John Preston / Licensing Director at MIT

MIT TESTIMONY

remarks that it was his view that it was a responsibility. Whether something derived by their own interpretation or by specific statutory language, I can't say, but I interpret his remarks to underscore the view within DOE that they should have a significant role in dissemination of technology.

I think that that--which, as I say is already carried in the Federal Acquisition Regs, statement of purpose, is the problem I have. I think that the flow from the Government-university-industry relationship must be clear and channeled through the university to its licensees, and those licensees cannot be subjected to the uncertainties and cross-currents that arise from knowing that the Government may, through some other distribution channel, also be making the technology available in some fashion, particularly if the industrial licensee has invested significant funds to develop it further, and then it looks like the Government might piggy-back its contractors on all of that effort.

Mr. Preston may want to add to that.

Mr. PRESTON. Yes, one of the comments I would like to ma about the issue of requesting waivers and giving waivers, is that the timing in licensing technology is so critical that even waiting six months is quite often prohibitive in getting an effective license deal.

I will give you an example. Two months ago in the area that we have been discussing today, I was approached by a couple of faculty members who had come up with an invention related to superconductors, a technique for making these brittle ceramic into ductile wires. We filed for a patent less than a month after they came into our office, and have now licensed it to a private sector through a major venture capital firm who has a created a company to commercialize this technology. In less than two months, we now have $1 million worth of private money invested into this technology. We have a company created, and we have a license agreement consummated and a patent filed.

If I had to wait six months or a year to get DOE waiver in order to move ahead with this, the venture community would probably be tied up in other deals and this would slow down getting the license done in the first place.

Another comment I wanted to make from the DOE paper that was submitted was that the DOE expressed considerable pride in the fact that there have been 27 start-up companies over the last year from DOE sponsored research, and 200 license agreements to major companies to commercialize DOE research.

MIT is perhaps a drop in the bucket to DOE total--we are less than one-tenth of their budget--our numbers are comparable.* We are creating about the same number of new companies per year, and consummating about the same number of license agreements.

* DOE should have 300-500 businesses instead of 27

Joe Allen 4837

Technology Transfer Isn't Working

The campaign to pass on the fruits of the federal research labs to industry could be a lost cause.

by Fred V. Guterl

In just a few years, a major new chip-manufacturing technology called X-ray lithography could well become the key to survival in the semiconductor industry. The question is, who will be the first to develop it?

Japan's Ministry of International Trade and Industry plans to spend $700 million on the problem this year. Among other things, it is funding the construction of four specialized synchrotrons for chipmakers to produce the X rays essential for research into the new technology.

In the U.S., the Department of Energy recently finished building the nation's first large-scale synchrotron at its Brookhaven National Laboratory in Upton, New York. But it is a general-purpose synchrotron used by about ninety academic and corporate research groups for a variety of projects. IBM Corp. is the only company using the synchrotron for X-ray lithography, and its researchers often have to wait in line to use it. "The IBM people are pretty unhappy with the schedule," says William Marcuse, director of technology transfer at the lab. "They spend a lot of time twiddling their thumbs."

The DOE plans to build two more synchrotrons for its labs, but neither one will be tailored to X-ray lithography. And to a growing number of industry leaders, government officials and scientists worried about the United State's flagging competitiveness in technology, this state of affairs is a vivid symbol of the inadequacy of the government's program for transferring R&D to industry.

The federal research labs constitute a formidable chunk of the nation's pool of talent and equipment. The 700-plus labs across the country spend more than $18 billion a year and employ one-sixth of the nation's research scientists and engineers.

By tradition, the labs disseminate technology to the public and issue licenses for their published patents to anyone who wants them. But American companies have used few of the thousands of new patents filed every year because they are loath to invest in a technology their competitors can obtain easily. It was a Japanese firm, for example, that developed solar cells for calculators from a National Aeronautics and Space Administration patent.

Since 1980 the Reagan Administration has been spearheading an ambitious campaign to make the fruits of the federal research labs available to private industry. One result is new legislation that now allows companies to license exclusive patents owned by the labs and encourages cooperative R&D programs for industry, government and universities.

These moves have been welcomed. But no significant technological benefits have yet accrued to industry, and the obstacles to implementing the transfer of technology now look so numerous and deeply rooted that it seems doubtful the government labs will ever be able to help industry fulfill its research needs. "The new laws are no panacea for getting technology into private industry," says William Burkman, director of physics at AT&T Bell Laboratories. "There are a lot of stumbling blocks involving the kind of priorities the labs have set up."

The basic problem is that the whole notion of working with private industry runs counter to the long-standing mission of the federal labs to serve the general public. For the better part of four decades, they have pursued their own agendas sheltered from the needs of the marketplace. Federal researchers have deepened the pool of scientific knowledge and enhanced the nation's weapons arsenal. Any benefit derived by industry has been a mere afterthought.

The need to keep classified weapons research under wraps has impeded technology transfer in the DOE and the Defense Department. That becomes a formidable barrier considering that defense will account for 72% of government R&D spending next year, up from 51% in 1980, and that the lion's share of the labs belongs to those two departments.

The DOE is particularly hostile to industry-directed research. It has refused to give its labs authority to license patents to companies—a step that industry considers crucial for making the technology accessible. The department's policy of reviewing every application for a patent license case-by-case, industry complains, is too much trouble and takes too long—anywhere from six months to several years—to pass through the labyrinth of DOE bureaucracy.

This procedure discourages companies from using the labs as a resource. Lee M. Rivers, who recently left the White House Office of Science and Technology Policy to represent the Federal Laboratory Consortium in Washington, says he is "up to my eyeballs" trying to get industry to take the labs seriously. "If a businessman has to take four months to figure out what he needs to do and then has to go through six layers of bureaucracy in Washington, that's going to be tough," he notes.

DOE officials insist they are proceeding with caution only until they learn more about technology transfer and promise to streamline the waiver process down to six months or so. Critics say they are stalling. And Bryan Siebert, DOE director of international security, admits, "I would err on the side of reviewing practically everything, even if it involves delays."

In fact, when Congress passed legislation in 1984 allowing universities and nonprofit organizations that operate DOE labs to license patents, the department tried to nullify the law by claiming that national security and nuclear nonproliferation took precedence. Its position led to an executive order by President Reagan last spring restricting the DOE's discretion to withhold patent licenses.

Regulations also limit the amount of money the DOE labs can spend on research for outside organizations to 20% of their budgets, with most of that going to other government labs. And no company can do research at a DOE lab if comparable facilities can be obtained elsewhere. Emphasizing the DOE's stand, Antoinette G. Joseph, director of field operations management, says, "People argue that there is this technology sitting on the shelf and that if you have a uniform technology transfer policy, the government can make it all available in one fell swoop. Well, it can't. The national defense mission is more important than the technology transfer mission."

The Defense Department has its own bureaucratic problems, but it has been more flexible in issuing licenses. For years, the DOD has allowed the companies it does business with to commercialize at no cost the patented technology they develop. These relationships, however, have existed primarily within the close-knit community of government contractors working on classified projects. "Everything done in the labs is documented and made available to people with the appropriate clearances," says Frank Sobieszczyk, chief of the DOD research program office. "The labs will call in defense contractors and give them a dog-and-pony show." Because of its fear of leaks, the DOD is reluctant to enter into cooperative R&D agreements with other companies.

In addition to the problem of classified R&D, identifying promising new

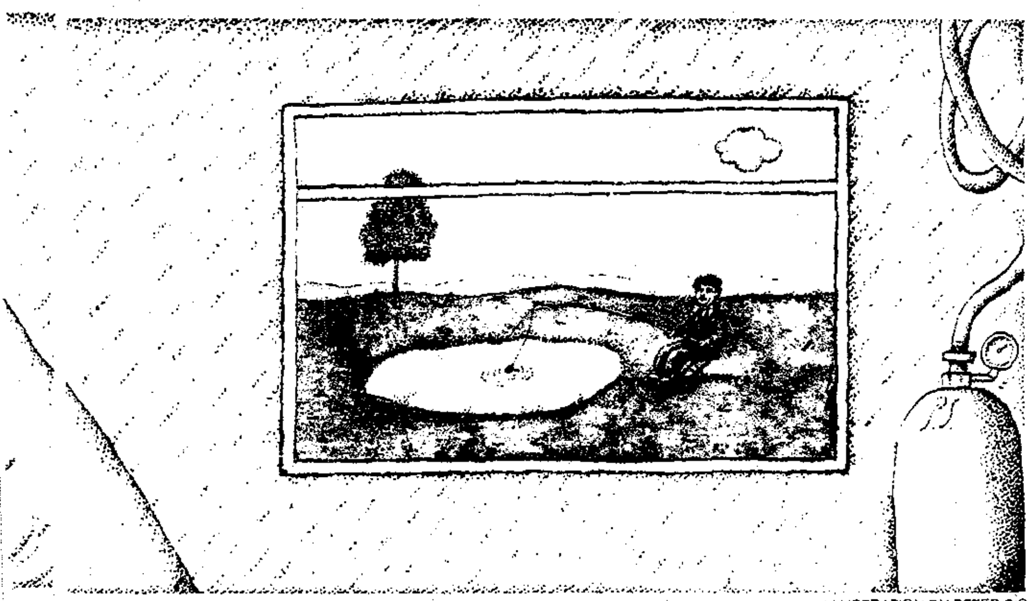

ILLUSTRATION BY PETER SIS

technologies for industry to exploit is a monumental task. Corporate R&D executives have largely ignored what goes on in the labs, viewing them as irrelevant and inaccessible. Reluctant to deal with the bureaucracy, they are unaware of helpful research buried within multimillion-dollar programs.

At the same time, most federal labs lack the staff necessary to sift through the enormous number of projects, ferret out the good ideas and target them for specific industries or companies. "There's a lot of research going on at the labs," says President A. Sidney Alpert of University Patents Inc., which sells university-owned patents to industry. "If they put enough manpower on it, there could be some good inventions. But you won't find them the way the labs are going about it."

It does not help that lab researchers must depend on their technology transfer specialists to explain their innovations to corporate R&D people. These specialists are in short supply—only one DOD lab has one, for instance—and they are a harried lot with responsibility for hundreds of different projects.

As intermediaries, they also are one more roadblock for industry. Hillard Williams, vice president for technology at Monsanto Corp., says that government tech transfer people lack experience in getting technology out to industry. John D. Hale, vice president for research at Kerr-McGee Corp., comments: "We have enough trouble transferring technology out of our own lab. How are we going to keep up with the technology coming from the federal labs?"

Even if industry had free access to the technology at the labs, raw research requires considerable development before it is applicable to new products, and much more input from the labs—information about manufacturing processes, the expertise and judgment of the original researchers, and so forth—is needed by a company planning to adopt a technology. "The basic research at DOE labs is one level less practical than the stuff that is done at universities, which isn't very practical" says University Patents' Alpert.

> ***"If the government labs move slowly, they will become irrelevant."***

The labs have limited resources to devote to the kinds of coooperative R&D programs that would help industry absorb basic research. And they have had trouble attracting financial support from industry because they lack the authority to issue patents in return for funds. (No longer true)

Companies are also put off by the government's inflexibility in negotiating cooperative research agreements. The agreements are often written like procurement contracts, with specific deadlines scheduled years in advance. Such tight schedules lead to misunderstandings when the research doesn't pan out the way it was originally planned. "Federal people don't speak the same language," says Monsanto's Williams. "Things get complicated, and industry tends to just give up."

Amid this bleak picture, there are a few hopeful signs. Payoff from exclusive patenting, for instance, is evident in Oak Ridge, Tennessee, where a dozen or so companies have sprung up to develop products—heat-resistant diesel engines, high-strength cutting tools and more—based on patent licenses granted by the DOE lab there.

"A kind of magic has set in," says William W. Carpenter, vice president for technology applications at Martin Marietta Energy Systems, which runs the lab for the DOE and aggressively pushed the patents through its licensing process. "In Oak Ridge, houses are selling, school enrollment is up for the first time in twenty years, a new missile plant has gone up. A great deal of that is due to our technology transfer program."

Inside the labs as well, there is some movement afoot to open the door. Eugene E. Stark, an engineer at DOE's Los Alamos National Laboratory, is one of a new generation of government researchers who now sees a unique opportunity to get the labs into the mainstream of technology.

In his spare time, Stark is chairman of the Federal Laboratory Consortium for Technology Transfer, an ad hoc government and industry group that is promoting technology sharing. "We can't wait ten more years to break down the institutional barriers to technology transfer," Stark says. "We're entering a period of restructuring in science and technology institutions. Whatever new relationships develop as a result of international competition will take place in the next three-to-five years. If the labs move slowly, they will become irrelevant."

Groundwork also has been laid for several cooperative agreements between industry and the labs. The Army's Electronics Technology and Devices Laboratory in New Jersey is setting up a consortium with several electronics firms to develop flat-panel display screens. And the DOE's Argonne National Laboratory and the University of Chicago are currently negotiating with companies to do superconductor research.

Meanwhile, the Defense Department is funding a study on building a synchrotron devoted exclusively to semiconductor research. And at the DOE's conference on superconductivity last July, President Reagan proposed a government-sponsored "Superconductivity Initiative," which would include, among other things, increased spending by the labs. In addition, DOD proposes spending $150 million over three years to apply superconductivity research to military ships and weapons.

How all the money is spent—whether industry gets to set at least part of the research agenda—may be the first real test of the technology transfer laws and the nation's resolve.

—with ANNE HOLLYDAY

STATE-OWNED PATENTS SPREADING ABROAD

Tokyo KOGYO GIJUTSU in Japanese Mar 86 pp 44-48

[Article by Mitsuo Suzuki, director of the Japan Industrial Technology Association]

[Text] Why International Technology Cooperation Is Now Important

With a turnabout from the first oil crisis, the focus of world technology development trend has been shifting toward lightness, thinness, shortness, and smallness [micro] from heaviest, thickest, longest, and biggest [macro]. Countries in the world are fiercely competing for the development of high technologies, amid the great surge of new technologies from the 1970's toward a peak in the early 2000's.

Emerging as advanced technologies are the technology for utilizing limited sources of energy on earth, electronics technology for fostering an information society, new materials technology for bringing about metamorphic progress in industries, and biotechnology with diverse potential.

The collapsing condition of the Japanese economy after World War II has achieved a marvelous recovery through the support of technical assistance from abroad and the concerted efforts of the people. As a result, Japan has now established a high technology level worldwide.

While Japan has currently achieved economic growth through active industrial activities based on high technologies, other countries have increasingly been seeking Japan's technical cooperation. Public opinion is taking root in that Japan should further promote contributions intellectual to the international society through technologies.

As regards technologies under such international circumstances, the recent activities concerning technology transfer and popularization of the Japan Industrial Technology Association (Inc.) (JITA) engaged in activities of spreading state-owned patents of the Agency of Industrial Science and Technology (AIST) at home and abroad will be outlined (see Figure 1)

Transfer of state-owned patents

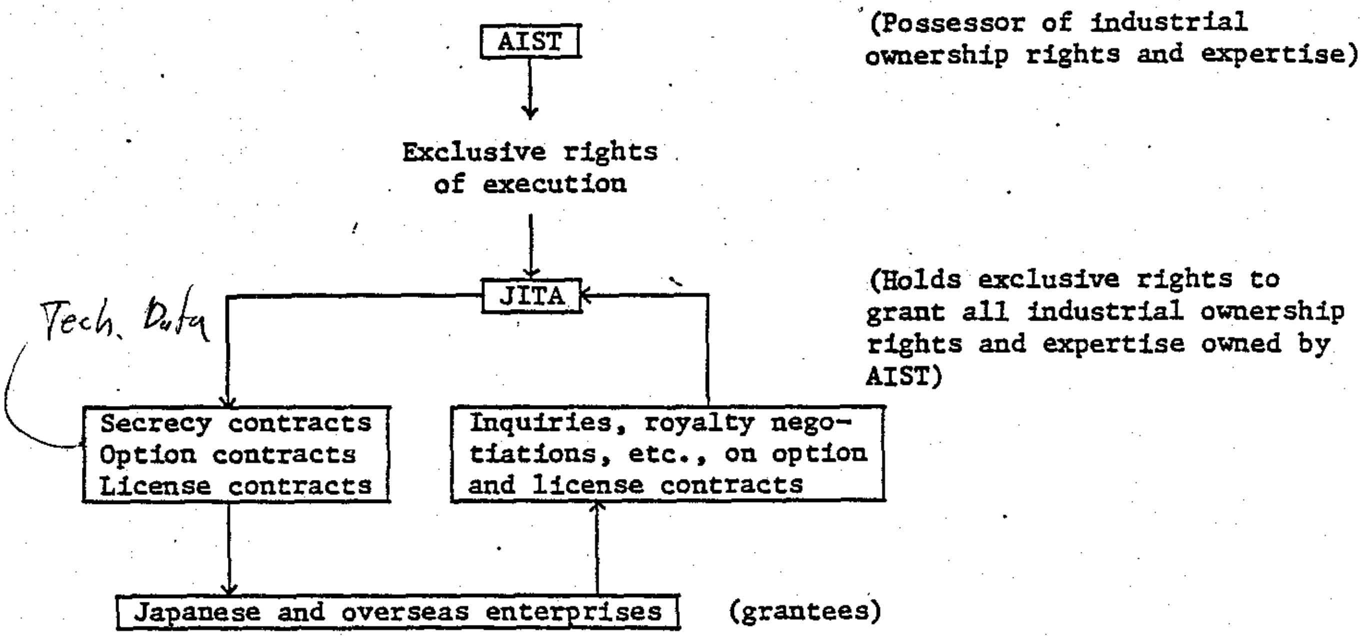

Figure 1. Technical Transfer System of AIST's State-Owned Patents

Activities of High Technology Interchange Missions

JITA has been sending missions to the various European and American countries annually since 1983 to introduce AIST's state-owned technologies in support of AIST and other quarters concerned. The dispatch of the missions is part of the technology interchange between Japan and the various European and American countries, and is also in response to criticism that Japan is not providing technology exports in comparision with the enthusiasm for exports of manufactured products. Among AIST's state-owned patents, 20 to 30 themes, which have been applied for industrial use by Japanese companies or those prospective technologies are selected annually for overseas supply upon approval for technical cooperation by the companies involved.

Missions comprising top technicians or leaders concerned in charge of technical development at such companies visited governmental organizations or research institutes of major enterprises in the various European and American countries to ascertain the needs of such countries (possibilities such as technology transfer and joint development). From this side, technical presentation was provided and at the same time relative discussions pursued.

Institutions visited by year follow:

1983	Sweden	(state) STU (Swedish Technology Development Agency) (private) ASEA Co., Volvo Co.
	West Germany	(private) Dynamite Nobel Co., Siemens Co.
	France	(state) CESTA (Advanced Technology System Development Center) (private) Toulouse City Chamber of Commerce and Industry
1984	United States	(state) Raleigh, North Carolina--Research Triangle Park (research consortium) (private) SWRI, IITRI, SRI (all nonprofit think tanks)
	Canada	(provincial) Montreal Urban Community (research consortium)
1985	Sweden	(private) IDEON (research consortium) (private) SKAPA (creative technology exhibit)
	Ireland	(state) IDA (Irish National Research and Development Agency)
	Britain	(state) BTG (British Technology Group, formerly NRDC) (private) Berkeley Tech Mart '85
	France	(state) CESTA (private) Rhone Poulenc Co.
	West Germany	(private) Bayer Co.

Fortunately, the dispatch of the missions over the past 3 years has resulted in steadily spreading state-owned technologies abroad due partly to the active cooperation of domestic licensee companies and various foreign governmental organizations and overseas companies. Among the themes presented, some concrete results are beginning to emerge, such as supplying information and samples, to include possibilities for future technology transfer and joint development, and the conclusion of secrecy contracts.

Table 1 shows typical technologies presented by the past three missions. A few examples among overseas responses to the missions were the request from Martin Marietta, a major U.S. enterprise, for a supply of several tens of kilograms of high-performance electromagnetic wave shield materials on a sample basis. Kuraray Co. and two other companies are now conducting experiments for practical application of the materials under the guidance of AIST's Industrial Products Research Institute. General Motors Corp. (GM), a major U.S. automaker, Alcan Canada Co. of Canada, Hinkley and ICI of Great Britain, and many other companies have shown interest in revolutionary fine ceramics processing technologies, and negotiations for a contract are now underway with a certain company. The ceramic technologies involved are the ceramics-metal

Table 1. Technologies Introduced Abroad Through State-Owned Patents

Category	Title of technology	Institute that made discovery	Year introduced		
New materials	High-performance electromagnetic shield material	Industrial Products Research Institute	1983	1984	
	Ceramics-metal bonding Ceramics-ceramics bonding	Osaka National Industrial Research Testing Institute (NIRTI)		1984	1985
	Zirconia sinter	Nagoya NIRTI	1983		1985
	Easy-to-sinter alumina	" "		1984	
	Lubricating agent for die-casting, forging	Osaka NIRTI	1983	1984	
	Lanthanum-chromate for heating	Daikoshi NIRTI	1983		
	Carbon-ceramics compound	Kyushu NIRTI		1984	
	High-performance pitch carbon fiber	" "	1983	1984	1985
	Ultrahigh-molecular polyethylene gel yarn	Research Institute for Polymers and Textiles		1984	
	Hydraulic injection plastic molding	"		1984	
	High-flux precision filtration membrane and its system	National Chemical Laboratory for Industry, Kyushu NIRTI, Osaka NIRTI	1983	1984	1985
	Photocrosslinkage polymer and screen printing	Research Institute of Polymers and Textiles	1983	1984	
	Gas separation using polyimide hollow fiber	National Chemical Laboratory for Industry			1985
	Ion exchange fiber and rare earth metal separation	Research Institute of Polymers and Textiles	1983	1984	1985
	High-performance deodorant	National Chemical Laboratory for Industry	1983		
Biotechnology	Production of oils and fats by mycosis	National Chemical Laboratory for Industry	1983		
	Production of gamma linolenic acid by mycosis	"		1984	1985
	Production of heat-resisting lipase and dissolution of oils and fats	Fermentation Research Institute		1984	1985
	High-performance cellulase	"		1984	
	Solidification of oxygen by ultrafine fiber carrier	Research Institute of Polymers and Textiles			1985
	Solidification of oxygen by photocrosslinkable polymer	"			1985
	Production of fry feed from alcohol fermentation wastes	Fermentation Research Institute			1985
	Artificial joints	Mechanical Engineering Laboratory			1985
Electronics	High-performance amorphous silicon solar battery	Electrotechnical Laboratory		1984	1985
	Semiconductor magnetic sensor and its applications	"		1984	1985
	Assessment of amorphous silicon manufacturing process under CARS system	"			1985
	ICTS system for detecting crystal defects	"			1985
	Nonvolatile semiconductor memory with floating gate	"			1985
	High-output GGG laser	"			1985
	Optical disk pickup (SCOOP)	"			1985
	Magnetic garnet film for optical IC	"	1983		

bonding and ceramics-ceramics bonding where research for practical applications is being conducted by Sumitomo Cement Co. and Daihen Corp., respectively, under the guidance of AIST's Osaka Industrial Research Institute. Negotiations are also underway with (Reuter) Gas Werke Co., a major West German pitch processing company, concerning technology to manufacture high-performance carbon fiber now being developed for practical application by more than 10 companies, including Nippon Carbon Co. Regarding lubricating agents for forging and die-casting, Hanano Shoji (Inc.) has completed development of manufacturing technology, and is now being made practical with a large amount of samples being supplied abroad for testing, while Great Britain's (Fuoseco) is seeking technology transfer.

In addition not only enterprises, but also Britain's BTG (R&D agency) and France's CESTA (advanced technology center) are requesting long-term, deliberative cooperative relationships with JITA missions, and are showing an active stance toward future technology interchange with Japan.

Progress in R&D of those technologies have been conducted by research institutions under AIST's umbrella with the cooperation of private-sector companies. Behind-the-scene movements concerning technology transfer through various channels have also been observed, and attention focuses on future developments.

Technological Transfer Based on Trusting Relationship

"The more information is assimilated, the more its essence is improved," is a wise statement about data bases by Tokyo University Professor Hiroshi Inose, last year's Cultural Merit awardee. In technology transfer, too, a certain preparatory period is initially required for the exchange of technologies and related information and establishment of a relationship of mutual trust between the provider and the receiver of technologies. The first problem in negotiating transfer of state-owned technologies abroad is that it takes considerable time to establish such relations of trust. Perseverance is required as in an extreme case where the party completely lacking information mutually about the other party begins from scratch. In addition, based on relations of trust, the supplier and receiver of technologies must seek terms on conditions which will mutually benefit both sides from a long-term point of view. Under such circumstances, recent trends for the future technologies or in exploring new areas such as cross-licensing and other forms are increasing.

Next is the establishment of relations of trust regarding protection of patents. The state-owned technologies to be definitely transferred abroad at present are basically on condition that the technologies involved are patented in the recipient countries. Accordingly, it is important that such technologies are fully protected under the recipient countries' patent system and in the operation thereof.

In the various countries visited by JITA's advanced technology exchange missions in the past 3 years, hardly a problem occurred due to the high reliability of the patent protection measures. However, of late, Japan has been strongly urged to expand technology transfer to the newly industrialized countries (NICS) and developing nations. The problem of patent protection in those countries will therefore be an issue to be resolved in the future.

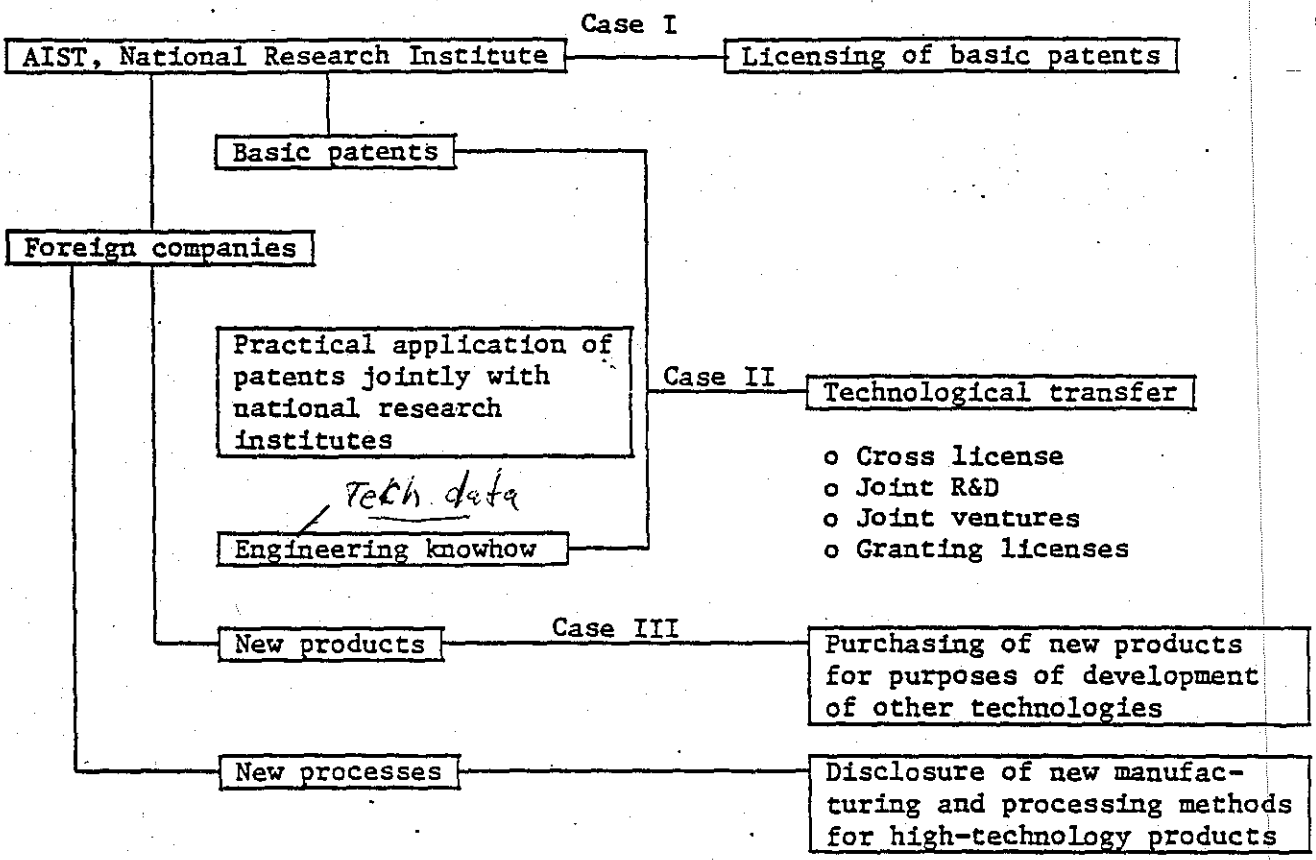

Figure 2. Technology Transfer of State-Owned Patents Abroad

Four Cases of Technological Transfer and Procedures for Transfer

Transfer of state-owned patents has various backgrounds depending on the technologies involved, which is not easy to generalize into one format. However, it can be classified roughly into four cases as shown in Figure 2.

Case I is the licensing of basic patents owned by the Agency of Industrial Science and Technology and of patents jointly owned by the national research institutes and private companies. Case II involves providing all the information necessary for commercialization ranging from basic patents owned by the AIST to related patents, manufacturing know-how and product specifications, etc., possessed by the implementing companies--in other words, the complete transfer of technologies. Depending on circumstances for the suppliers and the receivers of technologies, Case II can be subdivided into four types, i.e., cross-licensing mutually between companies, joint development by both companies for furtherance of technologies involved, establishment of joint ventures between companies based on mutual agreement and conditions for local production and sales, and the unilateral supply of all the technologies to the other country's enterprise in exchange for payment of certain remunerations.

In Case III foreign companies purchase products of technologies involved from the contract-implementing firms of Japan and use such items as a basis to develop new processes or new products. In Case IV foreign companies produce and process products on a contractual production basis, using high technologies developed from basic patents owned by the AIST. For example, one plan now under negotiation is the contractual production of special parts by a foreign enterprise using the "ceramics-metal bonding technology."

Table 2. Procedures for Technology Transfer

First stage Secrecy agreement	Providing secret information and samples necessary for assessment of technologies involved
Second stage Option agreement	Technical information including know-how, etc., data regarding economical phase, and samples or marketable products necessary for feasibility study
Third stage License agreement	All information necessary for practical application of technologies

Procedures for granting licensing of state-owned patents abroad are basically identical to those in Japan. The first stage, as shown in Table 2, is to cope with clients when they seek more detailed information and samples to be furnished so as to determine the industrial value concerning the nature of the technologies. In such case, if necessary, a secrecy agreement is concluded before providing them.

The second stage is for coping with cases where further concrete information beyond the first stage is sought by the clients such as information about economical feasibility, information concerning marketing and technical information to determine the industrial applicability of the technologies, as well as providing samples on a commercial basis, etc. Usually in this stage, information is furnished under an option agreement on the assumption that technologies involved will be applied for industrial purposes.

The third stage is the execution of technology transfer under a license agreement in which the contract discloses all technical information necessary for the application of technologies and the nature of the patents.

For the Future

Japan is a small country in terms of natural resources, energy, and food, but is substantially rich in intellectual resources. Using these resources, the country has accumulated industrial property and other technology assets since the end of the last war, making itself one of the leading technology-oriented countries in the world. Such intellectual assets will continue to serve as a bargaining power for Japan.

However, today's accumulation of technology assets has resulted from the introduction of technologies from advanced countries in Europe and America, and efforts for creative technology development. Moreover, in the background of facilitating Japan's introduction of technologies from European and American countries is the sense of trust when Japan was furnished technologies, being accustomed to assessing fair value of new, superior technologies which furthered the understanding of patent protection.

Meanwhile, Japan has been strongly criticized by various countries in Europe and America for its huge trade surplus stemming from expanding exports of manufactured products. Of course, free world prosperity lies in orderly exports and imports under the free trading system. However, Japan's export of its abundant intellectual resources, resulting in a surplus in the technology trade balance, would not create trade friction, but would rather contribute to the development and revitalization of the world economy. The conditions to smoothly transfer technologies overseas are as stated above. The three issues of relations of trust, mutual benefit, and patent protection have been proposed. However, these problems in the case of NIC's and developing nations are such that environments are yet to be sufficiently regulated. It is extremely important that Japan mutually cooperate in resolving these problems for future international cooperation.

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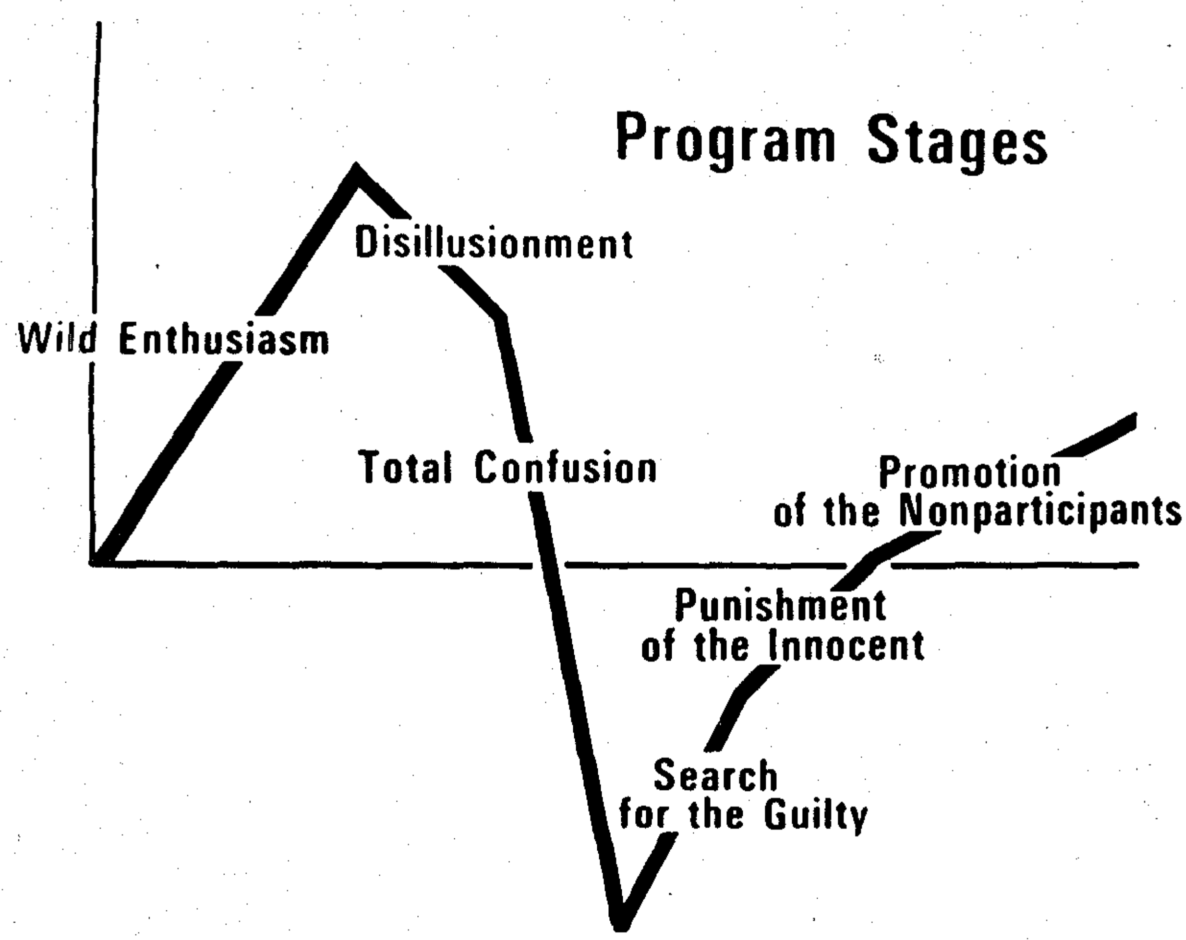
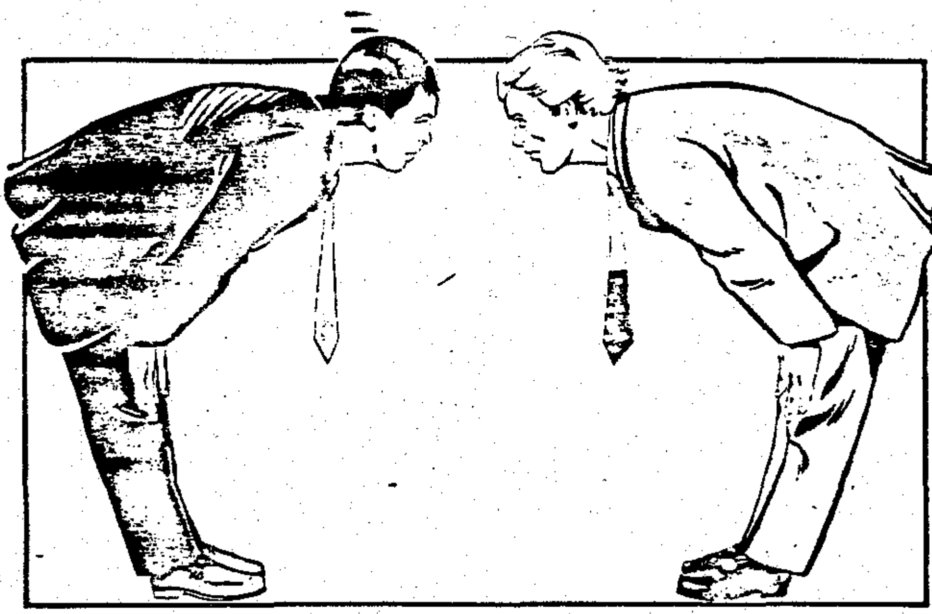

Program Stages
Wild Enthusiasm
Disillusionment
Total Confusion
Search for the Guilty
Punishment of the Innocent
Promotion of the Nonparticipants

HIGH TECHNOLOGY



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.

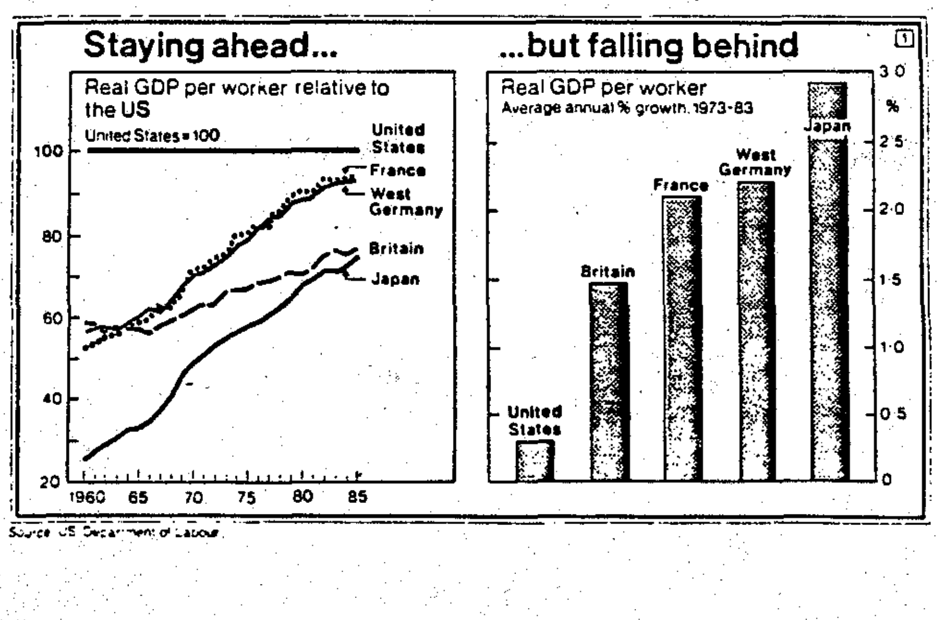
The agony for Americans does not end there. Over the past 25 years they have seen:

- 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 ¥220 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.

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"?

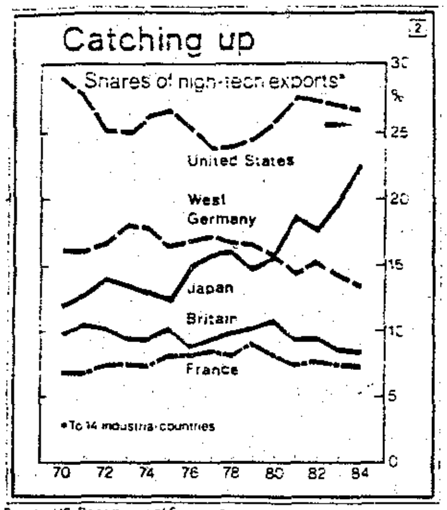
With the gloves now off, which of the two technological heavyweights should one put some money on? In the blue corner, Yankee ingenuity? In the red, Japanese production savvy?

*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.

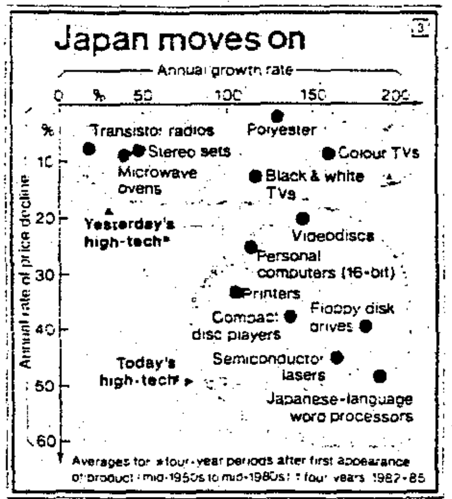
All these things—and more—have been true to some extent in the past; but all are also changing. The deregulation of Tokyo's financial markets, for instance, is forcing Japanese companies to reduce their levels of debt (see accompanying feature on next page). This, in turn, is making them more adventurous, 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 1:4.7 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) rôle 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 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?



Source Mitsubishi Bank

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

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%.

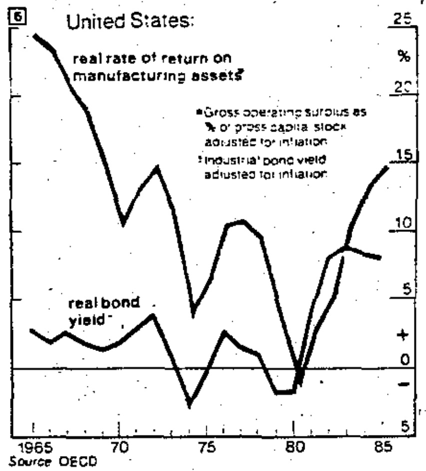
What about differences between America and Japan in terms of return on capital? Here things are actually better than most American businessmen imagine. True, real rates of return earned by American manufacturing assets in the 1960s were substantially higher than investments in financial instruments, 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

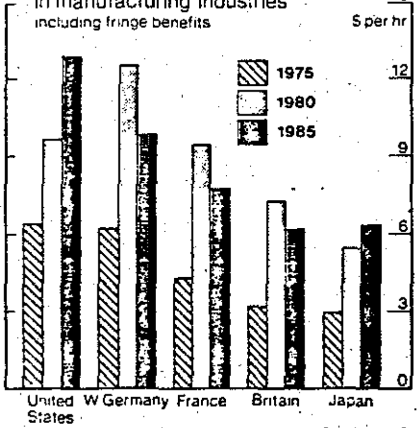
Another thing Japanese manufacturers resent about some of these allegedly cheap industrial loans are the strings and hidden costs involved. The most punishing are the so-called "compensating balances" which a borrower has to deposit (at a considerably lower interest rate) with the bank offering the industrial 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.

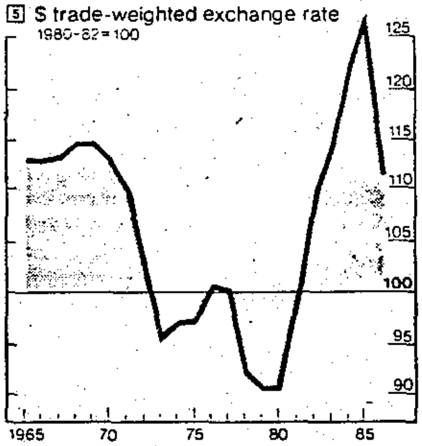
All that said, Japanese companies are on balance more highly geared than American corporations; and, overall, the cost of financing industry has been lower in Japan than in the United States. But at most only 20% lower, and nothing like the 50% lower claimed by lobbyists in America.

4 Hourly earnings of workers in manufacturing industries
including fringe benefits



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

5 $ trade-weighted exchange rate
1980-82=100



Source DRI

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, semi-conductors, 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

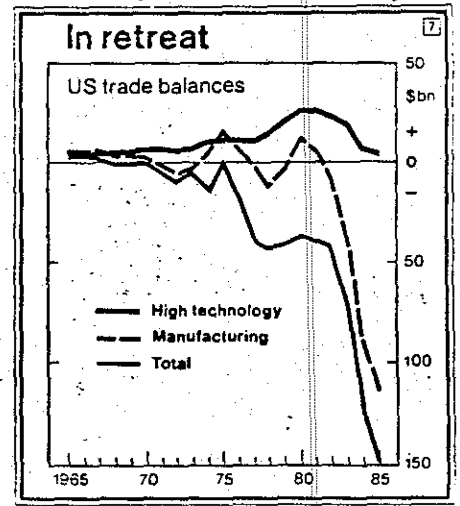
$20 billion in 1984. Along with aircraft, electronics and professional instruments, these "big four" account for more than three-quarters of the United States' exports of high technology (table 2). Despite the popular myth, America exports only modest amounts of missiles and aerospace products. But fears 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



Source: US Department of Commerce

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.

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.

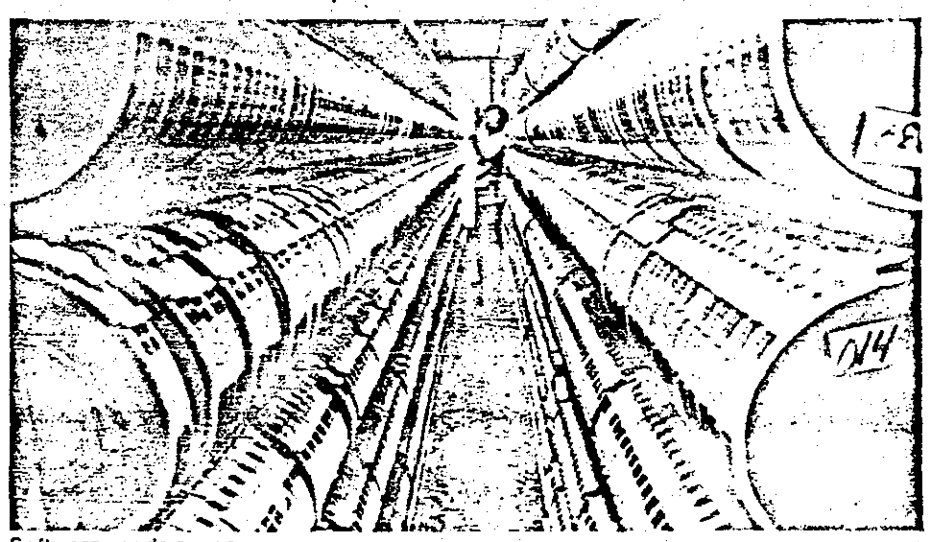
Most of Japan's computer makers came a cropper by riding a bit too blindly on IBM's coat-tails. Lacking the home-grown programming skills, Fujitsu, Hitachi and Mitsubishi made their computers imitate IBM's so they could sell cheaper versions to customers who were already using IBM machines equipped with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

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.

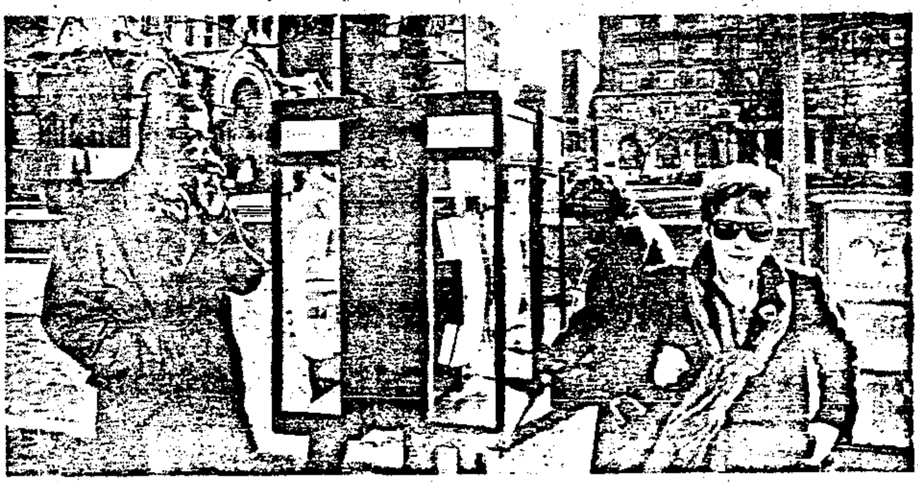
The other institution, the Microelectronics and Computer Technology Corporation (MCC), is an interesting experiment in its own right. Set up as a joint venture in 1983 by initially ten (now 21) rival American computer and semiconductor companies, MCC has 250 scientists carrying out research at its headquarters 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 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

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.

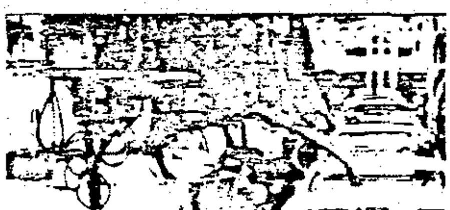
It does not require an MIT professor to explain why conventional manufacturing is limping out and new computerised forms of design and fabrication are muscling in. Using the favoured yardstick of productivity (return on investment after discounting for the current cost of money) even back-of-the-envelope 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 . . .

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.



. . . to robots . . .

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 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.

... to CIM

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.

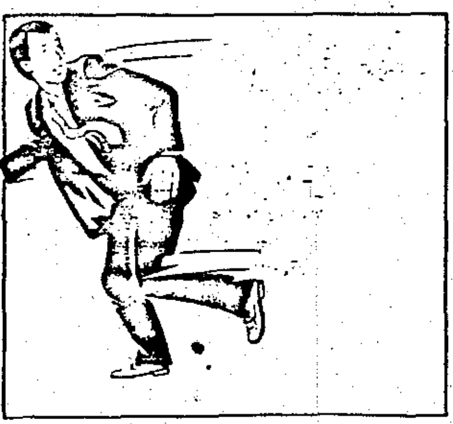
Every document in Xanadu's database has links to its intellectual antecedents and to others covering related topics. The linked references work like footnotes, except that Xanadu offers an electronic "window" through which they can be accessed there and then. Because the whole process works in a non-sequential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



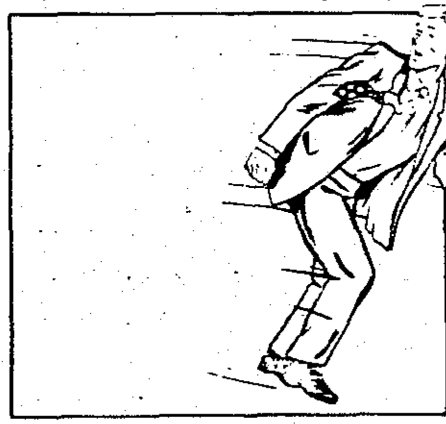
Lacking all these things, the Japanese have sought a substitute. This is one of the main reasons for MITI's special emphasis on collaborative research projects—as in VLSI or fifth-generation computers. To Mr Gary Saxonhouse of the University of Michigan, Japan's lauded industrial policies are little 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.



APR 8 1987

The Status of the Space Station Under the Technology Transfer Act of 1986

Concern has been expressed about the ownership and transfer of technology that may be created during the use of the Space Station. In particular, there is a need to find ways to encourage businesses in the United States to commercialize the technology created during the operation of the Space Station. This commercialization would benefit not only individual firms but the global competitiveness of the U.S. economy.

Treatment of the Space Station as a government-operated federal laboratory would make available a mechanism to resolve issues of ownership of technology created during research aboard that vehicle. This mechanism would be available if the Space Station were construed as a federal laboratory within the meaning of section 11 of the Technology Transfer Act of 1986, (P.L. 99-502), (the "Act"). This Act provides rules under which government-operated federal laboratories, as distinguished from contractor-operated laboratories, may enter into cooperative arrangements with other parties, including state and local governments, foundations, universities and other nonprofit organizations and private firms. Under these agreements employees of the laboratory and employees of the other party may work together, with ownership in any resulting inventions being distributed according to a pre-existing agreement between the parties.

This paper consists of two parts. The first part examines whether the Space Station might be treated as a federal laboratory for purposes of section 11 of the Act. The second part discusses in detail the advantages that recognition as a federal laboratory might offer to the operation of the Space Station.

Would the Space Station be a Federal Laboratory Under the Act?

Section 11(d)(2) of the Act defines a government-operated federal laboratory as "a facility or group of facilities owned, leased, or otherwise used by a federal agency, a substantial purpose of which is the performance of research, development, or engineering by employees of the federal government". The legislative history of the Act notes that "this is a broad definition which is intended to include the widest possible range of research institutions operated by the federal government". (Senate Report No. 99-283.) The Space Station under current plans will almost certainly meet this definition and qualify under section 11 of the Act as a federal laboratory.

The first criteria is that the Space Station must be "owned, leased, or otherwise used by a federal agency"; that is, as described in the Act's legislative history, the facility must be "operated" by the federal government. In the case of the Space Station, the National Aeronautics and Space Administration (NASA), under current plans, will have borne a major share of the costs of the development and construction of the facility, and will have the primary responsibility for operating the facility once it is successfully placed in earth orbit. Further, NASA will have the responsibility for providing transportation to and from the Space Station. NASA and other federal agencies will not only be operating Space Station, however, they will be making use of it both directly and through agreements with private firms and other governments. Thus, the first criteria under the present concept of the Space Station will be met.

The second criteria, that the Space Station must have the substantial purpose of "the performance of research, development, or engineering by employees of the Federal Government", is also met. The exact nature of the activities that will occur aboard the Space Station cannot be predicted at this time, but "research, development, or engineering" by federal employees will almost certainly be a major part of those activities. Other activities may occur on the vehicle, such as the conduct of research by employees of private businesses or foreign governments, or limited manufacture of products. As long as research, development, or engineering by government employees remains a substantial purpose of the Space Station, however, the authorities found in section 11 of the Act would remain available to the Space Station, as a government-operated federal laboratory.

However, if the Space Station is placed under international control, it will not be a federal laboratory. In such an instance, we would have to assure that any patent rights clauses in any international agreement would provide maximum rights of commercialization to U.S. industry.

Authorities Available to the Space Station Under the Act

Assuming that the Space Station were deemed a federal laboratory under the Act, the path would be opened for the transfer of technology created aboard the vehicle to U.S. firms. These firms would have the opportunity to commercialize these inventions, thus benefitting the individual U.S. companies, and indeed the competitiveness of the entire U.S. economy in the global market place.

Inventions by Government Employees Absent a Cooperative Agreement

Inventions created aboard the Space Station might be either the product of federal employees working alone, or the product of federal employees working together with scientists employed by a collaborating organization, such as employees of businesses, universities, state and local governments, or even of foreign businesses. If the invention were the product solely of federal employees who are not working under a cooperative agreement with a non-federal organization, the U.S. government would own any resulting patents, and would be free to license those patents on an exclusive basis to U.S. firms. In such a situation, section 13 of the Act provides that royalties earned by the invention would be retained by the federal agency whose laboratory made the invention. After payment of 15 percent of those royalties to the inventors, NASA could give the balance of the royalties to the Space Station, but must under any circumstances give it more than half with the remainder divided among other NASA laboratories. That is, the Space Station would receive at least the majority share of any royalties earned from inventions made solely by federal employees while aboard the Space Station. At the same time, the technology would have been transferred through the licensing process to a U.S. firm that would enjoy the benefits of its commercialization of the product.

Inventions Made by a Government Employee Under a Cooperative Agreement

Inventions made aboard the Space Station might also be the product of a collaborative effort between federal employees and employees of other organizations, entered into under cooperative research and development agreements under the Act. The official designated as "laboratory director" for the Space Station will be authorized under section 11(a)(1) of the Act to enter into agreements for the conduct of cooperative research and development aboard the Space Station with state and local governments, foreign and domestic businesses, public and private foundations, nonprofit organizations including universities, and other persons. As part of these agreements, under section 11(b)(1) of the Act, the Space Station would be permitted to accept funds, personnel, services, and property from collaborating parties, and in turn, to provide personnel, services, facilities, equipment or property, but not funds, to the collaborating parties. Further, under section 11(b)(2) and (3) of the Act, the director would be permitted to grant in advance to a collaborating party patent licenses or ownership to any resulting inventions made in whole or part by a federal employee under the agreement. Under these licenses, royalties would be paid to NASA by the collaborator in accord with section 13 of the Act. As explained above, the majority share or more of the royalties would thus return to the Space Station, where the funds could be used to pay for further research. The U.S. government, however, would retain a non-exclusive license to any inventions for its own use. This would provide the collaborating U.S. organizations the exclusivity needed to commercialize the invention.

In sum, in the context of the Space Station, a wide range of possible cooperative research activities might occur involving federal employees and employees of other organizations. For example, cooperative agreements might cover research aboard the Space Station between federal employees and employees of a U.S. corporation, university or other domestic organization, or research conducted only by employees of a domestic organization, where the facilities and/or equipment were provided by the U.S. government. By entering into a cooperative agreement under the Act, the U.S. government could assure that any resulting technology would be licensed or owned by a U.S. corporation. The U. S. government could agree to grant a royalty-bearing license, or ownership, for any inventions made by a federal employee under section 11(b)(2) or (3). This would permit the U.S. organization to take commercial advantage of any patents resulting from inventions made in the course of the research aboard the Space Station. In this way, the benefits of the research would go to the U.S. economy. At the same time, the Space Station would be the recipient of royalties earned by the licenses pursuant to section 13 of the Act.

The Act provides special rules for those circumstances in which a federal laboratory might agree to a cooperative research and and development venture with a foreign firm or firms, where employees of those firms would conduct joint research with federal employees aboard the Space Station. The Act, in section 11(c)(4)(B), permits cooperative agreements with foreign firms, but requires that the laboratories "give preference to business units located in the United States which agree that products embodying inventions made under the cooperative research and development agreement... will be manufactured in the United States". Further, the Act requires that the laboratory director, before entering into an agreement "in the case of any industrial organization or other person subject to the control of a foreign company or government, as appropriate, take into consideration whether or not such foreign government permits United States agencies, organizations, or other persons to enter into cooperative research and development agreements and licensing agreements". Should the Space Station decide to enter into cooperative research agreements with a foreign corporation it should assure that any patent rights clause in the agreement provide maximum rights of commercialization to U.S. firms.

Technical Data

For your information the latest draft of the proposed Executive Order on technology transfer requires agencies to delegate to its Federal laboratories the right to negotiate in cooperative agreements the disposition of intellectual property. As intellectual property includes technical data, the Space Station as a Federal laboratory could enter into a cooperative agreement leaving ownership or an exclusive license to technical data with a non-Federal entity.

Conclusions

(a) As Currently envisioned, the Space Station could be a Federal Laboratory for purposes of the Technology Transfer Act of 1986, as it falls within the "laboratory" cirteria of the Act.

(b) As a Federal laboratory, the Space Station could retain a significant portion of royalties generated by inventions made by federal employees either under a cooperative agreement with a non-Federal entity or made in the laboratory independent of such an agreement.

(c) As a Federal laboratory Space Station, Federal employees could receive up to 15% of royalties generated by inventions they made.

(d) The Space Station as a Federal laboratory could enter into cooperative agreements with non-Federal entities and provide the non-Federal entity with either ownership or an exclusive license of any inventions or technical data resulting from the agreement.

(e) The Space Station as a Federal laboratory permits cooperative agreements with foreign firms but requires preference be given to U.S. firms. Further, before entering into a cooperative agreement with a foreign firm the Space Station must determine that the country of the foreign firm accords equal treatment to U.S. firms vis-a-vis cooperative R&D agreements, licensing requirements, and access to the laboratories of the foreign country.

(f) However, if the Space Station is placed under international control it would not be a Federal laboratory under the Act. In such an instance the U.S. should assure that any international agreement contains intellectual property clauses (patents and technical data) which provide maximum rights of commercialization to U.S. industry.

Why Developing Nations Should Protect Intellectual Property

A strong case can be made that protection of intellectual property is in the long term interest of developing countries. Although a number of developing countries currently have policies designed to acquire their technology from developed countries in the belief that inadequate protection is in fact a positive step that will eventually produce their own technological self sufficiency and increase their international competitiveness. It is important that such countries be made to understand that they are in fact limiting their own development by restricting technological development to their ability to exapproprpriate foreign technologies. Policies of inadequate protection of intellectual property create a domestic environment that does not provide either incentives for development of indigenous R&D capability nor does it provide incentive for the necessary investment of technical skills and capital by large multinational research intensive corporations. The absence of proper protection of intellectual property often coupled with price controls that do not permit R&D cost to be recovered and requirements for technology sharing as a basis for doing business create an environment in which neither foreign nor domestic industries can afford to innovate and undertake research and development. Such situations actually lead to the irony of increased technological dependency on developed countries which are becoming increasingly unwilling to remain passive in the face of massive increases in counterfeiting and the production of inferior quality goods. Specific benefits of a system of adequate protection for intellectual property follow:

. <u>Access to Technology</u>

New products and technology flow into countries which have adequate protection because the developers of the technology can proceed without concern for loss of their innovation. This produces a more rapidly expanding economic base and enables the country as a whole to take advantage of and utilize such technologies with resulting benefits to the economy, including agricultural, industrial, and health and environmental benefits. For example, countries which do not allow adequate protection or agricultural chemicals create a system in which manufacturers simply cannot afford to produce the most modern and effective pesticides since without patent protection they cannot hope to recover their investments.

<u>Providing a General Climate of Trust</u>

With adequate protection for intellectual property the opportunities for potential capital investment and development are enlarged along all development lines. Growth of "state of the art manufacturing" facilities and expansion of the manufacturing base occurs when companies feel that it is safe for them to manufacture their newest lines of equipment without fear of loss of prioritary technology.

. Such a climate also provides the potential for a growth in partnership and joint ventures activities with developing countries. This kind of infusion of technology and expertise and capital simply will not occur at an optimal level without adequate protection.

Adequate protection for new technologies will increase and encourage innovation. Absent such protection it is not possible to recover R&D and other technology development costs which are essential to long term growth. Protection of intellectual property is based on the premise that progress of science depends on protection of intellectual property rights which promote technological advance, international competitiveness, and the ability to keep pace in the world of rapid technological change. As we continue to experience constantly evolving technology, the ability to attract and develop new technologies leads to new products and new manufacturing processes that improve quality, increase innovation, and reduce protection costs.

. The ultimate aim of protection of intellectual property is to promote technical, industrial and economic progress. The secrecy which must surround activities absent property patent protection interferes with the free flow of knowledge and technologies essential for the innovative process.

INTELLECTUAL PROPERTY AS A TRADE ISSUE

Protecting patents, trademarks, and copyrights abroad has become a vital trade policy issue as evidence of product piracy and commercial counterfeiting mounts. More and more innovators and creators are discovering their products and technology being copied and sold in the international marketplace in competition with the legitimate product. The laws of many countries do not provide means for innovators and creators to acquire rights in their intellectual creations or to protect the rights they have obtained. The copied products, therefore, interfere with legitimate trade flows. Industry calls such copying "piracy" when it involves copyrighted works like books, films, records and software, and "counterfeiting" when a product bearing a trademark is involved. "Counterfeiting" also can mean copying labels, graphics, and trade dress (i.e. the appearance of the nonfunctional features of a product). Using another's invention, whether by producing a product or using a process, is called infringement.

Intellectual property protection is particularly important for the growth and development of industries producing new products that change rapidly because of intensive research and development. Patents, trademarks, and copyrights provide the economic incentive that spurs the research and development. They also spur the competition among firms within a field. The ability of inventors, authors, and producers to acquire rights in intellectual property worldwide and the extent to which they can enforce those rights have a profound effect on international trade and on investment. Lack of rights or ineffective enforcement causes problems not only in a country where the protection is lacking, but in the home market of the innovator or creator and in third country markets. Improved intellectual property protection worldwide, therefore, should be a major trade objective of every country interested in improving its industrial base.

The actual revenue losses to innovators and creators caused by patent infringement, counterfeiting and piracy are impossible to estimate. Technology itself has made copying of most products in large quantities simple. Shipping goods throughout the world is easy. Those who copy have no incentive to keep permanent records of their activities. What records there are deal with incidents that are detected and estimates of the total problem are based on those. For example, using answers to questions on trademark counterfeiting submitted to U.S. companies, the U.S. International Trade Commission, in a recent report, estimated that $8 billion in income was lost in 1982 due to counterfeiting. The U.S. Customs Service estimates the annual loss to U.S. businesses as closer to $20 billion from trademark counterfeiting. No government estimates have been done of patent infringement or piracy.

The cost to developing economies also is impossible to evaluate in strict economic terms. Much of the cost involves that which never happened, i.e., the investment that was not made, the research and development that did not take place, the university graduate who did not remain at home to use his knowledge. That which never happened, however, does mean that a country has fewer businesses employing fewer people producing fewer goods. The country remains dependent on foreign technology rather than developing its own. The country's businesses are the followers, not the leaders in the international marketplace. Its exports are less competitive in the world market than those of other countries unless they are low priced copies of foreign goods. If the latter is the case, the exports become the subject of trade restrictions in the markets where intellectual property protection is strong. Export earnings are less than they might be. Scarce capital is used in unproductive ways. As the reputation of the country suffers and the flow of investment capital and technology decreases further. Educated nationals go to other countries to use their hard won knowledge.

It is important both to developed and developing countries to solve the problems created by the lack of an adequate framework for the acquisition and protection of rights in intellectual property. Solving the problem will require the combined efforts of national governments and of industry. Governments must enact effective laws protecting intellectual property rights. The creators and innovators must use those laws. The laws themselves should be harmonized in order to ensure that, in providing for enforcement of exclusive rights in intellectual property, governments don't establish barriers to trade in legitimate goods.

DEPARTMENT OF HEALTH & HUMAN SERVICES

Office of the Secretary

Office of the General Counsel
Washington, D.C. 20201

c/o National Institutes of Health
Westwood Building, Room 5A03
Bethesda, Maryland 20205
(301) 496-7056

January 26, 1984

Ms. Darcia Bracken
U. S. Department of Commerce
Room 4324
14th Street and Constitution Ave., N.W.
Washington, D. C. 20230

Re: Damon Collaborative Agreement

Dear Ms. Bracken:

This is in response to your telephone request for a copy of the collaborative research agreement between Damon Biotech, Inc., and the National Cancer Institute. The two exhibits of the Agreement are not enclosed. Attachment A is OMB Circular A-124. Attachment B contains trade secret information.

Sincerely yours,

Leroy B. Randall
Chief, Patent Branch

Enclosure

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PATENT BRANCH
OGC,DHHS Damon

NOV 2 1983

AGREEMENT

BETWEEN

DAMON BIOTECH, INC. AND THE NATIONAL CANCER INSTITUTE

WHEREAS Damon Biotech, Inc., 119 Fourth Avenue, Needham Heights, Massachusetts 02194, USA, (hereinafter designated as "Damon") has developed and is currently sole owner, by virtue of patent rights and ownership of proprietary know-how, of certain technology directed to the encapsulation of core materials, including biological materials and living cells, within semipermeable membranes, to methods of producing such capsules, and to processes employing such capsules (which technology as it presently exists and as it shall be developed or acquired by Damon independently of this Agreement, shall hereinafter be designated as "Encapsulation Technology"); and

WHEREAS the National Cancer Institute, a component of the United States Department of Health and Human Services (DHHS), through its Division of Cancer Treatment at the Frederick Cancer Research Facility, Frederick, MD 21701, (hereinafter designated as "NCI") engages in cancer research; and

WHEREAS the parties desire to engage in a joint development program for the application of the Encapsulation Technology to various experimental projects in the area of cancer research;

NOW, THEREFORE, IT IS AGREED BETWEEN DAMON AND NCI AS FOLLOWS:

1. The activities conducted under this Agreement are subject to the provisions of Attachment A to Office of Management and Budget (OMB) Circular A-124, which is attached hereto as Exhibit A, and by this reference made a part hereof. With respect to Exhibit A, the term "Contractor" will mean Damon Biotech, Inc., and the term "Federal Agency" will mean the Department of Health and Human Services.

2. Damon and NCI will engage in joint experimentation in the area of cancer research using the Encapsulation Technology. Such experimentation shall be organized into discrete projects each of which is directed toward experimentation with and development of a "NEW PRODUCT OR PROCESS." Each project shall be conducted under the joint direction of an appropriate representative of each of Damon and NCI. The scope of each project and particular allocation of responsibilities between the parties with respect to each project will be more particularly specified in a written project plan to be agreed upon by the parties. The NCI may at its option draft the initial proposal for each such plan after consultation with Damon and the final form thereof shall be subject to the approval of both parties. The first project plan is attached hereto as Exhibit B, and the signing of this Agreement signifies the parties' approval of that plan. Subsequent project plans shall be deemed to have been adopted by the parties upon the written approval thereof by any officer of Damon and the Associate Director, Biological Response Modifiers Program (BRMP) on behalf of the NCI. The attached initial plan and all plans which are subsequently adopted may be modified upon the written approval of any officer of Damon and the Associate Director, BRMP, on behalf of NCI.

3. Damon grants to NCI a nonexclusive, nonassignable, royalty-free license, without the right to sublicense, to practice the Encapsulation Technology only during the term of this Agreement, solely for the purpose of experimenting with, developing, and using in preclinical and clinical trials a NEW PRODUCT OR PROCESS in accordance with project plans approved and adopted under Section 2 of this Agreement. The Encapsulation Technology shall at all times remain under the control of Damon. NCI warrants that it will use the Encapsulation Technology only as authorized by Damon in this Agreement or as may be subsequently authorized by Damon in writing and agrees that use for any such unauthorized purpose shall, without limiting Damon's other rights and remedies therefor, have the effect of terminating this Agreement and all of NCI's rights hereunder.

Nothing in this Agreement shall be deemed to grant to DHHS (including NCI) or to any licensee of DHHS any rights or interests in any of the "Encapsulation Technology," as defined supra, except as specifically set forth in this Section 3.

4. To the extent permitted by the Freedom of Information Act, 5 U.S.C. 552, NCI agrees to use the Encapsulation Technology only in accordance with this Agreement and otherwise to treat the Encapsulation Technology, improvements to it arising from this Agreement and all other information having commercial value which pertains to the nature, manufacture, use and market potential of a NEW PRODUCT OR PROCESS, to which Damon has, under this Agreement, a first option to title or an exclusive license, as confidential trade secret information of Damon for the term of this Agreement plus an additional three (3) years beyond the term of this Agreement or until it becomes public information by virtue of the issuance of a patent, or by lawful disclosure not emanating from either Damon or NCI, whichever first occurs. Preclinical and clinical data developed by NCI in the course of testing a NEW PRODUCT OR PROCESS that has been developed shall be considered confidential trade secret information of Damon only if the parties agree that it is essential to a patentable invention to which Damon has a first option to title or an exclusive license.

To the extent permitted by the Freedom of Information Act, 5 U.S.C. 552, NCI will disclose confidential trade secret information only: to employees, agents and others under a contract with NCI to comply with NCI's obligations hereunder pertaining to the use and confidentiality of such information and to inventions arising hereunder. With respect to any licensing agreement which DHHS enters into pursuant to Paragraph j of Attachment A, to Office of Management and Budget (OMB) Circular A-124 (attached hereto as Exhibit A), NCI may disclose only so much confidential trade secret information as shall be required for that purpose, and NCI agrees to inform Damon of what information it is disclosing at least 30 days prior to the disclosure. Notwithstanding the foregoing, NCI may not disclose to its licensee pursuant to Paragraph j of Attachment A, to OMB Circular A-124, any of Damon's confidential trade secret information which is not developed under this Agreement, or license any of the "Encapsulation Technology" as defined supra.

If DHHS Freedom of Information Officials determine that the Freedom of Information Act requires disclosure of any of the information identified in this Section 4, other than disclosure of an invention which Damon or the DHHS may patent under this Agreement but has not filed therefor, Damon will be notified in writing fifteen (15) working days prior to the disclosure. The disclosure notification will include copies of the documents to be disclosed. If DHHS Freedom of Information Officials determine that the Freedom of Information Act requires disclosure of information which would identify or be essential to the use of an invention which Damon or the DHHS may patent under this Agreement, but has not yet filed an application therefor, such information shall be withheld from disclosure in accordance with 35 U.S.C. 205 until a patent application has been filed.

Damon recognizes that one of the purposes to be achieved by this Agreement is to create useful publications in the area of cancer research and agrees to cooperate with NCI in facilitating such publications so long as they do not result in the disclosure of Damon's confidential trade secret information. Authorship should be determined by customary procedures related to individual contributions. Unless a Damon employee coauthor (if any) has otherwise approved the final text of such a publication, NCI agrees that if NCI or any employee, agent or consultant of NCI proposes to publish any information pertaining to the Encapsulation Technology or any activities hereunder or the results thereof, NCI will cause the proposed publication to be submitted to Damon for review prior to publication. Damon agrees to determine within 30 days if said publication contains confidential trade secret information of Damon as defined in Section 4, and NCI agrees to delete any such information from the publication. This Agreement does not give Damon the right to delay or prohibit publication other than as stated above. Notwithstanding the foregoing, the publication of any preclinical or clinical data developed by NCI in the course of testing a NEW PRODUCT OR PROCESS will not be prohibited or delayed unless such publication would, as agreed by the parties, disclose information essential to a patentable invention. In that event, publication of the data will be delayed no longer than is reasonably required for Damon or DHHS to apply for a patent on such invention.

5. Each of Damon and NCI will maintain research records fully documenting its respective activities hereunder, and will regularly exchange with the other orally and in writing current information in its possession or under its control pertinent to the ongoing development of the NEW PRODUCT OR PROCESS, and shall collaborate and use its best efforts to advance development of the NEW PRODUCT OR PROCESS. Without limitation of the foregoing, each party will provide the other with a full written report of its activities hereunder no less frequently than quarterly. Nothing herein will require the disclosure to NCI of information in Damon's possession as to which Damon is under an obligation of confidentiality to a third party.

6. NCI will in connection with its activities hereunder inform Damon promptly of any invention made by NCI's employees, agent or consultants or jointly by NCI and Damon employees, agents or consultants in performance of work hereunder. The party entitled, under this Agreement, to hold title to an

invention arising hereunder (see Sections 7-9), shall be responsible for the preparation, filing and prosecution of each patent application relating thereto, including the costs associated therewith, except as specified in Section 8 below with respect to certain foreign counterpart patent applications which Damon may file for and on behalf of the Government. NCI and DHHS shall cooperate, as requested, in the preparation, filing and prosecution of a patent application by Damon. If DHHS is preparing a patent application, it will consult closely with Damon in advance of filing and give due consideration to Damon's suggestions.

7. DHHS shall have title to an invention arising hereunder if (i) the only named inventor or inventors are employees of NCI, or (ii) the invention is a clone and/or the antibody produced therefrom which was produced at NCI facilities, and the Encapsulation Technology is not claimed as a part of the invention.

8. In order to receive any license under this section Damon must advise NCI in writing, within 90 days after the date on which DHHS files for a United States patent, that Damon intends to develop and commercialize the invention which is the subject of the patent application. If the only named inventor or inventors of an invention arising hereunder are employees of NCI (see Section 7(i)), DHHS shall grant and does hereby grant at the time of execution of this Agreement, an exclusive, worldwide, royalty-free license to Damon which shall expire on the earlier of five (5) years from the date of the first commercial sale or use of the invention or eight (8) years from the issuance date of a United States patent on the invention; provided that, following that expiration Damon shall have, and is hereby granted, a worldwide royalty-free nonexclusive license that will terminate upon the expiration of the patent held by the Government claiming such invention. Each exclusive license granted to Damon shall be subject to the reservation to the Government of (1) a right to use the invention for governmental purposes and to grant others royalty-free licenses to use the invention for such governmental purposes, and (2) the march-in and other "Federal Agency" rights set forth in Exhibit A. If an invention arising hereunder is a clone, and/or the antibody produced therefrom which was produced at NCI facilities and the Encapsulation Technology is not claimed as a part of the invention, (see Section 7(ii)), DHHS shall grant and does hereby grant Damon a nonexclusive, worldwide, royalty-free license for the life of the patent held by the Government claiming such invention. Each license granted to Damon under this section incorporates a right to sublicense, to make, use and sell the invention (and the subject matter of any patent held by the Government claiming such invention).

Damon may file foreign counterpart patent applications at its own expense for and on behalf of the United States Government, provided that Damon informs the DHHS Patent Branch as to the countries in which it intends to seek patent protection, and the foreign counterpart patent applications are filed within six (6) months after the filing date of the United States patent application. It is understood and agreed that, with respect to all foreign counterpart patent applications so filed, Damon shall be solely responsible for maintaining the foreign patent applications and any patents that may issue thereon, including the payment of all fees and annuities, and that Damon may abandon any such patents and patent applications after informing the DHHS Patent Branch of its intention to abandon not less than thirty (30) days prior to the date a response to an official action from the patent examiner or an annuity payment is due, and offering the DHHS the opportunity to assume the prosecution and/or maintenance. Damon agrees that its use of such patent rights granted to it hereunder will benefit the public interest. Damon will have control over and bear the costs of any actions alleging infringement by third parties of such patents and actions alleging that Damon's use of such patent infringes their rights. NCI and DHHS agree to cooperate in Damon's conduct and settlement of any such action.

9a. Except as provided in Section 7(ii), Damon shall have a first option to title to a Subject Invention, as defined in Exhibit A, resulting from the performance of work under this Agreement if the inventor was at the time of conception or actual reduction to practice of the Subject Invention, an employee of, agent of, or under contract with Damon, as provided in Exhibit A.

9b. Except as provided in Section 7(ii), DHHS agrees to execute a written transfer and assignment to Damon of its right of title to each invention, and to any patent held by DHHS on such an invention, made jointly by employees of NCI and Damon in performance of work under this agreement. The title held by Damon under such a transfer and assignment shall be subject to all the applicable terms and conditions of Exhibit A.

9c. With respect to any invention arising hereunder in which Damon retains title, DHHS shall have a nonexclusive, nontransferable, irrevocable, paid-up license to practice, or have practiced, the invention on behalf of the United States throughout the world. DHHS hereby agrees to execute any releases, waivers, assignments, or other instruments necessary to perfect Damon's rights under Sections 9a. and 9b. of this Agreement.

10a. To the extent that title to physical materials, including, without limitation, clones, cultures or substances produced therefrom which result from the experimentation and work to be conducted hereunder, vests in the United States Government, it is understood and agreed that: (i) the United States Government shall have the right to use or authorize others to use such materials; and (ii) Damon shall have the nonexclusive right to make, use and sell such materials for its own account. Provision of materials by the NCI to Damon for production shall not imply transfer of ownership of such materials. Nothing in this Section 10 shall be construed to diminish the rights of the parties under Sections 7, 8, 9a, 9b and 9c.

10b. Physical materials, including but not limited to clones, cultures or substances, produced by or for the U.S. Government prior to, or independent of this agreement shall remain the property of the U.S. Government. Specifically, if such an HHS derived clone or its product, even if it is not described as an invention, becomes an integral part of an invention the title to which accrues to Damon as a result of this Agreement, HHS will retain unimpaired ability to further develop alternative options with such clone or product for any other purpose and with any other organization. Access to such materials by Damon shall be governed by standard Government regulations for disposition of Government property. Any previous agreements that the Government has in place relative to title, possession or use of these materials shall remain in place. NCI agrees to inform Damon in advance of any restrictions relating to such materials which would limit Damon's proposed use of the materials.

11. NCI and Damon warrant that they will conduct their respective activities hereunder in strict compliance with this Agreement so that no third party rights in any invention arising hereunder are created except as described herein.

12a. Each party will be responsible for its own compliance with all laws, requirements of Government agencies, and use of due care, and will bear its own expenses in the conduct of experiments hereunder.

12b. NCI's Institutional Review Board for clinical research will review all information related to the safety and efficacy of each product prior to administration of the product to any patient in the course of this Agreement.

12c. At NCI's request, Damon will provide NCI with analytical, chemical and other data related to the product provided by Damon hereunder. NCI will use this data to determine the safety and efficacy of the product for clinical use. If impurities are present in the product preparation which are caused by the use of Encapsulation Technology and which prevent the use of the product in patients, Damon will use its best efforts to remove such impurities. If such removal is not accomplished satisfactorily, the project involved may be discontinued at the option of NCI.

13. This Agreement will be binding upon and inure to the benefit of the successors and assigns of Damon. NCI may not assign this Agreement or any of its rights hereunder, or delegate any of its duties hereunder, without the prior written consent of Damon.

14. This Agreement and the license herein granted to NCI shall remain in effect for one (1) year from the date set forth below and thereafter until either party terminates it by giving the other no less than thirty (30) days' prior written notice of termination. The rights and obligations of the parties with respect to maintaining the confidentiality of Damon's trade secret information, and with respect to patentable discoveries and physical materials resulting from experiments hereunder commenced prior to termination of this Agreement, will survive such termination; specifically, NCI may complete the testing, preclinical and clinical, of such discoveries and materials, with Damon cooperating as necessary in that completion, and NCI's and Damon's rights to use such discoveries and materials in such preclinical and clinical trials as set forth in this Agreement will not be restricted by such termination.

15. Neither this Agreement nor any term or provision hereof may be waived in whole or in part except by a written instrument signed by one of Damon's officers and the Director, Division of Cancer Treatment, on behalf of NCI, expressly stating that it is intended to operate as a waiver or modification of this Agreement. If any term or provision of this Agreement shall be invalid or unenforceable to any extent or in any application, then the remainder of this Agreement, and such term or provision, except to such extent or in such application, shall not be affected thereby, and each and every term and provision of this Agreement shall be valid and enforced to the fullest extent and in the broadest application permitted by law.

This Agreement is effective as of October 18 1983.

NATIONAL CANCER INSTITUTE	DAMON BIOTECH, INC.
Vincent T. DeVita Director	Nigel L. Webb President