most advanced and high-volume ICs resides in automated work stations that any engineer can use, semiconductor producers will have to scramble harder to earn a buck. To avoid becoming mere silicon foundries for other's designs, the chipmakers are creating their own proprietary compilers. Silicon Design Labs and SDA Systems Inc., a newcomer in Santa Clara, Calif., offer systems that enable chip designers to save their best work as building-block modules within the company's proprietary compiler. The chipmaker with the best library of design modules would presumably secure an edge over the competition. SDL reports it has already shipped 40 systems to 17 semiconductor companies, including Motorola Inc. and NCR Corp.

Hardest hit of the chipmakers will be producers of so-called standard cells. These are semicustom chips that contain small circuit modules—such as those that do multiplication and keep time—that can be mixed and matched to produce an IC. Boston's Technology Research Group Inc. predicts that compilers, which work by assembling much larger and more flexible "megacell" building blocks, will completely displace standard cells by 1995.

Standard-cell specialists such as LSI Logic, VLSI Technology, and Gould's Semiconductor Div. are rapidly building their compiler capabilities. European Silicon Structures, a startup in Munich, claims that the semiconductor factory of the future will fabricate compiler-designed chips to order. So ESS formed an alliance with Lattice Logic Inc., a compiler company in Edinburgh, Scotland.

SKEPTICISM. Compilers have limitations that draw continued skepticism, however. The biggest issue is their inability to incorporate test circuits into the finished chips. Semiconductor engineers routinely include test circuits in their ICs, but that is possible only with an intricate knowledge of how the chip works—which is exactly what the compiler is designed to eliminate. For that reason, the excitement about compilers is "much ado about not much," declares Gerard H. Langeler, executive vice-president of Mentor Graphics Corp., a supplier of computer-aided engineering systems.

The size of compiler-designed chips is the other main criticism of the technology. The new tools usually yield chips at least 10% larger than hand-crafted designs. In the semiconductor industry, where chip size is measured in square millimeters, such "waste" is a sure ticket to financial ruin. But Andrew S. Rappaport, president of Technology Research Group, argues that silicon size is "no longer an issue" for custom chips. What's important to the system builders, he says, is designing better robots or telephone switching equipment and getting them to market as fast as possible. In the fast-paced electronics industry, the rule of thumb is that a six-month delay in getting to market costs one-third of potential profits.

The compiler companies are responding by delving into the realm of artificial intelligence to fashion programs that will automatically insert test circuits. Look for the first "smart" compiler to arrive within a year. After that, experts believe the systems will grow progressively smarter, to the point where an engineer need only describe what he wants a chip to do, and the computer will take over from there. When that day comes, compilers will return full control to the systems engineers, who used to rule before the electronics industry became dependent on the semiconductor industry's standard chips.

By Richard Brandt in San Francisco, with Otis Port in New York and bureau reports

RESEARCH

BUILDING BRIDGES BETWEEN PUBLIC AND PRIVATE R&D

CONGRESS WANTS NATIONAL LABS TO SHARE THEIR TECHNOLOGY WITH INDUSTRY—FOR PROFIT

For Richard A. Cortese, it's a dream coming true. The president of Alpha Microsystems has long—and longingly—admired the Jet Propulsion Laboratory. After all, that National Aeronautics & Space Administration lab in nearby Pasadena, Calif., is a technological powerhouse. But even though his little computer company is just 45 mi. away in Irvine, Cortese never figured he stood much chance of tapping JPL's technology storehouse.

But thanks to Rimtech, a nonprofit company that aims to push JPL technology into the commercial arena, Alpha Microsystems and other Southern California companies are getting a crack at pulling JPL's space-age developments into their businesses. "The JPL expertise may give us a leg up on the competition," says Cortese, who wants to learn about JPL's techniques for compressing computer data. That could boost the capacity of Alpha's tape-based storage system for personal computers.

Rimtech—which is short for Research Institute for the Management of Technology—is a new twist in the way the country's national labs interact with industry. For an entry fee of $25,000, Rimtech helps find solutions to specific problems. It asks a company to list its technical hurdles, then checks with JPL researchers to see if they can help. The company also markets JPL technology to likely prospects. "We see ourselves as a catalyst," explains Rimtech President Steven M. Panzer.

The new program at JPL is the latest step in an effort to better utilize the enormous scientific resources of the federally funded labs. In addition to such venerable institutions as Los Alamos, Lawrence Livermore, and Brookhaven, there are 700 more lesser-known lights. Collectively, they spend more than one-third of the government's annual research and development budget—$55 billion in fiscal 1986. Their work has produced some important commercial technologies: clean rooms for the semiconductor industry and nuclear magnetic resonance imaging, to name just two.

That's why Congress told the national labs in 1980 to get more bang for the tax buck by identifying R&D with commercial potential and passing it on to industry. Most labs, however, still aren't adept at spinning off R&D. Technology transfer has often meant little more than publishing research results and hiring someone to stage seminars. "It's catch-as-catch-can," admits Ronald W. Hart, director of the National Center for Toxicological Research.

SALES INCENTIVES. NASA, for example, spends $11 million a year to peddle its technology to industry. But since it began charging for technology licenses only in 1981, it collects a paltry $100,000 a year in royalties. Even lab officials admit they haven't been very effective at transferring technology. Partly that's because their researchers have little incentive to think along commercial lines, since they don't share in patent royalties. Eugene E. Stark, chairman of an action group called the Federal Laboratory Consortium for Technology Transfer, concedes that "at best, we're only at 20% of the optimum level of transferring technology."

But Washington is about to crack the whip again. This month, Congress will probably send President Reagan new legislation aimed at fostering even

tighter links between the labs and industry. The ticket to mobilizing the labs in defense of U. S. interests, Congress believes, is to make them more businesslike—and what better way to do that than to apply the profit motive? A key provision of the House bill, passed last December, will give each lab director the authority to sell licenses to his facility's work—and allow the lab to bank the royalties. An amendment in the Senate version would compel the labs to pay at least 15% of all royalties to the researchers who patented the technology.

Some labs are already implementing new mechanisms for technology transfer. In New Mexico, both Los Alamos National Laboratory and Sandia National Laboratories have emulated a recent university practice and set up "incubator" operations to nurture entrepreneurs. Tennessee's Oak Ridge National Laboratory even has its own for-profit venture capital group. "We've spun off seven companies in the last year," boasts E. Jon Soderstrom, director of technical applications. And if Rimtech is successful at JPL, NASA plans to roll out similar programs at all of its labs.

AN ACTIVE VENDOR. The National Bureau of Standards has long been effective at transferring its technology. That agency's secret: encouraging industry to assign researchers to temporary duty in NBS labs. As many as 900 industry-sponsored researchers have augmented the NBS staff of 1,400 professionals. "Technology is in the minds of people," observes Alfred S. Joseph, chairman and founder of startup Vitesse Electronics Corp. in Camarillo, Calif. "You can either send your people to the labs, or you can bring the federal-lab people out."

Industry, however, is hardly without blame for the poor results of technology transfer. Many companies are ignorant of the new openness of federal labs. Others remain unaware that Washington has changed the rules governing licenses to permit exclusive deals. As a result, says Robert H. Pry, a technology consultant who advises Washington, "you have to do a lot of evangelism just to get them interested."

Foreign companies don't need prodding. Overseas businesspeople are flocking to the national labs. Some lab officials confide that the number of visitors from offshore, especially Japan, is frightening: They far outnumber the representatives from U. S. companies. So unless more executives like Cortese take advantage of such programs as Rimtech, promising new technologies may go begging in America, while foreigners become the first to reap the benefits of U. S. tax-supported research.

By Scott Ticer in Los Angeles

Biotechnology in Europe

MARK D. DIBNER

The countries of the European Economic Community have recently mounted considerable efforts to commercialize biotechnology. Together, these efforts approach the same number of companies and level of government spending as those in the United States. In Europe there is more government emphasis on support for industry-university collaborations and industrial projects than in the United States, where basic research is emphasized. European efforts are often not easily deline... those in the United States; many E... have extensive U.S. ope... have involv... European ... those in th...

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RECENT ... nology ... industri... date, few major p... place, and strategi... throughout the w... commercialization ... efforts and governm... are expected to be th... success (*1*, *2*). How... European-based com... nology and, although ... be considered a major competitor to ... or Japan, a coordinated effort in Europe could ... highly competitive.

The success of European biotechnology will depend on multifaceted strategies. Each country has individual programs for government funding, education, and targeted areas of support. Also, specific programs unite the biotechnological efforts of the European Economic Community (EEC). Companies have individual strategies for their success which, in turn, affect the overall strength of European biotechnology. Programs employed by European countries and companies to gain success in the commercialization of biotechnology are described in this article and strategies compared with those in the United States.

Historical Perspective

The new biotechnologies can be related to advances in genetic research during the past 30 years, mostly in the United States or in the United Kingdom (*3*). Recombinant DNA technologies that evolved from basic discoveries enabled the engineering of cells to produce protein products with great commercial importance. The lure of new products spans many industries; chemical, agricultural, pharmaceutical, and energy, among others. Although many advances in basic research were made in academic or government laboratories, the commercial applications of these processes were clear, and new companies were formed to take advantage of the new opportunities (*4*). Thus, in the 1970's, the biotechnology industry was formed. Between 1979 and 1983, more than 250 such companies were founded in the United States alone, bolstered by an abundance of venture capital (*1*, *3*, *5*). Although venture capital was not readily available in Eu... new biotechnology companies were appearing th...

... re expected to generate immense ... ticals and diagnostics made by ... expected by some estimates to ... nual revenues within the next 5 ... DNA products involved in ... biomass conversion, oil recov... care, to name just some, a ... llion for recombinant DNA ... (*7*). Thus, large corpora... been prompted to become ... strategies to do so (*8*, *9*). In ... and development, large ... tionships with academic ... in order to more quickly ... products of biotechnolo... the United States and in ...

... are composed of both small ... corporations. The products of recombinant ... not easily gained, however, because of high costs, development time, competition, and regulation. Recently, many of the small firms have reduced the sizes of their staffs, and a few have been bought by large corporations amidst predictions that many small biotechnology companies will not survive the next 5 years (*13*). Thus, the biotechnology industry is changing, and strategies of governments and individual companies play an important role in the struggle for commercial success.

European Biotechnology

As in the United States, the 1980's brought the formation of small companies in Europe to pursue the commercialization of biotechnology (*14*). Although the origin of many of these companies was the same—basic research laboratories—their original sources of funding were considerably different. In the absence of significant venture capital, many new European firms were funded with money from traditional industrial corporations and financial institutions, or by direct or indirect government support (*1*, *14*–*16*). In addition, many large European corporations initiated major programs in biotechnology (*14*).

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The actual number of European companies involved in biotechnology is an elusive figure because there are many types of involvement. A recent compilation of companies with research, development, and production activities in biotechnology contained more than 250 firms located in Europe (Table 1) (*16*). Because of small size or improper categorization some companies may have been omitted (*17*). The greatest involvement in biotechnology in Europe is in the United Kingdom, followed by West Germany and France (*1*). With large pharmaceutical companies based in Switzerland, it also has considerable biotechnology efforts. Because of concerted government involvement, the Netherlands and Italy also have government efforts related to biotechnology (*1, 16, 18*).

European companies in biotechnology have interests ranging from food processing to chemicals to pharmaceuticals (*1, 3, 16*). Some are pursuing products of their own whereas others perform contract research employing hybridoma or recombinant DNA technology. Table 2 contains the number of companies in selected European countries listed by specific areas of concentration. These areas were provided by the companies, and many companies reported involvement in more than one area (*16*). Agriculture, diagnostics, and pharmaceuticals are the strongest areas of concentration. When normalized as a percentage of total companies, the percentage of companies in the United Kingdom and Japan working on fermentation technology is higher than that in the United States, possibly because of the historical involvement of these countries in fermentation (*1, 14*).

In addition to the newly formed companies, many larger established ones have significant involvement in biotechnology (*14*). Of the 20 largest pharmaceutical companies worldwide, eight are European and have major biotechnology programs (11 are in the United States and one is in Japan) (*16, 19*). These companies, Hoechst, Bayer, Ciba-Geigy, Hoffmann–La Roche, Sandoz, Boehringer Ingelheim, Glaxo and Imperial Chemical Industries (from West Germany, Switzerland, and the United Kingdom), represent over $13 billion in 1984 pharmaceutical sales (*19*). The largest pharmaceutical companies in Belgium, Denmark, France, Italy, the Netherlands, Norway, and Sweden also have major efforts in biotechnology (*16, 19, 20*). As with large U.S. pharmaceutical companies, the target markets for the large European-based companies are not just domestic, but worldwide. In turn, many Europea biotechnology companies are attempting to address world market to be known simply as "biotechnology companies," not just a "French" or "British" companies, for example (*17*).

Table 1. European biotechnology. The number of companies with biotechnology research efforts in 1985 are listed. For comparison, there were 312 U.S. companies (*16*).

Country	Number of companies	Representative companies
Austria	4	Biochemie
Belgium	15	Celltarg, Plant Genetic Systems
Denmark	8	Novo Industri
Finland	8	Genesit, Labsystems
France	31	Elf Aquitaine, G3, Genetica, Lafarge-Coppee, Transgene
West Germany	18	Applied Biosystems, Bioferon, Biosyntech
Greece	1	Biohellas
Hungary	7	
Ireland	12	Biocon, Bioquest
Israel	16	Interpharm Laboratories
Italy	16	Erbamont, Sorin Biomedica
Netherlands	12	Gist Brocades
Norway	3	
Spain	5	
Sweden	17	Cardo, KabiVitrum, Pharmacia
Switzerland	16	Ares Applied Research
United Kingdom	79	Celltech, Fermentech, Microbial Resources

Table 2. Involvement in specific areas of biotechnology. Data are selected t indicate the number of companies working in the indicated areas o concentration. U.S. and Japanese data are provided for comparison (*16, 20*).

Area	France	Italy	West Germany	United Kingdom	United States	Japa
Agriculture	5	1	2	15	73	12
Antibiotics	1	2	4	1	4	8
Chemicals	1	—	1	4	37	31
Diagnostics	3	5	6	10	141	15
Fermentation	3	—	—	6	21	13
Food	2	—	1	12	18	17
Hybridomas	2	4	4	4	50	13
Pharmaceuticals	2	5	4	5	28	28
Total	31	16	18	79	319	161

Larger companies, with their multinational presence and immens resources, have access to facilities that transcend national boundari (*15*). One example is the West German chemical and pharmaceutic giant Hoechst, which has donated a total of $100 million t Harvard University and Massachusetts General Hospital in order t gain access to basic research in molecular biology and to train i scientists (*16, 20*). Hoechst also has subsidiaries in the United Stat and France. In addition, Hoechst has formed coventures in biotec nology with firms in the United States, the United Kingdom, an Japan (*16*). Being able to work on all these fronts enables Hoech and other large companies to gain expertise and increase the chance of commercial success. The smaller European biotechnolog companies usually compete without the benefits of access to glob resources (*15*).

Government Coordination and Support of Biotechnology

With the lure of high revenues, governments in some Europe countries have sponsored multifaceted programs to achieve succ in biotechnology. Government strategies include support for ac demic programs in relevant sciences, support for new compani entering the industry, support for large corporation-based proje in biotechnology, and support for industry-industry or industr academic interactions (*21*). In contrast, U.S. government support primarily for basic research with little for the private sect although the presence of venture capital may obviate this need (*1, 5, 16*). Further, European government programs are aimed at lar targeted projects or commercial goals, whereas U.S. governm programs have less direct focus on commercial success (*1, 5, 1* However, recent U.S. funding of a large Center on Biotechnolo Process Engineering at the Massachusetts Institute of Technolo and other smaller programs may indicate a broadening of U. government focus in support of biotechnology (*2, 5*).

The combined government support in all European countri approaches the same level as U.S. government support, but t focus of support of the largest government programs is qu different (Table 3) (*15*). Some individual government programs described below.

United Kingdom. Support for biotechnology in the United Ki dom was minimal before 1980, when the Advisory Council Applied Research and Development published their report biotechnology (*22*), outlining shortcomings in the ability to deve biotechnology in the United Kingdom and recommending spec strategies to counteract them. Particularly encouraged were the transfer of technology from the public sector to industry and the enlargement of programs for basic research and innovation (*22*). The British government responded with a broad program of support (*23*).

Public funding in the United Kingdom comes from a number of sources. The Department of Trade and Industry (DTI) funds training programs, innovative industrial projects, and is establishing centralized database and cell depository centers (*16, 23*). The Science and Engineering Research Council (SERC) is developing a program to advance nine priority sectors (*15, 23*). The Medical Research Council (MRC) funds extramural programs as well as in-house research at its various units, including the Laboratory of Molecular Biology in Cambridge that has been the home of many Nobel laureates including Francis Crick, Frederick Sanger, James Watson, Cesar Milstein, and George Koehler (*3*).

The British Technology Group (BTG), a public corporation, was funded by DTI to assist in the transfer of biotechnology from the basic research laboratory through commercialization. As such, BTG is a public source of venture capital. For example, Celltech was formed in 1980, funded by BTG and four corporations, and given the first right of refusal for patents related to genetic engineering and hybridoma technologies that came out of in-house MRC research (*1, 24*). Thus far, Celltech has had considerable success, especially with monoclonal antibody technology and the scale-up production of custom-made antibodies. In 1984, Celltech's exclusive access to MRC patents was renegotiated and suspended, leading to their transition from government control to becoming a public company (*24*). This is an excellent example of a government-coordinated effort to foster the development of technology and, with its success, allowing private enterprise to take over. Another example is the transfer of the Centre for Applied Microbiology and Research (CAMR) to the Porton International Group, a private investment group with industrial and banking shareholders (*16*). CAMR was started as part of the Public Health Laboratory Service with eight laboratories related to microbiology and biotechnology.

A major focus of the British government's strategy is to scale up biotechnological processes. By making an effort to concentrate on production, the United Kingdom is hoping to attract foreign companies to locate manufacturing facilities within the British Isles or to gain revenues and employment by contract production. This strategy is apparently working; at least four foreign pharmaceutical manufacturers have gone to the United Kingdom for production (*20*). However, it is possible that the United Kingdom and other European nations cannot be competitive in scale-up production because of high costs of fermentation nutrients due to EEC pricing policies (*25*).

West Germany. The Federal Ministry for Research and Technology (BMFT) funds biotechnology research in West Germany with specific goals, such as basic technology development and technology transfer from academia and government to industry (*1, 26*). Especially supported are projects that address West Germany's traditional strength in fermentation processes (*14*). The BMFT also funds grants to institutes (such as the Max Planck Institute), universities, and government laboratories. The most notable government research center is the Society for Biotechnological Research (GBF), which has a research staff to perform basic studies and provide services to the public and private German community. A major focus of the GBF is to foster technology transfer to industry (*1, 14, 16, 26*). The goals of the GBF include bioprocess and scale-up technologies, joint projects with industry, and interdisciplinary training. The GBF is now considered one of the best biotechnology research facilities in Europe (*1*).

France. Despite a late entry into biotechnological research, the French government has stated a goal of capturing a 10% share of the world market for biotechnology by 1995 (*14, 16*). Government funding is provided by the Ministry of Research and Industry and specific government institutes. In an effort to support future commercialization, the major focus of government support is technology transfer to industry. Research centers, such as the Centre National de la Recherche Scientifique (CNRS) and the Institut de la Santé et de la Recherche Médicale (INSERM) have research programs in molecular biology (*27*). Despite these efforts, technology transfer from academia to industry in France has been reported to be far less than optimal (*1*).

In contrast, a number of institutions with a large percentage of government support have gained significant strength in biotechnology. The Institut Pasteur receives almost half its funding from

Table 3. Government funding of biotechnology (*1, 16, 20*).

Country	Government branch or institute	Goals and favored technologies	Annual funding ($\times 10^6$)*
France	Institut de la Recherche et l'Industrie; other biomedical agencies	Academic-industry collaboration Commercial processes Bioprocess scale-up	$100
West Germany	Ministry for Research and Technology; Society for Biotechnological Research	Academic-industry collaboration Technology transfer Basic biotechnology Scale-up Pharmaceuticals New compounds	$120
Netherlands	Ministry of Science Policy	Five-year plan to foster collaborations Scale-up	$30
Switzerland	Federal Institute of Technology	University-industry collaboration Bioreactor designs	
United Kingdom	Department of Trade and Industry; Medical Research Council; Science and Engineering Research Council; British Technology Group	Fund industrial projects Technology transfer to industry Scale-up Fermentation Downstream processing	$80
United States	National Institutes of Health; National Science Foundation; departments of Agriculture, Energy, Defense	Basic research (95%) Applied generic research (<5%)	$750

*Data are approximate for years 1983–1985 (*1, 5, 14–16*).

Table 4. European presence in the United States. European pharmaceutical companies with major U.S. operations and their world rank in 1984 pharmaceutical sales (*1, 19, 20*).

Company	Rank
Amersham (United Kingdom)	
Bayer (West Germany)	4
Ciba-Geigy (Switzerland)	5
Glaxo (United Kingdom)	18
Hoechst (West Germany)	3
Hoffmann–La Roche (Switzerland)	11
Imperial Chemical Industries (United Kingdom)	20
Rhone-Poulenc (France)	26
Sandoz (Switzerland)	12
Wellcome Foundation (United Kingdom)	23

Table 5. European companies with U.S. subsidiaries involved in biotechnology (*16, 19, 20*).

Company	Subsidiary
Bayer	Cutter Labs
	Miles Labs
	Molecular Diagnostics
Biocon (United Kingdom)	Biocon (United States)
Boehringer-Mannheim	Boehringer-Mannheim Biochemicals
Elf Aquitaine	Ceva Labs
Fisons PLC (United Kingdom)	United Diagnostics
Gist Brocades (Netherlands)	Gist Brocades (United States)
Hoechst	American Hoechst
	Hoechst-Roussel Pharmaceuticals
Imperial Chemical Industries	Stuart Pharmaceuticals

government grants. Institut Pasteur Production, a private company jointly owned by the Institut Pasteur and Sanofi (part of Elf Aquitaine, a nationalized pharmaceutical and chemical corporation) receives first right of refusal for discoveries in many areas of research conducted at the Institut Pasteur (*16*). Two other large pharmaceutical and chemical companies with substantial biotechnology programs are owned by the French government: Roussel Uclaf (a subsidiary of Hoechst, 40% owned by the French government) and Rhone-Poulenc (100% government owned) (*1, 16*). With the nationalization of these corporations, the French government is directly involved in the business of biotechnology and thus plays a large role in the commercial success of biotechnology in France.

Other countries. A few other European countries, such as the Netherlands, Switzerland, Belgium, and Italy, have government programs to develop biotechnology. These programs are more modest than those in the United Kingdom, West Germany, and France, but the goals are similar—technology transfer to industry and commercialization. Of course, there are individual approaches. The Netherlands, for example, has launched a program of support for biotechnology that includes tax and funding incentives to recruit biotechnology companies to locate facilities within its borders (*16, 21*).

Although government intervention in the commercialization of biotechnology has been predicted to play an important role in national success, the strength of individual companies also lends to that success. One company considered a leader in biotechnology in Europe is Novo Industri, which is based in Denmark, a country with no major national policy for supporting biotechnology (*16*). Novo, in collaboration with Squibb, has begun marketing its human insulin produced from genetically altered porcine insulin, a potential challenge to Lilly's recombinant DNA insulin market (*16*). Nevertheless, the greatest benefit of European government programs is likely to come from the transfer of people and ideas between the university and corporate sectors. This transfer generally does not occur easily without intervention (*15*).

Scientific Manpower

Two distinct categories of manpower requirements are necessary in biotechnology. For basic research, access to laboratory scientists engaged in molecular biology, genetics, and immunology is necessary. For commercialization and scale-up there must be sufficient manpower in bioprocess engineering. To achieve success in biotechnology, a country must have training programs and trained personnel in both areas. A few years ago, there was a projected shortage of researchers in the United States trained in molecular biology (*28*). Although this situation has abated, there is increasing concern that only few programs of instruction in bioprocess engineering are located in the United States (*1, 2, 29*). Japan reportedly has an ample supply of bioprocess engineers, which may contribute to their predicted commercial success (*2*).

In Europe the availability of trained personnel varies by country. The United Kingdom has sufficient training of basic research personnel (*1*). However, personnel trained in scale-up may be in short supply, in part due to a low salary scale and leading to a "brain drain" to other countries (*1, 14*). The outlook is brighter for West Germany, which has been training personnel in bioprocess engineering and in the new basic technologies for many years (*1, 14*). In France, the picture is much less optimistic, with predicted serious shortages in both categories of manpower (*1*). How this situation affects a country's success in biotechnology should become apparent within the next few years, as more products reach the marketplace.

European–U.S. Interactions

Many of the companies involved in biotechnology in Europe are large corporations with a considerable presence in the United States. Table 4 lists ten European corporations, including some of the world's largest multinational chemical and pharmaceutical companies, that have major U.S. operations (such as research or manufacturing facilities). For example, Ciba-Geigy has located its agricultural biotechnology research group in the United States (*16*). In Table 5 are eight European corporations involved in biotechnology that own U.S. subsidiaries. The Japanese presence in the United States is less obvious (*2*). With major research and development operations in the United States, European companies gain immediate access to trained manpower and proximity to the hundreds of U.S. biotechnology companies.

Just as the large U.S. and Japanese corporations work with U.S. biotechnology companies to gain access to basic research and development, so, too, do European corporations (*2, 8*). Joint efforts between European companies and U.S. biotechnology firms involving pharmaceuticals are shown in Table 6. The list of products involved is virtually identical to products being developed in conjunction with Japanese and U.S. corporations (*2, 20, 29*). Most of the European corporations listed in Table 4 already have substantial U.S. marketing operations and are well poised to capture a substantial U.S. market share for their products.

Many U.S. corporations have significant European subsidiaries or facilities. Also, many U.S. and Japanese companies have joint ventures with European biotechnology companies. For example, Celltech has joint agreements with Interferon Sciences and Serono Laboratories of the U.S., as well as with Sankyo and Sumimoto of Japan (*16*). However, there are no clear examples of U.S. firms with the majority of their biotechnology research facilities in Europe.

Current drug export laws in the United States do not generally allow the export, for purposes other than clinical testing, of drugs that have not received full Food and Drug Administration (FDA) approval. However, regulatory agencies in some European countries may approve the release of a compound before approval is completed in the United States. To gain access to European markets before FDA approval is granted, many U.S. pharmaceutical companies have built manufacturing facilities in Europe and other parts of the world (*30*). One U.S. biotechnology firm, Centocor, recently built a manufacturing facility in the Netherlands, at least in part for the same reason (*31*). If the U.S. drug exportation laws are not modified, this trend will likely continue (*18*). In addition, with European labor costs at 40 to 75% of those in the United States, and with European government programs to attract industry, U.S. firms have further incentive to locate facilities abroad (*22, 32*).

Consolidating European Efforts

Individual European countries have resources and industrial efforts in biotechnology that are overshadowed by those in the United States. However, as an aggregate, European biotechnology is almost as large in number of companies, training, and government funding. Historically, the unification of European countries has been difficult, but specific programs are directed at consolidating biotechnology efforts in Europe.

Realizing that European biotechnology might lag seriously behind programs in the United States and Japan, the Commission of the European Communities created programs to assist long-term research and development priorities in Europe (*33*). The Biomolecular Engineering Program, first proposed in 1976, was initiated in 1982 to support specific research projects (*15*). This program, due to end this year, has spent about $15 million on 100 contracts, yielding highly successful research, especially in the area of plant molecular biology. Another 5-year program, FAST (Forecasting and Assessment in Science and Technology), was initiated in 1978 to determine futures in science and technology (*15, 33*). Weaknesses in European biotechnology were noted, including lack of cohesiveness, emigration of scientists and isolation of individual efforts, thus preventing the attainment of "critical mass" (*33, 34*). Steps had to be taken to allow the European Community to create a concerted effort in biotechnology (*34*). The Biotechnology Action Program was established, along with the Concertation Unit for Biotechnology in Europe (CUBE), to help monitor and coordinate the program (*33, 35*). This six-point program was proposed in late 1983 and included support of research and training, concertation of government policies involving biotechnology processes, uniform regulatory policies and patent laws, and other special projects (*34*). Although not approved until March 1985 and funded at about $50 million (two-thirds of the requested budget), many research projects have already received support, especially transnational projects (*15, 34*). It is, however, too early to tell whether these programs will enable European biotechnology to coordinate efforts and allow Europe to catch up with the United States or Japan.

One program with funding from the European Commission is the European Biotechnology Information Project (EBIP), housed in the Science Reference Library in London. According to its director, John Leigh, the main purpose of EBIP is to "act as a focus for biotechnology information within the European Community" (*36*). Toward this end, EBIP conducts seminars in biotechnology information since "there is a need for a more cohesive approach to biotechnology information within the European Community . . . a federation of countries with different customs and languages, the EEC lacks the fluid exchange of information which Japan and the United States do have," according to Leigh (*36*).

Another group working on coordinating biotechnology in Europe is the European Federation of Biotechnology. Founded in 1978, this group now has 52 member societies from 17 European countries. Their goal is to promote the interdisciplinary nature of biotechnology and its development in Europe through working parties, conferences, and documentation (*37*). In addition, they organize a European Congress of Biotechnology every 3 years, next scheduled for May 1987 in The Hague (*37*).

Also serving biotechnology in Europe is the European Molecular Biology Organization (EMBO), based in West Germany. The primary functions of EMBO are to promote transfer of information about molecular biology and to promote basic research (*38*). The

Table 6. Joint agreements between U.S. biotechnology companies and European companies. Joint efforts involving pharmaceutical products between 1982 and 1985. Abbreviations: IFN, interferon; mAb, monoclonal antibody; KPA, kidney plasminogen activator; IL-2, interleukin-2; hGH, human growth hormone; HSA, human serum albumin; and CSF, colony-stimulating factor (*1, 16, 20*).

U.S. company	European company	Product
Biogen	Bioferon (West Germany)	IFN
Biogen	Burroughs-Wellcome (United Kingdom)	Vaccine
Biogen	KabiVitrum (Sweden)	Factor VIII
Centocor	Hoffmann–La Roche (Switzerland)	mAb's
Cetus	Roussel Uclaf (France)	Vitamin B_{12}
Collaborative Research	Sandoz (Switzerland)	KPA
Damon Biotech	Hoffmann–La Roche	mAb's
Flow Labs	Bioferon	IFN
Genentech	Gruenenthal GMBH (West Germany)	Urokinase
Genentech	Hoffmann–La Roche	IL-2
Genentech	KabiVitrum	hGH
Genentech	Speywood Labs (United Kingdom)	Factor VIII
Genetics Institute	Sandoz	IL-2
Genetic Systems	Cutter Labs (Bayer)	mAb diagnostics
Genetic Systems	Institut Pasteur (France)	Diagnostics
Genetic Systems	Miles Labs (Bayer)	mAb's
Genex	KabiVitrum	HSA
Genex	Schering AG (West Germany)	Blood protein
Hana Biologics	Recordati S.p.A. (Italy)	mAb diagnostics
Hybritech	Boehringer-Mannheim	mAb's
Immunex	Behringwerke (Hoechst)	CSF
Unigene Labs	Sigma-Tau S.p.A. (Italy)	Diagnostics

first function is accomplished by sponsoring workshops, courses, and other educational programs. The second important function is the basic research taking place in their centralized facilities, the European Molecular Biology Laboratory (EMBL) in Heidelberg. A third function is the funding of short-term and long-term fellowships for study in molecular biology totaling about 400 each in 1985 (*38*). According to its Executive Secretary, John Tooze, "EMBO does not see itself responsible for promoting biotechnology in Europe as such, but rather for promoting basic molecular biology in Europe. Of course, the biotechnology programmes and biotechnology companies recruit from the academic molecular biologists who benefit from EMBO's activities" (*38*).

Lastly, with a worldwide concern about the safety of molecular biological processes, the Organization for Economic Cooperation and Development (OECD) is in the process of creating a uniform set of guidelines to govern the use of these technologies. Along with many EEC countries, the United States has participated in this process. By providing a uniform set of regulations, the OECD guidelines should facilitate the transfer of biotechnology between countries and assist the commercialization process. On the other hand, the OECD guidelines will be in the form of advice rather than law. Also, it is not certain whether forthcoming U.S. government guidelines will encompass OECD guidelines and thus place U.S. firms in a favorable competitive position in Europe (*39*).

Conclusions

The term "European biotechnology," like "U.S. (or Japanese) biotechnology," is highly misleading. Clearly, European biotechnology is the summation of many efforts in biotechnology; it encompasses the activities of hundreds of companies and many governments. However, with billions of dollars and thousands of jobs at stake, if any one of these "entities" can achieve a competitive edge in biotechnology, considerable reward should follow. What distinguishes European biotechnology is that many different nations make up the aggregate effort, with their distinct programs, levels of support, targeted research areas, and so on. There are also strong individual company efforts in Europe, such as those by Novo Industri, Celltech, Elf Aquitaine, Hoechst, Bayer, Transgene, and others. Government programs in the United Kingdom, West Germany, and France appear strong, but, as with most ventures in biotechnology, the full extent of their success remains to be determined.

Three key features of European biotechnology bear repeating as they may lead to the success of the aggregate program. First, European programs that transcend national boundaries should enhance the aggregate program. Most notable in this category are the programs of the EEC Commission, which will provide common resources and foster collaboration, as well as the EMBO programs, which provide a unified source of training. Second, is the common focus on technology transfer seen in individual government programs as well as the EEC programs. By supporting academic-industry joint projects and the transfer of research from government laboratories to industry, these programs should facilitate the commercialization process. Although a passive transfer of biotechnology to industry in all countries normally exists, there has been little effort on the part of the U.S. government to assist in this process, possibly decreasing the future competitive strength of U.S. biotechnology. Third, the distinction between U.S. and European biotechnology is not as fine as that between U.S. and Japanese biotechnology. Many large European-based companies, such as Bayer, Hoechst, Ciba-Geigy, Hoffmann–La Roche, Wellcome, and Sandoz, have previously penetrated U.S. markets and have U.S. facilities for research and development. These companies thus have ready access to U.S.-trained personnel, as well as access to scale up in their home countries.

The race for success in the commercialization of biotechnology will have no clear winners for many years. Recent reports have predicted a close race between the United States and Japan. European biotechnology, although a dark horse, should not yet be eliminated from the running. Already, individual efforts from European companies are showing the first signs of success. If cohesiveness and critical mass can be achieved in the aggregate program, European biotechnology has the potential to become a strong competitor in the long run.

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BUILDING BRIDGES BETWEEN PUBLIC AND PRIVATE R&D

CONGRESS WANTS NATIONAL LABS TO SHARE THEIR TECHNOLOGY WITH INDUSTRY—FOR PROFIT

For Richard A. Cortese, it's a dream coming true. The president of Alpha Microsystems has long—and longingly—admired the Jet Propulsion Laboratory. After all, that National Aeronautics & Space Administration lab in nearby Pasadena, Calif., is a technological powerhouse. But even though his little computer company is just 45 mi. away in Irvine, Cortese never figured he stood much chance of tapping JPL's technology storehouse.

But thanks to Rimtech, a nonprofit company that aims to push JPL technology into the commercial arena, Alpha Microsystems and other Southern California companies are getting a crack at pulling JPL's space-age developments into their businesses. "The JPL expertise may give us a leg up on the competition," says Cortese, who wants to learn about JPL's techniques for compressing computer data. That could boost the capacity of Alpha's tape-based storage system for personal computers.

Rimtech—which is short for Research Institute for the Management of Technology—is a new twist in the way the country's national labs interact with industry. For an entry fee of $25,000, Rimtech helps find solutions to specific problems. It asks a company to list its technical hurdles, then checks with JPL researchers to see if they can help. The company also markets JPL technology to likely prospects. "We see ourselves as a catalyst," explains Rimtech President Steven M. Panzer.

The new program at JPL is the latest step in an effort to better utilize the enormous scientific resources of the federally funded labs. In addition to such venerable institutions as Los Alamos, Lawrence Livermore, and Brookhaven, there are 700 more lesser-known lights. Collectively, they spend more than one-third of the government's annual research and development budget—$55 billion in fiscal 1986. Their work has produced some important commercial technologies: clean rooms for the semiconductor industry and nuclear magnetic resonance imaging, to name just two.

That's why Congress told the national labs in 1980 to get more bang for the tax buck by identifying R&D with commercial potential and passing it on to industry. Most labs, however, still aren't adept at spinning off R&D. Technology transfer has often meant little more than publishing research results and hiring someone to stage seminars. "It's catch-as-catch-can," admits Ronald W. Hart, director of the National Center for Toxicological Research.

SALES INCENTIVES. NASA, for example, spends $11 million a year to peddle its technology to industry. But since it began charging for technology licenses only in 1981, it collects a paltry $100,000 a year in royalties. Even lab officials admit they haven't been very effective at transferring technology. Partly that's because their researchers have little incentive to think along commercial lines, since they don't share in patent royalties. Eugene E. Stark, chairman of an action group called the Federal Laboratory Consortium for Technology Transfer, concedes that "at best, we're only at 20% of the optimum level of transferring technology."

But Washington is about to crack the whip again. This month, Congress will probably send President Reagan new legislation aimed at fostering even tighter links between the labs and industry. The ticket to mobilizing the labs in defense of U.S. interests, Congress believes, is to make them more businesslike—and what better way to do that than to apply the profit motive? A key provision of the House bill, passed last December, will give each lab director the authority to sell licenses to his facility's work—and allow the lab to bank the royalties. An amendment in the Senate version would compel the labs to pay at least 15% of all royalties to the researchers who patented the technology.

Some labs are already implementing new mechanisms for technology transfer. In New Mexico, both Los Alamos National Laboratory and Sandia National Laboratories have emulated a recent university practice and set up "incubator" operations to nurture entrepreneurs. Tennessee's Oak Ridge National Laboratory even has its own for-profit venture capital group. "We've spun off seven companies in the last year," boasts E. Jon Soderstrom, director of technical applications. And if Rimtech is successful at JPL, NASA plans to roll out similar programs at all of its labs.

AN ACTIVE VENDOR. The National Bureau of Standards has long been effective at transferring its technology. That agency's secret: encouraging industry to assign researchers to temporary duty in NBS labs. As many as 900 industry-sponsored researchers have augmented the NBS staff of 1,400 professionals. "Technology is in the minds of people," observes Alfred S. Joseph, chairman and founder of startup Vitesse Electronics Corp. in Camarillo, Calif. "You can either send your people to the labs, or you can bring the federal-lab people out."

Industry, however, is hardly without blame for the poor results of technology transfer. Many companies are ignorant of the new openness of federal labs. Others remain unaware that Washington has changed the rules governing licenses to permit exclusive deals. As a result, says Robert H. Pry, a technology consultant who advises Washington, "you have to do a lot of evangelism just to get them interested."

U.S. PATENT PRODUCTIVITY

Analysis shows a decline in inventive output for the U.S. chemical industry between 1965 and 1980 that may well be representative of industry as a whole.

Stephen F. Adler and Herbert H. P. Fang

On the basis of trends in patenting activity, one of us reported in an earlier study that there was compelling evidence of a decline in innovative activity in the U.S. for the period 1965–1975 (*1*). During the past decade or more, other observers have reached the same conclusion by other methods of measurement or reasoning (*2,3*). Since no one has yet proclaimed a renaissance of innovative activity, we may assume that things are still as they were or that they may have gotten worse.

The study reported in this article includes data from the mid-1960s through 1982–83 to get a longer view of this phenomenon. We have also examined several variables not studied in the first paper to see if we can better understand what accounts for the patterns of patenting activity both by U.S. industry and within various segments of the industry.

Recognizing that there are year-to-year variations in the patents issued by the U.S. Patent Office, most of the data used in this paper are running three-year averages reported for the second year of the period. The smoothed data for 1966–1982 (Figure 1) show that the total number of patents per year rose from ca. 60,000 in 1966 to ca. 75,000 in the early 1970s (*4,5*). Since about 1977, the level of activity has again declined to ca. 60,000. The data contain an important underlying message about the nationality of the inventors. Non-U.S. inventors have increased their absolute rate of generation from ca. 10,000 to ca. 25,000 patents per year. During the same period, U.S. inventors' production declined from ca. 50,000 to ca. 35,000 patents per year. In 1965, about 20 percent of U.S. patents were issued to non-U.S. inventors (Figure 2); by 1983, that figure had risen about 41 percent, and the Patent Office reports that for 1985 it was 43.9 percent.

The decline in U.S. inventive output is the most fundamental observation we have made. All of the other facts and observations that follow are merely elaborations of this.

In the earlier study we analyzed patent generation and R&D expenses over a decade for the 12 largest chemical companies. The R&D expenses were published figures corrected for inflation. The patent data were obtained from Information For Industry. A minor concern in the first study was that not all of the patents issued to any one company might have been counted because of assignments to subsidiaries with names that might not have been included. In the present paper, the patent data are those that were graciously supplied by each of the chemical companies (*6*).

The so-called "Big 12" companies can be used to monitor the activity of the chemical industry because they account for a large fraction of research expenditures and patent activity for that industry. For example, the "Big 12" spent ca. 40 percent of the industry's research dollars and got ca. 30 percent of the patents. Figure 3 shows how the "Big 12" share of the U.S. patents granted to U.S. inventors has changed between 1967 and 1980. Since 1974, that share has been down to a nearly constant 5.1 percent starting from ca. 6.5 percent at the beginning of the period. There is, thus, a double decline to be noted—(a) U.S.-invented patents have declined both in absolute terms and as a percent of the total patents, and (b) the chemical industry is getting a reduced share of that smaller pool.

Patent Productivity

"Patent productivity" is the ratio of patents issued in any year to the money expended on R&D in the same year. It has units of number of patents/$MM of R&D. Admittedly, this productivity quotient is simplistic because it ignores expenditures that do not have patents as an expected outcome. It also sidesteps the question of the time lag between the doing of the research and the issuance of the patent. Nevertheless, patent productivity is a concept that is useful for tracking an industry or a company to spot trends over a period of time. In this paper, the number of patents will always be the smoothed average and expenditures will always be reported as constant 1967 dollars by correcting actual figures with GNP price deflators (*7*).

Figures 4, 5 and 6 show the patent productivity for the "Big 12" as a function of time in groups of four companies arranged according to sales volume. The four largest companies (Du Pont, Union Carbide, Dow

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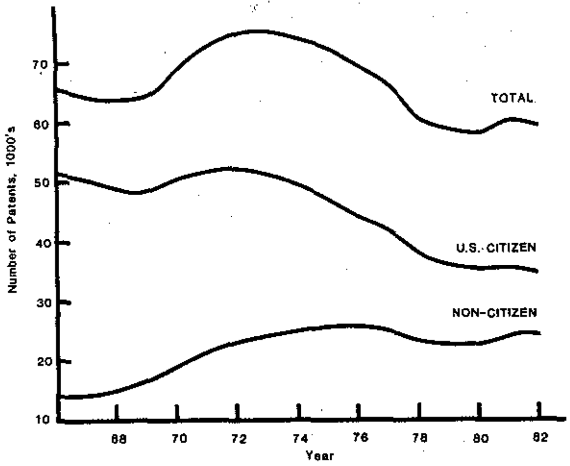

Figure 1.—U.S. Patents Issued.

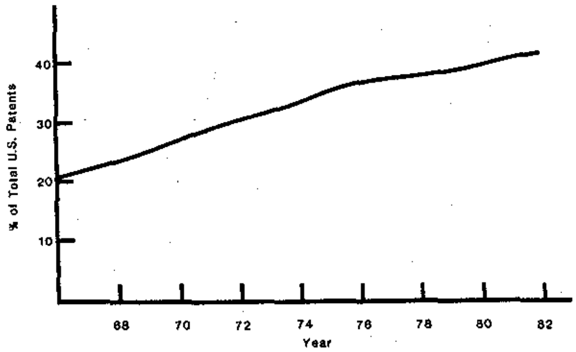

Figure 2.—Percent of U.S. Patents By Non-Citizens.

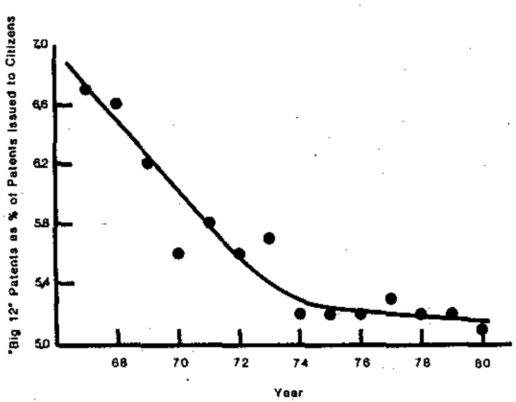

Figure 3.—Percent of U.S. Patents Issued To "Big 12" Chemical Companies.

and Monsanto) show a similar pattern. The data show an inverse relationship between patent productivity and company sales. This fact is examined in more detail in a following section. The middle group (Allied, Celanese, American Cyanamid and Hercules) follows a somewhat different pattern with time, with a more distinct maximum for each curve in the mid-1970s followed by a steep decline. There is once again the observation that patent productivity is apparently larger when sales volume is lower. In the third group, the curves for Ethyl and Stauffer have the maximum in the mid-1970s as noted in Figure 6, but Olin and Rohm and Haas have very different shapes. Also, one cannot say for Figure 6 that there is an obvious correlation between productivity and company size.

In the view of people who see research as a vital function of a corporation, sales might be expected to increase with more research (of the right kind). The same might be said of patents. That is, more research should lead to more patents. Figures 7 and 8 show how patents vary with R&D expenses for the "Big 12" (in constant 1967 dollars). The expected relationship of more patents with greater research expenditures is readily seen.

When the same analysis is made once more for patent productivity (number of patents/$mm of R&D), the picture is entirely different. We plot patent productivity against sales for two periods, 1971–75 and 1976–80 (*8*). Figures 9 and 10 show that productivity varies inversely with sales volume. What this says is that the efficiency of the R&D organization in producing patents goes down as the size of the parent corporation in constant 1967 dollars gets bigger. Is there no efficiency of scale in this process? We will return to this question again.

Figures 11 and 12 show the relationship of patent productivity to the percent of sales allocated to R&D. The two periods are once again 1971–75 and 1976–80, respectively. Although some scatter is seen in both plots, the predominant feature is an inverse relationship of patent productivity to R&D as a percent of sales. Both the abscissa and the ordinate refer to quantities that are the ratio of an output to an input:

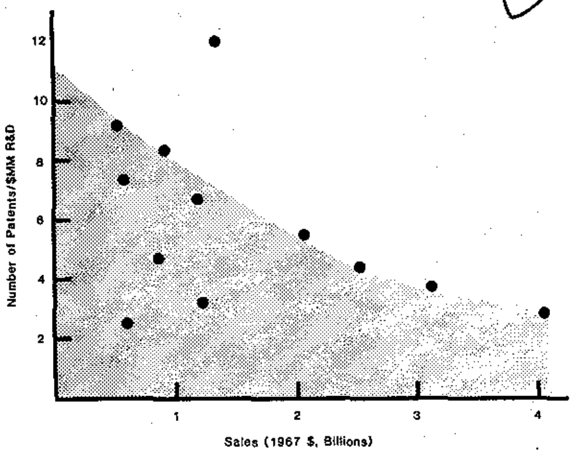

Figure 9.—Patent Productivity Vs. Sales (1971–75 Average).

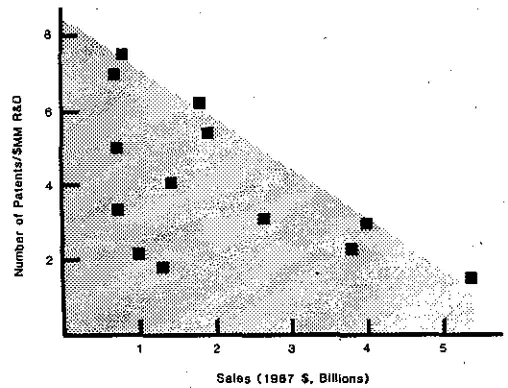

Figure 10.—Patent Productivity Vs. Sales (1976–80 Average).

$$\frac{\text{R\&D expenditure}}{\text{Sales volume}} \quad \text{and} \quad \frac{\text{Number of patents}}{\text{R\&D expenditure}}$$

It is also possible to see whether patent productivity increases with the absolute level of R&D expenditure. This is the most direct way to test the efficiency of the "process" of producing patents. In other words, if there is efficiency of patent productivity, we should see it reflected in the absolute size of the R&D organization and, therefore, in its annual expenditures. Figures 13 and 14 present these data. There is no doubt that, for both time periods, patent productivity decreases as the absolute level of R&D expenditure increases. It is not at all clear why patent productivity does not increase instead. The expected increase in efficiency is simply not there. In fact, larger R&D units become less efficient in the context of this paper.

One might wonder whether the findings about patent productivity for the chemical inudstry can be explained by the position of the "Big 12" relative to the U.S. as a whole. Table 1 shows the sales, R&D expenditures, sales volume, patents and patent productivity of the "Big 12" compared to total U.S. figures.

The table shows that sales, as a fraction of GNP, increased 17 percent but that R&D expenditures rose only about one-sixth as much from the early 1970s to the late 1970s. During that period the fraction of U.S. patents assigned to the "Big 12" declined 5 percent. (The patent statistics of the years 1982–84 show a modest upturn in the number of patents for the companies in the "Big 12." However, the ratio of patents to constant dollar R&D has continued to decline to ca. 1.2 for the group.) The large chemical companies invested more in research and got fewer patents out of the process. The data, when stated in terms of patent productivity, show that the "Big 12" had a decrease in the period studied that was half again as big as the 27 percent reduction experienced by the entire U.S. That is to say, the "Big 12" (and the chemical industry by extension) behaved like the whole country, just more so.

A comparison of the patent activity of the chemical industry with other industries is beyond the scope of this paper although it might lead to some important conclusions. However, one can choose representative companies from other business sectors and look for similarities in patent productivity. Table 2 presents such information for a group of companies compared to the "Big 12" and to Du Pont as a representative of the chemical group, and for the U.S. on average.

The data in Table 2 show that most of the companies have had reduced patent productivity and in three cases a larger reduction than is true for the "Big 12." Only one company in this group, General Electric, shows an increase of 14 percent. Further, the absolute level of productivity for the "Big 12" is higher in both periods than for any of the other companies reported. The picture that emerges is that most sectors of U.S. industry were declining in patent productivity over the decade of the 1970s and that the chemical industry is not atypical. Thus, if there is an innovation malaise, it is very widespread, and all sectors of U.S. industry need to be concerned.

Interpreting the Data

Before proceeding to a detailed examination of U.S. patent productivity, we should note that Gilman described another concept in 1981 which he called "patent inventivity" (*9*). This quantity is the ratio of patents issued to sales volume. He concluded from an analysis of patent inventivity that the largest companies were less inventive than smaller ones. This result was disputed by Jackson et al. who felt that Gilman had used a sample that led to an incorrect conclusion (*10*). Gilman and Siczek subsequently reported on a function that is the same as the one that we had

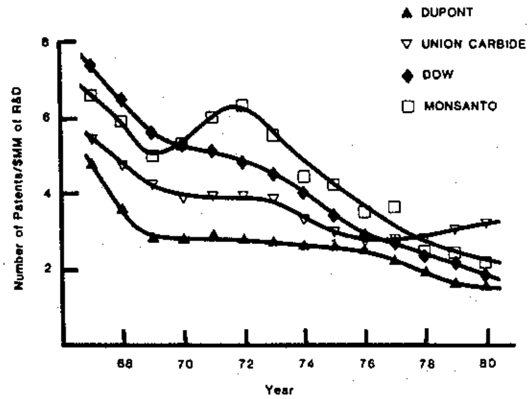

Figure 4.—Patent Productivity Vs. Time.

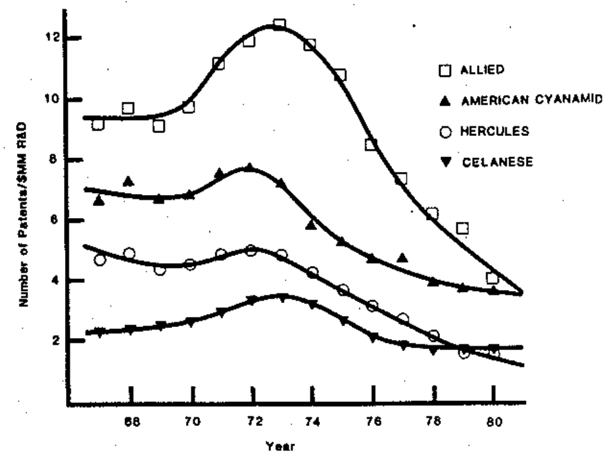

Figure 5.—Patent Productivity Vs. Time.

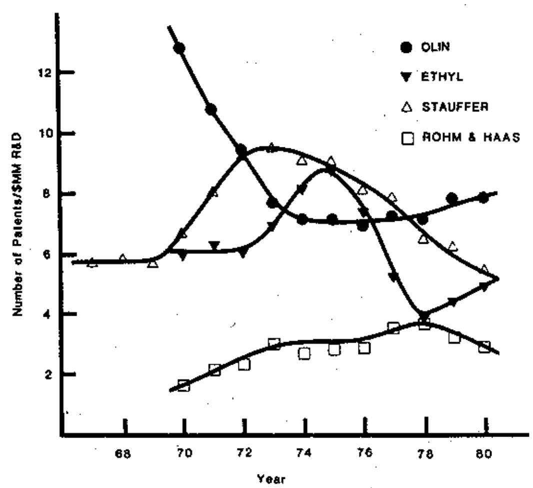

Figure 6.—Patent Productivity Vs. Time.

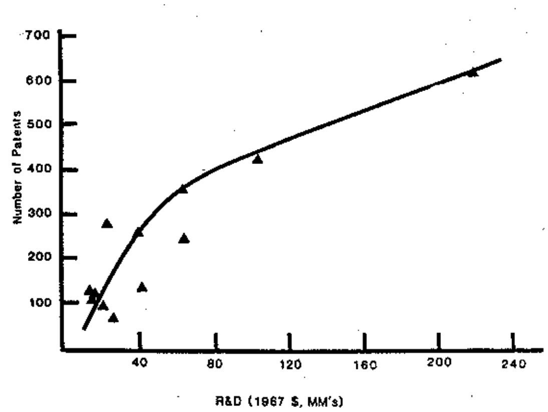

Figure 7.—Patents Vs. R&D (1971–75 Average).

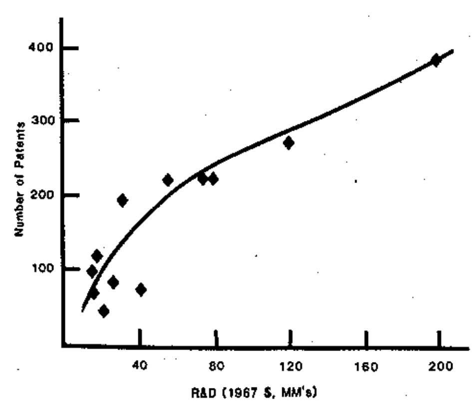

Figure 8.—Patents Vs. R&D (1976–80 Average).

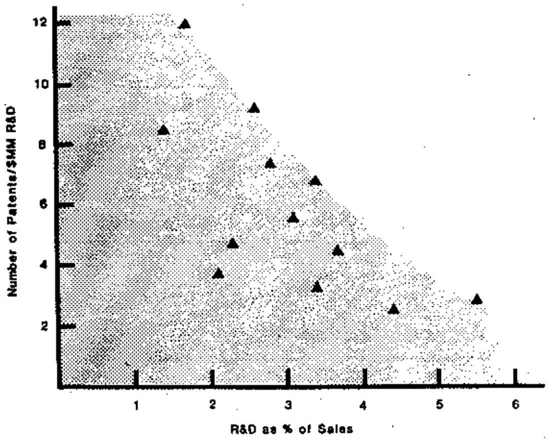

Figure 11.—Patent Productivity Vs. R&D As % of Sales (1971–75 Average).

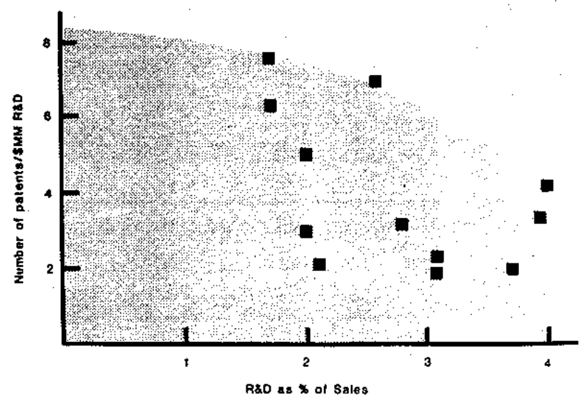

Figure 12.—Patent Productivity Vs. R&D As % of Sales (1976–80 Average).

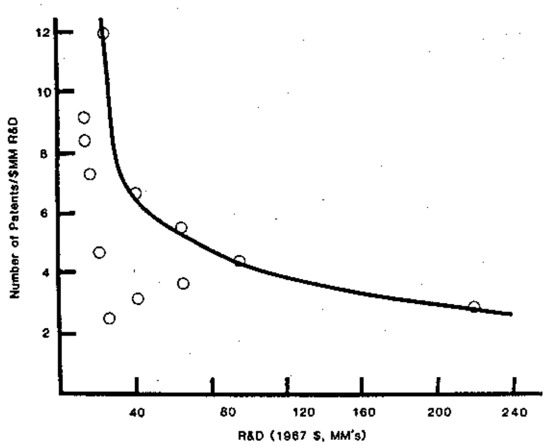

Figure 13.—Patent Productivity Vs. R&D (1971–75 Average).

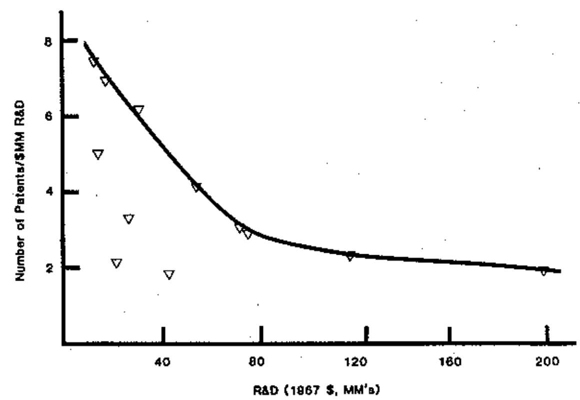

Figure 14.—Patent Productivity Vs. R&D (1976–80 Average).

previously called "patent productivity" (*11*). They looked at a broad range of companies whereas we looked in detail at the chemical industry. In this paper, we have examined only a handful of companies in other industries (Table 2).

In the earlier study, we speculated about the most likely cause or causes of the slowing in U.S. patent activity. Among the causes proposed and rejected in that study were the following:

- Companies are more careful or selective in choosing patents to file.
- Less R&D money is available because of funds diverted to meet regulatory requirements.
- There is more reliance on "trade secrets" vs. patents.
- The U.S. market is viewed as not worth the cost of getting patent protection.
- More stringent criteria are being applied by the U.S. Patent Office for allowing patents.

None of the above explanations makes any more sense today than it did in 1980. The one explanation that was thought to be most plausible then was that a shift in R&D orientation had taken place toward low-risk research such as product and process development. These activities are less likely to lead to large numbers of patents because they are designed to fine-tune formulations, discover new uses of a chemical or improve the process by which the chemical is made. We can test this hypothesis by looking at the record of three chemical companies with very different patent productivities. For each of three companies, Allied, Du Pont and Stauffer, the patents in each of three years were examined to find out what fraction were "composition of matter" as opposed to those with use or process claims only. It was assumed that larger numbers of composition of matter patents would correlate with higher patent productivity. Table 3 shows the results of this analysis. There is no obvious correlation between the type of claims and the number of patents per $MM of R&D for all three companies taken together. There is, however, an apparent

*Table 1—Sales, R&D Expenses and Patent Productivity**

	1971–75 avg.	1976–80 avg.	% Change
$(Sales)_{12}/(GNP)_{12}$	1.94%	2.27%	17
$(R\&D)_{12}/(R\&D)_{US}$	2.76%	2.84%	3
$(Patents)_{12}/(Patents)_{US}$	5.5%	5.2%	−5
$(Patent\ Productivity)_{US}$	2.2	1.6	−27
$(Patent\ Productivity)_{12}$	4.4	2.9	−33

*Number of patents per million of 1967 dollars spent on R&D.

Table 2—Patent Productivity in Various Industries

	Patent Productivity (# Pat/$MM R&D)		
	71–75 avg.	76–80 avg.	% Change
"Big 12" (Chemical companies)	4.4	2.9	−33
Du Pont (Chemical)	2.8	1.9	−30
AT&T (Communications)	3.0	1.0	−67
Hewlett-Packard (Electronics)	1.2	0.6	−49
General Electric (Electrical)	2.4	2.8	+14
Eastman Kodak (Photography)	2.7	1.2	−57
Merck (Pharmaceuticals)	1.9	1.8	−8
Motorola (Semiconductors)	3.0	2.6	−13
U.S. Average	2.22	1.61	−27

Table 3—Relationship of Patent Productivity To Type of Patent Claims

Company	No. of Patents Studied*	% of Patents with Comp. of Matter Claims	Patent Productivity No. of Patents/$MM R&D
Stauffer—1970	71	51	6.6
1975	127	60	9.0
1980	99	50	5.4
Allied —1970	39	26	9.7
1975	43	19	10.7
1980	38	11	4.0
Du Pont—1970	162	31	2.8
1975	112	39	2.6
1980	63	46	1.5

*All of Stauffer's patents were examined in the three years; one-third of Du Pont's and Allied's patents were examined.

correlation for each company by itself (Figure 15). Because of the few data plotted, it would be desirable to extend this analysis to other companies over more years to see if our observation is more than a coincidence.

It is undeniable that chemical and other companies have experienced a steady decline in both the number of patents granted and in patent productivity. The latter is a crude measure of the return on research investment. One can find a variety of explanations. Abernathy pointed the finger at management (*2*), whereas Kline indicated that we are about to enter a new age in chemistry (*3*). However, it is also possible that we are experiencing an effect in research that is analogous to the finding that "new oil is harder to find than old oil." Any resource that must be mined out becomes progressively more expensive because the most easily reached deposits are taken first. Is there such a phenomenon in industrial research? If there is, we should find that the money will increase that must be spent on R&D to achieve a fixed amount of progress. This should lead to the observations reported here.

Among the factors making research progressively more expensive is that the infrastructure required to do research in the 1970s and 1980s is increasingly sophisticated and expensive. For example, most research laboratories of any significance have analytical facilities that include NMR spectrometers, HPLCs, ESCA-Auger spectrometers, SEMs and the like. This equipment is typically run by highly skilled specialists. In an earlier time, analyses were thought to be adequate or acceptable with much simpler, less elegant and far less costly techniques. Also, the laboratory of

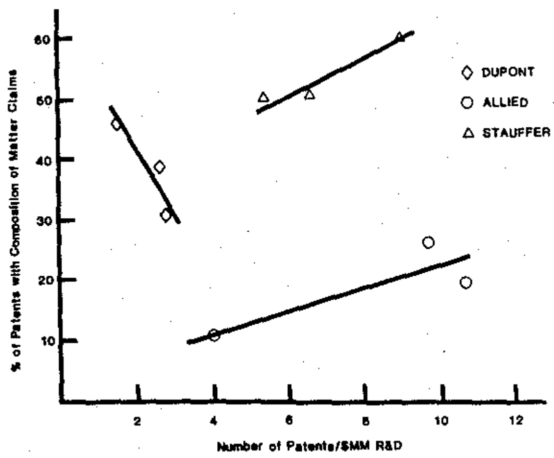

Figure 15.—Patent Productivity Vs. Type of Patent.

today is equipped with a full range of sophisticated computers and database searching facilities. These are only two examples that can be cited. No wonder R&D costs are escalating. Furthermore, this is a factor that affects the larger companies more than the smaller ones. The large companies are the ones most likely to feel the need for highly sophisticated facilities to match the technological demands of their research areas.

If one now adds the economic criteria attendant to new research, the picture of high costs becomes even more pronounced. The chemical industry has seen a steady decline in profitability in the last two decades, and new research must face far more hard-nosed criteria of profitability and return on investment than ever before. New chemicals that might have been considered acceptable in an earlier time may now be thought to be too unprofitable to develop. This leads to R&D that has fewer commercial successes as a fraction of the numbers of areas explored.

Finally, we should address the question of the adequacy of R&D funding in the U.S. Between 1964

It is possible that we are experiencing an effect in research that is analogous to the finding that "new oil is harder to find than old oil."

and 1978 the level of R&D funding as a fraction of GNP dropped 25 percent, from 2.96 percent of GNP to 2.22 percent. By 1985, however, it had moved back up to an estimated 2.7 percent. Increased spending on R&D cannot of itself guarantee greater innovation, and there is probably no "right" level to ensure a revitalized atmosphere of innovation. Nevertheless we are encouraged by this dramatic turnaround. Now it remains to be seen whether the U.S. patent output as a measure of innovation also turns around and heads back up. Ⓐ

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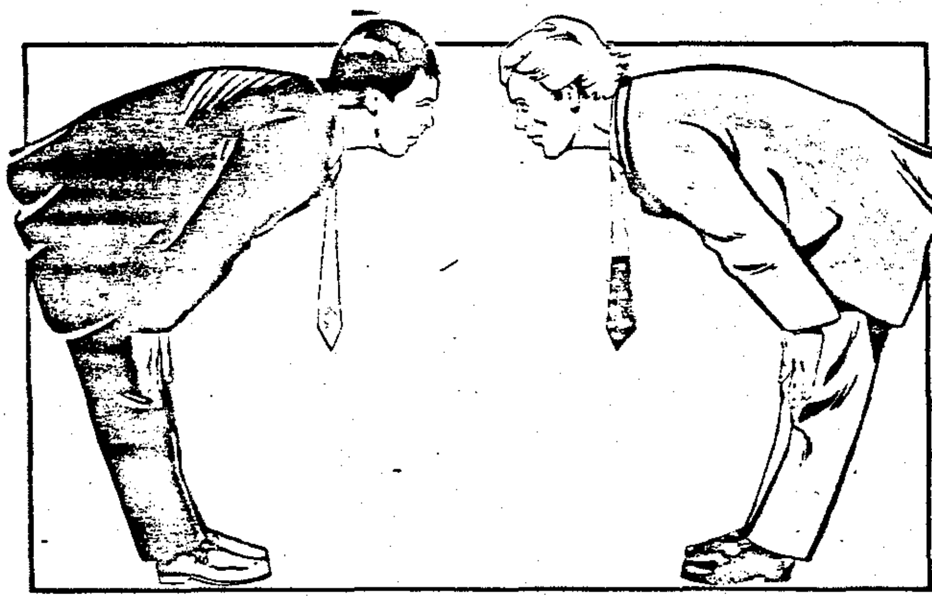


Clash of the titans

After steel, motor cars, consumer electronics and cheap microchips, Japan has begun to challenge American pre-eminence in the one industrial area the United States has long cherished as its own: high technology. The two are girding up for a trade war in high-tech that threatens to be bloodier than anything yet. Nicholas Valéry reports on the strengths and weaknesses of the two technological superpowers

The recent movie "Gung Ho" gets a lot of laughs out of the many misunderstandings that ensue when a Japanese car firm moves into a sad little town in Pennsylvania. Stereotypes abound: dedicated Japanese managers putting in double shifts, lazy American loudmouths slowing down the assembly line—with the locals winning a baseball match between the two sides only through brute force and intimidation.

All good clean fun. In real life, however, American workers—despite the popular myth—remain the most productive in the world (see the feature on the next page). In terms of real gross domestic product (GDP) generated per employed person, the United States outstrips all major industrial countries, Japan included (chart 1). The problem for Americans is that the rest of the world has been catching up. In the decade from the first oil shock to 1983, increases in annual productivity in the United States had been roughly a seventh of those of its major trading partners.

In the 1960s, American companies held all the technological high cards and dominated the world's markets for manufactured goods. The United States supplied over three-quarters of the television sets, half the motor cars and a quarter of the steel used around the world. Yet, a mere two decades later, Japan had taken America's place as the dominant supplier of such products.

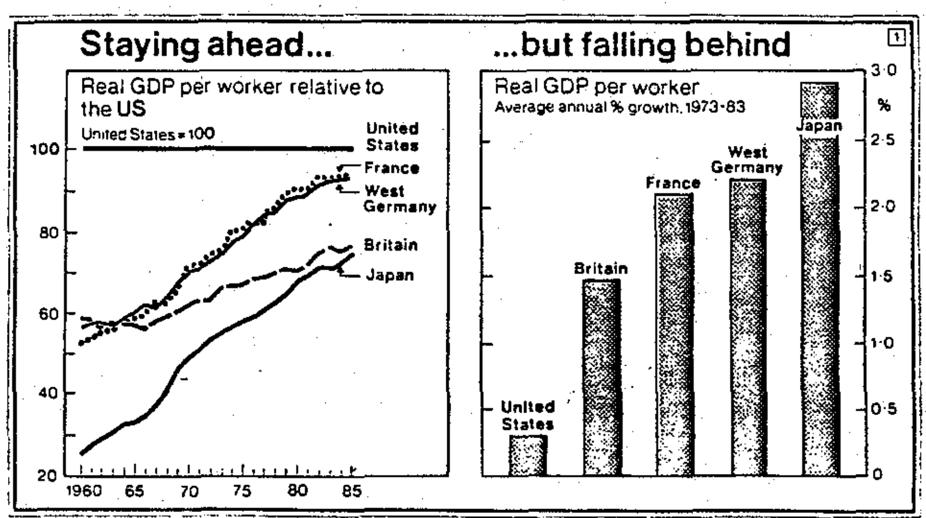
The agony for Americans does not end there. Over the past 25 years they have seen:

- Their share of world trade fall from 21% in 1960 to 14% in 1985.
- The American trade balance go from a surplus of $5 billion in 1960 to a deficit of $150 billion last year.
- More worryingly still, the country's trade balance in manufactured goods slip from a healthy surplus of $11 billion as recently as 1981 to a deficit of $32 billion last year—approaching 1% of America's total output.
- The volume of its manufacturing exports tumble 32% over the past five years—with every $1 billion of exports lost costing an estimated 25,000 American jobs.

Angry and confused, businessmen in the United States have had to stand by and watch as "smokestack" industry all around them has been snuffed out. Then came the unthinkable: if the Japanese could thrash them in mainstream manufacturing, would they give them a mauling in high technology, too?

By the beginning of the 1980s, it began to look as if they would. It became clear that the Ministry of International Trade and Industry (MITI) in Tokyo had "targeted" not just semiconductors and computers but all of America's high technology industries—from aerospace to synthetic materials—for a blitzkrieg attack.

Six years on, Japan has scored some



Source: US Department of Labour

Power to the elbow

Americans work every bit as hard as (and often a lot harder than) the Japanese—and generate proportionately more wealth in the process. The average output of American workers last year was $36,800. The Japanese equivalent was $22,500 (at an average 1985 exchange rate of Y220 to the dollar).

But labour productivity is only half the story. The amount of capital applied to a worker's elbow is crucial, too. The traditional definition of productivity (output per hour of all workers) makes it difficult to measure these inputs separately. True, the definition reflects all the factors that contribute to rising output—from advances in technology, better utilisation of capacity, improvements in the way production is organised and sharper management, to harder efforts by the workers themselves as well as the impact of changes in the amount of capital employed.

In 1983, the American Bureau of Labour Statistics introduced a yardstick called multifactor productivity. This shows the changes in the amount of capital as well as labour used in production. Reworking its data for 1950-83, the bureau found that multifactor productivity in the United States increased at an average annual rate of 1.7% for the period. As output per hour over the same period increased by an annual 2.5%, capital productivity inched up by only a modest 0.8% a year.

Overall, America's multifactor productivity has shown two distinct trends over the past 35 years. Up till the first oil shock of 1973, the country experienced an annual 2% multifactor growth; then an annual average of only 0.1% from 1973 to 1981. The post-OPEC slowdown seems to have resulted from high interest rates keeping the brakes on capital spending, while more people were having to work longer hours to hang on to their jobs.

How did the Japanese fare? The driving force behind the Japanese economy over the past 25 years has been the high growth in capital input. Mr Dale Jorgenson and his colleagues at Harvard University reckon it has been roughly double that in the United States. Growth rates in labour productivity have been much the same for the two countries. All told, the growth in Japanese productivity outstripped that in the United States until 1970, when productivity growth began to slow dramatically in Japan. Thereafter, with Vietnam behind it and two oil shocks ahead, the American economy flexed its muscles and coped more effectively. Then the competitive advantage started to move back in America's favour.

The interesting thing is what has happened since the last recession. Multifactor productivity in the United States has been running at an average of 5% a year, while the growth in labour productivity is now averaging nearly 4% a year. That means that productivity of capital employed is now growing at well over 6% a year.

Could this be the first signs of the productivity pay-off from the $80 billion that Detroit spent on new plant and equipment over the past half dozen years; the combined (additional) $180 billion invested by the airlines since deregulation, telecommunications firms since the AT&T consent decree and the Pentagon since President Reagan's defence build-up began in 1980? It looks remarkably like it.

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notable hits. A group of American economists and engineers met for three days at Stanford University, California, last year to assess the damage*. They concluded that Japanese manufacturers were already ahead in consumer electronics, advanced materials and robotics, and were emerging as America's fiercest competitors in such lucrative areas as computers, telecommunications, home and office automation, biotechnology and medical instruments. "In other areas in which Americans still hold the lead, such as semiconductors and optoelectronics, American companies are hearing the footsteps of the Japanese", commented the Stanford economist Mr Daniel Okimoto.

How loud will those footsteps become? American industry may have been deaf in the past, but it certainly isn't any more. And never forget that Americans are a proud and energetic people. More to the point, they are prone to periodic bouts of honest self-reflection—as if, throughout their two centuries of nationhood, they have been impelled forward by a "kick up the backside" theory of history.

Once every couple of decades, America has received a short and painful blow to its self-esteem; Pearl Harbour, Sputnik, Vietnam are recent examples. What follows then is usually a brief and heart-searching debate along with a detailed analysis of the problem, then an awesome display of industrial muscle coupled with unexpected consensus between old adversaries—most notably between Congress, business and labour.

With its ceaseless shipments of cameras, cars, television sets, video recorders, photocopiers, computers and microchips, Japan unwittingly supplied the latest kick up the broad American buttocks. After witnessing Japanese exporters almost single-handedly reduce Pittsburgh's steel industry to a smouldering heap, drive Detroit into a ditch, butcher some of the weaker commodity microchip makers of Silicon Valley, and threaten America's remaining bastions of technological clout—aircraft and computers—then, and finally then, American lethargy ceased.

This survey tries to assess the strengths and weaknesses of the world's two technological superpowers. For if the past decade has seen some of the ugliest recrimination between Washington and Tokyo over trade issues generally, imagine what the coming decade must have in store. Henceforth, industrial competition between America and Japan is going to range fiercely along the high-tech frontier—where both countries take a special pride in their industrial skills and cherish sacred beliefs about their innate abilities.

The question that ultimately has to be answered is whether America is going to allow the Japanese to carry on nibbling away at its industrial base without let, hindrance or concession? Or are the Americans (as some bystanders have begun to suspect) "about to take the Japanese apart"?

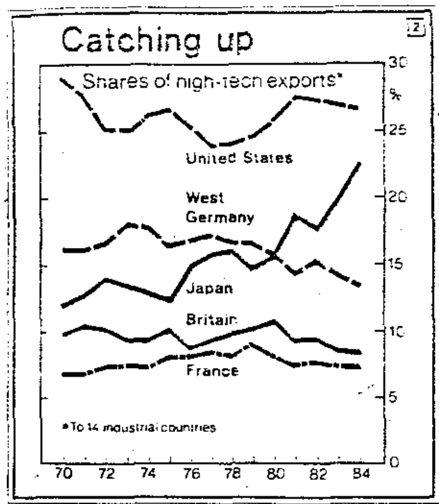
With the gloves now off, which of the two technological heavyweights should one put some money on? In the blue corner, Yankee ingenuity? In the red, Japanese production savvy?

*Symposium on Economics and Technology held at Stanford University, March 17-19 1985. Now published as "The Positive Sum Strategy: Harnessing Technology for Economic Growth" by National Academy Press, Washington, DC.

Copycat turns leader?

Is Japan still a technological free-loader—or has it become a pacesetter in high-tech?

America may still have the largest share of high technology exports, but Japan is catching up fast. It skipped smartly past West Germany to become the second largest supplier of high-tech goods in 1980 (chart 2 on next page). Only in three high-tech industries—communications and electronics, office automation, and ordnance—have American companies increased their market share.



Source: US Department of Commerce

The Japanese know they do not have a chance in fields that are either defence-related (for example, weapons, aircraft, satellites and avionics) or too dependent on imported energy or raw materials (like petrochemicals). But they see everything else as up for grabs. Even in lasers, software and computer-integrated engineering—where American pre-eminence was long thought unassailable—the Japanese have begun to make inroads.

Who would have thought it possible a decade ago? Of the 500 breakthroughs in technology considered seminal during the two decades between 1953 and 1973, only 5% (some 34 inventions) were made in Japan compared with 63% (315 inventions) in the United States. Despite its large, well-educated population, Japan has won only four Nobel prizes in science; American researchers have won 158. It is not hard to see why Japan has been considered more an imitator than innovator.

Stanford University's Mr Daniel Okimoto lists half a dozen reasons for Japan's lack of technological originality in the past:

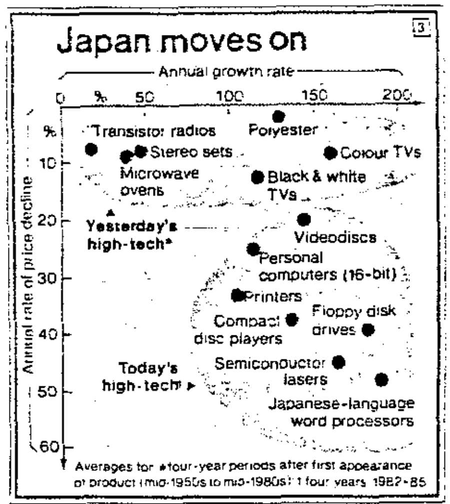
- As an industrial latecomer, it has always been trying to catch up.
- The Japanese tendency towards group conformity has made it difficult to win a hearing at home for radical ideas.
- Research in Japanese universities is bureaucratic, starved of cash and dominated by old men.
- The venture-capital market is almost non-existent.
- Lifetime employment, along with a rigid seniority system, stifles innovation inside industry.
- And the traditional heavy gearing (high debt-to-equity ratio) of much of Japanese industry has made firms think twice about taking risks.

All these things—and more—have been true to some extent in the past; but all are also changing. The deregulation of Tokyo's financial markets, for instance, is forcing Japanese companies to reduce their levels of debt (see accompanying feature on next page). This, in turn, is making them more adventurous, while at the same time helping ferment a number of venture-capital funds.

Japan's "invisible" balance of technological trade (its receipts compared with payments for patent royalties, licences, etc) which had a ratio of 1:47 a couple of decades ago came within a whisker of being in balance last year. That said, Japan still buys its high-tech goods and knowhow predominantly in the West and sells them mainly to the developing world.

In certain industries, however, Japanese manufacturers have already started bumping their heads against the ceiling of current knowhow. There are no more high-tech secrets to be garnered from abroad in fibre optics for telecommunications, gallium arsenide memory chips for superfast computers, numerically-controlled machine tools and robots, and computer disk-drives, printers and magnetic storage media. In all these, Japan now leads the world. Today, Japanese-language word processors represent the cutting edge of high-tech in Japan—taking over the technological (but hardly export-leading) role that colour television played earlier (chart 3).

Although it is no longer quite the technological free-loader it was in the past, is Japan's new reputation as a pace-setter in high-tech justified? A new image has certainly emerged over the past few years of Japan as an invincible Goliath, capable of vanquishing any rival, whatever the field. Yesterday, the smokestack



Source: Mitsubishi Bank

sectors. Today, high technology. Tomorrow, services. . . "Which is the 'real' Japan?" asks Mr Okimoto:

> Is it a technological imitator and industrial over-achiever? Or is Japan an astute learner and unbeatable colossus? Will Japan dislodge the United States from its current position of dominance in high technology as convincingly as it did in the smokestack sectors? Or has it reached the limits of its phenomenal postwar growth?

Japan is all these things and more. And to understand what the future holds, and whether America is up against a David or a Goliath, means looking closely at the frontiers of modern electronics. For the country that commands the three most crucial technologies of all—semiconductors, computing and communications—will most assuredly command the mightiest industrial bandwagon of the twenty-first century.

Made in the USA

Just as Japan has begun to muscle into high-tech, America has raised the technological stakes. The name of the game now is ultra-tech

High technology is an American invention. Despite the near meltdown at Three Mile Island, broken helicopters in the Iranian desert and recent disasters on the launch pad, Americans remain the supreme practitioners of this demanding and arcane art. And while the United States has racked up large deficits on its international trading account, it has enjoyed growing surpluses in its worldwide sales of high-tech goods. Or, rather, it did so until recently. Once again, blame the Japanese.

Five years ago, America sold the world $23.6 billion more technological widgets than it bought. That handy surplus had dwindled, says America's Department of Commerce, to a token $5 billion by 1984 (chart 7 on later page). Meanwhile, foreigners had grabbed three-quarters of the world's current $300 billion in high-tech trade. In the process, Japan has gone from being a small-time tinkerer in the 1960s to becoming (as in everything else) the Avis of high technology to America's Hertz.

Even so, trade in high-technology goods remains a crucial breadwinner for the United States. Since the mid-1960s, high-tech's share of American manufactured goods sold around the world has gone from a little over a quarter to close to a half.

Office automation is now America's most competitive high-tech industry as well as its biggest revenue-earner abroad. Selling its trading partners computers, copiers and word processors brought in

Technology's top ten

How high is the high in high-tech? Difficult to say. Most economists at least agree that high technology products embody an "above average" concentration of scientific and engineering skills. As far as the National Science Foundation in Washington is concerned, this means anything produced by organisations employing 25 or more scientists and engineers per 1,000 employees and spending over 3.5% of net sales on R&D.

The American Department of Commerce is a bit more scientific. Its definition of high-tech is derived from input-output analyses of the total R&D spent on a spectrum of individual products. Thus an aircraft gets credit for not only the R&D done in developing the airframe, but also the relevant contribution of the avionics supplier and even the tyre maker. Using this definition, high-tech industry is a ranking of the ten most "research-intensive" sectors, where the tenth has at least double the R&D intensity of manufacturing generally (table 1).

A laudable effort, but not without criticism. First, such a definition focuses entirely on products, ignoring the booming business in high-tech processes—and, increasingly, high-tech services as well. Second, it favours systems (that is, collections of interdependent components) over individual widgets, as well as products manufactured by large companies rather than small firms.

Third, because the data come of necessity from broad industrial categories, anomalies crop up—like cuckoo clocks being labelled high-tech because they fall within the eighth-ranking group, professional instruments.

Fourth, and perhaps most damning, the Commerce Department's definition is based on Standard Industrial Classification (SIC) codes—many of which have been rendered irrelevant by technological changes that have occurred since the SIC codes were last overhauled in 1972.

Table 1: Product range

	HIGH-TECH SECTOR	EXAMPLES OF PRODUCTS
1	Missiles and spacecraft	Rocket engines; satellites and parts
2	Electronics and telecoms	Telephone and telegraph apparatus, radio and TV receiving and broadcast equipment, telecoms equipment, sonar and other instruments, semiconductors, tape recorders
3	Aircraft and parts	Commercial aircraft, fighters, bombers, helicopters, aircraft engines, parts
4	Office automation	Computers, input-output devices, storage devices, desk calculators, duplicating machines, parts
5	Ordnance and accessories	Non-military arms, hunting and sporting ammunition, blasting and percussion caps
6	Drugs and medicines	Vitamins, antibiotics, hormones, vaccines
7	Inorganic chemicals	Nitrogen, sodium hydroxide, rare gases, inorganic pigments, radioactive isotopes and compounds, special nuclear materials
8	Professional and scientific instruments	Industrial process controls, optical instruments and lenses, navigational instruments, medical instruments, photographic equipment
9	Engines, turbines and parts	Generator sets, diesel engines, non-automotive petrol engines, gas turbines, water turbines
10	Plastics, rubber and synthetic fibres	Various chemicals derived from condensation, polycondensation, polyaddition, polymerisation and copolymerisation; synthetic resins and fibres

$20 billion in 1984. Along with aircraft, electronics and professional instruments, these "big four" account for more than three-quarters of the United States' exports of high technology (table 2). Despite the popular myth, America exports only modest amounts of missiles and aerospace products. But fears that foreigners may eventually storm even the high frontier of aerospace keep Washington officials awake at night.

Of the ten industrial sectors designated high-tech (see feature above), America has managed to increase its share of the global market in only two: office automation and electronics. For which, it should thank the likes of IBM, Hewlett-Packard, Digital Equipment, Xerox, ITT, RCA, General Electric, Texas Instruments and a host of brainy technological-based businesses scattered around the West Coast, Rockies, Sunbelt, Mid-Atlantic and New England.

A common cry in Washington is that this "narrowing" of America's high-tech base is one of the most disturbing problems facing the United States today. Others see this trend as more or less inevitable—and perhaps even to be encouraged. Trade ministers in Western Europe, for instance, only wish they had such "problems"; Japanese bureaucrats are doing all they can to create similar "problems" back home.

The reason is simple. These so-called "problems" concern a focusing of all the underlying technologies that have come to drive the computing, office automation and communications industries. All three provide the tools for handling information; and information—its collation, storage, processing, transmission and use elsewhere—will, quite literally, be the oil of the twenty-first century (see the survey on information technology in *The Economist*, July 12 1986).

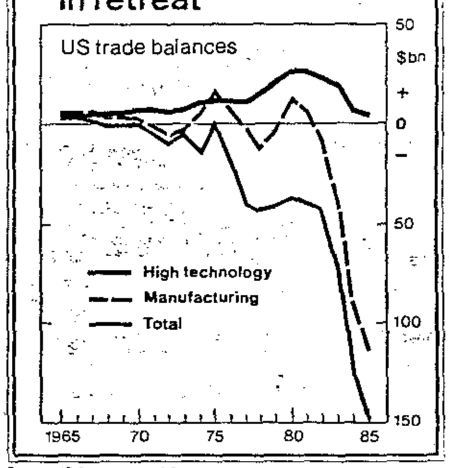
All that noisy jostling going on right now between the IBMs, Xeroxs and AT&Ts of the corporate world is merely the

Table 2: High-tech exports in 1984

High-tech sector	American exports Value	American exports % of total	Others' exports* Value	Others' exports* % of total
Office automation	$19.7bn	22.4	$6.5bn	14.5
Electronics & telecoms	$14.4bn	22.0	$53.8bn	29.4
Aircraft and parts	$13.5bn	20.7	$15.4bn	8.4
Profess'l instruments	$7.2bn	11.0	$27.0bn	14.7
Plastics, rubber, etc	$4.4bn	6.7	$26.5bn	14.5
Inorganic chemicals	$3.5bn	5.4	$10.9bn	6.0
Engines and turbines	$3.2bn	4.9	$10.7bn	5.9
Drugs and medicines	$2.7bn	4.1	$10.7bn	5.9
Missiles and spacecraft	$1.0bn	1.5	$0.6bn	0.3
Ordnance	$0.8bn	1.3	$0.7bn	0.4

*Of the 14 other countries (apart from America) exporting high-tech goods, France, West Germany, Japan and Britain accounted for three-quarters of total trade.
Source: US Department of Commerce.

In retreat



Source: US Department of Commerce

Crying all the way to the bank

One thing Americans have learned is that having the world's most productive labour force does not guarantee industrial competitiveness. At least three other things are needed. The first is to keep a lid on wages. The second concerns exchange rates. The third involves the return on capital employed. All three have been seen lately as spanners in the American works.

Take wages. During the ten years before 1973, real wages for American workers had increased steadily at an average rate of 2.6% a year. But ever since the first oil shock, real wages in the United States have stagnated. So American labour is becoming more competitive, yes?

Unfortunately no. When fringe benefits are included, hourly compensation for blue-collar workers in the United States has continued to rise. American labour has sensibly been taking raises less in cash than kind. Total compensation for American industrial workers—a modest $6.30 an hour in 1975—had climbed to $9.80 an hour by 1980 and to $12.40 by 1983.

Compared with Japan, hourly labour costs in America went from being on average a little over $3 more expensive in 1975 to becoming nearly $6 more so by 1983 (chart 4). So much for narrowing the $1,900 gap between making a motor car in Nagoya compared with Detroit.

Ah, yes, but hasn't the dollar tumbled dramatically? It has indeed—from a 1985 high of over Y260 to the dollar to a low this year of Y150 or so. In trade-weighted terms, that represents a drop for the dollar of 28% in 15 months. Meanwhile, the trade-weighted value of the yen has appreciated by over 40%.

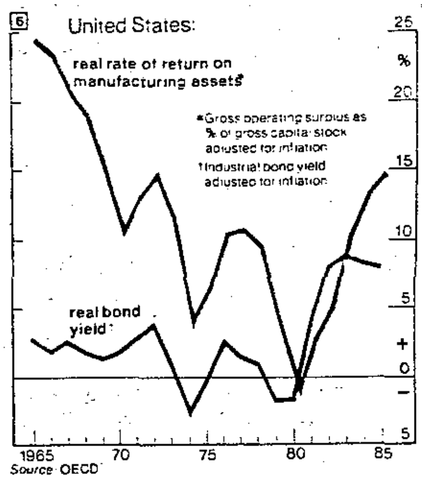
What about differences between America and Japan in terms of return on capital? Here things are actually better than most American businessmen imagine. True, real rates of return earned by American manufacturing assets in the 1960s were substantially higher than investments in financial instruments, while things were briefly the other way round during the early 1980s (chart 6). On the face of it, capital for buying equipment or building factories seems twice as expensive in America as in Japan.

Today's most cited account comes from Mr George Hatsopoulos of Thermo Electron Corporation in Massachusetts. Comparing the cost of (non-financial) capital in the two countries between 1961 and 1983, Mr Hatsopoulos found real pre-tax rates ranged between 6% and 10% for Japanese firms and anything from 13% to 20% for their American counterparts.

The conventional explanation for this difference is that Japanese firms are more highly geared (leveraged) and thus benefit because debt generally costs less than equity—interest payments being deducted from pre-tax profits, while dividends come out of taxed earnings.

Then there is Japan's two-tier interest rate structure, which is carefully regulated to favour business debt at the expense of consumer credit. Throw in a banking system that is bursting at the seams with yen being squirrelled away by housewives worried about school fees, rainy days and the ever-present threat of their husband's early (and often unpensioned) retirement. All of which, say American trade officials, adds up to a financial advantage that makes it tough for American firms to compete.

What is studiously ignored in the financial folklore about Japan Inc is the fact that, over the past decade, Japanese manufacturers have been getting out of debt as fast as decently possible (see the survey on corporate finance in *The Economist*, June 7 1986). The most compelling reason right now is because Tokyo's financial markets have joined the fashionable trend towards liberalisation. With old controls over the movement of capital going out of the window, Japanese interest rates are destined to become more volatile. So who wants to be highly geared when interest rates are rising or (worse) becoming less predictable?



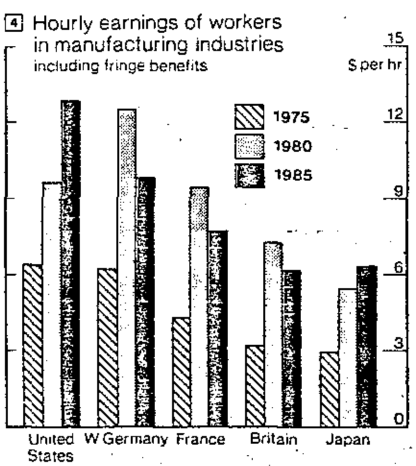
Source: OECD

Another thing Japanese manufacturers resent about some of these allegedly cheap industrial loans are the strings and hidden costs involved. The most punishing are the so-called "compensating balances" which a borrower has to deposit (at a considerably lower interest rate) with the bank offering the industrial loan. And so he has to borrow more money—at higher cost and with greater restrictions—than he actually needs.

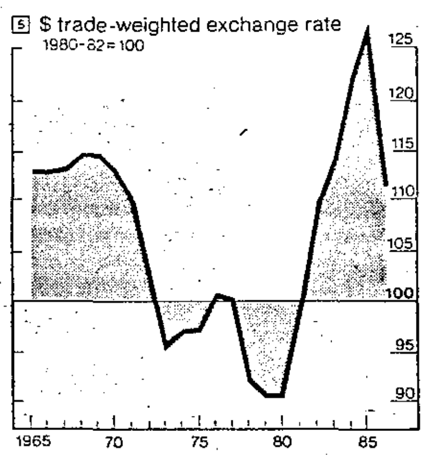
Yet another thing that muddies the water is the way debt in Japanese balance sheets is grossly overstated by western standards. For one thing, the compensating balances, though they are actually deposits, are recorded as borrowings. Then there is the habit Japanese companies have of doing much of their business on credit, especially with suppliers and subsidiaries. This makes their accounts payable and receivable look huge—in fact, twice as large as in America.

Other factors inflating debt among at least the bigger Japanese companies are things like non-taxable reserves for special contingencies and (if they pay them) pensions. The last time figures were collected in Japan (in 1981), employees in large corporations with established retirement plans were divvying up 15-20% of their companies' capital through their pension contributions. All of which showed up in their corporate accounts as debt.

All that said, Japanese companies are on balance more highly geared than American corporations; and, overall, the cost of financing industry has been lower in Japan than in the United States. But at most only 20% lower, and nothing like the 50% lower claimed by lobbyists in America.



Source: US Department of Labour, Bureau of Labour Statistics, 1984



Source: DRI

clatter of these three industrial sectors (each with its own distinctive style of manufacturing, procurement and customer support) being forged together by their underlying technologies into a single, ultra-tech activity called information services.

Yes, beyond high-tech in the industrial spectrum lies ultra-tech—today a mere multi-billion-dollar stripling of a business, but by the year 2000 potentially a trillion-dollar leviathan. As such, ultra-tech alone will come to dwarf all manufacturing sectors before the century is out. America is well on the way to making that happen. A lap or two behind, Japan at least is getting up speed. Europe is barely in the race.

Chips with everything

Gone are the days when American semiconductor firms short-sightedly sold their licences and knowhow to Japanese microchip makers

America's electronics firms have maintained their global leadership in all branches of their business save one. They kissed goodbye to consumer electronics (television, hi-fi, video recorders, etc) as customers across the country voted with their pockets for shiny boxes with flashing lights and labels like Panasonic, Technics, JVC and Sony.

The American electronics industry came close to allowing much the same to happen in microchips. In 1982, Silicon Valley took a caning when the Japanese started flooding the market with cheap 64k RAMS (random-access memory chips capable of storing over 64,000 bits of computer data). Most beat a hasty retreat up or out of the market.

From having a dozen mass producers of dynamic-RAMS in 1980, only five American chip makers were still in the high-volume memory business by 1983. Today, there are effectively only two or three with the capacity to produce the latest generation of memory chips (1 megabit RAMS) in anything like economic volumes. Meanwhile, the six Japanese firms that plunged into the memory-chip business back in the early 1970s are still around—and now have a 70% share of the dynamic-RAM market in America.

Microchips have been the engine powering Japan's drive into high-tech generally. But before it could join the microchip generation, Japan had to find a way of disseminating this vital American technology throughout its fledgling semiconductor industry. The trick adopted was, first, to protect the home market, and then to bully abler firms into joining government-sponsored research schemes—one run by the Japanese telephone authority NTT and the other by the Ministry of International Trade and Industry—to develop the knowhow for making their own very large-scale integrated (VLSI) circuits.

Next, by "blessing" VLSI as the wave of the future and crucial to Japan's survival, the government triggered a scramble among the country's electronics firms (encouraged by their long-term investment banks) to build VLSI plants. The net result was massive over-capacity (first in 64k RAMS and then in 256k versions), abundant local supply for the domestic consumer electronics makers and an impelling urgency to export (or dump) surplus microchips abroad.

This targeting ploy had been tried before. Japanese manufacturers found it worked moderately well with steel, much better with motorcycles, better still with consumer electronics and best of all with semiconductors. The only requirement was a steeply falling "learning curve" (that is, rapidly reducing unit costs as production volume builds up and manufacturers learn how to squeeze waste out of the process).

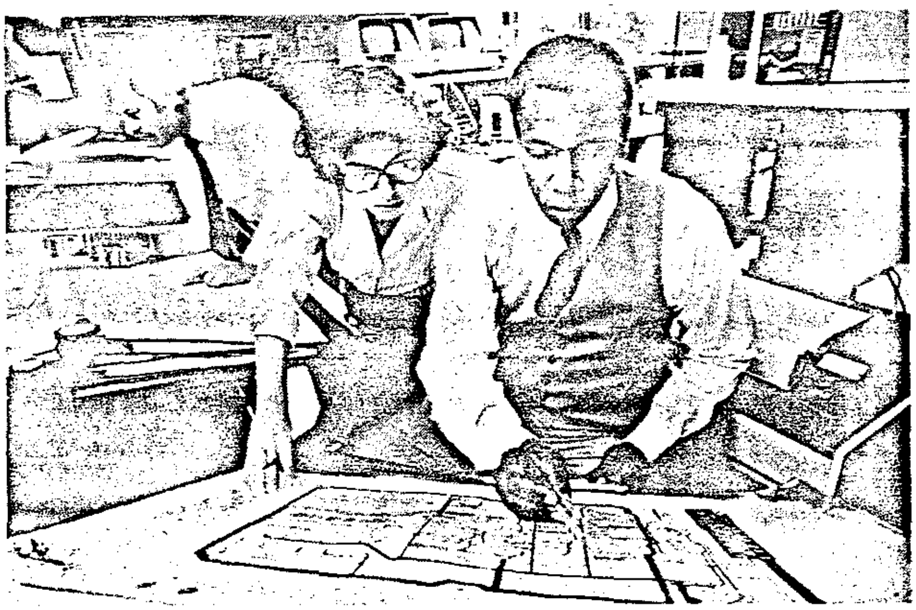
The trick was simply to devise a forward-pricing strategy that allowed Japanese manufacturers to capture all the new growth that their below-cost pricing created in export markets, while underwriting the negative cashflow by cross-subsidies and higher prices back home.

The Americans finally lost their patience when the Japanese tried to do a repeat performance with pricier memory chips called EPROMS. The price fell from $17 each when the Japanese first entered the American market with their EPROM chips early in 1985 to less than $4 six months later. Intel, National Semiconductor and Advanced Micro Devices promptly filed a joint petition, accusing the Japanese of dumping EPROMS on the American market at below their manufacturing costs in Japan (then estimated to be $6.30 apiece). The issue is currently being used by Washington as a battering ram to breach the wall Japan has erected around its own $8 billion semiconductor market back home.

For America, this get-tough policy has come only just in time. Japan now enjoys a 27% share (to America's 64%) of the world's $42 billion semiconductor market. And while cut-throat competition may make memory chips a loss-leader, acquiring the technology for producing RAMS has given Japan's microcircuit makers a leg-up in getting to grips with more complex semiconductors used in computer graphics, communications and video equipment.

So far, however, it has not helped Japanese chip makers to loosen the stranglehold that American semiconductor firms have on the lucrative microprocessor business. Where 256k RAMS have become commodity products that sell wholesale for $1 or so each, 32-bit microprocessors from the likes of Motorola, Intel, National Semiconductor, Texas Instruments, AT&T and Zilog cost hundreds of dollars apiece. Between them, these six American chip makers control 90% of the world market for the latest generation of microprocessors, leaving just 10% for the rest of the American semiconductor industry, Europe and Japan.

Fortunately for the Americans, micro-



Street map for a microchip circuit

processors are not like memory chips. Being literally a "computer-on-a-chip", they are vastly more complex and cannot be designed in any routine manner. Sweat, insight and inspiration are needed every step of the way. And they have to be designed with their software applications in mind. Americans have been doing this longer, and are better at it, than anyone else.

More to the point, American firms are not parting with their patents as readily as they did in the past. Hitachi has been trying (with little luck) to persuade Motorola to sell it a licence for making its advanced 68020 microprocessor. Meanwhile, Japan's leading electronics firm, NEC, is having to defend itself in the American courts for infringing one of Intel's microprocessor patents.

With America's new, stricter copyright laws making it difficult to imitate American designs, Japanese chip makers are being shut out of all the major markets for microprocessors. Fujitsu, Matsushita, Mitsubishi and Toshiba are all gambling on a microprocessor design called TRON developed at the University of Tokyo. But nobody, least of all NEC or Hitachi, holds out much hope for the TRON design winning a big enough share of the market in its own right to be economic—at least, not until the mid-1990s. And, by then, Silicon Valley will have upped the technological stakes again.

When, late at night, the conversation gets down to *honne* (brass tacks), even Japan's ablest microchip wizards despair at ever matching Silicon Valley's mix of entrepreneurial and innovative flair. "Japan is powerful in only one sub-field of a single application of semiconductors tied to a specific line of products", bemoans Mr Atsushi Asada of Sharp Corporation.

Calculus of competition

Aping IBM has given Japan's computer makers a toe-hold in the market—but largely on Big Blue's terms

America's response to Japan's challenge in microchips is being repeated in computers. Here, Japan's specialty has been making workalike copies of IBM's big office machines (mainframes). The most one can say about these "plug-compatible" computers is that they have managed to prevent IBM from swamping the Japanese home market completely. Big Blue has to put up with being number two in Japan. Overall, however, Japanese compatibles have had only a marginal impact on the $150 billion computer business worldwide.

American manufacturers have established an almost impregnable position in mainframes and minicomputers—the stuff of corporate sales and accounting departments. And in the push to put a microcomputer on every desk, a handful of American firms (IBM, Compaq, Apple, Atari and Commodore) have been feeding the market a feast of cleverer, faster and (in many cases) cheaper machines that have left Japan's "IBMulators" nibbling on the leftovers of yesterday's lunch. In the personal-computer market, the IBM clone makers having the most impact come mainly from low-cost South Korea and Taiwan rather than Japan.

Meanwhile, in developing the programs that make computers tick, American software engineers have been every bit as clever as their chip-designing colleagues in Silicon Valley. In the process, they have increased their share of the world's software market (worth $40 billion a year) from under 65% a decade ago to over 75% today.

All this does not mean Japan's computer industry is a write-off. Its component suppliers have quietly established a significant position for themselves in the United States and elsewhere. In personal computers, for instance, Japanese machines account for less than 2% of the $14 billion annual sales of PCs in America. But Japanese components and peripherals (chips, disk-drives, keyboards, monitors, printers, etc) account for nearly 30% of the market's wholesale value.

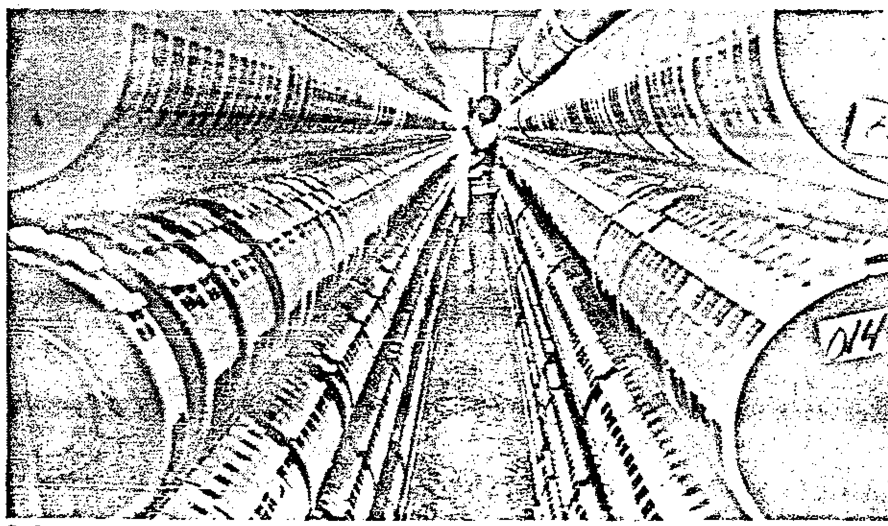
Most of Japan's computer makers came a cropper by riding a bit too blindly on IBM's coat-tails. Lacking the home-grown programming skills, Fujitsu, Hitachi and Mitsubishi made their computers imitate IBM's so they could sell cheaper versions to customers who were already using IBM machines equipped with the necessary software. That worked well until the slumbering giant woke up.

Then, in 1979, IBM introduced its 4300 series computers at a price that shook not just rival Japanese makers, but other American suppliers too. Since then, IBM's aggressive price-cutting and frequent model changes have made life tough for the plug-compatible trade.

Not only is IBM automating vigorously (the company is spending $15 billion over the next four years to achieve lower production costs than anyone in Asia), but it has also begun flexing its technological muscles. Its R&D expenditure is now running at $3.5 billion a year—more than all other computer manufacturers combined. Though for antitrust reasons it will never say so publicly, IBM is nevertheless determined to trample the plug-compatible makers down—both in the personal-computer end of the business as well as among its mainframe competitors.

One of the dodges being adopted is to incorporate more "microcode" in its computers' operating systems (the basic programs that manage a machine's internal housekeeping and support the customers' applications software). Used as an offensive weapon, microcode replaces parts of the computer's electrical circuitry, making it possible to change the whole character of a machine long after it has been installed at a customer's premises. The implication is that IBM can then sell products that can be continuously enhanced—something customers appreciate and will pay a premium for.

Starting with its 3081 series in 1981, IBM caught the competition off guard with a new internal structure called XA ("extended architecture") which allows customers to update their machines with packets of microcode whenever IBM decrees the market needs a shake-up. This



Software needs space

expected to grow to $83 billion by 1987. American manufacturers have 42% of it; Japanese firms 8-9%. But that has not prevented Japan from becoming a major exporter of telecoms products. It now sells well over $1 billion worth of telephone equipment abroad, a quarter of it even to the United States. How did that happen?

The main reason is the size of the American market itself. Though the American share of the global telecoms business is five times bigger than Japan's, practically all of it is at home. Some 90% of the domestic market is controlled by the mighty American Telephone and Telegraph ("Ma Bell"). GTE has 10% of the American market, while ITT has traditionally sold its telephone equipment almost exclusively abroad.

Until the deregulation of the American phone system in the wake of AT&T's 1982 consent decree, Ma Bell's manufacturing arm (Western Electric) directed its entire production effort at meeting just the needs of the various Bell phone companies around the country. It got all its inventions and designs from the legendary Bell Laboratories in New Jersey, and neither imported nor exported a single transistor.

Bell Labs has been responsible for a blizzard of innovations (transistor, laser, stored-program control, optical fibres, etc) that have driven down the real cost of communications and raised the quality and availability of telephone service throughout the United States. But because of AT&T's preoccupation in the past with just the domestic market, the best of its technology has had little direct impact on the rest of the world. The door to export sales was thus left ajar for telecoms suppliers elsewhere—from Europe (Siemens, Ericsson, Thomson, GEC and Philips), Canada (Northern Telecom and Mitel) and Japan (NEC, Oki, Fujitsu and Hitachi).

American firms retain their dominant position in supplying switching and transmission equipment. But the Japanese have mounted a serious challenge based on their growing expertise in transmitting messages on the backs of light beams. Made out of cheap silica instead of costly copper, optical fibres can carry three times the telephone traffic of conventional cables, need few repeater stations to boost the signals and send them on their way, are immune to electrical interference and do not corrode like metal wires.

The early American lead in fibre optics, built up by Western Electric and Corning Glass, has been chipped away by scientists at NEC, Sumitomo and Japan's telephone authority (NTT). Apart from learning how to manufacture low-loss fibres, Japanese companies have become superb at making the minute lasers, light-emitting diodes and minuscule receivers used for projecting and catching the messages.

Hand in glove with fibre optics is the growing trend towards digital transmission—sending spoken or picture messages coded as the ones and zeros of computerspeak. The transmission part is easy, but optical switching has presented horrendous headaches and the competition here is fierce.

But American makers have used their knowhow to better commercial ends. In particular, digital transmission has been used to speed the growth in data traffic between big computer systems, especially those owned by airlines, banks, insurance companies and financial institutions. Here, the Federal Communications Commission has taken the initiative, by freeing America's telecommunications networks so anyone can plug in, switch on and sell an information service. Other countries—Britain and West Germany particularly—have been inexplicably making life as difficult as possible for their own infopreneurs.

The lesson has not been wasted on telecommunications mandarins in Japan. They have seen how getting the government off the back of the telephone companies in America has spurred a vibrant free-for-all in "value-added networking", creating numerous jobs in information services and giving local manufacturers a headstart in carving out a piece of a brand new high-tech business for themselves.

This new communications freedom—even more than the changes in digital switching and new transmission technologies—is one of the key driving forces behind the merger between computing, office automation and telecommunications that is beginning to take place within the United States. Last year, computer maker IBM absorbed Rolm, a leading manufacturer of digital private-branch exchanges. At the same time the telephone giant, AT&T, broadened its growing base in computing and office equipment by buying 25% of Olivetti in Italy. The leader of the office-automation pack, Xerox, is still suffering from a surfeit of exotic technology dreamed up by engineering wizards at its PARC laboratories in California.

Japan has no intention of being left behind. The government in Tokyo is pressing on with its plan to privatise as much of its telecommunications services as possible. And while the big names of the Japanese telecoms business (Fujitsu, Hitachi, NEC and Oki) may have deficiencies of their own, each is nevertheless a big name in computing too. And though smaller, all are more horizontally integrated than AT&T, IBM or Xerox.

Will Japan close the technological gap in telecoms with America? Quite possibly. But only through setting up shop in the United States. The reason concerns one missing ingredient, now as essential in telecoms as in computing: ingenious software. Just as Motorola and Texas Instruments have built semiconductor factories in Japan to learn the secrets of quality and cost control, Japanese firms will have to establish telecoms plants in the United States if they are to acquire the necessary software skills. NEC has now done so—for precisely that reason.

Getting smart

Manufacturing is also going high-tech, threatening to turn today's dedicated factories full of automation into relics of the past

Microchips, computers and telecoms equipment will be to the next quarter century what oil, steel and shipbuilding were to the years between Hiroshima and the Yom Kippur war. More than anything else, these three technologies will fuel the engine of economic growth in countries that learn to manage their "smart" machinery properly. This will hasten not so much the trend towards service jobs, but more the revitalisation of manufacturing itself.

Manufacturing? That grimy old metal-bashing business which the more prosperous have been quietly jettisoning for better-paid office jobs in the service sector? It is true that manufacturing jobs in all industrial countries (save Italy and Japan) have been shed continuously since 1973. In the United States, employment in manufacturing industry fell 2.5% last year to less than 20% of the civilian workforce.

But looking at jobs alone is misleading. In terms of manufacturing's contribution to GNP, for instance, little has changed. In fact, manufacturing's share of value added (at current prices) in America was 22% of GNP in both 1947 and 1984, and has wavered narrowly within the 20-25% band for close on 50 years. So much for de-industrialisation.

Manufacturing still means big business in anybody's book. It currently contributes $300 billion and 20m jobs to the American economy; about $350 billion (at today's exchange rate) and 15m jobs in Japan. But manufacturing is really a matter of how you define it. Traditional measures based on Standard Industrial has thrown the plug-compatible makers on the defensive, forcing them to devote more of their development resources than they can afford to trying to anticipate IBM's next round of operating system changes and to try to match them with hurriedly engineered modifications to their hardware. That involves digging ever deeper into their profit margins.

America's other computer firms are also pushing this trend towards replacing hardware with software wherever possible. Writing and "debugging" the programs now accounts for 50-80% of their budgets for developing new computers. Two reasons, then, why American computer executives are smiling:

- At a stroke, the trend towards greater use of software helps neutralise the one great advantage their Japanese competitors have long possessed—namely, the ability to manufacture well-made mechanical components at a modest price.
- And it changes the business of manufacturing computers from being heavily capital-intensive to becoming more brain-intensive. The large pool of experienced programmers and diverse software firms in the United States puts the advantage firmly in American hands.

The Japanese response has been to launch another government-sponsored scheme, this time to help the country's computer makers invent "intelligent" machines for tomorrow. The ten-year fifth-generation project, based largely on "dataflow" concepts pioneered at Massachusetts Institute of Technology, will have cost $450m by the time it is completed in 1992. The aim is to create computers able to infer answers from rough information presented to them visually or orally. Even Japanese scientists working on the project are not sure whether such goals are realistic.

The Americans are not leaving anything to chance. Congress has been persuaded to relax the antitrust rules so that rival manufacturers can collaborate on advanced research without running foul of the law. Two of the first collaborative research institutions to spring up aim to match any challenge the Japanese might offer in computing, software and components for the 1990s. In one, the Semiconductor Research Corporation, 13 microchip companies have clubbed together to form a non-profit consortium for supporting research on advanced integrated circuits at American universities. The consortium is now doling out $35m a year to designers of tomorrow's microchips.

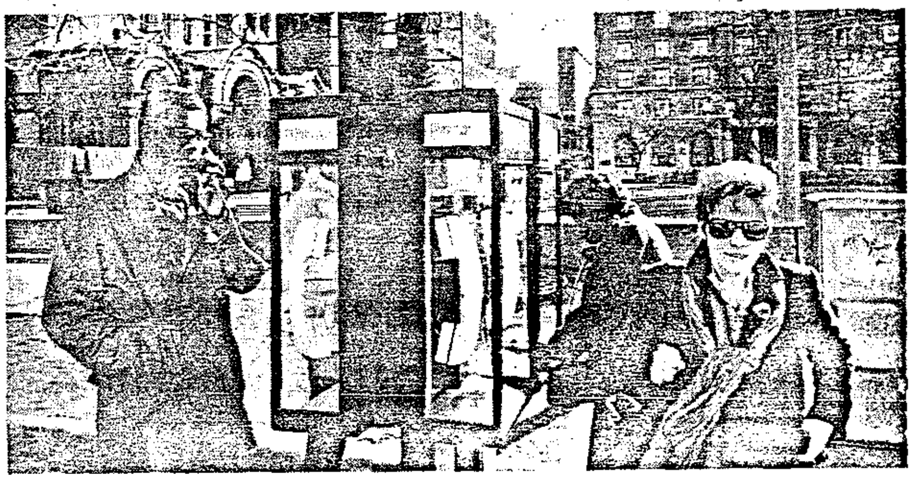
The other institution, the Microelectronics and Computer Technology Corporation (MCC), is an interesting experiment in its own right. Set up as a joint venture in 1983 by initially ten (now 21) rival American computer and semiconductor companies, MCC has 250 scientists carrying out research at its headquarters in Austin, Texas, to the tune of $75m a year. What is for sure, says Mr Bobby Inman, MCC's chief executive and former deputy director of the CIA, "MCC wouldn't have occurred except for MITI."

But the most orchestrated response of all to the Japanese challenge in computing comes not from IBM, Silicon Valley or collaborative consortia of American chip makers and computer firms. Though it is rarely in the public headlines, the Pentagon has been pouring barrels of cash into computing. Its Defence Advanced Research Projects Agency (DARPA) in Washington has been playing busy midwife to some of the most exotic technology of all for computers, communications and electronic equipment generally.

Its VHSIC (very high-speed integrated circuit) project alone has pumped $300m over the past five years into advanced methods for making the superchips needed for radar, missiles, code-breaking and futuristic computers. Also earmarked for DARPA is a reported $1 billion for sponsoring a range of supercomputers which, say insiders, "will outperform anything the Japanese can develop under their super-speed computing project or their fifth-generation programme."

At least a dozen "fifth-generation bashers" have surfaced as research projects around the United States, mainly in university laboratories, but also in small start-up companies founded by academics, entrepreneurs and engineering emigrés from the mainframe computer industry. The latest supercomputer to go public (the prototype was shipped last year to the American navy) is a cluster of boxes a yard square capable of calculating over a billion instructions per second (the Japanese government hopes to have a similar greyhound of a computer by 1992). The group that built it spun off mainly from nearby Massachusetts Institute of Technology to form their own company, Thinking Machines. The firm is now taking orders for a bigger brother with four times the processing power.

If only a handful of the score or so of American groups building advanced computers survives, the United States is going to enlarge its existing technology base in computing over the next decade by as much new engineering talent as its rivals have in totality. And that, not least for the Japanese, is a sobering thought.



Reach out and crush someone

Even more than breakthroughs in telecommunications technology, America's new deregulated freedom to plug in, switch on and sell an information service is breeding a whole new generation of infopreneurs

Americans complain about it, but if truth be told they still have the best and cheapest telephone system in the world. Japan's is a good one too—about as good as the Bell System was in the late 1960s. Which means it is reliable and cheap when making calls within the country, but not particularly good at performing electronic tricks like automatic call-forwarding, call-waiting, short-code dialling, credit-card billing, conference calling—all things Bell users take for granted today.

Americans also take for granted the choice of being able to dial long-distance numbers using alternative carriers who offer cheaper rates. Liberating the phone system from the state monopoly's clutches (so customers may choose what they want instead of what they are given) has barely begun in Japan.

The United States is the world's dominant supplier as well as its most prolific user of telephone equipment. The global market, worth $57 billion in 1982, is

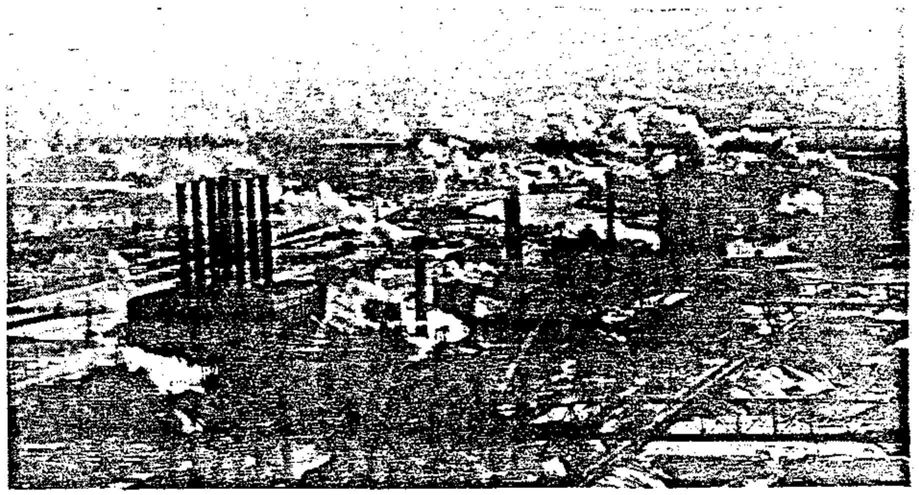
Classification codes continue to give the impression that making anything in a factory is going the same way as smokestack industry generally—up in smoke. Yet software engineering alone is an explosive new "manufacturing" industry that barely enters the American Treasury Department's calculations of growth, let alone its vision of what constitutes industry.

What is for sure is that the new battle in manufacturing competitiveness and productivity is going to be fought in the fields of process and design technology. Here is what Mr Daniel Roos of Massachusetts Institute of Technology has to say:

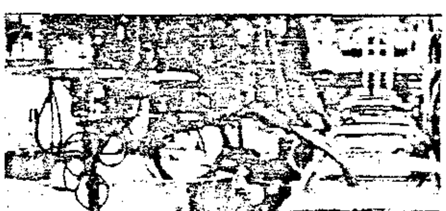
> Over the next 25 years, all over the world, semi-skilled labour—whether cheap or expensive—will rapidly give way to smart machinery as the key element in competitiveness. Neither cheap Korean labour nor expensive American labour is our real problem. Rather the challenge lies in rapidly introducing and perfecting the new generations of design and process equipment—and the complex social systems that must accompany them.

It does not require an MIT professor to explain why conventional manufacturing is limping out and new computerised forms of design and fabrication are muscling in. Using the favoured yardstick of productivity (return on investment after discounting for the current cost of money) even back-of-the-envelope calculations show only two factors really count. Energy costs are irrelevant, being typically 3-4% of factory costs. Much the same is true for labour, which now accounts for only 5-15% of total costs.

"The only significant, and controllable, factors are material costs and production volume", preaches Dr Bruce Merrifield of the American Department of Commerce. Thus, with roughly 30% of material costs being in inventory, a "just-in-time" delivery system (like the Japanese *kanban* method for supplying components to motor manufacturers) could improve the real return on investment by as much as 15%.



From smokestack ...



... to robots ...

Getting manufacturing volumes right is trickier. Here high technology is making the whole notion of the special-purpose factory—with its automated equipment purring smoothly along as it churns out millions of identical parts all made to the same high standard of precision—a relic of the smokestack past. The marketplace is much more competitive today, no longer accepting the 10-12 year product life cycles needed to justify the investment of such dedicated plants. The pace of technological change is demanding that manufactured goods be replaced every four or five years; in consumer electronics, every two or three years.

The Japanese factory devoted solely to turning out 10,000 video recorders a day with a handful of operators is the end of the line—not quite yet, but destined shortly to become, a magnificent anachronism and epitaph to the age of mass production. It was a brief and grimy era, spanning just the single lifetime from Henry Ford to Soichiro Toyoda. To take its place, a whole new concept of manufacturing is being hustled out of the laboratory and on to the factory floor. This is the final melding of microchips, computers, software, sensors and telecoms to become in themselves the cutting tools of manufacturing industry.

The retooling of America

Flexible make-anything factories are beginning to sprout across America, bringing back jobs that had slipped offshore

American engineers call it CIM. Computer-integrated manufacturing—hurried into the workplace by a kind of Caesarian section—has arrived before managers have had a chance to find out what they really want or are able to handle. The trouble—and there have been plenty of teething troubles—is that CIM has a grown-up job to do right now. To corporate America, it is the one remaining way of using the country's still considerable clout in high technology to claw back some of the manufacturing advantage Japan has gained through heavy investment, hard work and scrupulous attention to detail.

American companies began pouring big money into high-tech manufacturing around 1980. All told, firms in the United States spent less than $7 billion that year on computerised automation. Today they are spending annually $16 billion, mostly on more sophisticated CIM equipment. By 1990, investment in computer-integrated manufacturing will have doubled to $30 billion or more, forecasts Dataquest of San Jose, California.

General Motors has spent no less than $40 billion over the past five years on factories of the future. Even its suppliers are being hooked into GM's vast computerised information net, allowing them to swap data with the giant motor maker as a first step towards integrating them wholly within its CIM environment. IBM has been spending $3 billion a year on computerising its manufacturing processes. In so doing, it has been able to bring numerous jobs, previously done offshore, back into the United States. Pleased with the results so far, IBM has raised its investment in CIM to an annual $4 billion.

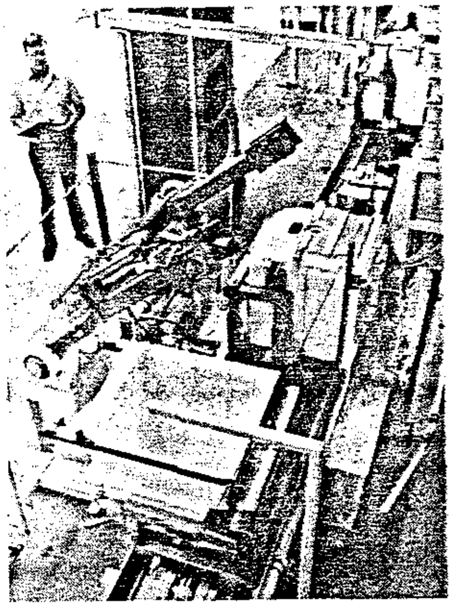
The heart of a CIM plant is a flexible manufacturing shop which can run 24 hours a day, but which is capable of being retooled in minutes rather than days, and able to turn out hundreds of different products instead of being dedicated to just one line. The difference between the best of traditional automation (for example, Toyota's Corolla line in Nagoya) and the best of new style CIM plants (for example, General Electric's household-appliance centre in Kentucky) is that the former automates just the flow of material through the factory, while the latter automates the total flow of information needed for managing the enterprise—from ordering the materials to paying the wages and shipping the finished goods out of the front door.

The aim of CIM is not simply to reduce the amount of direct labour involved in manufacturing a product (only 5-15% of the cost). The real savings come instead from applying strict computer and communications controls to slash the amount of waste (typically 30% of the cost) through having up-to-the-minute information on tool wear, while minimising the handling, management and overhead charges (rarely less than 40%) by knowing precisely where items are at any instant during the manufacturing process. The net result is that a CIM factory has a much lower breakeven point than a highly automated conventional plant. The majority of the CIM plants now onstream in the United States break even at half the level of a conventional plant (typically 65-70% of full capacity). And because it does not have to operate flat out from the start to be efficient, a CIM plant makes it easier and cheaper to launch new products. That spells shorter life cycles—and hence more frequent (and more attractive) model updates.

That would be reason enough for enterprising high-tech companies to invest in CIM. But a number of American corporations are being encouraged for other, more strategic, reasons to integrate their computerised manufacturing processes. The Pentagon sees CIM as a nifty way of allowing manufacturing capacity to be sprinkled lightly across the land, instead of being concentrated heavily in targeted areas along the Ohio Valley, parts of Illinois and up through Michigan.

The generals also see CIM plants—with their rapid response and flexible, make-anything nature—as handy standby capacity ready to be instantly reprogrammed to meet the military surge of a national emergency. Apart from its costly military stockpiles, the Pentagon has to underwrite a good deal of redundant and idle capacity among America's defence contractors. That is a political luxury it can no longer afford.

Pressure from other parts of Washington is also helping to usher high-tech



... to CIM

manufacturing into American factories. To government gurus like Dr Bruce Merrifield, the attraction of these flexible manufacturing plants is that they are ideal not just for industrial giants like General Electric, Westinghouse or IBM, but even more so for the tens of thousands of tiny workshops across the country. While Japan has two-thirds of its industrial output within the grasp of broad-based *keiretsu* manufacturing groups, American industry by contrast has always relied heavily on its 100,000 or so independent subcontracting firms. In metal working, for instance, 75% of the parts made in the United States are manufactured by small independent workshops in batches of 50 or less.

The American Commerce Department sees no antitrust reasons why smaller firms should not band together to share a flexible manufacturing centre, making spindles for washing machines one minute, wheel bearings the next, then switching to precision mounts for a microscope maker, crankshafts for diesel engines, microwave cavities for radar equipment, nose-cones for missiles and so on. This would reduce the investment risk for the individual firms, while providing a higher return for the CIM plant as a whole. It could also help rebuild much of the industrial base of rustbowl America.

Let the daisies grow

Bureaucratic guidance is still no match for a fertile economy where anything can take root and flower

Who, then, is better suited to life on the high road of technology—America or Japan? The answer is complicated by the way the two industrial superpowers have honed their separate skills in wholly separate ways (table 3). American technology is overwhelming in big systems, software, computing and aerospace. But nobody can touch Japan in the process technologies that underlie conventional manufacturing. American technology reaches out for the unknown; Japan's bends down to tend the commonplace.

The differences in style mirror the differences in ideals that the two peoples hold dear. The Japanese have a saying: "The nail that stands up will be hammered flat." The Americans say: "Let the daisies grow." So it is hardly surprising that American technology is individualistic, often erratic and always iconoclastic. Japan's, if anything, is pragmatic, geared primarily to problem-solving and hustled along by a herd-instinct.

To date, Japan's high-tech success has been almost exclusively with developments that were predictable—like packing more and more circuits into dynamic RAM chips, or making video recorders smarter and smaller. This is a result of having total mastery of the process technologies. While all the basic breakthroughs for making semiconductors—electron beam lithography, ion implantation, plasma etching, etc—came from the United States, Japanese firms improved the ideas step by step until their equipment was a match for anything made abroad.

By carrying out development continu-

Table 3: Balance of forces

Japanese strengths	American strengths
Applied research and development	Basic research
Incremental improvements	Breakthroughs and inventions
Commercial applications	Military applications
Process and production technology	New product design
Components	Systems integration
Hardware	Software
Predictable technologies	Less predictable technologies
Quality control	New functionalities
Miniaturisation	New architectural designs
Standardised, mass volume	Customisation

Source: *"The Positive Sum Strategy", National Academy Press, Washington DC, 1986* ously in small incremental steps (instead of the American way of great quantum leaps every decade or so). Japanese firms have been able to bombard customers with a barrage of new models offering yet better value, quality and reliability. American firms, by contrast, have traditionally made cosmetic improvements every few years, and then brought out complete model overhauls once a decade or so. That has made their products look long in the tooth, then suddenly change dramatically—often for the worse while design bugs and production wrinkles are sorted out.

American technology has also tended to be geared for use mainly at home (for example, telephone systems, motor cars). With its smaller domestic market, Japanese technology has been forced to look farther afield. The Stanford economist, Mr Daniel Okimoto, makes the point that though Japanese firms have excelled at technologies tied closely to commodities with huge export markets (for example, continuous casting in steel, emission-control for motor cars, optical coatings for camera lenses), lately they have begun to do well in technologies for domestic use too. Some examples include gamma interferon and Interleukin II in pharmaceuticals, digital switching and transmission in telecommunications. And with their breakthroughs in gallium arsenide semiconductors, optoelectronics, superceramics and composite materials, the Japanese have shown themselves selectively capable of innovating at the frontier of knowledge as well as anyone.

On the whole, however, Japanese firms have been less successful with technologies that are inherently complex, not particularly predictable and dependent upon ideas springing from basic research. Making jet engines is one such technology. Designing air-traffic-control radars is another. Developing computer-aided design and manufacturing systems is a third. And despite MITI's "targeting" of lasers as a technology to be conquered, little progress has been made here to date—because not enough basic research has been done in the necessary branch of physics.

Such incidents point to serious problems in Japan's educational system. While Japanese youngsters out-perform western school children in all meaningful tests of mathematics and science, their training stresses rote learning rather than critical analysis and creative synthesis. At university, their skills in problem-solving are enhanced at the expense of their abilities to conceptualise.

As faculty members, Japanese academics are civil servants unable to fraternise as paid consultants in industry during the summer vacation. So Japan has none of the cross-fertilisation between basic research and commercial development that characterises MIT and Route 128, Stanford and Silicon Valley and a hundred other campuses across America. Also, because all the leading universities in Japan are state-owned and run rigidly by a conservative central bureaucracy, it is difficult to allocate grants (by peer-review) to the most deserving researchers rather than the most senior.

In the days when Japan could storm the

Lift-off for the airborne economy

Forget about America's underground economy of do-it-yourselfers pushing hamburger carts, paint brushes and illicit drugs. Above the conventional economy, a star-spangled wealth launcher lifted off three or four years ago—to take advantage of the soaring power and plummeting cost of microchips, the breakup of the geriatric telephone monopoly, the chimera of President Reagan's space shield and, above all, the technological collision of computing, communications and office automation. Meet America's exciting new airborne economy.

The first thing to understand is that nobody is quite sure how well even America's conventional economy is performing, let alone its underground or overground components. The only items reported properly seem to be imports and unemployment. The trouble is that the economy is changing so fast—from old-fangled businesses based on metal bashing and carting things around to new-fangled ones that massage, transmit and memorise scraps of information. What is for sure, the leading economic indicators—those monthly headlines that send shockwaves around the world's financial markets—seriously underestimate some of the most important growth sectors within the United States.

Because the statistics have not kept pace with the way American business is becoming internationalised, computerised and more service-oriented, the picture the statisticians paint depicts an economic landscape of a decade or two ago. Here are some examples of lagging statistical response:

- Companies are classified by industrial sectors using definitions last updated in 1972.
- Twenty years after computers swept manual accounting into the dustbin, the first price index for computers has just been introduced—and is still incomplete. Where America's computing costs have been assumed to be fixed, henceforth they will be deemed to fall (as they have actually been doing) by at least 14% a year—adding nearly 1% to GNP.
- An archaic processing system for logging foreign trade, confronted with a 90% increase in imports over the past decade, is ignoring America's growth in foreign sales. A significant proportion (some say 15-20%) of American exports now goes unreported.
- Measures of family income, designed in an age when welfare was a dirty word, omit non-cash components such as company fringe benefits for professionals (pension rights, deferred income plans, health and life insurance, etc) and in-kind government assistance for the poor (food stamps, rent subsidies, etc).
- Poverty is still defined by consumption patterns of the mid-1950s, when a family of three spent a third of its income on food. The same food basket today costs a fifth the equivalent family's income.

Don't snigger. Despite budgetary cuts, the American statistical system is still one of the best in the world. Its only real weakness is that—employment figures aside—the statistics used for determining, say, GNP or growth tend to be by-products of non-statistical agencies (such as the Internal Revenue Service, the Customs Service, Medicare and the Department of Agriculture). As such, they are far from being as clean, complete or timely as the experts would like.

Consider some recent anomalies caused by the quickening pace of technological change. With 70% of Americans being employed in the service sector, you might be tempted to categorise the United States as essentially a service-based economy. It is. But you would not think so from the Standard Industrial Classification (SIC) used in generating the input-output tables for measuring GNP. This has 140 three-digit codes for manufacturing firms, only 66 for services. Moreover, since the SIC system was last revised in 1972, whole new business activities (for example, video rental, computer retailing, software retailing, discount broking, factory-owned retail outlets) have sprung up, while others have withered away.

Nuts and bolts, for instance, are in an SIC category all of their own, employing a grand total of just 46,000 people. Envelope makers, again with their own SIC category, provide fewer than 25,000 jobs. Yet one SIC code in the service sector alone, general medical and surgical hospitals, now covers some 2.3m people. Lots of high-tech service businesses—including computer stores and software publishers and manufacturers—do not even qualify for their own SIC codes yet.

There is no reason why all SIC categories should be the same size. But the imbalance exaggerates the importance of traditional manufacturing at the expense of services in the American economy. Above all, it allows whole sections of America's booming high-tech economy to go unreported.

Back to the future

A glimpse or two at the future will dispel any doubts about Yankee ingenuity as it probes the limits of tomorrow's technology. First, to Silicon Valley where Mr Alan Kay, refugee from such technological hotbeds as DARPA, Stanford, Xerox PARC and Atari, is nowadays visionary-at-large at Apple Computer. Building on the learning theories of John Dewey and Jean Piaget, Mr Kay is trying to create a "fantasy amplifier"—a computer with enough power to outrace the user's senses, enough memory to store library loads of reference material, and enough clever software to couple man's natural desire for exploring fantasies with his innate ability to learn from experiment.

The concept, called "Dynabook", combines the seductive power of both a video game and a graffiti artist's spray-can with the cultural resources of a library, museum, art gallery and concert hall combined. Difficult to make? You bet, especially if the whole gizmo has to fit in a package no bigger than a notepad and be cheap enough for every schoolkid to own.

Smalltalk is the computer language Mr Kay has developed to allow kids to converse with the fantasy amplifier. The rest of the ingredients are all technologically imaginable, just prohibitively expensive and unwieldy for the time being. But a decade ago the first personal computer was just being built at considerable expense. Its functional equivalent today costs less than $50. Still only in his mid-40s, Mr Kay has ample time to put a Dynabook in the hands of millions of youngsters with open minds and a sense of wonder still intact.

Next, meet Mr Ted Nelson, gadfly, prophet and self-confessed computer crackpot, with a lifetime's obsession wrapped up in an enormous program called (after Coleridge's unfinished poem) Xanadu. Boon or boondoggle, nobody is quite sure. But the giant piece of software for steering one's own thought processes (including alternative paths, mental backtracks and intellectual leaps) is hardly lacking in ambition or vision.

Conceived originally by Mr Nelson while a student at Harvard as simply a note-keeping program for preserving his every thought, Xanadu has evolved into a total literary process: creating ideas; organising the thoughts, with traces showing backtracks, alternative versions and jumps to cross-referenced documents; manipulating the text; publishing the results; and logging a share of the royalties to every other author cited.

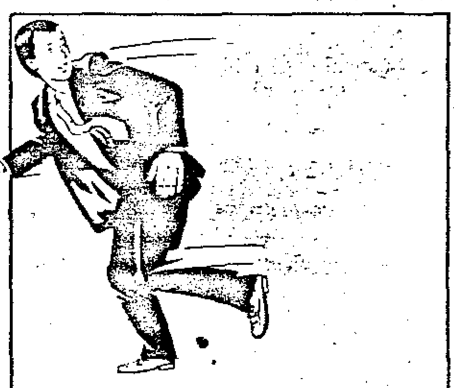
Every document in Xanadu's database has links to its intellectual antecedents and to others covering related topics. The linked references work like footnotes, except that Xanadu offers an electronic "window" through which they can be accessed there and then. Because the whole process works in a non-sequential way, the inventor calls the output "hypertext".

Mr Nelson looks forward to the day when anybody can create what he or she wants—from recipes to research papers, sonnets to songs—and put it into Xanadu's database and quote or cite anybody else. Royalties and sub-royalties, monitored automatically by the host computer, would be paid according to the amount of time a user was on-line and reading a specific document. It sounds pretty wild at the moment, but hypertext could be commonplace before the century is out.

industrial heights with foreign licences, homegrown development and production excellence, the inadequacies of its educational system and academic research hardly mattered. But such shortcomings are becoming increasingly a problem as high-tech competition intensifies.

Nor can Japan call on its little firms to provide the invigorating fillip of innovation such enterprises provide in the United States. And with their lifetime employment practices, Japan's big technology-based corporations rarely get a chance to attract high-flying talent from outside. Technological diffusion between small firms and large corporations, and between companies generally as engineers swap jobs, is one of the more invigorating forces for innovation in the United States.

Nor, also, is there an adequate way in Japan for financing risky innovation outside the big corporations. Since 1978, American equity markets have raised $8 billion for start-ups in electronics alone and a further $3.3 billion for new biotech companies. Over the same period, Japan's venture-capital investments in high-tech have totalled just $100m.



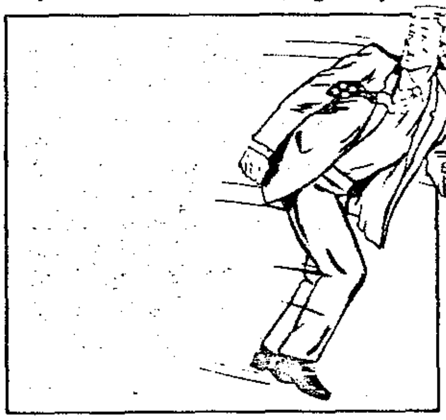
Lacking all these things, the Japanese have sought a substitute. This is one of the main reasons for MITI's special emphasis on collaborative research projects—as in VLSI or fifth-generation computers. To Mr Gary Saxonhouse of the University of Michigan, Japan's lauded industrial policies are little more than a substitute for the ingredients that American companies enjoy from their vibrant capital and labour markets.

As for MITI's infamous industrial targeting, many Japanese (as well as foreigners) have long doubted its effectiveness and believe it is now wholly inappropriate anyway. All technologies have started moving simply too fast to wait upon the whim of bickering bureaucrats. It is not as though Japanese civil servants have shown themselves any better at picking industrial winners than officials elsewhere; and none has bettered the invisible hand of the marketplace.

Apart from possessing vastly greater resources of well-trained brains, more diverse and flexible forms of finance, and a bigger and more acquisitive domestic market, America has one final, decisive factor moving in its favour—the pace of innovation itself.

High-tech products tend to have two things in common: they fall in price rapidly as production builds up (they possess steep learning curves) and they get replaced fairly frequently (they have short life cycles). The trend in high-tech is towards things becoming steeper and shorter. So the competitive advantage of being first to market is going increasingly to outweigh almost everything else.

This spells an end to the traditional low-risk, low-cost approach that Japanese companies have used so successfully to date—coming in second with massive volume and forward prices after others have primed the market. Henceforth, Japanese firms are going to have to take the same technological risks—and pay the same financial penalties—as everyone else. And that puts the advantage decidedly on the side of Yankee ingenuity.



Intellectual Property: Foreign Pirates Worry U.S. Firms

Overseas companies are increasingly infringing patents, trademarks, other intellectual property of U.S. drug and agrochemical firms; better protection is now high-priority item in Washington

Earl V. Anderson, C&EN New York

Rohm & Haas has a Brazilian patent on its acifluoren herbicide, Blazer. When a Brazilian company started producing the product, not only couldn't Rohm & Haas collect royalties, it couldn't even get the permits needed to export its own patented product to Brazil. A $5 million market was closed to Rohm & Haas.

Pirate companies in Taiwan are selling Bristol-Myers' antibiotics amikacin and cefadroxil. Since Bristol introduced amikacin in Taiwan in 1976, five other companies have started marketing imported amikacin and account for more than 40% of amikacin sales. Six firms sell cefadroxil and command about 70% of the market. Bristol won't even try to enforce its patents in Taiwan because there's not much chance of success.

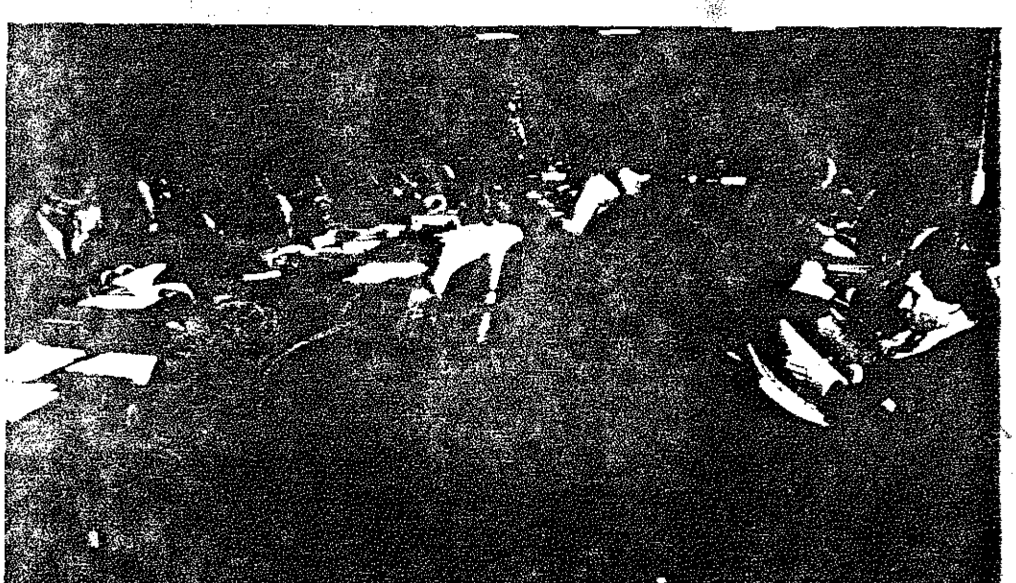
Different companies. Different products. Different countries. But the underlying problem is the same. Overseas pirates are stealing the intellectual property of U.S. companies.

Increasingly, U.S. companies are finding it more difficult to stem the abuse of their intellectual property rights in many other countries. Most of the abuse occurs in developing countries, where patent and trademark laws are weak or don't exist at all. Ten developing nations have been identified as the major problem areas: Taiwan, South Korea, Thailand, Singapore, Malaysia, Indonesia, the Philippines, Mexico, Brazil, and India.

But the intellectual property problem does not end at those countries' borders. It extends to many other countries, including some in the industrialized, western world.

Stories of fake designer jeans, bogus watches, and illegal copies of books, records, and movies are well known. Not so well known is that pirate operators abroad skirt the intellectual property rights of many U.S. companies to crank out computer software and chips, automotive and airplane parts, machine parts, electronic equipment, and even sophisticated medical equipment.

Quite a few chemicals can be added to that list. Toiletries, perfumes, and some rubber and plastics parts have been pirated. But particularly hard-hit have been agrochemicals and pharmaceuticals. "We find ourself with some strange bedfellows on this one," says Edmund T. Pratt, chairman and chief executive officer of Pfizer.



Industry representatives listen to comments of Department of Commerce foreign nation experts at meeting on intellectual property rights

It's difficult to put a precise dollar figure on the amount of sales

Congressional hoppers are full of intellectual property legislation

Better international protection for the intellectual property rights of U.S. companies has become a popular cause in official Washington. Literally dozens of bills dealing with the issue now await Congressional action. Here's a sampling (the legislator introducing the bill and the initial committee referral are in brackets):

- H.R. 1069, Process Patent Amendment [Moorhead (R.-Calif.), Judiciary]. Amends copyright law to make it an infringement of a patent to use, sell, or import into the U.S. a product produced by a patented process without the authority of the patent holder.
- H.R. 3246, Patent Cooperation Treaty Authorization [Kastenmeier (D.-Wis.), Judiciary]. Implements Chapter II of the Patent Cooperation Treaty and authorizes the Patent & Trademark Office to become an international preliminary examining authority.
- H.R. 3668, Unfair Foreign Trade [Pease (D.-Ohio), Ways & Means]. Makes it unlawful to sell or distribute counterfeit goods in countries outside the U.S., requires counterfeit goods to be seized and forfeited if they are imported into the U.S., and makes it unlawful to sell or transport such goods in the U.S.
- H.R. 3776, Intellectual Property Rights Protection & Enforcement Act [Moorhead (R.-Calif.), Judiciary]. Amends patent law to prohibit sale, use, or import of products through unauthorized use of a patented process; removes the "injury" requirements in section 337 cases (unfair import practices); and amends copyright law to provide for protection of original industrial designs of useful articles.
- H.R. 4312, Intellectual Property Rights Protection Act [Frenzel (R.-Minn.), Ways & Means]. Amends the Tariff Act of 1930 to remove "injury" and "domestic industry" requirements in section 337 cases.
- H.R. 4800, Trade & International Economic Policy Reform Act [Wright (D.-Tex.), several committees]. Basically the omnibus trade bill passed recently by the House, it amends section 337 of the Tariff Act of 1930 and implements several other reforms designed to strengthen U.S. intellectual property rights.
- S. 1543, Process Patent Amendment [Mathias (R.-Md.), Judiciary]. Similar to H.R. 1069, it amends copyright law to make it a patent infringement to use, sell, or import into the U.S. a product produced by a patented process without authority of the patent holder.
- S. 1869, Intellectual Property Rights Enforcement Act [Lautenberg (D.-N.J.), Finance]. Amends section 337 of the Tariff Act of 1930 to remove "injury" and "domestic industry" requirements in cases brought before the International Trade Commission, and shortens the time in which ITC must act on 337 cases.
- S. 2435, International Intellectual Property Protection & Market Access Act [Wilson (R.-Calif.), Finance]. Augments existing provisions for intellectual property protection and market access contained in the generalized system of preferences (GSP) and the Caribbean Basin Initiative laws. Establishes a new enforcement office within the Office of the U.S. Trade Representative, and incorporates section 337 changes identical to those in S. 1869.

that U.S. companies lose to foreign intellectual property pirates. Like crime, intellectual property abuse is too shadowy and too widespread to come up with solid numbers. Even the definition of "intellectual property" is inexact, although it generally refers to such things as patents, trademarks, copyright, trade secrets, and industrial designs. For agrochemical and pharmaceutical companies, patent infringement is by far the biggest headache, although they have had their share of trademark problems, too.

In 1982 the International Trade Commission estimated that intellectual property infringement cost U.S. industries \$5.5 billion per year in sales and cost the nation 131,000 lost jobs. And that was only in five industries. Assuming that figure is accurate, it undoubtedly would be higher today. Intellectual property pirates have become much more active since then and they certainly affect more than five U.S. industries.

In a report it submitted last year to the Office of the U.S. Trade Representative (USTR), the National Agricultural Chemicals Association (NACA) came up with some estimates for the agrochemical industry. Working with 1983 data, NACA estimates that the U.S. agrochemical industry probably lost \$123 million to \$246 million that year to pirate operations. Losses uncovered in specific company case studies in only nine problem countries added up to a hefty \$230 million—a reasonable check on NACA's estimate.

Applying a simple 6% annual growth rate to the world agrochemical market, NACA pegs possible piracy losses last year at \$138 million to \$277 million. But this assumes that pirates maintained the same "operating rate" that they had in 1983. If instead the U.S. is "on the front edge of an epidemic of piracy," as NACA puts it, then the association's estimates are also vastly understated.

NACA speculates, for instance, what might happen if pirates took over the entire agrochemical market in Brazil. In view of recent developments in the computer industry in Brazil, that is not too farfetched. If Brazil permitted only local production of all ag chemicals, NACA says that U.S. producers would lose more than \$200 million in that country alone.

As serious as these dollar losses may be, the consequences of intellectual property abuse extend beyond economics. Shoddy pirated products are health and safety hazards. Cases of paper-thin brake linings, faulty medical equipment, and dangerously off-specification drugs have been documented. Bogus pesticides have ruined entire crops.

For good reason, then, protection of intellectual property overseas has blossomed into a major trade

Baldrige (left): proposed measures approved by President. Yeutter (center): put rest of world on notice. Pratt: protection high up on priority list

policy issue in Washington, D.C. "We've pushed it high up on the priority list," says Pratt.

Actually, the piracy problem has been around for years. "We knew they were stealing our know-how," Pratt recalls, "but we lived with it." James R. Enyart, Monsanto's director of international and government affairs, says that Monsanto started feeling the pirates' sting in the late 1970s. While discussing the problem with some European counterparts, he too was told that he would just have to live with it.

Barry MacTaggart, president of Pfizer International, says that until recently many top managers didn't take the problem seriously. "All too often, I hear that countries with strong intellectual property laws account for 80% of our [the drug industry] market," he says. The inference, according to MacTaggart, is that the remainder of the world market, where pirates tend to operate, is not worth worrying about.

As losses to pirates mounted, that passive attitude evaporated. Monsanto's Enyart, for one, was not ready "to live with it." He drafted a long-term program to improve the protection of Monsanto's intellectual property. A big part of that program is to make the issue more understandable: Educate the public and the government. Make them realize just how costly a problem it really is.

Many other companies and their trade associations have joined the battle. In the chemical industry, NACA has emerged as the lead spokesman for better protection of intellectual property. The Pharmaceutical Manufacturers Association (PMA) is carrying the ball for proprietary drug companies.

Many broad-based associations have become involved in the issue. The International Anticounterfeiting Coalition (IACC), for instance, unites about 150 private sector groups to fight for better intellectual property protection. The coalition lobbies for better laws, holds educational events, and provides its members with legal advice.

IACC, until recently based in San Francisco, has just moved its headquarters closer to the action in Washington, D.C. It also has hired a new executive director—Richard M. Brennan, an old international trade hand since his days with Union Carbide.

Also involved is the International Intellectual Property Alliance, whose members come from the publishing, recording, film, and software industries. In addition, several major business groups—among them the U.S. Chamber of Commerce, the National Association of Manufacturers (NAM), and the influential Business Roundtable—have put intellectual property issues on their priority lists.

Brendan F. Somerville, NAM's director of innovation, technology, and science policy, says that much of what these groups have been doing is to "raise the consciousness level" about the intellectual property problem. This is particularly true, he adds, among the "movers and shakers" in government.

Apparently, they have been successful. Last year, the President's Commission on Industrial Competitiveness issued a special report on intellectual property rights. And earlier this year, a task force on intellectual property completed its report for the Advisory Committee for Trade Negotiations. Within the labyrinth of private-sector advisory groups established to funnel advice on trade policy into USTR, a new one has just been established—the Industrial Functional Advisory Committee on Intellectual Property Rights for Trade Policy Matters.

Literally dozens of bills have been introduced in Congress recently dealing with some aspect of intellectual property. Some are process patent bills, designed to prevent imports of products that are produced by the unauthorized use of a patented process.

Others would strengthen section 337 of the Tariff Act of 1930. Section 337 provides for relief from unfair import practices and, although weak, has been one of the few tools U.S. companies have had to fight pirated imports. Section 337 cases require proof of injury. The new bills would remove the injury requirement. Some would speed up the review investigation process at the International Trade Commission.

There are patent term restoration bills for agricultural chemicals, designed to add back the time that U.S. patent holders lose as their products go through an arduous and lengthy registration process. This is a major legislative goal of NACA. A law passed in 1984 did the same thing for pharmaceuticals.

The Trade & Tariff Act of 1984 hinges generalized system of preferences (GSP) treatment for developing countries to intellectual property rights. Under GSP, imports from a qualifying developing country enter the U.S. duty-free. The 1984 act requires the President to consider whether those countries are providing adequate protection for U.S. intellectual property in all of his or her GSP decisions.

The major omnibus trade bills—H.R. 4800 recently passed by the House and S. 1860 now being considered in the Senate—contain several intellectual property provisions. And other legislative proposals have been introduced to plug leaks in the Freedom of Information Act.

The Department of Commerce has been active in the intellectual property issue. Country specialists in its International Trade Administration and experts from the Patent & Trademark Office have been meeting with and holding seminars for officials in developing countries. The goal: Advise them how their intellectual property laws can be improved.

That's one of the carrot approaches. A good example of how the U.S. government can wield the stick is the "301 case" that it concluded in July with South Korea. Last fall, rather than wait for a complaint from industry, as is typically the case, USTR self-initiated an unfair business practices case under section 301 of the 1974 Trade Act. After eight months of negotiations, South Korea agreed, among other things, to provide comprehensive protection for patents, copyrights, and trademarks. Had agreement not been reached, President Reagan could have hit South Korea with retaliatory trade measures. Pfizer's Pratt considers the Korean 301 case "tremendously important."

In April, the Reagan Administration also unveiled its own package of measures to improve protection of U.S. intellectual property rights. The program, says Secretary of Commerce Malcolm Baldrige, was recommended by the President's trade strike force, endorsed by the Economic Policy Council, and approved by the President. The package includes a legislative proposal (the Intellectual Property Rights Improvement Act of 1986), the threat of additional section 301 investigations, and possible denial of GSP privileges. U.S. trade representative Clayton Yeutter says that the package "will put the rest of the world on notice that the U.S. will not tolerate the piracy that has emerged ... in recent years."

The outlook for the Administration's legislative proposal is cloudy. Some sections, such as strengthening section 337 (unfair import practices), process patent protection, and extending the patent term for

Many international intellectual property agreements exist but they have very little muscle

U.S. companies have had more than their share of problems protecting their intellectual property throughout the world despite a seemingly endless list of international, regional, and bilateral agreements governing intellectual property protection. Most, but certainly far from all, of these agreements fall under the aegis of the World Intellectual Property Organization (WIPO), an agency of the United Nations.

No international laws spell out explicit rules to protect intellectual property. Nor do international agreements establish rights. Instead, they attempt to harmonize divergent national laws.

The two primary agreements under WIPO are the Paris Union for industrial property and the Berne Convention for copyright. The U.S. does not belong to the Berne Convention.

The Paris Union covers a wide range of industrial intellectual property—inventions, tradenames, trademarks, industrial designs, and much more. Presumably, each member country must grant the same protection to nationals of other member countries that it grants to its own nationals. However, if one country's patent protection is weak or nonexistent, it doesn't do another country much good to receive the same protection.

Several other industrial property agreements also fall under WIPO, including:

- Madrid Agreement (false or deceptive source of goods).
- Madrid Agreement (registration of marks).
- Hague Agreement.
- Nice Agreement.
- Lisbon Agreement.
- International Convention for Protecting New Varieties of Plants.
- Locarno Agreement.
- Patent Cooperation Treaty.
- International Patent Classification Treaty.
- Trademark Registration Treaty.
- Budapest Treaty.
- Nairobi Treaty.

Some regional agreements do not come under the WIPO umbrella. For instance, the European Patent Convention covers members of the European Economic Community, and the Council of Mutual Economic Assistance Agreement covers the communist countries of Eastern Europe. There are several others.

Similarly, there are no specific international laws for copyright protection. That, too, is based on national laws that apply only in a particular country. In addition to the Berne Convention, several other copyright agreements fall under WIPO—the Rome Convention, the Geneva Convention, the Brussels Convention, and the Madrid Multilateral Convention.

Also, there are about a half-dozen other international copyright agreements outside WIPO.

Horror stories abound of how intellectual property pirates overseas victimize U.S. firms

Many drug and agrochemical companies can spin incredible—but true—yarns of how they have been ripped off by intellectual property pirates overseas. Following are just a few:

Three of Eli Lilly's pharmaceutical products—antibiotics cephalexin and tobramycin and the anticancer agent vincristine—are being [illegible] by third-party pirates in South Korea. Lilly, in fact, doesn't even sell cephalexin in South Korea. [illegible] It was so readi[illegible] a pirated product that it has become a commodity before Lilly [illegible] the Korean market. The company figures it is losing [illegible] million per year in lost sales of these three [illegible] alone in South Korea.

Monsanto ran into pirate production of some of its proprietary herbicides in Taiwan. Although patented in many countries, the company didn't obtain patent coverage in Taiwan for its rice herbicide, Machete (a butachlor herbicide), because the weak patent protection would have made it virtually meaningless. As a result, Taiwanese pirates produce an imitation product, cranking out almost 800 tons annually. At the farm level, that represents a $10 million per-year loss in sales. These Taiwan producers also export their product to several countries, including some with little or no patent protection, such as India and Indonesia. More than 500 tons have been exported, worth about $6.5 million at the farm level.

Monsanto also has had [illegible] but [illegible] problems [illegible] with its glyphosate herbicide [illegible] up. The company has a [illegible] patent plus several process [illegible] Taiwan. Nevertheless, at least two and possibly three Taiwanese companies have made glyphosate-based products. Despite Monsanto's objections, one producer was exonerated because "he did not know glyphosate was a pesticide" (it has no other use). The same producer was granted an exemption from pesticide laws to produce only for the export market. As much as 22 tons of pirated product have been exported in a single year, perhaps more if the material shipped under false labels is included.

In 1980, Pfizer was poised to introduce its new antiarthritic drug piroxicam (Feldene). A local Argentine company launched its own copy of the drug three weeks before Pfizer. By 1984, more than 20 generic piroxicam products were on the market, with sales of more than $17 million. Pfizer itself sold only $1.6 million [illegible] product. The company holds [illegible] patents on piroxicam in Argentina, [illegible] legal [illegible] make it impossible to enforce them.

Although FMC's carbofuran insecticide was covered by patents in Brazil, a Brazilian company began importing a similar active ingredient from Eastern Europe, formulating it into an insecticide, and selling it on the local market in direct competition with FMC. Despite efforts to enforce FMC's patents, the situation persisted for five years. FMC estimates it lost $5 million in sales in each of those five years.

agrochemicals, stand a good chance of passing—if not in the Administration bill in one of the many pieces of duplicate legislation floating around Congress. Other proposals, tying licensing arrangements to antitrust considerations, are more doubtful.

But by far the most important part of the Administration's package concerns the proposed new round of multilateral trade negotiations under the General Agreement on Tariffs & Trade (GATT). This is nothing new. Ever since the U.S. proposed the new round of trade talks, it has wanted to negotiate a multilateral code or agreement covering all forms of intellectual property.

According to Pratt, getting intellectual property rights included on the GATT agenda is virtually a "must" from industry's point of view. The consensus seems to be that, without it, there should be no new round of trade talks.

Obviously, U.S. companies and their trade associations have managed to get Washington's attention on the intellectual property issue. "For the first time, we have the political will in the U.S. government to do something about it," says MacTaggart.

But why now, after so many years of trying? One big reason is the devastating trade deficits the U.S. has been racking up in recent years. Last year, the deficit hit $132 billion on a customs basis and a whopping $148 billion on a cost, insurance, and freight basis.

Even the country's vaunted chemical trade surplus slipped to $7.2 billion last year. It was more than $12 billion in 1980.

The usual explanations for the country's dismal trade performance focus on such things as a strong dollar, a strong domestic economy that sucks in imports, and weak economies overseas that demand less U.S. exports. All of these are less important than they were only a short time ago.

But there's another reason that's more important than it was only a short time ago. U.S. industries have been losing their competitive edge in the international marketplace. And, as the President's Commission on Industrial Competitiveness points out, U.S. industrial competitiveness—both at home and abroad—depends increasingly on innovation. It may be the one comparative advantage that the U.S. has left, and it should be protected.

Innovation, of course, smacks of research and development, technological breakthroughs, and know-how—all the things that make up intellectual property. And, as the commission also points out, "We have sometimes lost sight of what it is we are protecting, and how we can best protect it."

The "best way to protect it" certainly hasn't been by relying on the many existing international agreements that cover intellectual property rights. There are about 30 such major agreements, but they don't really offer much protection.

There are no international laws covering intellectual property, only national laws. The national laws, of course, are valid only in a particular country. And if a country's laws are weak or nonexistent, as they often are, then U.S. companies can't expect much in the way of intellectual property protection. All the international agreements do is attempt to harmonize the national laws. The effort leaves a lot to be desired.

As a result, patent standards vary widely from country to country. Some countries, indeed, have no patent laws at all or place unjustified restrictions on their coverage. Indonesia, for instance, has no patent law. Mexico has no patent coverage for chemicals and pharmaceuticals. Brazil, Argentina, and Colombia offer no patents for selected industries. Costa Rica reserves the right to nullify patents if the country thinks it's in the national interest.

Often patent terms are inadequate, particularly in developing countries. India allows seven years from filing date or five years from the time the patent is granted, whichever is shorter. Costa Rica has only one year for food, agrochemical, and drug patents.

Compulsory licensing requirements are commonplace. These require a company to "work" its patent in the country within a short period of time. If it doesn't, the company may be forced to license the patent to a domestic firm, usually at well below true market value. Sometimes a company can lose its patent entirely. Compulsory licensing requirements such as these exist even in industrialized countries—for instance, France and Canada.

Procedures for obtaining patents may differ and those differences can create problems. The U.S., for example, uses a "first to invent" rule. Some other countries use the "first to file" rule. An awesome array of procedural roadblocks are available in some countries to delay, possibly for many years, the granting of a patent to a foreign company.

In addition to patented products, patented processes are a headache, particularly to U.S. drug and agrochemical companies. In many countries, only the process, and not the product, is patentable. Often, that process protection is paper-thin. By making very minor and meaningless changes in the process, a domestic company in another country can legally skirt the process patent laws.

It's very hard, and often impossible, for a U.S. company to prove process patent infringement in another country. The U.S. company has the burden of proof, but has no access to a competitor's plant to come up with the proof.

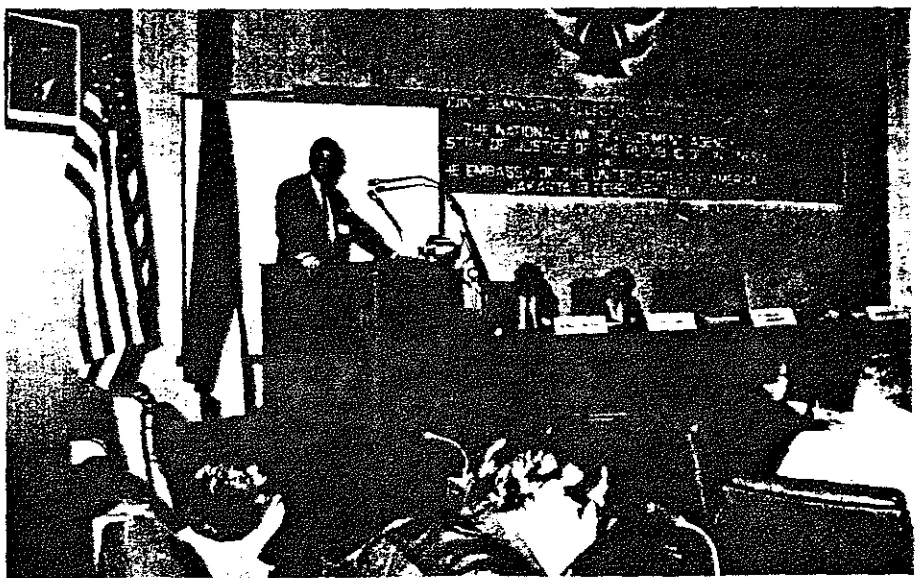
Meanwhile, there are many other drawbacks to the international agreements on intellectual property rights. In most cases, too few countries are party to the agreement, and the agreement, of course, doesn't apply in nonsigning countries. The agreements have no power of enforcement and no mechanism to settle disputes. Despite their number, the scope of existing agreements is far too limited. Many crucial areas remain unprotected. Computer chips and developments in biotechnology are good examples. In short, such international agreements have just not kept pace with technology.

Thus it's not surprising that these shortcomings have hurt the U.S. agrochemical and drug industries particularly hard. Both sectors spend heavily on R&D. Health and safety testing, registration, and market development are expensive. NACA estimates that it may take up to 10 years to develop a single new pesticide and cost more than $40 million just to develop and register it. PMA goes one better—about $80 million to discover, test, and secure marketing approval for a drug in the U.S.

Patents are the commercial lifeblood of these research-based industries. To get an adequate return on their extensive R&D outlays, agrochem and drug companies naturally depend on patent protection—both in the U.S. and abroad. They rely on the time during which an effective patent system gives them an exclusive market position.

Because both industries are so internationally oriented, foreign as well as U.S. intellectual property protection is vital. Without it, foreign pirate companies that have invested nothing in R&D or development costs and have taken no risks can easily and cheaply reproduce a U.S. product. They rush into the market at cut-rate prices, cut into a U.S. company's sales volume and profit margin, and threaten its return on investment. According to NACA, pirate sales in a foreign country can easily cut a U.S. company's profit margins on a pesticide 20 to 40%.

Agrochemicals and pharmaceuticals are particularly susceptible to overseas pirating, because foreign pirate operators are naturally attracted to the high,



U.S. Patent & Trademark Office's Michael Kirk described improved protection for intellectual property rights at seminar in Indonesia earlier this year research-based selling prices that these products command. Once the hard job of nursing the products through the research labs and developing the markets is out of the way, they are relatively easy to produce. Companies in any country with a reasonably developed fine chemical industry can do the trick. Newly emerging countries such as Taiwan and South Korea fall into that category.

What's more, many of the emerging countries are precisely the ones that have weak intellectual property laws. Thus, it's difficult—and often impossible—for U.S. companies to prevent foreign locals from duplicating and selling an imitation product. Initially, the pirates flood their local market, where it is difficult for the U.S. originator to stop them. Later, they may even export, usually to other developing countries that also have only weak patent protection. Bogus material may even find its way into industrialized countries where the original product is patented. But, because the pirates ship through a web of middlemen, they are difficult to catch and prosecute.

There have been instances in which a U.S. company has lost a foreign market completely. A country, for instance, can shut out a U.S. export by denying an import license, or by slapping an ultrahigh duty on the product. If the U.S. company wants to produce its product in the country, local officials may claim that local pirate capacity is "sufficient for the needs of the country" and deny permission. U.S. agrochem and drug companies have run into just such problems in Brazil, South Korea, and Mexico.

Another problem that U.S. research-intensive companies face is compulsory licensing. More than a few countries, primarily developing countries, are quick on the compulsory licensing trigger, forcing U.S. companies to license local companies long before they are ready or willing to do so.

Compulsory licensing is embedded in the Paris Convention. It's there to compensate countries in case a foreign patent holder doesn't "work" the patent in that country. The problem is that some countries don't consider imports as "working" the patent. Yet, it makes no economic sense to build sophisticated and expensive chemical plants in each country merely to satisfy the "working" requirement.

Several years ago, the so-called Group of 77 developing countries, along with a few industrialized nations, including Canada, suggested some amendments to the international patent agreements administered by the World Intellectual Property Organization (WIPO). Among the suggestions: that compulsory licenses automatically be granted for only 30 months if a patent holder doesn't produce its product in the country. Those compulsory licenses may be exclusive; that is, the licensee may have the exclusive rights to use the patent in a particular country. Meanwhile, the original patentee would be denied use of its own patent for two and a half years. The patent holder would forfeit the patent entirely if it did not "work" the patent in the country for five years.

Fortunately for U.S. companies, these proposals have not been adopted yet. But they still are pending in WIPO. According to some experts on intellectual property, the proposed compulsory licensing amendments to the Paris Convention may have been the last straw for U.S. technology-based companies, the development that put them in a fighting mood. But those companies that gauge the issue with economics alone are shortsighted.

Like so many other important issues, economic or political, adequate protection of intellectual property boils down to a squabble between developing and developed countries. It is another in a long line of so-called "north-south" confrontations—the haves vs. the have-nots.

Philosophical differences lurk behind many of the disputes over intellectual property rights. Many, if not most, developing countries think that technology developed in the industrialized world is prohibitively, even unjustly, expensive. They argue that owners of patents and other intellectual property, say, in the U.S., use their rights to nurture monopolies. Then, they contend, those companies charge unreasonably high prices for that knowledge, either as costly products or high-priced licensing arrangements. They often place very severe restrictions on technology use.

To developing countries, such actions are just another in a long list of reasons why they can't crawl out of their own poverty and modernize their industries. They maintain that demand for better intellectual property protection merely perpetuates the north-south dispute.

Some developing nations go so far as to say that knowledge, including that covered under intellectual property rights, is the "common heritage of mankind" and should be made available to everyone at little or no cost. If that phrase sounds familiar, it's because it is exactly the same one that the developing world used in the United Nations Law of the Sea Conference as they tried to gain access to the potentially valuable manganese nodules on the seabed.

U.S. companies naturally don't buy those arguments. But those arguments are likely to play a pivotal role in determining whether intellectual property will be on the GATT agenda for its upcoming round of trade talks. Hardline developing countries, led by Brazil and India, have been battling the U.S. and other industrialized nations over this for some time.

Later this month, when GATT ministers meet at Punta del Este, Uruguay, to decide the fate of a new multilateral trade negotiation, these hardline countries are expected to submit their own draft ministerial declaration. Conspicuously absent from that declaration will be the so-called "nontraditional" GATT issues—intellectual property rights, foreign investment guidelines, and trade in services—that the U.S. wants on the agenda.

So what Pratt says that U.S. industry wants most on the trade agenda, that is, intellectual property rights, is far from a fait accompli. If intellectual property does not make it, it will be interesting to see how strenuously U.S. business will demand no trade talks at all. It also will be interesting to see if the Administration has the political courage to heed the advice. □

The New American Challenge

By George Gilder

In the late 1960s, Jean-Jacques Servan-Schreiber alerted the world to the American Challenge, *Le Defi Americain*, in a book that became a world-wide bestseller. As the L'Express editor saw it, the U.S. was launching a gigantic, new world industrial empire, spearheaded by multinational corporations, government research labs and Pentagon contractors, all guided and subsidized by Washington. To compete, Europe would have to create a similar military-industrial complex led by government on the frontiers of high technology.

Soon, Europe resounded with appeals for new industrial policies. But nothing happened as Mr. Servan-Schreiber anticipated. The parts of Europe where his policies were adopted suffered the worst slump of the post-World War II era. Since the publication of his book, no net new jobs have been created on the continent. Europe fell ever further behind in the very information technologies that were targeted by national industrial policies.

The U.S. followed totally different policies. It deregulated finance, telecommunications, and air and ground transportation. The Reagan administration drastically lowered tax rates across the board and in 1985 proposed a new top rate of 35%.

Dire Predictions Misread Impact

These policies, beginning in 1978, led to a massive upsurge of entrepreneurship and innovation. Small-business starts nearly doubled, to 640,000 in 1985 from 270,000 in 1978. Some 15 million new jobs resulted.

Now a new tax reform will bring the top rate to 28% on individuals and smaller businesses and to 34% on larger corporations. Rather than increase benefits for conventional capital formation, the new bill removes the investment tax credit.

Many Americans are predicting dire results. Operating from the same assumptions as Mr. Servan-Schreiber, they expect the American economy to become less competitive. In particular, they declare that the new technologies demand more government guidance rather than less.

All these prophesies drastically misread the impact, meaning and prospects of the new information age. Contrary to some analyses, the pace of progress in computers is on the verge of a drastic acceleration, through the convergence of three

The first is artificial intelligence. In the past several years, scores of firms in the U.S. have introduced computer products that manipulate symbols, deal with uncertainty, use rules and inferences to solve practical problems, and simulate human modes of intelligence in expert systems. A second major breakthrough is the silicon compiler. This allows the complete design of integrated circuits on a computer. Now any computer-literate person with a $50,000 work-station can author a major new integrated circuit adapted to his needs. The third key breakthrough is massively parallel processing, in which many computer operations occur simultaneously.

Any one of these breakthroughs alone would not bring the radical advances now in prospect. But all together they will increase computer efficiency by a factor of thousands. Carver Mead of California Institute of Technology, perhaps the industry's most penetrating analyst, predicts a 10,000-fold advance in the cost effectiveness of information technology over the next 10 years. The use of silicon compilers to create massively parallel chips to perform feats of artificial intelligence will transform the computer industry and the world economy.

The chief effect of these converging technologies can be summed up in a simple maxim, a hoary cliche. Knowledge is power. Today, however, knowledge is not simply a source of power. It is, supremely, *the* source of power.

The most important immediate effect, already evident, is a drastic decline in the value of natural resources. A computer chip is made of sand, one of the most common substances. While pots and pans are 80% raw materials and automobiles 40% raw materials, an integrated circuit is less than 2% raw materials. Within five years, a few pounds of fiber-optic cable, also made essentially of sand, will carry as much information as a ton of copper. Indeed, a single satellite now displaces many

In the past, the domination of particular regions of the world imparted great political and economic power. Today not only are the natural resources under the ground rapidly declining in value, but the companies and capital above the ground can rapidly leave. Capital markets are now global; funds can move around the world, rush down fiber-optic cables and bounce off satellites at near the speed of light. People can leave at the speed of a Boeing 747 or a Concorde. Companies can move in weeks. Control of particular territories confers virtually no advantage in the present era.

These changes collectively explain the failure of the policies and predictions of Mr. Servan-Schreiber. The balance of power in the world has shifted massively against the state and in favor of the individual. The three great breakthroughs in computers, for example, all favor entrepreneurs and small companies.

> *The state can expropriate the means of production. But when it does, it will find mostly sand. For the producers, the entrepreneurs, run for the light of liberty.*

Artificial intelligence is simply a new form of software, which is chiefly a creation of individuals or small groups and requires virtually no capital. The silicon compiler moves control over the microchip from large capital-intensive firms to any designer with a salable idea. In conjunction with other gains, parallel processing allows tremendous advances of computational power at small cost and without expensively stretching the state of the art in manufacturing processes. All allow entrepreneurs to use the power of knowledge to economize on capital and enhance its efficiency—mixing sand and ideas to generate new wealth and power.

The good news for entrepreneurs, however, is bad news for socialism. The state can dig iron or pump oil, mobilize manpower and manipulate currencies, tax and spend. The state can expropriate the means of production. But when it does, it will find mostly sand. For the men of production, the entrepreneurs, run for the light of liberty. One way or another, most

money with them or se... always they take their mi... edge is their crucial power.

The new *Defi Americain* is the... form lowering the top federal rate to... on all individuals and small businesses. Make no mistake, this bill poses a devastating threat to all high-tax economies. As the British prime minister, Margaret Thatcher, says, "With a top rate lower than Britain's bottom rate, the U.S. will attract still more of Britain's most productive scientists and entrepreneurs."

The price of government is summed up in its tax rates. Governments compete for a share of the global tax base. They have to compete for that elite of productive and inventive men and women who contribute most to the global economy and tax base. These key producers are disproportionately British, and British accents ring out all over Silicon Valley today. But entrepreneurs from all high-taxed countries are increasingly willing to shop around for the most favorable places to make their taxable contributions. With the jetliner and discount fares, they do not even have to separate themselves from their homes and families.

Immigrants Critical to Success

Government has become a commodity, and if you look around you will find that it is not exactly scarce or underpriced. Increasingly, in the epoch of global capital markets and rapid travel, workers and entrepreneurs will purchase their government services and abuses at the lowest possible price.

Immigrants are already absolutely critical to the success of American high technology. Investors are already sending their funds to the U.S. in great volumes. But you haven't seen anything yet. In the next decade, America will be a mecca for all the world's entrepreneurs and investors.

Under this pressure, countries everywhere will begin lowering their tax rates to compete. The result will be an overwhelming surge of global growth. We are moving toward a general triumph of capitalism.

Mr. Gilder is the author of "Wealth and Poverty" and "The Spirit of Enterprise." This is adapted from a recent speech to the London Conference on Taxes and Growth, held jointly by the Adam Smith Institute

Engineering research and international competitiveness

by Roland W. Schmitt
Senior Vice-President, Corporate R&D
General Electric

Fundamental scientific knowledge is one of America's most effective forms of foreign aid. Unfortunately, it's foreign aid for our strongest rivals. The Japanese, for example, appreciate our research efforts so much that their industries spend two and a half times as much money funding university and nonprofit research laboratories outside their own nation—mainly in the U.S.—as they spend on such laboratories at home. And Japan pays us nearly ten times as much on patent licenses and other forms of technology imports as we pay them. That favorable balance of trade in intellectual property more than doubled in the 1970s, the decade when all other balance-of-payments figures with Japan were moving in the opposite direction.

These numbers challenge the assumption that doing more of our own research will improve our international competitiveness. Japan's experience shows that it is possible to succeed technologically while relying on others for fundamental knowledge and new ideas. But instead of rushing off to blindly imitate Japanese methods, we might formulate better ways of directing and using our own research.

Perhaps we're doing the right kinds of basic research, but making it too easy for our international rivals to get their hands on the results. The apparent cure would be to put controls on the movement of our basic research results across international boundaries. But such a policy would be shortsighted. Any conceivable method of slowing down the flow of fundamental ideas between us and our competitors would severely damage our own creativity.

A second possibility is that our government might be overinvesting in basic research and underinvesting in applied research. The cure would then be to adjust the focus of our national research effort. This would also be shortsighted. Government must not turn from a job it does well (supporting basic research) to one it does poorly (trying to anticipate markets in areas where it is neither a consumer nor a producer).

I believe that a third conclusion is most appropriate. We must build upon, rather than abandon, one of our greatest strengths: our fundamental research capability. But we must also make sure that we put our scientific knowledge to use more quickly than others do. We've got to increase our efforts in engineering research—the link between fundamental scientific research and application.

The middle ground between science and engineering, where the leading edge of research meets the cutting edge of application, is becoming more critical than ever before. In fields such as computer-integrated manufacturing, communications systems, very-large-scale integrated circuits, advanced engineering materials, artificial intelligence, supercomputers, and biotechnology—where international competition is beginning—the strengths of engineering researchers will especially be needed.

But although we need stronger and wider bridges between the people doing engineering in industry and the people teaching engineering and doing research in universities, we have not paid enough attention to designing and building those bridges. Engineering researchers have traditionally come to their trade with little encouragement from the government, and few emerge directly from the graduate schools.

In some ways, engineering researchers resemble the Shakers—the religious sect renowned for its fine furniture and practical inventions—who thought procreation a sin. Engineering researchers similarly fail to regenerate themselves, although more as a matter of circumstance than of morality. Young engineers are typically trained in conventional engineering programs, and even those headed for careers in engineering research are rarely exposed in school to the kinds of working conditions or professional relations they will later encounter. In contrast, scientists are usually trained in laboratories very much like those in which they will later work.

So there is not only a gap between the generation of knowledge and the application of knowledge but also a gap between the apprenticeships of potential engineering researchers and the roles they will eventually fill.

In the past, we have relied on chance to produce engineering researchers, and have made no concerted effort to create institutions that focus on engineering research. We are now designing such institutions at our universities, of which the Engineering Research Centers are noteworthy examples. These centers, to be established initially at six universities, will focus on areas of technology—such as robotics, microelectronics, telecommunications, composite materials, artificial intelligence, biotechnology, and computer-integrated manufacturing—that are crucial to the future of U.S. industry. They will be supported by the National Science Foundation, which will provide $94.5 million in funding over the next five years.

We often hear that these centers will be distinguished by three principal features: industrial support, interdisciplinary scope, and research aimed at utility. These descriptions are correct, as far as they go, but they miss the essence. "Industry support"—the bridge established between universities and industry—should carry much

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more than dollars. As one university president put it: "Don't just send us your money, send us your critical problems and people who understand them." And sending problems does not mean sending applied research problems. The idea is not to create job shops for industry but to do fundamental research in the areas of engineering practice being taken on by industry. The centers should not be building factory robots, for example, but generating new understanding of the fundamentals of robotic vision, touch, and control; not programming expert systems for use in diagnostics or repair, but acquiring new understanding of knowledge representation and developing the fundamentals of artificial intelligence; not building biotechnology production facilities, but devising new unit-operations concepts for biological processes.

The goal of industry–university interaction should be a two-way flow of information. From industry to universities should flow understanding of the barrier problems that practice is running into. From universities to industry should flow the knowledge and talent needed to overcome the fundamental problems. The main point is not to drive universities away from fundamental research but to orient them toward the areas of fundamental research that are most needed by industry.

The second important feature of the Engineering Research Centers is their cross-disciplinary nature. But let us strenuously avoid creating just another interdisciplinary program, which more often than not simply means a collection of specialists in different disciplines sharing a roof or a secretary. We need organizations whose shape is dictated by the problem to be solved or the type of result needed, not by the disciplines involved.

I'm under no illusions about the difficulty of realizing such a goal. The problem-solving culture of engineering practice is coming up against the disciplinary culture of engineering science. There will be mutual suspicion and resistance to change, just as there always is when cultures clash. But this interaction of cultures can actually strengthen the disciplinary base. Programs that transcend disciplines can enhance the excellence of disciplinary research both by revitalizing established fields and by creating new ones.

Finally, and most difficult of all, let's not take too narrow a view of the connections between engineering research and innovation. We must embed engineering research in the total process of innovation—from identifying the market all the way through production, quality control, maintenance, and improvement of the first product into a commercial success.

Moreover, these parts of the innovation process can't be separated into watertight compartments. The separation of marketing and engineering has killed many promising innovations in their early stages. Typically, the marketing people don't know enough about the future possibilities of the technology to ask the right questions of the users, and the technologists don't know enough about the users to make the right demands of the technology. For similar reasons, the separation of engineering and manufacturing can be just as fatal.

Building this total process awareness into the work of the new institutions should reflect the spirit of the late George Low, president of Rensselaer Polytechnic Institute and a pioneer of the Engineering Research Center concept. To train engineers, he believed, it wasn't enough just to put them to work in the classroom and the laboratory. They also had to experience the frustration and the excitement of putting advanced technology to work. In a program at RPI involving composite materials, for example, the students conceived of a product concept—a glider made of new composites—and immersed themselves in all the difficulties involved in getting a product out the door. As the final exam, they were required to test-fly the glider themselves! The glider flew, and so should the philosophy behind it. The Engineering Research Centers should get students used to the idea that the engineer does research in order to do, not merely to know.

Let's create a golden age for engineering research by designing such centers to forge links with industry that carry not only money but also the practical barrier problems that inspire research; to be not merely interdisciplinary but problem-oriented in a way that transcends disciplines; and to imbue students with an understanding of the place of research in the entire process of innovation. □

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[a]

BOOKS: 'The Poems of Lincoln K

,oes 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."

BITS OF OWNERSHIP

Growing computer software sales are forcing universities to rethink their copyright and patent policies

By IVARS PETERSON

Item: As a course assignment and using a university's sophisticated computer graphics system, three students create a short animated film. The film wins a prestigious international award, and the students receive lucrative offers from various movie companies. But the question of who holds the film's copyright — the students or the university — stalls possible deals.

Item: A computer science professor develops a clever computer program that a French company wants to use for research purposes. University officials claim that the professor has no right to sell or even give the software to the company without permission from the university.

Item: A graduate student writes a computer program as part of a large, ongoing research project. He copyrights the program and refuses to let other researchers in the department run the software until they agree to pay him a fee for its use.

Item: A team of faculty members and staff programmers puts together a computer program for handling library loans and other functions. The program is so successful that several dozen copies are sold to other libraries. Thousands of dollars accumulate in a bank account while the university tries to establish a policy for handling the twin questions of computer software ownership and the division of royalties.

These incidents, all of which have actually occurred at universities in the United States, reflect some of the sticky copyright issues now befuddling university administrators, faculty, staff and students. Universities are starting to review their "intellectual-property" policies, covering everything from copyrighted textbooks to patented inventions, to see where computer software fits in.

The real issue is money. Traditionally, universities have allowed faculty members who write books and create works of art to hold the copyright and keep any money earned from sales. On the other hand, most universities already enforce patent policies that call for a share of income from inventions.

The debate stems from a 1980 federal law that says computer software should be protected by copyright rather than by patent. Many university administrators, noting the increasing potential commercial value of software developed at universities, want to treat computer programs like inventions. In opposition, some professors argue that software, like any other copyrightable material, should belong to the creator.

Most universities don't yet have a comprehensive copyright policy, says Brian L. Hawkins of Drexel University in Philadelphia. "From the university's perspective, there's been money in patent policy," he says. "But copyrights, until software emerged as a copyrightable entity, didn't matter. Historically, there wasn't much money in them."

Now, universities are scrambling to catch up with technology. The issues surfaced early at places like Stanford University, the California Institute of Technology in Pasadena, Carnegie-Mellon University (CMU) in Pittsburgh and the University of Illinois at Urbana-Champaign, where software development has a long history. These and a few other institutions already have policies in place or are about to implement new policies. In many cases, the policies took years to develop. Bitter arguments often punctuated discussions.

One of the more contentious issues is the concept of "work for hire." Employees of a business usually must agree as a condition of employment to assign to the company all copyrights and patents. Even without a signed agreement, companies automatically own the copyright if the work is done on company time and with company resources.

The response of universities to this issue has been mixed. Some university officials argue that everything that takes place at a university is properly "work for hire" and really belongs to the institution. At a few universities, officials see the software copyright debate as a chance to gain greater control over everything that faculty and staff produce.

Others contend that universities are not like businesses. They say that a university's mission is the generation and dissemination of knowledge. A greedy administration and an overly restrictive copyright or patent policy can impede this function. It can also poison the atmosphere on a university campus.

Several universities are actually heading completely away from the work-for-hire concept. Some policies allow not only faculty but even staff hired to write specific computer programs to collect as much as 60 percent of the income from marketed software, although the university holds the copyright.

"There are arguments on both sides of that issue," says Thomas K. Wunderlich, associate dean of research at Brown University in Providence, R.I. "We're leaning toward a nondiscriminatory policy that says we'll treat faculty, staff and students alike. If there's going to be money made, then there will be sharing whether within the computer science department or within the computer center itself."

"This is a new form of incentive within the academic institution," says Hawkins, "where a different sense of community can be created."

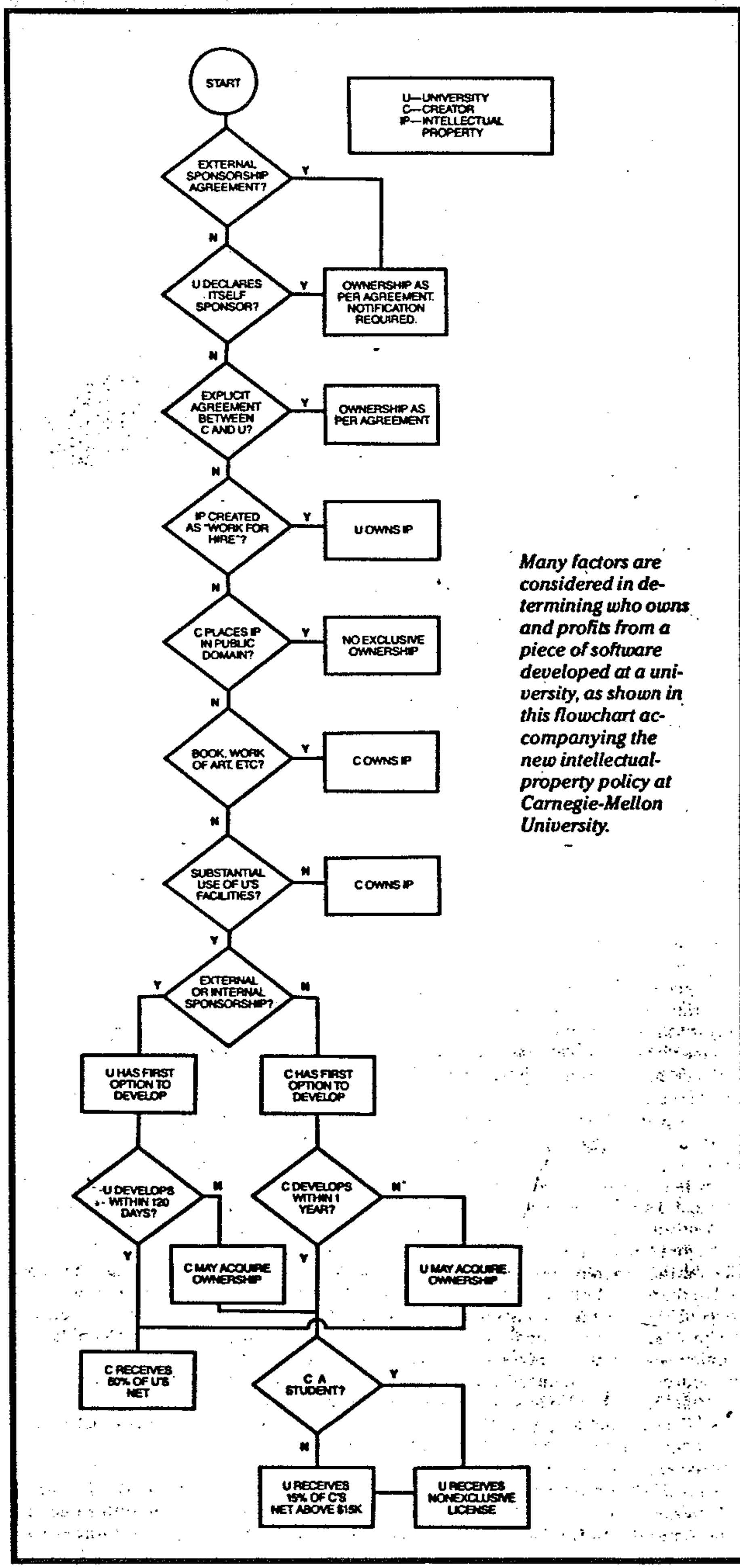
Most university software policies, however, don't go this far. More often, if faculty or staff are hired or assigned time to write a program for a specific purpose, then the university holds the copyright and the creators involved usually don't share in any income from marketing the software.

But establishing ownership can get complicated. "There are so many different scenarios under which creators can develop something," says CMU's Richard M. Stern. The CMU document includes an intricate flowchart showing all the different possibilities.

Software itself also covers a broad spectrum of creations — from "computer courseware," which is often little more than a video textbook, to programs that run scientific instruments and collect data. Also included are operating systems for computers and microcode, which converts commands in a programming language into instructions in a microprocessor chip. Some universities have chosen to divide software into two or more categories, depending on whether the software is more like a book or a patentable invention.

Another sticking point is the definition of "substantial use of university resources" in deciding whether a university holds a copyright. Brown University, in its proposed policy, takes a liberal approach. In general, unless the university's large "mainframe" computer is used extensively, the programmer holds the copyright. Exceptions would occur when research is sponsored by a government agency, industry or foundation and the contract specifically requires the university to claim ownership of any software produced for the project.

"There are concerns about use of university facilities," says Wunderlich, "but you can't police everything." The task becomes overwhelming with the proliferation of computers on campuses. "People use computers the way they would turn on a light switch," says Henry A. Scarton, a



Many factors are considered in determining who owns and profits from a piece of software developed at a university, as shown in this flowchart accompanying the new intellectual-property policy at Carnegie-Mellon University.

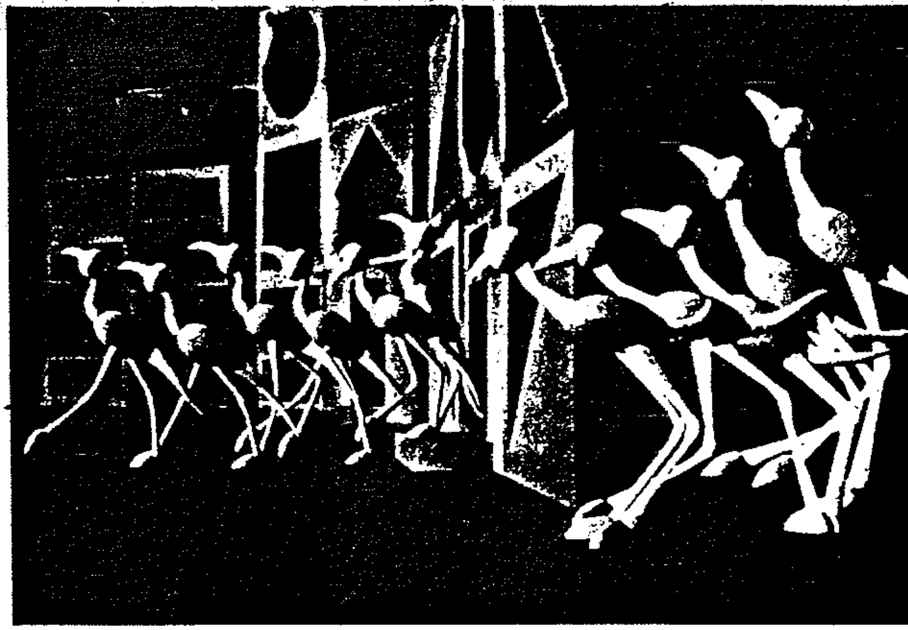
CMU

mechanical engineer at Rensselaer Polytechnic Institute in Troy, N.Y. "Using a computer is like having a pencil."

Nevertheless, CMU, in a quest for precision, is one university that has tried to put a dollar figure on "substantial use." In CMU's policy, "extensive" use of university facilities means that the programmer would have had to spend more than $5,000 to buy or lease equipment and services similar to those used at the university.

Wary of potential accounting problems, other schools have included a "substantial use" clause but have chosen to leave it undefined. At the Virginia Polytechnic Institute and State University (VPI) in Blacksburg, a special committee settles the matter.

Another touchy issue concerns the role of graduate and undergraduate students. At places like Ohio State University (OSU) in Columbus, the school has strongly championed students' rights by encouraging students to copyright their work, including class assignments and dissertations. In general, a student's work belongs to the student, unless the student has been hired for a specific project or makes extensive use of university facilities.



OSU/Computer Graphics Research Group

Three students at Ohio State University last year won several top international awards for their three-minute, computer-animated film "Snoot and Muttly." However, determining who owns the software that generated the images and who benefits from any proceeds from its sale turns out to be a very difficult question to resolve. Now OSU has a copyright policy that in the future may help settle such disputes.

Not all universities follow this approach, partly because of differences in state laws governing contracts and related matters. VPI lawyers recently studied the question as it applies in Virginia and concluded that a submitted class assignment, for instance, becomes the property of the professor involved. Students also cannot claim a share in any university software they helped to develop unless the professor, in a written agreement, decides to give them a percentage of any royalties.

The ownership of work done by students is a tricky question, says OSU's Gary L. Kinzel, who discussed the problem at a recent meeting in Boston on computers in engineering. "Students rarely work on a significant piece of software without major supervision from a faculty member," he says, "although the faculty member may or may not actually write part of the code."

In his paper, Kinzel gives an example of what could happen: "An adviser works with a student for several years and provides many of the ideas for a software package. The adviser may also arrange for computer support, financial support through a teaching assistantship and advice on the program development. At the end of the project, the student may decide he would like to start a company based on the program. He can then copyright the program and deny the university access to the source code. Technically, the student is within his rights because he alone did most of the actual programming."

Of course, because a copyright covers only the expression of an idea and not the idea itself, the professor is free to work with another student to redo the program from scratch. "However, with research that is highly associated with computer programming," says Kinzel, "the inability to be assured access to programs for future development has a significant damping effect."

Several new and proposed intellectual-property policies now try to circumvent such problems. At Illinois, for example, users, to get access to major university facilities, in effect agree to give the university a royalty-free license to use, within the university, any software developed using the facilities.

However, the best way to overcome these and other potential copyright problems is to come to some agreement before a project starts. "Contrary to all the good old academic traditions," says Dillon E. Mapother, associate vice chancellor for research at Illinois, "there are certain areas where you've got to put things in writing if you want to avoid trouble."

"Potential conflicts can be avoided if reasonable written agreements are made with students prior to any software development effort," says Kinzel. "Presumably, an important aspect of any such agreement would be that the university should have use of any software developed and this use should include the right to modify the source code."

More and more faculty members are taking this approach, not only with students but also in dealing with a university's administration. The CMU policy, in fact, states that because "it is frequently difficult to meaningfully assess risks, resources and potential rewards, negotiated agreements are to be encouraged whenever possible."

"The purpose of a policy is to establish the ground rules and to set the defaults — in a sense, the starting point for negotiations," says CMU's Stern. "We never really attempted to consider every possible scenario in detail." He adds, "I think it would be foolish to try to do something like that."

Although a few universities have intellectual-property policies that include computer software, most are just starting to wrestle with the problem. And new issues keep coming up.

"I don't think the debate on this is over," says Scarton. "If anything, it's only beginning." Rensselaer Polytechnic Institute started debating the issue several years ago but still has no policy. Now, a faculty committee has proposed that a modified version of CMU's policy be implemented. "CMU did a very nice job," says Scarton, "but their policy is a little bulky. We tried to streamline it a little bit."

Although policies like those at CMU and Stanford University are being used as models, the issues are complicated enough that universities are generally taking somewhat different approaches. "There's not a right way or a wrong way," says Brown's Wunderlich. You need to look for "a path of least resistance" to get a policy through at any particular university, he says.

Even universities that have policies see that changes are needed. Both the Massachusetts Institute of Technology and Stanford, which have had patent and copyright policies for years, are tinkering with their schemes. Commenting on OSU's recently adopted "interim policy," James B. Wilkens of OSU's patent and copyright office says, "This field is sufficiently complex that in two years we probably will find that we want to make a few changes."

"The main point is that if you adopt a policy that alienates the original authors [of a copyrightable piece of work]," says Mapother, "the property that you claim is largely without value." □

Germany's 75 Years of Free Enterprise Science

The Max-Planck-Society has celebrated its 75th birthday with its third Nobel Prize in 3 years and bright prospects, but tensions remain over its relationship to German universities

Munich

THE core idea of the modern research university—that teaching and research thrive best if carried out in close proximity—was conceived by the German scientist Wilhelm von Humboldt in the early 19th century. It is therefore ironic that Germany's foremost organization for the support of basic research, the Max-Planck-Society (MPG), was created deliberately to free scientists from the heavy burden of teaching and administration that the pursuit of Humboldt's ideals had imposed on universities.

Currently celebrating its 75th birthday, the Max Planck's network of independent research institutes remains the envy of scientists throughout the world. Although the society has been contending with serious budget difficulties and tensions in its relations with German universities in recent years, it enjoys what research institutions in few other countries have been able to achieve: substantial public funding with almost complete scientific and administrative autonomy.

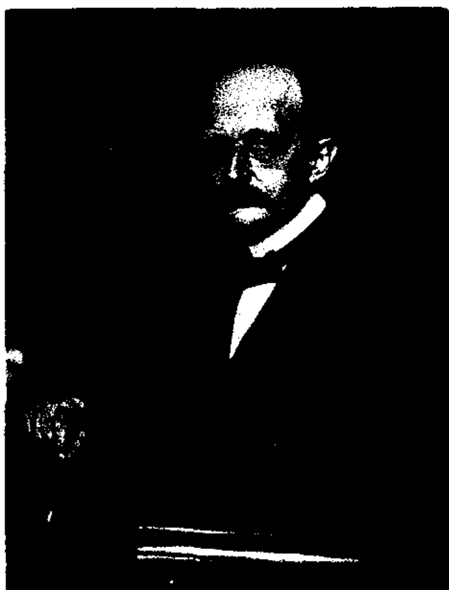
The society's scientific reputation was reconfirmed last month by the award of the Nobel Prize in physics—shared with Gerd Binnig and Heinrich Rohrer of IBM—to Ernst Ruska, the 79-year-old inventor of the electron microscope and formerly the director of MPG's Fritz-Haber-Institute in Berlin. Ruska is the MPG's 23rd Nobel prizewinner since its foundation, and the third in three successive years.

The publicity that has surrounded both this string of successes and the current birthday celebrations will, it is hoped, help break a funding deadlock that has held the Max-Planck-Society's budget constant at about $500 million a year for more than a decade. At the beginning of October, the länder (state) governments, which provide almost half the public financing, agreed to support a real budget increase of 3.5% next year. However, the MPG had been hoping for an increase of 5%, as well as an additional $10 million over the next 5 years for scientific equipment.

The Max-Planck-Society did not get its present name (suggested by British scientist Sir Henry Dale) until 1948. It began in Berlin in 1911 as the Kaiser-Wilhelm-Gesellschaft, and originated from a joint proposal by a group of scientists and industrialists who argued that advanced research was sufficiently important to receive public funding but to remain separate from the constraints of the university world.

Despite the many changes that have taken place in the world of science over the past 75 years, the philosophy of the Max-Planck-Society is largely unchanged. As a result, it remains an essentially elitist and conservative (some even use the word "feudal") organization, wedded to the idea that a nation's industry can prosper through the careful nurturing of basic science, but run with the traditional German emphasis on organizational efficiency and discipline.

The scientific activities of its 60 research institutes and project groups cover topics from nuclear physics through molecular genetics and coal research to the study of patent law. In size, they range from the 1000 scientists and technicians employed in the Max Planck Institute for Plasma Physics at Garching near Munich, to others—such as the new mathematics institute in Bonn—with no more than a dozen people on the staff.



Culver Pictures, Inc.

Max Planck. *Presided over the Kaiser-Wilhelm-Gesellschaft in the 1930's and immediately after World War II. The organization was named after him in 1948.*

Whatever an institute's size, its scientific autonomy is jealously guarded. The 200 scientific directors who are responsible for the individual research programs are each carefully selected. Once appointed, however, they are free to appoint their own staff and choose their own research topics. But they have to rejustify their support every 7 years.

Accountability is primarily scientific. Each institute is regularly scrutinized by an international team of visiting scientists, who report directly to the Max-Planck-Society president. The reports perform a double function, not merely checking on the quality of the work being performed, but also, says one administrator, "making us trustworthy on the political scene."

According to the current president, chemist Heinz Staab of the Max Planck Institute for Medical Research in Heidelberg, this independence has been made possible because the society's support has always come from two separate sources, each of which has tended to neutralize the influence of the other, leaving the MPG free to determine its own policies.

"There has always been a balance of power," says Staab. Initially it was between government and private sponsorship; now it is between the federal and state governments. "The research has never been dependent on just one of these groups," he adds.

In addition, Max Planck scientists work in an environment that reflects what one official describes as the "higher bourgeois" values of the early years of the century. This means, for example, that there has never been much reluctance to engage in research of explicit value to the private sector (provided individual topics remain set by the scientists themselves).

At the same time, it also means that there has been a conscious effort to isolate the content of research from political debates. During World War II, this led to some murky dealings with the Nazi regime, which later prompted the United States to propose that all the research institutes be disbanded (they were saved after intervention by the British).

In principle, however, the result has been to create a protected system of free enterprise science that is unique in the industrialized world. Scientists with a proven track record are provided considerable flexibility and freedom to innovate. "It is very effi-

Wall Street Journal 10-1-86

Bill Aims to Ease Transfer of Technology From Federal Laboratories to Businesses

By TIMOTHY K. SMITH
Staff Reporter of THE WALL STREET JOURNAL

Clifford Hesseltine's experience as a U.S. government scientist was classic. He did some research on toxins, published results that caught the eye of industrialists with a problem, and won a government citation for saving an industry.

The citation was the Third Order of the Rising Sun, bestowed on behalf of the Emperor of Japan, in recognition of Mr. Hesseltine's service to Japan's soy-sauce brewing industry.

The taxpayer-funded research done in the 700 or so federal laboratories should be a rich mine of ideas that U.S. businesses can develop into new technologies. But it hasn't worked that way. Most American companies shun the laboratories, and the technology that comes out of them usually goes to foreign countries.

"Private companies do not take seriously looking for new technology" at the federal laboratories, says Clifford Lanham, executive secretary of the Federal Laboratory Consortium for Technology Transfer, an umbrella group.

Problems on Both Ends

The transfer of technology from the U.S. government to corporations is rife with problems on both ends. Finding and developing basic research at companies rarely commands a priority as high as quarterly profits. And at the government laboratories, red tape and legal obstacles prevent most inventions with commercial potential from ever getting out the door.

"The labs spend about $18 billion a year" on research, says Bruce Merrifield, the Commerce Department's assistant secretary for productivity, technology and innovation. "I would say that about 95% of (their work) has not been been available for commercial development."

But that may soon change. A House-Senate conference panel yesterday completed negotiations on a bill that would make it easier for companies to exploit government research, primarily by removing administrative hurdles and giving laboratories incentives to commercialize their ideas. The legislation now goes to the House and the Senate for final votes, and sources on Capitol Hill say its chances for passage are good.

"We see this as landmark legislation," Mr. Merrifield says. "It seems so obvious and so much in the national interest."

He and other proponents of the bill argue that one reason the American technological edge has been slipping is that unlike other countries, the U.S. has been unable to narrow the gap between basic and applied research. That, they say, is why the U.S. still wins plenty of Nobel prizes but no longer seems able to build a decent automobile.

Congressional Action

Prodded by Congress, federal laboratories have been trying to promote their inventions in recent years, with varying degrees of enthusiasm and success. A 1980 law required the laboratories to appoint part-time officers to encourage technology transfer. Another law passed the same year permitted some laboratories—but not all—to do cooperative research with outside entities such as universities and small businesses. And legislation in recent years allows federal laboratories to get exclusive rights to inventions and license them—keeping some of the revenue.

> 'WE SEE this as landmark legislation,' says a Commerce Department official. 'It seems so obvious and so much in th national interest.'

Still, the bureaucracy remains nightmarish, and progress has been slow. Glenn Kuswa, technology transfer manager at the Department of Energy's Sandia National Laboratories in Albuquerque, N.M., describes the arduous journey an invention takes from his laboratory to the market. "It's checked for classification, and if it's not classified, it's sent to the local DOE office to see if a search for licensing should be made. Then it goes to Washington for evaluation, and if it looks promising, we write a disclosure, and it goes to a patent attorney and gets sent off to the patent office. The end result is a patent that is owned by DOE. If the inventor wants to, he can ask for license rights." Mr. Kuswa adds that from the time the inventor asks for a license until the product is developed is usually more than a year.

And that's just one laboratory owned by one agency; rules and procedures differ at laboratories owned by the Defense Department, NASA, the National Institutes of Health and other branches of the government. "It's going to take a while to turn this dinosaur around," Mr. Lanham says.

The new bill would grant blanket authority to all federal laboratories to set up cooperative research-and-development agreements with businesses. It would provide money to expand a communications system linking federal laboratories, giving businesses centralized access to a smorgasbord of government research. It would raise the status of technology transfer officers and make their positions full-time. Perhaps most important, it would reward government researchers whose inventions are licensed, requiring the laboratories to give them either 15% of license revenue or a fixed minimum payment.

Optimism at Labs

Officials at the laboratories are optimistic about the bill. "There has been a slow change, but now it almost looks like we might be on an exponential change curve," Mr. Lanham says.

But there are some problems that the bill can't address. There is, for instance, the basic difference in the cultures of scientists and businessmen. Scientists generally disseminate their findings as widely as possible; businessmen keep information secret to make money. "There is a feeling that the growth of science takes place by a vigorous exchange of information among scientists, and anything that inhibits that exchange is detrimental," says James Wyckoff, liaison officer for state and local governmental affairs at the National Bureau of Standards in Gaithersburg, Md.

And some of the agencies running federal laboratories fear that injecting a dose of entrepreneurship could divert researchers' attention from larger national goals and cause laboratories to compete with one another. "The question is: What is the mission of the labs? Is it to develop near-term technologies for development, or to focus on long-term research, national security and so forth?" says Vid Beldavs, executive director of the Technology Transfer Society, Indianapolis.

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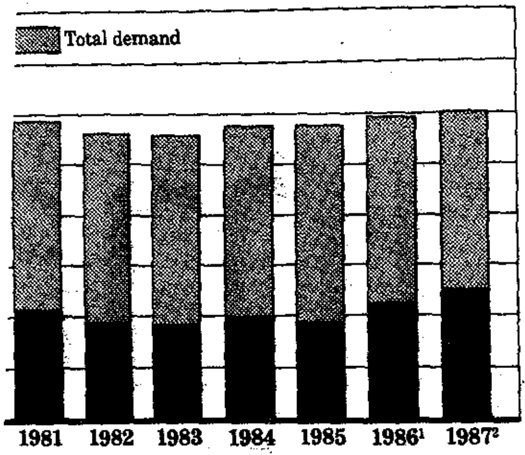

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of the 1973-74 Arab oil embargo and with 47.7% in 1977, the previous peak.

The rate of increase this year may moderate slightly from last year, when there was considerable inventory-building by U.S. refiners. Even so, industry estimates of 1987 import volumes range between 6.5 million and seven million barrels a day, as demand increases and there is an accelerating decline in domestic production.

Turnabout in Demand

U.S. petroleum demand began increasing last year after falling for several years. According to industry estimates, petroleum demand averaged slightly under 16.2 million barrels a day in 1986, up nearly 3% from the 1985 level. Oil economists expect that, barring a recession, demand will rise again this year, perhaps at a lower rate of increase. A 2% gain in 1987, the generally anticipated increase, would add an additional 300,000 barrels a day to import requirements.

But even if demand were to remain flat this year, imports still would have to increase because of falling domestic production. After holding steady or rising for four years, domestic oil output began dropping shortly after prices collapsed in early 1986 as U.S. producers began closing marginal wells. Lately, the declines have begun to snowball as a result of severe cutbacks in exploration and development spending by the oil companies.

Last year, as oil prices plunged, the American Petroleum Institute estimated that $15 oil would wipe out domestic production of 900,000 barrels a day within a year's time. But in just nine months, a decline of 800,000 barrels a day already has occurred, says Edward H. Murphy, API's director of statistics.

For all of 1986, domestic crude-oil production averaged 8.7 million barrels a day, down 300,000 barrels a day from the 1985 average. Natural gas liquids, which can be processed ... oil, accounted

Agency Seeks Reactivated Panel to Settle Disputes Over Exports of Strategic Goods

By Eduardo Lachica
Staff Reporter of The Wall Street Journal

WASHINGTON — The Commerce Department is seeking the reactivation of a cabinet-level panel to help unsnarl bureaucratic disputes over the extent to which the U.S. should control exports of strategic goods.

Bruce Smart, undersecretary of commerce for international trade, said the department urged the White House to reconstitute the Export Administration Review Board to avert delays and inaction on export-licensing issues. The problems, a source of frustration to U.S. exporters, result from disagreements between the Pentagon—which generally takes a hard-line approach to export-licensing issues—and the Commerce Department, which puts relatively greater emphasis on promoting exports.

The Export Administration Review Board was created by President Kennedy in 1961, but it "hasn't been used effectively in recent years," Mr. Smart said. During the past two years, Commerce Department aides argued, the Pentagon often stalled board action on export-control matters. But they said other agencies, fearing they lacked strength to persuade the White House to set aside Pentagon objections, were reluctant to take their case to the president.

Under the new Commerce Department proposal, the Pentagon or any other dissenter from a board decision would have to bear the burden of proof in appealing a decision to the White House.

Move to Restore 'Balance'

The board is led by the secretary of commerce and made up of the secretaries of defense, state and energy.

In another move to restore "balance" to the panel's decision-making, the Commerce Department proposal would reinstate the treasury secretary as a member of the board. The treasury seat was eliminated during a Carter administration reorganization. The Commerce Department contends it should be restored because of the profound impact export controls have on the U.S. trade balance.

A revived board could take up a number of export-control revisions that the Commerce Department proposed last year. These include a proposal to eliminate export controls on foreign products containing U.S. components if the value of those parts doesn't exceed 20% of the value of the entire products. Another such proposal that has languished since last year was to waive licensing requirements for foreign buyers whose reliability can be certified.

Skepticism Over Plan

Some U.S. exporters were skeptical that the Commerce Department's plan to resurrect the board would help. "If the Commerce Department and the Pentagon can't resolve their differences head-to-head, I don't know how bringing in a roomful of other people will help," said Eric Hirshhorn, a former Commerce Department lawyer who now represents technology-exporting companies.

The board could operate alongside another dispute-resolving mechanism that the White House established in 1984, Mr. Smart said. This system provides for arbitration of interagency disputes by the National Security Council. A National Academy of Sciences study released last week advised the Reagan administration to strengthen this process.

U.S. to Seek Allied Help

Mr. Smart said the administration is determined to remove unnecessary burdens on U.S. exporters. He said the administration plans to seek greater cooperation on export-control issues between the U.S. and its allies. He also said the U.S. will try at a meeting next month of the Coordinating Committee on Multilateral Export Controls to enlist allied help in urging nonaligned nations to cooperate more fully in export controls. Cocom, as the Paris-based body is called, is made up of the U.S., Japan and 15 North Atlantic Treaty Organization allies.

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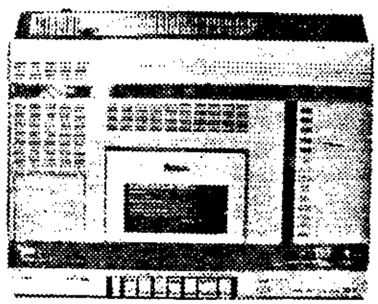
Lessons of the VCR Revolution

How U.S. Industry Failed to Make American Ingenuity Pay Off

Second of a series

By Boyce Rensberger
Washington Post Staff Writer



RUDE AWAKENINGS
THE CHALLENGE OF THE GLOBAL ECONOMY

The videocassette recorder is an American invention, conceived in the 1960s by Ampex and RCA. The first VCR for home use to reach the U.S. market, in 1971, was the American-made Cartri-Vision.

By the mid-1970s, however, every American manufacturer had judged the VCR a flop and had left the business.

Today not one American company makes VCRs. All of the 13.2 million units sold in the United States last year—36,000 every day for a total of $5.9 billion—were made in Japan or Korea.

Even RCA, once a proud, patent-holding pioneer of the new technology, is now simply a middleman, buying Japanese VCRs and reselling them under its own label.

The story of the VCR, according to many experts, illustrates some of the reasons why American industry is losing its global competitiveness. It challenges the popular notion that a loss of innovative capacity lies at the heart of this country's eroding economic position. While there is evidence that American innovation may have lost some vigor and that other nations are gaining fast, many experts believe the United States is still the world leader in scientific and technological innovation.

"The problem is not so much with American innovation," said Harvey Brooks, a specialist in technology and public policy at Harvard University. "Our scientists and engineers still lead the world in the origination of new ideas. The problem is what happens after that point. Where we're falling behind is in the ability to develop new ideas into products and to manufacture them to the high standards that we've come to expect from the Japanese."

The VCR is an example.

In the early '70s several companies in the United States, Holland and Japan unveiled VCR prototypes with great fanfare. Industrial-sized video recorders were already common in television studios, and the key to the home market seemed to be scaling down size, cost and complexity of operation. Most of the problems seemed near solution when the prototypes were demonstrated.

One hitch, it developed, was that the cassette would record only one hour of program. Market research showed that people wanted to get two hours on a tape, enough to record a movie. Cartri-Vision, named when cassettes were cartridges, was a one-hour machine that industry analysts say failed for that reason and because the recorder came built into a 25-inch TV set.

Despite the Japanese and Dutch activity in VCR development, the American firms did not think of

See COMPETE, A10, Col. 1

A TALE OF TWO PATRONS

by Robert M. Rosenzweig

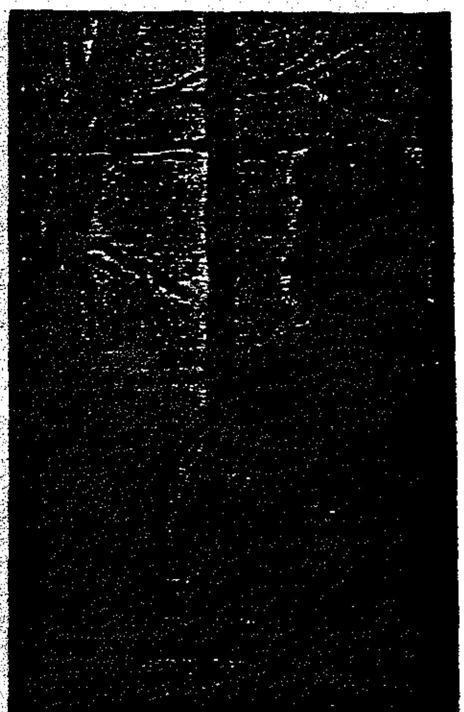
It is illuminating to compare the circumstances that attend the growth of new associations between universities and industrial patrons with those that attended the growth of the new (at the time) relationships between universities and their government patrons. It is illuminating because the contrast is so sharp as to be shocking. One will search the record in vain from 1945 to about 1965 for evidence of the kind of concern about the impact of government patronage that is represented by the Pajaro Dunes meeting [California. March 27, 1982], by tens of other meetings, and by the carload of published material on the subject of universities and business.

Can it be that association with industry either threatens or promises greater change in universities or in science than was occasioned by government's role? To ask the question is as good as to answer it. It is improbable . . . that anything coming out of industrial sponsorship can approach the fundamental transformation of American universities and American science that began with World War II and continued with the peacetime growth of federal programs.

Can it be, then, that dealing with business presents greater danger to important academic and scientific values than did dealing with government? Is the prospect of profit, in other words, a greater inducement to compromise than were the benefits—personal and institutional—that came with government money? Well, perhaps for some people that is the case, but it is hard to imagine a set of challenges to long-held values greater than those that grew out of the conditions attached to government funding.

The secrecy imposed by classified research was more complete, more constraining and more long-lasting than anything that is likely to flow from proprietary considerations, and ordering of the research agenda was surely influenced in important ways by priorities derived from outside the logic of science itself. One could cite many examples, but the one closest to current concerns about the commercialization of biology would probably be the effect on research programs induced by the politically inspired decision to wage war on cancer.

My purpose in citing this record is surely not to suggest that since we endured large effects more or less thoughtlessly, we can endure probably smaller effects equally well without thought. On the contrary, what I intend by the comparison is to demonstrate that we appear to have learned something. The experience with government, the knowledge that good fortune frequently carries danger in its wake, has led to an attentiveness to the risks of new relationships that should encourage our belief in the ability of people to learn from experience.



Difficult and searching questions about the dangers of business involvement in university-based research have been raised by Congress, the media and the faculties, administrators and trustees of universities.

A large number of institutions have undertaken reviews of policies governing faculty consulting, conflicts of interest, patents and licensing, secrecy in research and a variety of other topics raised by contracts with business. There is an unprecedented amount of thought being devoted to the policy consequences of these new associations. And what is most encouraging is that individual institutions—the proper makers of policy in a society that values pluralism and that rejects the notion that there is only one road to heaven—are looking for solutions that make sense for them.

Let me be careful to say exactly what I mean to say. I emphatically do not mean to say that the possibility—I would personally say, the probability—of foolishness and error has been removed. It has surely been reduced, but no one has yet discovered, in any activity involving human beings, the way to eliminate bad decisions. What I do mean to say is that never in my memory have the conditions been more propitious for the development of sound institutional policies about such important issues.

There is room for improvement; there always is. In this case, one needed improvement is in the national capacity to gather and disseminate information about a wide variety of developments at a large number of institutions. Good policy making rests on good information, and we can improve the quality and quantity of information available for institutions.

The Association of American Universities, in cooperation with other concerned national organizations, hopes to start an information clearinghouse that will distribute widely the experience of institutions and business as they come to terms with one another. If the clearinghouse succeeds, it will bring assistance to where it is most needed, namely to the universities and businesses that will be grappling with the policies that should govern their mutual relationships. ■

Robert M. Rosenzweig, who organized Pajaro Dunes for Stanford University, is now president of the Association of American Universities. Preceding portions from Robert M. Rosenzweig, "The Pajaro Dunes Conference" in *Partners in the Research Enterprise: A National Conference on University-Corporate Relations in Science and Technology* are used with permission of the University of Pennsylvania Press. To order, contact University of Pennsylvania Press, 3933 Walnut Street, Philadelphia, PA 19104.

Norm: FYI

Jack

[Wash]ington Times — WEDNESDAY, MAY 28, 1986, PAGE 3A

Many Dixy Lee Ray backers shocked she may not get post

By Ed Rogers
THE WASHINGTON TIMES

Prestigious scientists and scholars who support President Reagan's policies expressed shock yesterday that Dixy Lee Ray, former Atomic Energy Commission chairman, may not be chosen as the presidential science adviser.

The scientists said they had learned that Miss Ray, 71, who has served on the National Science Foundation and as governor of the state of Washington, was being edged out by Dr. Robert O. Hunter Jr., 39, a San Diego research executive.

"He probably is a worthy young man, but I do not believe that he is in the same league with Dr. Dixy Lee Ray," Frederick Seitz, president of the National Academy of Sciences from 1962 to 1969, said in an interview.

"I was a little suprised when I read someone pushing his candidacy over Ray," Mr. Seitz said. "This led me to a profound suspicion that perhaps he is being pushed on political grounds rather than on scientific grounds."

Robert Tuttle, White House personnel director, when asked about the scientist's suspicion that a political deal was underway, had a one-word comment: "Preposterous!"

"No decision has been made; I expect one will be made shortly," Mr. Tuttle said in a telephone interview. He would not discuss the matter further.

The White House announced yesterday that astrophysicist Richard Johnson will serve as interim director of the White House science office until a new permanent science adviser is chosen. Mr. Johnson, 58, is currently assistant director for space science and technology in the White House science office.

Mr Seitz said he, Edward Teller, known as the father of the H-bomb, and Miro Todorovich, executive director of Scientists and Engineers for Secure Energy, had recommended Miss Ray for the science adviser post months ago.

Commenting on speculation that Mr. Hunter is being favored for the job, Mr. Seitz said, "I would certainly like to be further enlightened as to what quality he possesses, besides perhaps friendship among Republican politicians, that would make him a superior candidate to a woman of such recognized scientific achievement, who has had experience in government."

Mr. Teller was in the Mideast and could not be reached for comment.

"I guess what we are afraid of is having another unknown who spends three years learning the post," Mr. Seitz said. "He might be a splendid person, but there's a chance he might be new to the Washington scene and new to the scientific community as a whole."

There was some criticism of George A. Keyworth, who resigned as the president's science adviser Dec. 31, because of his inexperience. Critics said he used the appointment to get on-the-job training for his private career. He has formed a consulting firm that will advise businesses on how to establish intelligence-gathering systems.

New York University professor emeritus Sidney Hook, who gave the prestigious Jefferson Lecture before the National Endowment for the Humanities two years ago, also expressed concern about Miss Ray being bypassed.

"My astonishment is due to the fact that Dr. Ray is being passed over without any public evidence that the person who seems to have the inside track to this post has scientific and administrative merits," Mr. Hook said.

"Is Mr. Tuttle a Republican trying help another Republican from San Diego?" he asked. "The interest of the country transcends the interest of San Diego Republicans. I'm surprised. I don't think the president is aware of this situation."

Mr. Hook, widely known in the scientific community, although his field is philosophy, was asked if any scientists oppose the selection of Miss Ray for the job.

"Any scientist might on political grounds. People who don't like this administration don't like Republicans and don't like atomic energy," Mr. Hook said.

Ernest W. Lefever, president of the Ethics and Public Policy Center and a friend of Miss Ray, said she recently told him that the position of presidential science adviser is the only one that would bring her back to Washington.

"She's proud to announce that she's 71 years old and says, 'I'm too old to change my honest, plain American ways,'" Mr. Lefever said.

"She thinks the president would be well served by having a fearless, courageous honest person and loyal person, next to him, and that's why she's interested in this position," he said.

Mr. Lefever said he personally believes the job requires maturity and a broad range of experience.

"That's my answer to putting in these youngsters," Mr. Lefever said.

Lt. Gen. Daniel O. Graham, director of High Frontier — a private organization that promotes President Reagan's proposed Strategic Defense Initiative — said either Miss Ray or Mr. Hunter would be acceptable to him.

"Dixy Lee is an old friend," he said. "She is a great supporter of SDI. But I know that Hunter has his head screwed on right, too. Robert Hunter is also a supporter of SDI, so from my point of view they're still getting a good guy.

"What I was worried about was getting a non-supporter of SDI in there."

... said a veteran ... corre- ... it's well known that ... hates Ortiz's guts."

'Work of Justice'

Ambassador Edward L. Rowny, special presidential adviser for arms control, is scheduled to address the Cardinal Mindszenty Foundation conference on Saturday in Chevy Chase. His topic is "Peace is the Work of Justice," an important theme to Cardinal Mindszenty that recurs in major papers issued by the Roman Catholic Church. An aide to Mr. Rowney said the ambassador would speak about his belief that "we cannot avoid the grim realities of the world. Peace can only be maintained by effective deterrents while we negotiate."

So, sue me

President Reagan said it made him feel better to see so many lawyers present when he signed the proclamation of Law Day yesterday. "You make me feel very good in case Mr. Qaddafi brings legal action against me."

Kevin Loughery

Against the odds

Some Washington Bullets fans spotted the team's new coach, Kevin Loughery, decked out in a bright pink sweater and betting with "both fists" Tuesday night at Rosecroft Raceway. They wondered if he shouldn't be holed up somewhere reviewing films for the upcoming playoff series with the Philadelphia 76ers.

But their concern was assuaged somewhat as the rumor spread that Mr. Loughery was just getting used to betting on the long shot.

It ain't us

Mergers, acquisitions and divestitures are not without consequences. Standard Oil Company of Ohio (SOHIO) learned some of the hazards when it bought Gulf stations in Florida and seven Southeastern states. "We've had bomb threats, people cutting up their credit cards and sending them back, one small bomb that went off in a station in Kentucky," said SOHIO spokesman David Franasiak. The problem? As part of the deal, SOHIO retained the Gulf logo on the stations.

The Gulf logo made them a target of grass-roots anger at Chev-

... the ... Soviet man ... in him a hatred and ... of religion and superstitions."

Toward this end, "3,084 general secondary schools; 409 preschool establishments; 10 institutions of higher learning; 105 special secondary schools, vocation and technical schools; 4,275 public libraries, clubs, people's theaters, cultural and rest gardens and museums are taking part in the atheist education of workers."

Kennedy immersion

Sen. Ted Kennedy has joined the Senate Judiciary Subcommittee on Patents, Copyrights and Trademarks. There is no training course for membership, and Mr. Kennedy found himself listening to the complex and arcane inside details of the ways in which television stations pay for the music they play, a subject on which he had no previous knowlege or demonstrated interest.

Sen. Charles McC. Mathias, thought he'd help out. "We're going to give you a Baptist welcome, senator," he intoned. "Total immersion." Replied Mr. Kennedy with a grin, "I just hope you bring me up."

John Elvin

Ca... of N...

By John McCaslin
THE WASHINGTON TIMES

Assistant Attorne... Herrington said yes... had hoped to keep a... to New York's sleaz... trict of Times Square...

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Dole adviser says Senate leader is more conservative than Bush

By Mark Tapscott
THE WASHINGTON TIMES

A strategist advising Sen. Robert Dole on how to win the 1988 Republican presidential nomination says the Kansas Republican is about 10 percent more conservative than his strongest competitor, Vice President George Bush.

Mr. Dole, the Senate Majority Leader, is laying a careful foundation for a long-haul campaign designed to outshine competitors who spurt and fall in the polls.

"In terms of Bush and Dole, it looks like Dole is about 10 percent more conservative," said Donald J. Devine, a veteran conservative campaign strategist who spent four years working in the Reagan administration.

"The normal perceptual map people have of where the candidates are can be inaccurate and ... what this shows is that Dole should be acceptable to conservatives," Mr. Devine said.

Last week, at a luncheon at The Washington Times, Mr. Dole expressed frustration that his voting record has not received more careful — and favorable — analysis from conservative political leaders.

"I can't change my voting record," Mr. Dole said. "I just want people to look at it. It's been there for 20 years. Bush hasn't had a vote since 1970, except for four tie-breaking votes in the Senate."

Mr. Dole challenged his critics to look carefully at what Mr. Bush stood for as a congressman.

"If people are going to measure A, B and C, they ought to measure against something other than what someone says they will do," said Mr. Dole, who was elected to the House in 1960 and won a Senate seat in 1968.

A spokesman for the vice president, who served in the House for two terms but lost a 1970 bid for the Senate, said voting record comparisons "prove once and for all that Bush has a conservative voting record."

A look at the voting records of the two men during the time they shared in Congress shows agreement on most issues, but includes differences that will likely be magnified as the 1988 campaign intensifies.

Using the ratings of several major organizations who chose key issues, the two men show some marked differences.

In 1970, for example, Mr. Dole got a 71 percent mark from the Americans for Constitutional Action — a conservative organization. Mr. Bush got a 75 percent rating.

But, despite the similar evaluations, the ACA tally shows that Mr. Dole voted for a pro-busing measure while Mr. Bush took the ACA position and voted against it.

Mr. Dole joined with the ACA in voting to uphold then-President Nixon's veto of an appropriations bill funding the Health, Education and Welfare Department while Mr. Bush voted to override the veto.

On a third vote, Mr. Dole supported the ACA position in upholding the veto of a bill calling for increased hospital construction while Mr. Bush voted against the veto.

Over the 1967 to 1970 period, the ACA rating said Mr. Dole voted right 82 percent of the ti... Bush got a 72 percent...

The U.S. Chamber ... also showed that Mr. ... a 10 percent conserva... Mr. Bush during the 19... Dole got an 80 percen... Mr. Bush got a 70 perc...

A rating compiled ... sional Quarterly of su... position taken by the ... congressional coalitio... Dole with a 88 perce... Mr. Bush with a 71 p... during the same peri...

Viewed from the ... spective of American... cratic Action, a libe... group, Mr. Dole and ... peared closer philosop...

While Mr. Dole rece... rating of 10 and Mr. Bu... 7, they parted company... tant anti-busing vote.

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Norm JUL 1 1985

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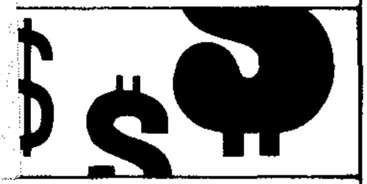

Prepared by Willis H. Shapley, Albert H. Teich, Stephen D. Nelson, and June Wiaz, *Research & Development, FY 1986* reports that the total amount recommended for R&D in FY 1986 is $60.3 billion. Of this, 72 percent is for national defense R&D and 28 percent is for non-defense R&D. Defense R&D would increase 22.6 percent over FY 1985; non-defense R&D would remain almost exactly the same, in total, in current dollars. In constant dollar terms, based on the Administration's forecast of about 4 percent inflation in FY 1986, defense R&D would have "real growth" of 17.8 percent, while non-defense R&D, in total, would decline about 4.4 percent.

However, projections through FY 1990 show that while defense R&D should continue growing by about 12 percent per year (in current dollars), non-defense R&D shows a decrease averaging over 7 percent per year. The report observes that while some people believe funds could readily be found for necessary non-defense R&D by capping the increases in defense R&D spending, this approach "will have to contend with the strong policy support for the defense build-up the administration has repeatedly demonstrated and the fact that so many other non-defense programs, as well as deficit reduction, will be powerful competitors for any 'savings' in defense."

For example, nine Stanford University professors, including three Nobel laureates, have warned the Senate and House appropriations subcommittees that the Administration's budget cuts will place the U.S. in a non-competitive position in fields dependent on sophisticated new instrumentation. In urging Congress to restore support for NIH biomedical research technology to the level originally mandated by Congress, they wrote that, "especially alarming are the disproportionate and selective cuts in instrumentation programs."

Military R&D Spending Hit As Excessive

The U.S. "is overspending on military R&D and underspending in civilian R&D," Colorado's Governor Richard D. Lamm told the Industrial Research Institute's Annual Meeting in May. While acknowledging the importance of a strong defense, Gov. Lamm observed that 70 percent of all U.S. government R&D funds now go to the development of destructive weapons. Spending for civilian research is 1.9 percent of GNP, compared with 2.6 percent for West Germany and 2.5 percent for Japan.

In voicing his concern, the admittedly outspoken Governor was also reflecting a recent study by the Center for Defense Information in Washington, D.C. That study, authored by Brian McCartan, found that military research produces few profitable payoffs for civilian R&D. It warned that the current emphasis on military research is diverting attention from commercial technology, where the U.S. world lead is narrowing.

In his keynote address to the IRI meeting, Gov. Lamm illustrated this issue with the following examples:

- The Air Force spends more on nuclear missile R&D than the entire research budget of General Motors, the largest corporate R&D spender.
- In 1983 the Defense Department spent more on B-1 bomber R&D than the total research budget for the U.S. steel industry.
- A 90 percent increase in military R&D spending is anticipated between 1983 and 1987.
- Military funds spent on "the technology base"—the area of greatest commercial application—grew only 34 percent from 1980 to 1984, while R&D on strategic nuclear weapons increased over 350 percent.
- One-third of all U.S. engineers and scientists are involved in military projects, while there is a shortage in the commercial sector, especially of computer specialists.

Insisting that there is not much spin off to the commercial sector from military R&D, Gov. Lamm warned that this imbalance will have "profound consequences" for the future of the American economy, which he sees as already deteriorating seriously. The growth in military R&D spending will further disrupt our economy, bringing on larger trade deficits, slower growth and personnel shortages, he asserted.

Improving Access To Federal Technologies

A major new source of federally-funded technology may open to private development if two new bills introduced by Senator Robert Dole (R-Kan.) become law. S. 64 would allow large company contractors as well as university and small business contractors to retain title to federally-funded inventions. S. 65 is aimed at federally owned and operated laboratories such as the National Institutes of Health, the National Bureau of Standards, and hundreds of other laboratories on which the Government currently expends something on the order of $13 billion a year for research.

Federal agencies have authority to grant exclusive licenses in inventions after publication of notice in the Federal Register. There is, however, uncertainty over the authority of agencies to enter into collaborative research arrangements with industry and to agree, in advance, to license or assign rights to the industrial partner in inventions that might emerge from the collaboration. S. 65 would remove this uncertainty and specifically authorize such Government-industry arrangements.

Other features of S. 65 are designed to create positive incentives for government operated laboratories to pursue industrial support and collaboration. The incentives include retention of income by the laboratories and payment of royalties to the inventor. (Currently, all revenues are returned to the Treasury.) Since many of these labs are not set up or authorized to carry their research beyond the basic or applied stages, there is a real potential for industrial firms to collaborate in areas of interest to them and then to move inventions from Federal laboratories to

RESEARCH**MANAGEMENT**

An International Journal Dedicated to Enhancing the Effectiveness of Industrial Research

Volume XXIX No. 2 March-April 1986

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PERSPECTIVES

News and Views of the Current Research Management Scene
M. F. Wolff, Editor

Companies To Spend 9% More on R&D in 1986 . . .

The National Science Foundation estimates that company-funded R&D expenditures will reach $58 billion in 1986, a 9 percent increase over 1985. This estimate is based on information from 74 corporate R&D officials queried in the spring of 1985. Their firms account for an estimated 53 percent of all company-funded R&D expenditures, and include 17 of the top 20 R&D spenders.

More than in previous years, the company officials who were surveyed expressed considerable uncertainty about the economic outlook for 1986. Although they considered R&D spending necessary to protect profits and market share, they were hesitant about forecasting a final figure for 1986 R&D expenditures because sales and other economic variables were showing no clear direction in mid-1985.

The 1986 projection compares with a 12 percent growth (in current dollars) in 1985. This decrease mirrors the drop in R&D spending growth forecast in the IRI's R&D trends survey for 1986 (*Research Management*, January-February 1986, pp. 12–13). Respondents to the NSF survey attributed it to expectations of lower profit growth and budget constraints.

According to the annual NSF survey, companies spent almost $48 million of their own funds on R&D projects in 1984, the most recent year that actual NSF survey data are available.

Between 1974 and 1984 the average annual percentage increase in R&D expenditures in constant dollars was 5.3 percent. Company R&D officials predict a slightly higher average annual constant-dollar growth rate of 5.9 percent for the period 1984 to 1986 with greater growth in 1985 than in 1986.

R&D spokesmen attributed the 1985 increase in R&D spending to a strong commitment to R&D as a means of protecting profits and market share, and an increased focus on process-oriented R&D to improve productivity and competitiveness. There is also increased emphasis on the rapid transfer of new technology from the labs to the operating units and on effective research project management.

Each of the six major R&D-performing industries projects increases through 1986, averaging annually from 14 percent in machinery to 8 percent in professional and scientific instruments.

- The machinery industry increase is fueled by a 14-percent average annual increase in the computer segment, NSF reports. This reflects increases in computer R&D of almost 16 percent in 1985 and 12 percent in 1986. The industry as a whole is dominated by the computer segment's 70-percent share of machinery R&D and tentatively expects increases of almost 15 percent in 1985 and 11 percent in 1986.

R&D directors in machine tool, farm equipment, and robotic companies blamed poor sales—especially overseas where the dollar remains strong—for the limits on their R&D budgets. A typical explanation: "Due to the pressure of imports on both sales and margins on our product lines, we were forced to make two budget reductions. . . . The opportunity for new and improved manufacturing equipment is great, but the risks today are even greater because of the strong dollar."

- *The aircraft industry* projects increases in company-funded spending of 11 percent in 1985 and 10 percent in 1986. These increases are in sharp contrast to the 11-percent decrease in company-funded R&D in 1983 which followed the 1982 decline in sales and profits in the aircraft industry. R&D directors anticipate a continuation of the current recovery in worldwide sales through 1986.

- *The electrical equipment industry* projects R&D spending increases of almost 12 percent in 1985 and 8 percent in 1986. The communications sector is leading the industry with a 14-percent increase in 1985 and an 8-percent increase in 1986, spurred by developments in computer technology, photonic transmission of information, and new opportunities as a result of the deregulation of the communications industry.

- *The chemicals industry* predicts R&D spending increases of 10 percent in both 1985 and 1986. Drugs and medicines companies lead the increases, predicting 12-percent growth in 1985 and an additional 13 percent in 1986 as they work on virus treatments, biotechnology and projects that affect areas as diverse as agriculture, livestock, energy, and the environment. Some companies are purchasing licenses to duplicate processes of other firms and are using the technology to quicken the pace of their own R&D. From 1984 to 1986, the average annual increase of almost 13 percent by drugs and medicines companies is lower than the previous growth rate of 17 percent from 1980 to 1984, as the availability of funds from sales and profits for R&D is constrained by the strength of the dollar, NSF finds.

- *The motor vehicles industry* expects to increase its R&D outlays almost 9 percent in 1985 and 7 percent in 1986. R&D officials in this industry believe that economic times are better for them now vis-a-vis two or three years ago and that the removal of import restraints is the driving force for R&D to meet quality and product goals. Two other reasons given for increased R&D spending were domestic competition and attempts to improve profitability by diversifying into fields such as robotics, automation, and aerospace.

- *The instruments industry* projects increases in R&D spending of 8 percent in both 1985 and 1986. These estimates are well below the 17 percent predicted a year ago as companies now have lower expectations of domestic and foreign sales. Medical equipment companies have modified their R&D spending plans since hospital administrators have cut budgets for major equipment purchases.

ERTA's Influence

In response to a question on how the tax credit or its impending termination affected their spending plans for 1985 and 1986, 30 percent of the companies in this year's survey (compared with 1984's 33 percent and 1983's 37 percent) reported that the temporary tax credit had favorably influenced their R&D budgets. Among the companies increasing their R&D as a result of the tax credit, officials mentioned that they financed certain R&D projects in their 1985 budgets deliberately to use the tax credits before they expire.

About 10 percent of the R&D directors said that they expected the termination of the tax credit to decrease the funds that would have been available for their 1986 budgets. Many R&D officials recommended extending or making permanent the tax credit for incremental increases in R&D so that a credit could be used to best advantage in long-range budget planning. Several R&D directors mentioned that because of the short-term nature of the credit, there was no incentive for their companies to develop an accounting mechanism to channel directly back to the R&D department the moneys saved on taxes as a result of the R&D credit.

. . . While Total Spending May Reach $117 Billion

Battelle's annual forecast sees expenditures in calendar year 1986 for U.S. R&D reaching $116.8 billion. This represents a 9.5 percent increase over the $106.6 billion NSF estimates was to be actually spent for R&D in 1985.

While part of the increase will be absorbed by continued inflation (estimated at 4.9 percent for R&D in 1986), Battelle forecasts a *real* increase in R&D expenditures of 4.4 percent. This is slightly higher than the ten-year average rate of 4.0 percent in *real* R&D effort experienced since 1975.

Industrial funding for R&D will account for 49.8 percent of the total. Industrial support is forecast to be $58.2 billion, up 9.3 percent from 1985.

Battelle sees an increase of 9.6 percent in federal support for R&D, with funding expected to be $54.5 billion. This is 46.7 percent of total expenditures for 1986.

Funding by academic institutions is expected to be 2.2 percent of the total, while other nonprofit organizations will account for 1.3 percent.

The report notes that during the past decade *real* industrial R&D support has increased at an average compounded rate of 5 percent per year, while federal support has increased at 3 percent on average. Prior to 1979 government supported more R&D than industry did.

Performers of Research

As far as actual performance of R&D goes, Battelle reports that industry will remain dominant in 1986, with performance expected to rise to more than $85 billion, or 73 percent of all research performed. This compares with $14 billion (12 percent) each for the federal government and for academic institutions, and almost 3 percent for other nonprofit organizations.

The Battelle forecast, prepared by Jules J. Duga and W. Halder Fisher of the Columbus (Ohio) Division, also estimates that overall costs for all R&D will increase 4.9 percent this year. Government will experience a 3.1 percent increase, industry 4.6 percent, colleges and universities, 9.2 percent, and other nonprofits, 6.5 percent. From 1972–1985, costs of all R&D, as an average, are estimated to have risen by 163.2 percent.

The report concludes that over the past few years, federal support tended to shift toward more "development" and less basic and applied "research." However, within the category of basic and applied research, there is a small—but perhaps significant—continuing trend toward increasing the basic research component.

In addition, industrial support of basic research is expected to increase, largely through cooperative programs between universities and consortia of industries.

Ask $1 Billion To Bolster Universities

The best way for the Federal government to enhance the nation's ability to compete in the international marketplace is to increase its support of university research and education, Roland W. Schmitt, General Electric senior vice president for corporate research and development, told the New York Science Policy Association recently.

That observation by GE's research director, who is currently chairman of the National Science Board, came in a speech calling for a reallocation of some $1 billion in existing Federal R&D monies for that purpose. Citing statistics that indicate a serious decline in the resources available to universities, Schmitt called for a reallocation of Federal funds to help universities overcome the major problems they face in the areas of "equipment, facilities, and attracting and keeping outstanding faculty members."

"The first-rate minds in our universities represent one of our nation's most valuable resources," Schmitt pointed out. "By strengthening that resource, we strengthen the generation of knowledge and make our nation's industries more competitive," he continued.

Schmitt warned that the Federal R&D system "is not providing an adequate science and engineering base for international competitiveness. There was a time when all the United States needed to do to win victories in the international marketplace was to show up. That time is long past—as we have learned in such fields as consumer electronics, compact automobiles, machine tools, and steel, and as we are learning now in the integrated circuit business. There are a lot of reasons other than technology explaining the poor showing of the U.S. in these fields, but technology's role is crucial in correcting it," he stated.

"A main source of science and technology is our university research and education system," Schmitt pointed out. "But that system is under more strain today than at any time since World War II. In the past, there would have been an easy answer to this problem—apply more money. But today that strain coincides with an era of enormous deficits and tightening budgets. We cannot depend on increased spending to strengthen our R&D system. Instead, we have to reorder priorities within the national R&D effort," he said.

Among the statistics Schmitt cited in presenting his case for shifting more R&D funding to university research were the following:

- A recent National Science Foundation study found that only about one-sixth of academic research equipment could be called state-of-the-art, while about one-fifth of it was obsolete and about one-third of it was more than ten years old.
- Studies estimate that between $5 billion and $20 billion will be needed during the next decade just to upgrade university facilities for science and engineering—that is, buildings and fixed equipment.
- Ph.D. production is not keeping pace with the nation's needs. U.S. universities annually award about 3,000 Ph.D. degrees in engineering—

some 500 fewer than they did back in 1972. Meanwhile, the share of those engineering Ph.D.s going to foreign nationals has increased from one-quarter in 1970 to more than half today.

- In 1984, 590 persons received Ph.D.s in electrical and electronic engineering in the U.S., compared with 787 in 1973. Forty percent of them were foreigners on temporary visas.

- The American Society for Engineering Education estimates university engineering faculties are in total more than 20 percent below the number needed to get student-faculty ratios back to where they were in the 1960s.

- Only 7 percent of U.S. undergraduates major in engineering, compared with 17 percent in Japan.

Schmitt said that current Federal R&D policies fall far short of meeting the pressing needs of universities. He called for a reallocation of $1 billion within the package of Federal spending for science and technology from applied R&D to the support of university research and education. "This sum would begin to make a dent in those growing facilities, equipment, and faculty problems," he said.

The GE executive said such monies could also be used to accelerate and extend initiatives such as the National Science Foundation's Engineering Research Center Program, which will fund new interdisciplinary programs in engineering research and education at various universities throughout the country.

Schmitt suggested that this is more than a matter of merely directing money at universities. "Funding of university efforts will be coupled with some reshaping of the way many university scientists and engineers choose research targets and train their students," he said. Research on topics important for industrial competitiveness can be as intellectually exciting as other research, he pointed out. Reshaping research priorities simply means widening the sphere of research with special emphasis on those problems that combine fundamental significance with payoff to society, he said.

Seek To Amend Stevenson-Wydler Act

Amending the Stevenson-Wydler Technology Innovation Act of 1980 is one of 11 legislative initiatives the Republican Task Force on High Technology Initiatives intends to pursue during this session of Congress in order to make U.S. industries more competitive in world markets. The Task Force wants to amend the Act "to streamline and make uniform the procedures used by federal and national laboratories for entering into cooperative R&D agreements with private and local government entities, and provide greater monetary incentives for laboratories and their employees to transfer their technologies to the private sector."

The Task Force's recommendations were released at a recent press conference as part of a 25-page report on industrial competitiveness.

"American workers and companies face an enormous competitive challenge today," said Task Force chairman Rep. Ed Zschau (R-CA), a former Silicon Valley entrepreneur. "Rather than using protectionism to run from the competition, we believe that America should rise up and meet the competitive challenge. We can be the best if government provides a sound economic environment for innovation and entrepreneurship."

Five of the 11 recommendations are taken from the 1985 report of the President's Commission on Industrial Competitiveness. The initiatives address a broad range of issues including tax reform, science policy, worker retraining, the Freedom of Information Act, and trade law reform. One initiative is to make the R&D tax credit permanent and broaden its applicability to cover computer software and start-up companies.

Warn Against Talent-Draining "Megaprojects"

The United States' R&D enterprise is in danger of becoming overloaded by "megaprojects" like the Strategic Defense Initiative which require significant amounts of scientific and engineering talent, Edward E. David, Jr. warned the annual meeting of the National Conference on the Advancement of Research last fall.

David, a former Presidential Science Adviser and former president of Exxon Research, said in his keynote address that such megaprojects represent "an opportunity, a temptation and an intoxicating elixir." They draw scientific and technological talent away from other endeavors, without prior assessment being made of the consequences to the programs which lose the talent; often, they draw away the brightest and the best, David said. He suggested that the government has a responsibility to sustain the R&D enterprise so that it can meet the demands which the nation places on it.

Subsequent speakers and discussants presented different views on three emerging trends affecting the management of R&D: Large government R&D initiatives such as SDI; Federal emphasis on the support of basic research; and improving U.S. international technological competitiveness through cooperation among different sectors.

For example, it was observed that while the U.S. is at the frontiers of basic science, the development of processes and products from U.S. inventions is often left to others, with the result that the commercial advantage goes to our trading competitors. In light of this, participants questioned whether, if there is a limit on available funding, the U.S. should continue to strengthen what it is best at—namely, basic scientific research—or whether it should reprogram resources into areas where our efforts appear lacking, such as developing more process technology and improving technology transfer to U.S. industry.

There was sharp disagreement as to whether or not there is a shortage of R&D manpower in the U.S. Some thought that there is a distribution problem, with not enough engineers in some fields and an over-supply in others; others felt there was an absolute shortage of U.S. engineers and scientists. However, there was a consensus about the need for more, higher quality manpower in all categories and at all levels of training.

There was agreement that the university infrastructure for scientific R&D is in bad shape. If the government wishes academic research and training facilities to be available to meet pressing national needs, then prompt and positive action must be taken to remedy the years of neglect of the universities physical facilities.

David challenged the meeting "to foster closer connections between basic research and commercial technology, in the interest of higher productivity, greater competitiveness, and more jobs."

Top Computer Scientists Debate Need For Supercomputers

Not all scientists are enamored with the new supercomputers. Questions concerning the need for supercomputer technology arose at a recent roundtable discussion held at the University of Maryland among three top computer scientists. MIT professor Joseph Weizenbaum, who has been building and designing computers since 1950 and was a member of the General Electric team that built the first computer banking system, disputed the views held by supercomputer supporters Kenneth Wilson, professor of physical science at Cornell University and recipient of the 1982 Nobel Prize in physics, and Joan Centrella, associate professor of physics at Drexel University and guest scientist at Cray Research, Inc.

The three scientists discussed the need for supercomputers at a symposium sponsored by the Scientists' Institute for Public Information (SIPI), the American Association for the Advancement of Science, and the Association of American Universities.

Both Wilson and Centrella staunchly defended continued development and use of supercomputers, pointing to its practical use in the fields of meteorology, hydrodynamics, and relativity. Centrella stressed the importance of the computers in the understanding of scientific theory. "Supercomputers can help us understand the relationship of theory to experimental data and the use of experimental data to put limits on the theoretical models," she explained. She described how supercomputer simulations have helped scientists understand how wind shears develop.

Wilson emphasized the revolutionary impact supercomputers will have in the field of engineering. He is director of the supercomputer program at Cornell University, one of four university centers selected by the National Science Foundation to share $200 million over the next five years on supercomputer research. Supercomputers will also help the U.S. economy expand, he pointed out, by making possible the development of new materials.

While he agreed with Wilson and Centrella that supercomputers could greatly accelerate scientific research, Weizenbaum asked, "What's the rush? The discoveries we would make with supercomputers we would make anyway; it would just take longer." He raised objections to the vast amount of money being spent on supercomputers, at a time when resources are so scarce. "Supercomputers will be used to simulate nuclear events," he said, "and this is a mistaken priority. Is it science we're worried about or our economy? Do we really need new products, or do we just want them?"

Meanwhile, the vast computational power offered by such machines as the CRAY-II is arousing interest in the industrial research community (see "Improving R&D Effectiveness Via Computers," *Research Management*, July-August 1985, pp. 19–21). In June, the Industrial Research Institute and Lawrence Livermore Laboratory will hold a two-day workshop for research executives to explore what such computing power may mean for the chemical, aerospace, materials and other industries. Observing that it's easy to fall behind in such a fast-moving technology, Harry Paxton, a professor at Carnegie-Mellon University and one of the workshop organizers, warned that it's time our own industries become familiar with the options that will exist for them with supercomputers.

A transcript of the SIPI roundtable discussion can be obtained from Jayne F. Cerone, Scientist's Institute for Public Information, Dept. NR, 355 Lexington Ave., New York, NY 10017.

BRIEFS

Board on Mathematical Sciences Education has been established by the National Research Council to assess math instruction in the U.S. and serve as a resource to state and local school districts. In helping to implement improvements, it will work with federal, state and local agencies, and business and industry. The new board was formed in response to numerous national studies which revealed declines in test scores on standardized exams, lowered graduation requirements in math, and severe shortages of qualified math teachers in some states.

Aerospace engineering departments on many campuses are facing faculty shortages, uncertain research support, and inadequate funding to operate and maintain their research support, according to a National Research Council committee. The committee asks NASA to increase its support of campus research efforts that address "long-term fundamental problems whose solutions are likely to have lasting impact."

No dramatic increase in demand for technical employees was expected for the next couple of months in a year-end report by the consulting firm of Deutsch, Shea and Evans. The firm's High Technology Recruitment Index stood at 99 for November, 1985, the lowest single month level in 2½ years.

Applications are being accepted for the June 1986 class of MIT's Management of Technology Program. Contact Jane Morse, MIT Sloan School, 50 Memorial Drive, Cambridge, MA 02139.

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Democrats Plot Course

Party Told to End Its 'Vietnam Syndrome'

By Paul Taylor
Washington Post Staff Writer

ATLANTA, May 3—The Democratic Policy Commission completed a harmonious two-day session here today, listening to its leaders call for the party to rid itself of "the paralysis of the Vietnam syndrome" abroad and to adopt an industrial policy at home built around federally funded regional research-and-development centers.

The panel also heard proposals for more federal funding for day care, Head Start, college loans and other programs for families with children.

The year-old commission, chaired by former Utah governor Scott M. Matheson, is made up of 100 elected officials, most of them at the state and local level. Next month, it will present to the Democratic National Committee a final report intended to serve not as formal party platform but as a statement of values and policy goals.

In a foreign policy speech to the panel today, Sen. Joseph R. Biden Jr. (D-Del.) called on his party to find a "common-sense" middle ground between "the ideological demons of both the right and the left."

"The right is mobilized by simplicity, but the left is immobilized by complexity," Biden said. "There are people in our own party . . . who see a potential Vietnam in every hot spot in the Third World, and their doctrinaire prescription is that the consequences of action are always more undesirable than the consequences of inaction."

Biden said the test of whether the United States should resort to the use of force should be based not on ideology, but on two questions: "Is it right, and will it work?"

Sen. Sam Nunn (D-Ga.), ranking minority member on the Armed Services Committee, said the increase in terrorism has made funding for U.S. intelligence activities a top priority. Rep. Dave McCurdy (D-Okla.), called on Democrats to support continued adherence to the unratified SALT II treaty and to back the mobile, lightweight, single-warhead Minuteman missile as a solution to the vulnerability of land-based nuclear weapons.

On the domestic front, Gov. Michael S. Dukakis of Massachusetts called for the federal government to put up seed money to create 15 to 20 regional Centers of Technological Excellence, where local industry, academic and research institutions could develop ways to improve regional economies. He also urged creation of federal Economic Development Block Grants that would be targeted to economically distressed regions.

In addition, Dukakis called on Democrats to make an issue of tax evasion, saying the federal government should follow the example of Massachusetts and other states and crack down on tax cheats.

Northwest Nuclear Energy Co.	105,619
7. Beaver Valley (Shippingport, Pa.) Duquesne Light Co.	105,000
8. Turkey Point (Miami, Fla.) Florida Power & Light Co.	88,000
9. Duane Arnold (Cedar Rapids, Iowa) Iowa Electric Power & Light Co.	79,310

Source: Nuclear Regulatory Commission

they going to say, 'I don't want to get radiated. I'm taking off'?"

Before the Chernobyl accident, Massachusetts Gov. Michael Dukakis and Seabrook officials had appeared close to a compromise that would have addressed the governor's major concern—evacuating nearby beaches. The proposed compromise: Shut the plant in the summer until bunkers would be built in the sand. But now the governor has pulled back, saying he wants to study the implications of the Chernobyl accident.

Oyster Creek also has a beach problem, in part because the prevailing winds would probably blow a radioactive cloud directly over some 20,000 sunbathers. But rather than the use of bunkers, the current plan is to keep the main bridge open no matter what. Emergency sirens would jolt sunbathers to attention. State police would prevent people outside the 10-mile evacuation radius from leaving until the others had been evacuated. Stalled cars would be pushed off the bridge into the water.

Much depends on a timely forecast of where radioactivity released by an accident will spread. Engineers at GPU recently developed a computer program that has cut to 15 minutes from 25 the time needed to project the direction of a radioactive cloud. The engineers can also determine exactly what radioactive gases and elements are in that cloud in just 45 minutes, compared with 90 minutes before. Data would be fed to the computers by up to 12 mobile monitoring teams, including one at sea.

John Sullivan, Oyster Creek's operations director, adds that the control room is more dependable now that GPU has hired an airline industry consultant to install "cockpit team training," which teaches plant controllers to work together smoothly during an emergency.

"Even a technically competent person can screw it up if he lacks leadership skills," Mr. Sullivan says. As a result, controllers at the Oyster Creek plant now are screened to avoid those with personality traits that could prove dangerous in an emergency, such as inability to get along with others and boisterousness.

Occasionally, the emergency drills themselves are hazardous. During an exercise at the Tennessee Valley Authority's Browns Ferry plant in Alabama last November, a technician from the Alabama Bureau of Radiological Health squirted a TVA employee—playing an injured farmer—with technetium, a radioactive liquid. "Apparently this was his idea of injecting some realism into the drill," says Joseph Gilliland, a spokesman for the NRC, which subsequently reprimanded the Alabama agency. Six people were contaminated, but no one suffered lasting injury.

again ... ing outdoors for long periods of time.

Alexander Lyashko, the premier of the Ukraine, told the reporters that 84,000 people have been evacuated from areas around the four-unit Chernobyl plant and that people living from six to 18 miles

Tax Measure's Impact On Industries Varies; Some May Be Hurt

Continued From Page 3

countant who has been working with a group of investors in San Antonio, Texas.

"If this bill is passed, we are sure it will be amended in a period of two years after 75% of the entire construction industry is out of work," said John Barron, executive vice president of Trump Organization, the giant New York-based developer.

Uncertainty in real estate could have serious ramifications for troubled thrifts. "This doesn't bode well for the thrifts. And if it's bad for the thrifts, it is certainly bad for the Federal Savings and Loan Insurance Corp.," said Kenneth Leventhal, a managing partner of Kenneth Leventhal, an accounting and consulting firm in Los Angeles. He said, "This is very, very serious."

Venture Capital Firms

Venture capital firms are also frightened that the proposed tax overhaul will wipe out much of the investment in new companies, because capital gains would no longer be favored by a huge break under current tax law. Long-term gains are now taxed at a top rate of 20%, compared with the top rate of 50% for ordinary income.

The Senate panel's bill would treat all individual income the same, and there would be even less incentive to take risks because the top individual tax rate would fall to 27%, reducing the tax benefits in the event of losses.

"They're going to do away with capital formation .... The newer industries, which aren't paying dividends, won't be able to get capital. That's what happened in the '70s. It seems we've got to relearn these lessons every 10 years," said Kevin C. Landry, managing partner at TA Associates, a Boston-based venture capital firm.

Stanley E. Pratt, chairman of Venture Economics Inc., a Wellesley, Mass.-based consulting firm and publisher of Venture Capital Journal, says he is worried that the bill will discourage new entrepreneurs, most of whom come from large corporations. He says their employers are trying to discourage them from starting their own venture. Now the new tax plan "kills incentive to go out and be innovative and do anything," he says.

However, high-technology companies are split over the proposal. They would benefit from the lower tax rates and wouldn't lose heavily from the repeal of the investment tax credit. They also would keep their favorite tax preference—the research and development credit.

Individual Retirement Accounts

In the financial markets, the proposed phase-out of tax breaks for individual retirement account contributions for people covered by other pension plans might hurt

with an alternative of evacuating some areas for long periods or undergoing massive cleanup efforts.

The Livermore computer model, which attempts to reconstruct the initial moments of the accident, estimates that 40% of the lighter elements in the reactor, including cesium and iodine, blew skyward in a very hot fireball after the plant exploded shortly after midnight April 26.

Heat carried the plume of debris up to 20,000 feet and then the cesium, iodine and other noxious contaminants were carried to the northwest over Byelorussia, Poland, Lithuania and Latvia toward Sweden in the form of a "fine aerosol," Mr. Knox said.

'Kiev Was Very Fortunate'

"Kiev was very fortunate," said Mr. Knox, because the initial direction of the wind carried the bulk of the debris from the reactor away from the city—the third-largest in the Soviet Union. An additional 10% of the lighter, noxious elements of the reactor, he said, has been distributed by the continued smoldering of the reactor and some of that, Mr. Knox estimates, has blown southward over Kiev.

Soviet authorities, he said, may have to develop plans to wash down buildings and streets in entire villages before they are safe for long-term habitation.

In its statement yesterday, the U.S. task force monitoring the Soviet accident said it was "plausible" that large amounts of molten uranium fuel may be lying on the floor of the reactor.

The problem posed by the molten reactor fuel has been dubbed the "China syndrome" by nuclear engineers because of disputes over how far the mass of glowing metal would burn into the ground.

Could Cool in Earth

Kerry Dance, president of GA Technologies Inc., the only U.S. company that has designed a commercial power reactor with a graphite core, said his company has estimated the molten fuel may burn through the cement and eventually cool off a few feet below it in the earth.

"The so-called China syndrome was nice to talk about," said Mr. Dance, but he said the phenomenom might be a relatively safe solution for the problem because the ground would block the radia-

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Donald Allen, University of Washington
Gary R. Argue, Arizona State University
Stephen H. Atkinson, Harvard Medical School
David C. Auth, Biophysics International
Donald R. Baldwin, University of Washington
Jim Barrett, University of Washington
Fred H. Bennett, University of Victoria
Spencer L. Blaylock, Iowa State University Research Foundation, Inc.
Larry Bonar, Harvard Medical School
Allen C. Braemer, Syntex (U.S.A.), Inc.
Henry E. Bredeck, Michigan State University
Howard W. Bremer, Wisconsin Alumni Research Foundation
A. Terry Brix, Temar Ltd.
Bill Brown, Portland State University
Norman A. Brown, University of Utah
Shirley M. Brown, Rutgers Research and Educational Foundation
Beatrice Bryan-Dietrick, University of California
Kathleen Byington, Colorado State University Research Foundation
Donald Chisum, University of Washington
Sunny T. Christensen, University of Illinois
Robert Compratt, University of Illinois at Chicago
C. Thomas Cross, University of Cincinnati
Michael D. DeLellis, Health Research, Inc.
Nathan B. Dinces, Dartmouth College
Crystal L. Dingler, University of Washington
Lynne K. Downs, BCM Technologies, Inc.
F. Philip Dufour, University of Maine at Orono
Bernard J. Downey, Villanova University
Valentin D. Fikovsky, University of California
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Peter Gray, University of Washington
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Al Halluin, Cetus Corporation

Patricia Harsche, Fox Chase Cancer Center
Joseph J. Hauth, Battelle Northwest Laboratories
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Sandra Shotwell, Stanford University
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Lamar Washington, The Research Foundation of SUNY
Robert B. Whittemore, Baylor College of Medicine
Mel Witner, Eastman Kodak
Anne Woolf, University of Washington
Walter C. Zacharias, Jr., University of Texas at Dallas

This list will be updated and copies inserted in the packets at the meeting.

June 3, 1986

Norm L

Technology Transfer Policies Are Still Lacking

Washington sees outpouring of studies and hearings on innovation policy; rethinking of federal role in diffusing know-how to industry urged

Ideas about the federal role in development of a national innovation policy continue to simmer like a pot of stew. In the economic policy field, there still may be some idle remnants of a "Reaganomics," but what is lacking is a "Reagatechnics" that would involve the government as a partner with industry in diffusing important, fundamental technology throughout industry.

"There is little unanimity," declares IBM chief scientist Lewis M. Branscomb, "on the effect of current R&D policies and activities, and even less on what kinds of federal actions will actually help. Few people in government have either the information or the management environment required to operate a program of technology development for commercial use."

Lately Washington has seen a fresh outpouring of studies, conferences, and hearings on technology policy in an advanced economy and a competitive world. One of the leading generators of ideas on the subject is Congress' Office of Technology Assessment. In one of its unofficial staff memorandums just completed by senior analyst John Alic for the House Committee on Banking, Finance & Urban Affairs, OTA has sounded a call for a rethinking of the government role in diffusing technological know-how to business and industry.

The market target would not be the consumer, for OTA agrees with the Reagan Administration that this is industry's role. Instead, the target would be industries themselves, through the concept known as generic technology, a term coined some years ago at the National Bureau of Standards and urged on Congress by the Carter Administration. "Generic technology development and technology diffusion to U.S. firms are primary needs for strengthening the international position of American industry," OTA says.

Rep. LaFalce led floating of bill

To begin, OTA suggests removing engineering research from the mainstream of National Science Foundation directorates to form a separate entity inside or outside the agency. As justification, it says industrial technology "has no home within the federal government," and that only 10% of NSF's budget is applied to engineering research. And that amount has only remote relevance to the development of technologies geared toward solving immediate problems facing industry.

The U.S. Constitution has established, at least in principle, the idea of generic technologies, under the concept of "Internal Improvements." These have included public projects like roads, canals, dams, waterway navigability, and beach erosion control. Without them, the country could hardly have embarked on its pre- and post-Civil War industrial revolution. More lately, Internal Improvements came to include funding for sewage treatment plants, air pollution control, atomic energy, and new drug development and testing.

In the new thinking, Internal Improvements would include buttressing the development of engineering principles that the totality of industry needs to regain parity with Japan's technological dynamism.

On Capitol Hill a group of Congressmen led by Rep. John J. LaFalce (D.-N.Y.), chairman of the House Subcommittee on Economic Stabilization, have floated a bill, H.R. 4361, the Advanced Technology Foundation Act. The bill, opposed by the Administration, was just sent to the House Committee on Banking, Finance & Urban Affairs after hearings held last month. Under this proposed legislation, ATF would be an independent agency like NSF and would establish, through loans and grants, centers for the development of these "generic technologies." The bill doesn't specify what these technologies would be, but examples, according to OTA, would include digital systems design, applied research on microelectronic devices, auto engine combustion processes, automobile safety technology, control system models for robot arms, engineering design, lubrication, wear, and structural integrity.

Some generic technology centers, privately supported, do already exist.

Semiconductor Research Corp. is one; Microelectronics & Computer Technology Corp. is another. And, of course, there is what might be called an "invisible college" of generic technologists, including engineers employed by the National Bureau of Standards, the private American National Standards Institute, academic engineering departments, and the many testing laboratories around the country.

Not to be ignored is the role of the state universities in providing, on the agricultural model, technological extension services to small and large businesses in their states. NSF, rather quietly, has established a number of cooperative research centers and small business innovation centers housed in universities. Under these programs, the agency provides modest startup funds for these centers on the condition that industry will come in and keep them going.

What exists then, is a more or less unorganized smattering of technology transfer activities around the country, all in search of a guiding principle. H.R. 4361 is an effort to establish such a principle. The bill would authorize $500 million over the first four years to fund such centers through ATF and would establish a Federal Industrial Extension Service that would provide grants and loans to states for technology transfer programs. The most obvious model for this activity would be the 125-year-old Agricultural Extension Service and land-grant research system.

What seems to be needed, OTA indicates, is a more cohesive sense of what these centers, whoever supports them, should be doing. "Because technical know-how is embodied in people," the OTA memorandum says, "a company may not even know that it is missing a piece of the puzzle: No one with the needed perspective can be found within the organization. The need is generally to bring the right kind of knowledge to a given problem. The important role of government would be to coordinate and link the network of centers already doing this sort of thing, while providing partial funding for these centers."

Wil Lepkowski, Washington

Federal Alert—new legislation

This C&EN listing highlights legislation introduced between Feb. 20 and April 5. Senate and House bills are listed under subject area by bill number, primary sponsor, and committee(s) to which referred.

SENATE

Business. S. 2447—Specter (R.-Pa.). Limits the deductions a corporate shareholder that acquires another corporation can take for the dividends received from the acquired corporation; referred to Finance.

S. 2448—Specter (R.-Pa.). Makes it unlawful for any person to make an offer for more than 20% of an equity class of a company's stock unless the offerer is the issuer of the security or the offer is a cash offer for all of the outstanding shares of the equity class; referred to Banking, Housing & Urban Affairs.

Energy. S. 2358—Proxmire (D.-Wis.). Prohibits U.S. Synthetic Fuels Corp. from making any new financial assistance awards until a comprehensive strategy document is drawn up and approved by Congress; referred to Banking, Housing & Urban Affairs.

Environment. S. 2407—Proxmire (D.-Wis.). Ensures that federally owned or operated hazardous waste sites comply fully with the requirements of the Superfund law; referred to Environment & Public Works.

S. 2421—Specter (R.-Pa.). Amends Superfund to allow cleanup of groundwater contaminated by petroleum products, regulation of underground storage tanks; referred to Environment & Public Works.

Nuclear. S. 2356—Specter (R.-Pa.). Requires that an environmental impact statement be filed and given due weight by the Department of Transportation before any truck carrying high-level nuclear wastes can be routed through a standard metropolitan area; referred to Environment & Public Works.

Research. S. 2525—Quayle (R.-Ind.). Clarifies the status of fundamental engineering research within NSF, makes engineering education an agency priority; referred to Labor & Human Resources.

HOUSE

Business. H.R. 4940—Wyden (D.-Ore.). Eliminates states' ability to impose a unitary tax—treating a company's worldwide income as a single unit and taking a share of the whole unit's income, rather than the income generated just within a state—on business activity that occurs outside the U.S.; referred to Judiciary, Ways & Means.

Data. H.R. 5073—Boxer (D.-Calif.). Sets standards for the government's rights to technical data produced by defense contractors, establishes a mechanism to safeguard contractors' rights to proprietary data; referred to Armed Services.

Environment. H.R. 5084—Wirth (D.-Colo.). Provides for the control of hazardous air pollutants from stationary and mobile sources; referred to Energy & Commerce.

H.R. 5249—Bryant (D.-Tex.). Requires any person selling a hazardous waste site to tell the purchaser the type and amount of waste that has been treated and disposed of on the land, the dates when these activities occurred, any closure, removal, or remedial action that has been taken; referred to Energy & Commerce.

H.R. 5314—Waxman (D.-Calif.). Requires 10 million ton reduction in sulfur dioxide emission in the continental U.S., places a fee on generated electricity, requires expedited control of hazardous air pollutants; referred to Energy & Commerce.

H.R. 5370—Udall (D.-Ariz.). Calls for reductions of 11 million tons per year in sulfur dioxide emission in 31 eastern states by 1996, prohibits further increase in SO_2 and NO_x emissions after 1996; referred to Energy & Commerce.

Health. H. J. Res. 514—Vento (D.-Minn.). Expresses the sense of Congress that all workers, not just those in manufacturing industries, have a fundamental "right to know" when they are handling or exposed to hazardous substances; referred to Energy & Commerce.

Patents. H.R. 4964—Sensenbrenner (R.-Wis.). Places the title to any inventions to the contractors who conducted the federally sponsored R&D which led to them, allows the government to utilize the invention royalty free; referred to Judiciary.

H.R. 5003—Fuqua (D.-Fla.). Establishes a uniform federal system for management, protection, and utilization of the results of federally sponsored scientific and technological R&D; referred to Judiciary, Science & Technology.

Pesticides. H.R. 4939—Waxman (D.-Calif.). Authorizes EPA's administrator to revoke an exemption and set a tolerance level for any pesticide that poses an imminent hazard to public health; referred to Energy & Commerce.

Research. H.R. 4501—Rodino (D.-N.J.). Codifies the application of the rule of reason in all antitrust cases involving joint R&D ventures, limits the potential damage exposure of such a joint venture to actual damages if the venture has been properly reported to the antitrust agencies; referred to Judiciary.

H.R. 5098—Torricelli (D.-N.J.). Requires the National Library of Medicine to make available to all medical libraries the full text of published research results, establishment of a committee to conduct a full-text literature search prior to the funding of grant proposals involving the use of live animals to prevent duplicative research; referred to Energy & Commerce.

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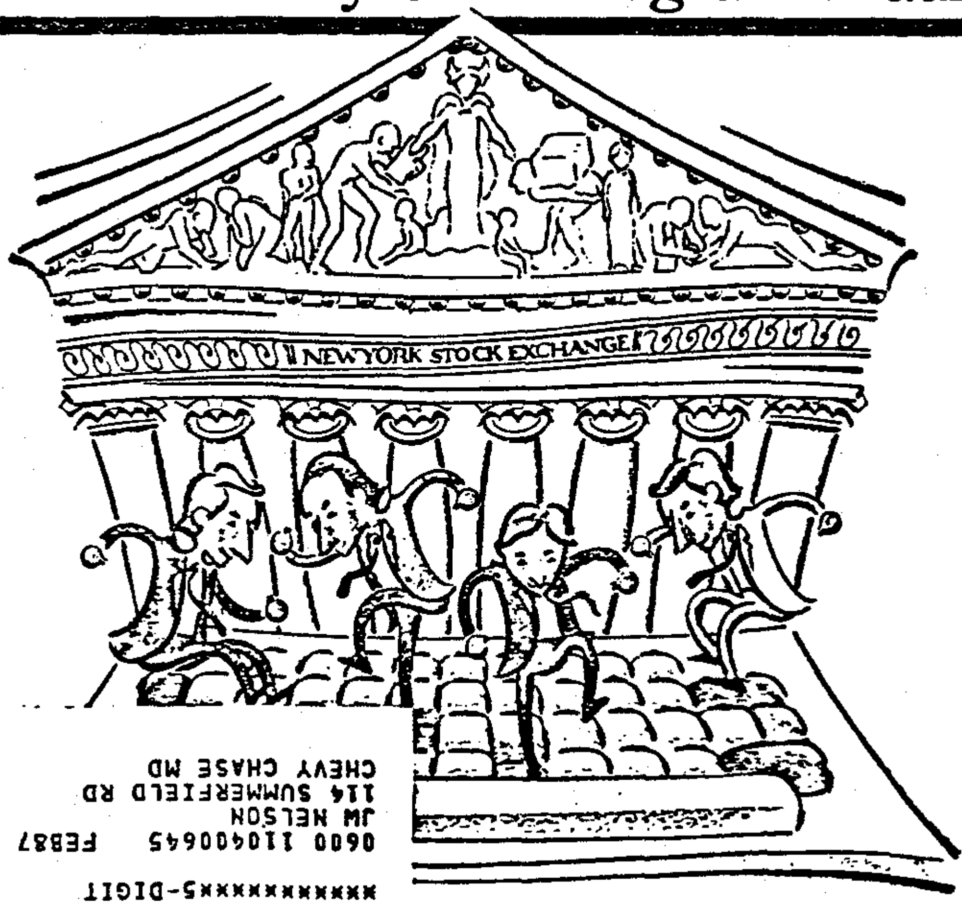

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