline has had marginal effects at most. Even the massive job losses in the steel and automotive industries have barely left a trace in national unemployment rates. To be sure, the current 6½% unemployment rate for both adult men and adult women is probably somewhat above the rate of "natural unemployment" (the rate needed for normal job changes)—but not by much, considering the age structure of the working population. And the 4½% unemployment rate for married men is, if anything, below the natural rate and constitutes virtual "full employment." "Hidden unemployment"—that is, people who have given up looking for a job—is very big in union propaganda but probably quite scarce outside of it. A larger proportion of American adults than ever before in peacetime history—almost two-thirds—is in the labor force and working. One explanation for the low unemployment rates is surely that American workers are singularly adaptable and mobile—far more so than anyone would have thought possible. But, equally significant, blue-collar labor in manufacturing may also have already shrunk to a point where it only marginally affects total employment and unemployment rates, consumer spending, purchasing power and the economy as a whole. This would mean that we should stop looking at manufacturing employment as the economy's bellwether and should look at manufacturing output instead; as long as its volume continues to rise, the industrial economy is healthy almost regardless of employment.

Drucker on Management

There has been labor militancy in only one developed country: Canada. Elsewhere there is much bitterness among the rank and file. But it is the bitterness of resignation.

Equally novel is the behavior of wage costs in the U.S. That unions give priority to the maintenance of nominal wages rather than accept lower wage rates to gain higher employment has been one of the axioms of modern economics. It still holds in Europe. But America's unions have shown an amazing willingness to make sizable concessions on wages—and even on work rules—to prevent plant closings and massive layoffs. In the U.S., at least, the principal cost-rigidity inhibiting the "self-correction" of a market economy surely no longer lies in wage costs (as economics has assumed since Keynes) but in the cost of government.

Every labor economist and every labor leader would have expected the decline of the blue-collar worker to lead to "labor militancy" on a grand scale. Some politicians still expect it—for instance, the Rev. Jesse Jackson in the U.S., the "Militants" in the British Labor Party and the "Radicals" among the German Social Democrats. But so far there has been labor militancy in only one developed country: Canada. Elsewhere there is much bitterness among the rank and file. But it is the bitterness of resignation, of impotence rather than of rebellion. In a way, the blue-collar worker has conceded defeat.

And this may underlie the most startling, and least expected, development: the political one. It is almost an axiom of politics that a major interest group actually increases its political clout for a long time after it has begun to lose numbers or income. Its members join ranks, learn to hang together lest they hang separately, and increasingly act and vote in concert. The way in which farmers in every developed country have maintained political power and increased their subsidies despite their rapid decline in numbers since World War II is a good example.

Political Strength Eroded

But though it is only 10 or 15 years since the decline of the blue-collar workers first began, their political strength has already been greatly eroded. In the midst of World War II, John L. Lewis of the United Mine Workers defied the country's most popular president—and won. Thirty years later, another coal miners' leader—this time in Britain—forced a prime minister to resign. But in 1981 President Reagan broke the powerful and deeply entrenched air traffic controllers union; and a few years later British Prime Minister Margaret Thatcher broke the union that had driven her predecessor into political exile. And both President Reagan and Prime Minister Thatcher had overwhelming popular support. The labor vote may still be needed for a "progressive" candidate to be nominated. But then, in the election, labor's endorsement has become a near-guarantee of defeat, as shown by Walter Mondale's debacle in the U.S. presidential election of 1986, by the German election this January and by numerous British by-elections.

In little more than a decade before World War I, the blue-collar worker rose from impotence to become a dominant economic and social power in Western Europe, and his party the largest single political factor. The U.S. followed suit 10 years later. This transformed the economy, the society and the politics of every developed country, transcending even two world wars and tyrannies beyond precedent. What then will the decline of the blue-collar worker—and its counterpoint, the rise of the knowledge-worker—mean for the rest of this century and the next one?

Mr. Drucker is Clarke professor of social sciences at the Claremont Graduate School.

How Japan Inc. is cashing in on free U.S. R&D

Technology transfer between federally funded labs and Japanese firms is flowing only one way — Eastward

It's a familiar scene. Japanese scientists tour U.S. laboratories to visit with their American counterparts and share information. In many cases, however, U.S. industrialists and government officials argue, the sharing is strictly one-sided. The Japanese, they contend, often walk off with innovative technology — for free — and offer little in return. "They recognized early that the U.S. is funding the entire world's basic research," says Norman Latker, director for federal technology management policy in the U.S. Department of Commerce's Office of Productivity, Technology and Innovation.

There is nothing illegal about this. Information on nonclassified research and development at national laboratories has been readily available. So it's no surprise that the Japanese and others have launched concerted efforts to cash in for free R&D. "They would be nuts to pay for research they can get for nothing," says one government official. "And the Japanese are anything but dumb."

What is perhaps more of a surprise is that few U.S. companies have followed suit. Some companies, such as Harris Corp. and Intel Corp., have technology transfer agreements with national laboratories, but U.S. industry in general has kept its distance from federal labs. One reason might be that U.S. companies want guarantees in the form of patents before they will invest heavily to adapt basic research for commercial applications. Until recently, this has been a difficult procedure.

Representatives of Japanese firms, however, point out that there is nothing illegal about picking up technology that is in the public domain. "It is a mistake to single out the Japanese for cleverly taking technology that is freely available to everybody on a nondiscriminatory basis," says H. William Tanaka, an attorney with the Washington, D.C., firm Tanaka-Walders-Rigter, which represents the Electronic Industry Association of Japan.

Furthermore, Tanaka contends, the technology transfer legislation goes against the current trend for companies from different countries to link up to share enormous R&D costs. "It is highly questionable whether this legislation will help American companies develop technology out of federally funded laboratories in the face of structural changes that are forcing companies and countries to pool their resources."

> U.S. companies want guarantees in the form of patents

Nevertheless, new legislation could change the often asymmetrical nature of technology transfer. At the very least, its proponents hope the Federal Technology Transfer Act of 1986 will give U.S. companies a beat on foreign competitors in making the most of U.S.-developed basic research. At best, supporters predict this new method of exploiting technological breakthroughs will give birth to creative Silicon Valley-like communities around many of the labs. "Our economic future depends on encouraging the efficient dissemination of skills and information within our communities," says Senator Patrick J. Leahy (D-Vt.).

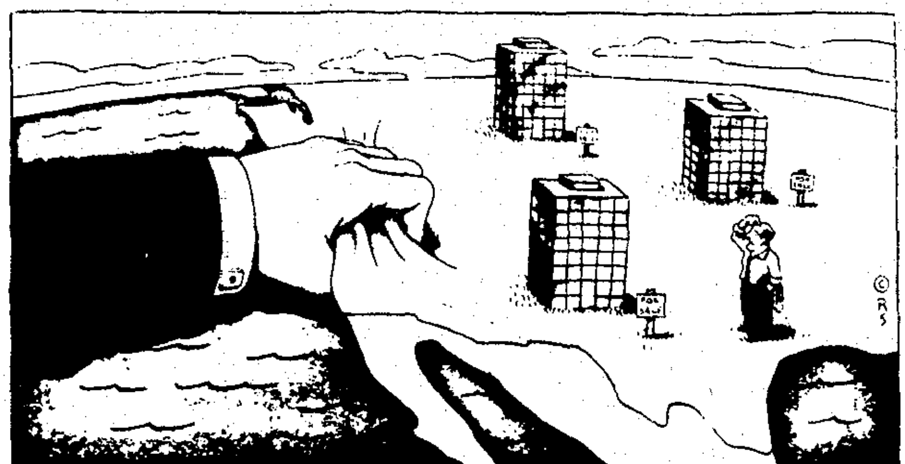
Under the new law, national labs will get first crack. The law:

- Allows labs to enter into cooperative research agreements with industry, universities and others, and to negotiate patent licensing agreements
- Directs heads of agencies with large labs to institute cash award programs to reward scientific, engineering and technical personnel
- Requires agencies to give at least 15% of royalties received from licensing an invention to the inventor and distribute the balance of any royalties among its labs
- Creates the Federal Laboratory Consortium for Technology Transfer at the National Bureau of Standards.

Publish and perish

The need to make federal labs more responsive to national needs was outlined in a 1983 report by the Packard Panel, headed by David Packard, cofounder of Hewlett-Packard Co. and former deputy secretary of the Defense Department. "The national interest demands that the federal labo- will decide how best to disseminate internally developed technology. They can cut their own deals with interested companies and share the profits. "To improve technology transfer, the federal laboratories need clear authority to do cooperative research and they need to be able to exercise that authority at the laboratory level," states a Commerce Department report. Until recently, such information was routinely published and available to anyone — from the United States or abroad. Now, American companies will get first crack. The law: ratories collaborate with universities and industry to ensure continued advances in scientific knowledge and its translation into useful technology," the report states.

Although the legislation encouraging such interaction was approved late



Rob Saunders

CRITICS CONTEND the Japanese are too aggressive in acquiring U.S. technology last year, it will be some time before the provisions are routinely enforced, according to Latker. "We're now trying to implement the law," he says. "But first we have to change a significant cultural bias away from the idea of publishing everything."

It might seem naive to some that inventions funded by taxpayers were made equally available to everybody, but that policy reflects the democratic attitude that no individual or company should get preferential treatment. And federal researchers have felt uncomfortable coming down from their ivory towers and hooking up with private companies in commercial ventures. The financial incentives could help change these attitudes. "It [will be] interesting to see the response when the first researcher pulls up in a red Ferrari," says Joseph Allen, technology policy liaison in the Commerce's Office of Productivity, Technology and Innovation.

Lab officials are learning the benefits of licensing and cost-sharing arrangements from universities, which lately have expanded their ties with industry. Some particularly aggressive institutions like Stanford University and the University of Wisconsin reportedly have made more than $5 million a year in profits by licensing technology and sharing research costs.

By contrast, the U.S. Treasury made only $2 million on patents in 1985 even though it spent $18 billion — a third of all R&D spending — at about 400 federal labs. The labs do research on everything from thin film and optoelectronics technology to boll weevils, with the heaviest funding going to the relatively large labs for weapons, space science and energy research, medical programs, and physics experiments.

The labs, which employ a total of 185,000, including one-sixth of the country's scientists, have produced 28,000 patents. Only 5% of those patents have been licensed. "This statistic is a reflection both of the fact that many government patents have little or no commercial value and that agencies have made little effort to seek private sector users for even their most important commercial inventions," says E. Jonathan Soderstrom, director of technology applications for Oak Ridge National Laboratory at Martin Marietta Energy Systems in Tennessee.

It is difficult to track the evolution of basic research, so there are no clear-cut examples of U.S. technology that the Japanese have exploited for commercial products. But no one denies that there has been a concerted effort by aggressive foreign companies (and country-sponsored initiatives) to acquire technology from America. In 1983, for example, the Japan Economic Institute reports that the United States transferred to Japan six times as much electronics technology and almost eight times as much machine-tool technology as it acquired from Japan.

In all, 70% of Japan's worldwide technology imports that year came from the United States, according to Senator J.D. Rockefeller IV (D-W. Va.) "This asymmetry in the international flow of knowledge has real repercussions for our country's competitiveness in world markets," says Rockefeller. "If our cutting-edge technology is made fully available to our rival in international trade . . . we stand to lose not only foreign markets but also jobs and income at home."

Lab officials are learning the benefits of licensing

It's not that Rockefeller and others want to totally stop technology exchange programs with foreign countries. Rather, they want to guarantee that technology swaps are equal. "It's time we started bartering a little more," says Robert Stromberg, technology transfer officer at Sandia Laboratories in New Mexico. "We want a fair, equal exchange on a tough Yankee-trade basis." Stromberg cites, for example, that Sandia no longer allows routine visits by foreign scientists unless "we are sure they are as good as ours and that any exchange of technology goes both ways."

SEMICONDUCTOR RESEARCH at Sandia Labs, where scientists no longer allow routine visits by foreign scientists

Allen of the Commerce Department points to the lopsided international scientist exchange programs as one of the most obvious inequities. "The Japanese have been able to place a lot of people in labs here," he says. "But we have a hard time placing them over there." At the National Institute of Health, for example, some 397 Japanese scientists were working in U.S. facilities in fiscal 1985, while only three U.S. NIH scientists were assigned to Japanese labs.

Even without their aggressive attempts to acquire U.S. technology, industry sources contend, the Japanese have a significant R&D advantage. Even though U.S. R&D spending has leveled off at about 2.7% of the gross national product, the Japanese project that, by 1990, R&D expenditures will rise to 3.2% of GNP.

"We're stagnating at 2.7%, much of it for the military, while they keep increasing spending for commercially exploitable R&D," says Ralph Thomson, senior vice president of the American Electronics Association. "Our one remaining competitive advantage was innovation, but we're wrong to believe the Japanese are just copiers. Their emphasis on commercial R&D has got them to the point where they are better than the U.S. in many products."

BETH KARLIN

Business and universities

Brain gain

Each year Britain's universities spend about £2 billion and turn out 76,000 graduates. Of these, 33,000 have studied vocational subjects such as science, engineering, technology or management. Yet unease persists that somehow British industry fails to capitalise on the treasures of scientific knowledge that lie buried on campuses. Government tightens the financial squeeze on universities and hopes that somehow the private sector will plug the gap: the theory is that this should not only save public money, but make university research more "relevant"; to the needs of industry, that is.

Big British companies think otherwise. They reckon it is unrealistic to expect the private sector to put up enough money to replace what is no longer forthcoming from government, either through the University Grants Committee (which pays salaries and overheads) or the research councils (which finance specific research work). Last week ICI's chairman, Sir John Harvey-Jones, accused politicians of "living in dreamland" if they thought that would happen.

In the main, British industry wants universities to carry on developing new scientific knowledge and turning out well-trained minds, rather than being forced to become academic annexes to corporate research labs. For their part, the universities fear that the more money they get from industry the less they will get from government. That has been the fate of Salford University, in Lancashire, which pioneered industry links and financing, only to have the state tourniquet tightened to the point where it has to charge high fees for its services to industry.

Yet industry and universities are growing closer in down-to-earth ways, partly spurred by the government's tight-fistedness. In 1981-82, companies spent £26m on university research. By 1984-85 that had grown to £47m. The 1985-86 figure looks like turning out around £70m, and the current year is expected to see another 50% rise to about £100m.

There is more to this new togetherness than money. The universities are now hustling companies for business. At the Techmart (new technology) exhibition at the National Exhibition Centre near Birmingham this week, 33 universities have been showing off what they can offer and the ways they are prepared to link with industry. No university today seems to be without an industrial liaison officer. There are now 26 campus science parks around Britain, housing 380 companies.

This increasing supply means that companies face a buyer's market for fairly ordinary research not needing rare talent. But the universities are not a pushover. Some, such as Manchester, have formed their own companies to handle licensing of patents and to nurture small businesses based on ideas developed in their labs. Nor are universities always ready to sell their intellectual property to the first buyer who comes along. Manchester is sitting on a valuable innovation that can detect the Aids virus rather well; but the university will not license its idea until it has an idea how much money the buyer will make out of it, so that it can pitch for a good price.

Although most of the research financed by big industrial companies is long-term, ICI is in addition now using Manchester's chemistry department to speed up its search for products using liquid crystals to sell to the electronics industry. It is looking for fast results, not blue-sky research.

For a long time companies have financed chairs or paid for fancy buildings out of a vague sense of corporate civic responsibility. Now they are getting more practical in their links. Plessey wanted a supply of graduates who would be equally at home designing computers and programming them. So it paid for a new lab at the University of Manchester Institute of Science and Technology. Plessey's scientists helped design the curriculum; soon other firms joined in supporting the new course, which has been swamped with applicants.

BTG - Picking winners & losers - where does money come from

Inherent defect

NTIS
Research Corp.
University Patent Inc. (formerly)
Technology Transfer Inc. (formerly)
To far down innovation scale.

U. of Maryland
Georgia Tech.
U. of Vermont.

Semiconductors

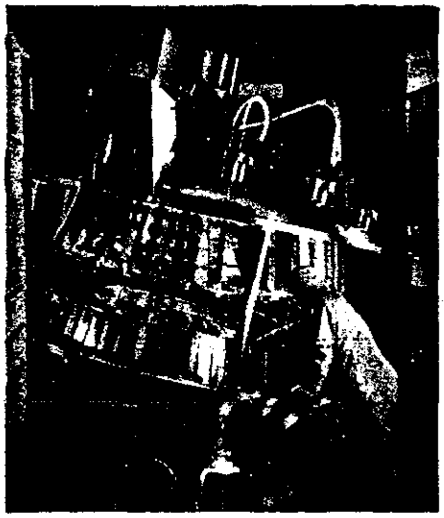
Cheaper than sapphire

The more chips shrink, the more their switches interfere with each other. Strong electric currents are prone to leak from one part of the circuit to another through the silicon base in which the circuits are etched. Chips in space are especially at risk because they are exposed to cosmic rays that do not penetrate the atmosphere; on a chip they cause havoc by making electrons jump between parts of the circuit. A burst of electromagnetic radiation from a nuclear explosion has the same effect.

Protecting chips from radiation and cross-talk is not hard, but it is expensive. One way to produce chips that are, in the jargon, rad-hard, is to create an insulating layer just beneath the surface of the silicon, a process known as silicon-on-insulator. A slab of sapphire works well as the insulator, but silicon dioxide, better known as sand, tends to be cheaper. Simply heating a piece of silicon in oxygen will produce the oxide. The snag is that oxide is formed on the surface of the silicon and not below it, where the insulating layer is required.

The answer is to inject oxygen ions (atoms that are electrically charged and accelerated into a beam) under the surface of the silicon to form the oxide layer. A British team reckons it has put together a commercial oxygen-implantation process with a prototype machine called OXIS 100. It was jointly developed by VG Semicon of East Grinstead, Surrey, and the Culham and Harwell laboratories of the Atomic Energy Authority.

OXIS produces silicon-on-insulator wafers, the standard silicon discs on which hundreds of individual chips are made in a conventional manner. The machine is designed automatically to produce 800-



Toughening up chips

2,000 four-inch wafers a week—about the whole of the world's production of buried oxide wafers two years ago. Its nearest competitor makes 500 wafers a week.

Increasing the power of the ion beam is the key. Conventional ion-implanters produce a beam with a current up to 10 milliamps. The OXIS machine produces a beam of 100 milliamps with an energy of 200 kilovolts. The effect of the bigger beam is to drive oxygen ions more efficiently into the silicon. The wafers are processed in a vacuum at 400-750°C, which maintains the crystal structure at the surface of the silicon. An automated handling system is used to load and unload wafers from cassettes, which are sealed to provide the ultra-clean conditions needed to keep out any impurities.

Batches of more than 100 wafers can be processed at a time. Dr Steve Moffatt, the system manager, estimates that a 5 milliamp implanter would produce 100 millimetre wafers at a cost of \$570 each, compared with an OXIS cost of \$58 (including \$15 for the untreated wafer to begin with). That, says Dr Moffatt, works out a few cents per chip to provide silicon-on-insulator. Costs could fall further. The team is already looking to turn up the power to 200 milliamps, which would reduce the cost to \$28 a wafer.

THE ECONOMIST NOVEMBER 15 1986

New Scientist · 1/20/83 GM

THIS WEEK

Scientists will be set free to sell their inventions

NRDC

THE GOVERNMENT'S monopoly on inventions at British universities and publicly-funded research establishments seem set to end. In mid-February the Prime Minister should approve a plan by Sir Keith Joseph, the Education Secretary, to scrap the role of the British Technology Group (BTG) as a broker for public-sector research. But scientists seem uncertain about whether the idea is good for them—or the nation.

The plan, first proposed by the Advisory Council on Applied Research and Development, would allow research councils and individual scientists to get the chance to patent and market their own inventions. In the past the BTG has had first refusal on all inventions.

The government formed the BTG in 1981 by amalgamating the National Enterprise Board with the National Research Development Corporation. The group describes its function as "to develop technology in British industry, and to advance the use of British technology throughout the world". Last year it had an income of more than £26 million, and took on 47 new projects.

But the National Research Development Corporation has been widely criticised for failing to exploit inventions quickly enough, and for putting a bureaucratic stumbling-block in the way of innovative scientists. One survey, carried out for the Leverhulme Trust by the Polytechnic of Central London, found that the NRDC's success rate as less than half of that chalked up when a university or industrialist took over marketing.

But the report found that the NRDC had a much better record as a banker. The report, "Inventions from non-industrial sources," concluded that the corporation should simply lend money to inventors, with repayments depending on the success of the invention.

This kind of role would obviously be more in keeping with the Conservative government's non-interventionist stance.

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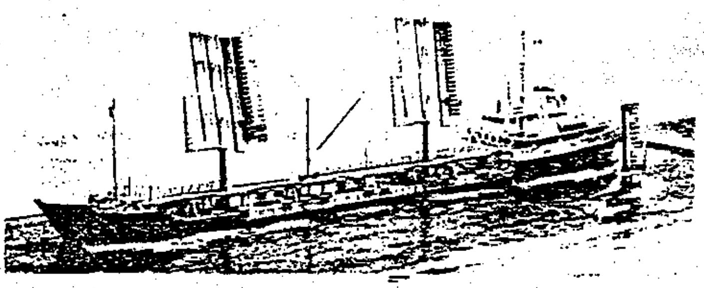

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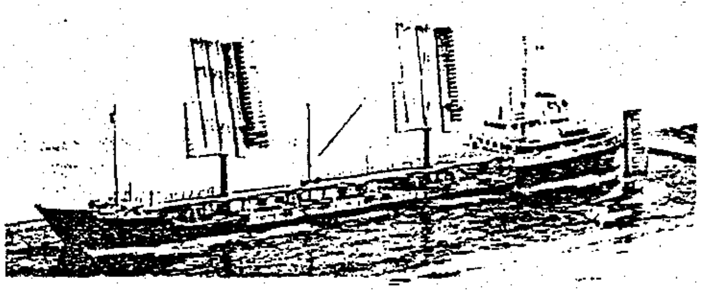

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New Scientist 1/20/83 GM.1

THIS WEEK

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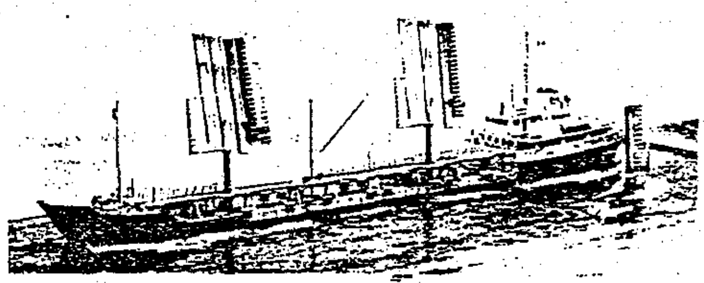

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COMMENT

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Free the campus entrepreneurs

BREATHLESS PHONE calls first thing in the morning; indecipherable typescripts bristling with spidery illustrations; wild-eyed magnetic levitationists turning up at reception—*New Scientist* has dealt with the British inventor in his most extreme forms. Lone inventors are by no means all nutters, but we can sympathise with anyone who has to deal with them all the time. That is one of the jobs of the British Technology Group (BTG), which the government created in 1980 by merging the National Enterprise Board with the National Research Development Corporation. The BTG's job, according to its latest annual report, is "to promote the development of technology throughout British industry and to advance the use of British technology throughout the world". To achieve this goal, the BTG has a priceless asset: a "first bite" at the patent rights and market opportunities of any invention developed in Britain's universities and government research laboratories.

Now the departments of education and industry—against the wishes of the Treasury—want to take away that first bite. They plan to give university researchers the chance to patent and exploit their own inventions (This Week, p 141). Such a move will provoke howls of rage within the BTG—"Britain will lose the fruits of its research", "where will inventors turn to for impartial advice"—and so on. But for once, the government is right in this move to "privatisation". Although it has mended its ways in recent years, the NRDC deserves some of the criticism that has come its way. It has been too complacent in collecting large sums of money from a few lucrative inventions, such as the cephalosporin antibiotics, and has not taken on enough risky new ventures. Indeed, its method of taking decisions is inherently biased toward caution. As one vice-chancellor said to *New Scientist* this week, "a government scientist does not stand to gain anything by backing a successful idea. But if he recommends support for an idea that does not work, he will hear all about it." Caution and innovation do not mix.

So what can be done? First, the government should not abolish the BTG. If anything, like the Patent Office, it probably needs more staff to deal properly with new ideas and to advise inventors. Most importantly, it needs to be able to tackle the "pre-development gap"—the time between an idea and a prototype. To develop ideas at this stage means taking risky decisions, so the BTG must have the cash to throw after promising ideas. And it must be prepared to lose a few million pounds in the process.

Where does this leave scientists at universities? Some innovation-inclined institutions, such as Salford and Heriot-Watt, already have the expertise to put inventions on the market. Others will have to learn, and some will get their fingers burned. Without the NRDC to blame, academics will have to take the task of innovation more seriously. The British Technology Group should be there to support them—but it should not have a monopoly on Britain's brains. □

The shadow of Zeta

TWENTY-FIVE years ago Zeta was heralded as proof that science had tamed the process that powers the hydrogen bomb—fusion. Cheap electricity would soon be issuing forth from reactors fed by an inexhaustible resource—seawater. It did not work out like that, and the world still awaits that scientific proof (this issue, p 166). The scientists involved blame the press and its lurid headlines for giving people the wrong impression about Zeta. But if the project's scientists—and the intellectual giants who ran Britain's nuclear programme at the time—weren't all that sure about the measurements, why did they call large press conferences (on 23 January, 1958) and flood the scientific press with detailed descriptions of the work? The answer to these questions lies in the intense international rivalry to be first with fusion, a rivalry that persists to this day. Also still with us is the "imminent" proof that fusion will work, not to mention the hyperbolic headlines. "Scientists achieve nuclear fusion", "US triumph in race to tame nuclear fusion", they said when Princeton turned on its large new experiment (*New Scientist*, 6 January, p 8). Well, not quite. Maybe next year, or the year after. In the meantime we can mark the anniversary of Zeta. It isn't rewriting history to say that the project was a successful one, albeit less spectacular than first thought. Perhaps next time. □