Perilous Times for U.S. Microcircuit Makers

Is Japan's success in microelectronics a threat to U.S. industry, or will both countries be hard pressed to meet demand in the 1980's?

If any American industry should feel secure against threats to its dominance from overseas, it ought to be the semiconductor manufacturers. The technology originated in the United States and domestic practitioners of the art of integrated circuitry (miniaturized electronic circuits imprinted on tiny chips of the semiconductor silicon) have rushed advances at rates that make other industries look static. American companies hold more than two-thirds of the world market for semiconductor products. Nonetheless, the U.S. integrated circuit makers see themselves sitting squarely on the horns of a dilemma.

This is the second of a series of Research News articles on microelectronics.

To stay ahead in an increasingly feverish worldwide integrated circuit competition, manufacturers must develop new microcircuit technologies, and this requires investing in large amounts of very expensive equipment. But competition is so intense that prices remain only marginally above production costs. Therefore, the profits necessary to finance the capital investment for the next round of integrated circuit technology can only come by maintaining a large share of the market.

The problem, industry officials say, is that competitors overseas, primarily the Japanese but increasingly the Europeans, are playing by rules that put U.S. companies at a disadvantage. One tactic alleged to be practiced by Japanese companies is selling in the American market at prices lower than U.S. manufacturers can match, while making up the loss by selling at a much higher price at home. At the same time, it is said, legal and informal trade barriers protect Japan's producers from competition from American-made microcircuits in their home market. Industry executives charge that such practices directly threaten the survival of American microelectronics because they unfairly deny the industry its rightful share of the worldwide semiconductor market and its ability to accumulate the capital needed to stay competitive in the future.

Even more serious, because of the increasing importance of electronics in the world economy, the position of the United States as the leading industrial nation is thereby also threatened. If steel and oil have been two of the key ingredients of modern, industrialized society up to now, many believe that in the remainder of the century it will be the state of a nation's electronics industry that signifies whether it is a developed country or not. Integrated circuits are increasingly the heart of electronic equipment of all kinds from computers to children's games. By the late 1980's, integrated circuits will account for 10 percent of the value of the products of a projected $400 billion electronics industry. According to a widely quoted assessment by Jerry Sanders, Chairman of Advanced Micro Devices, a California microcircuit maker, "Semiconductor processing technology is today's crude oil. And the people who control the crude oil will control the electronics industry." The Japanese see things the same way. "Semiconductors are the basis for everything," says Shunkichi Kisaka of the Matsushita Research Institute. And the Europeans, who have not aggressively pursued microelectronics up to now, are likewise determined not to be left in underdeveloped country status.

As a portent of things to come if the United States does not take action, Japanese consumer electronics companies already are relying on American workers for some manual assembly jobs, a startling turnabout of the American practice of using Asian labor for such tasks. Also disturbing is a trend toward acquisition of capital-starved U.S. semiconductor firms by European conglomerates, thus providing a conduit for American know-how to flow across the Atlantic.

In actuality, the issues surrounding international competition in microelectronics are not nearly so black and white as the charges against the Japanese would indicate. For one thing, worldwide demand for integrated circuits is considerably greater than manufacturers can supply right now. A good portion of Japan's rising share of the American computer memory chip market, for example, seems to be due to a shortage of American-made chips. Some analysts are saying that the growth of the U.S. semiconductor industry in the next decade will be limited by how fast companies can add new production capacity because demand will continue to exceed supply for many more years. In short, American companies do indeed face huge needs for capital to increase capacity and to get ready for the next generation of microcircuits. But there is a big question as to whether it is the Japanese that are preventing its acquisition by unfair trade practices. (See box for a discussion of another factor in Japanese success—quality control.)

While some American allegations are admitted by the Japanese to have been true in the past, the main explanation of the U.S. companies' professed woes seems to lie in the simple fact that the United States and the rest of a competitive world have different approaches to promoting international trade. In particular, if the United States plays by one set of rules and everyone else plays by another, then who is out of step with whom? Crying "unfair" may be just another way of admitting that times, typified by Japan's approach to high-technology industries, have passed America by.

Japan is export oriented, whereas the United States is not. With a population nearly half that of the United States but with few natural resources, Japan has had to rely on exporting high-value-added, manufactured products to pay for imports of raw materials it has needed since entering industrialized society just over a century ago. Moreover, in the current inflationary times, Japan still pushes hard to produce, sell, and "pay the oil bill," whereas the United States' policy is to slow the economy. But not just any industry is selected for development. According to a General Accounting Office (GAO) report issued last October, "The question constantly being addressed in

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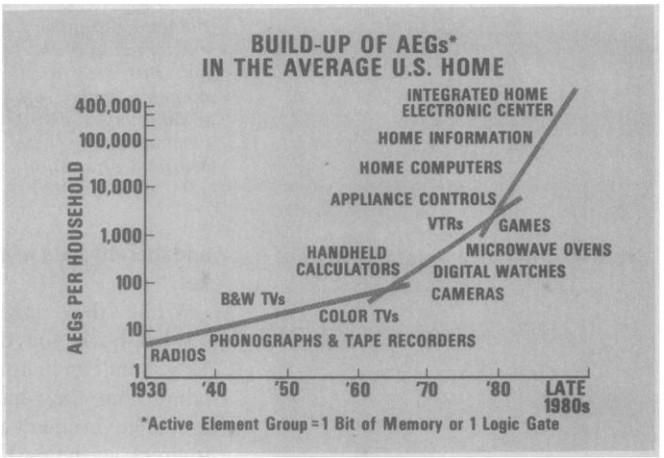
Japan is what industries will give the economy the best development and export performance." *

After World War II, heavy industries and chemicals (including steel, shipbuilding, and petrochemicals) were the "key" industries. In the 1960's, an assortment of problems, including heavy pollution, forced a shift in emphasis to clean, knowledge-intensive industries, such as computers, electronic products, and aircraft. After the 1973 oil embargo, the emphasis was even more toward computers. Not only was the computer market growing rapidly, but the machines were thought to make Japan's other industries more efficient.



Increasing usage of microelectronics in the home is one reason for intense international competition to sell chips. This projection suggests that the VLSI era will see an accelerated penetration of semiconductors into the home. [Source: Texas Instruments Incorporated]

The GAO report goes on to answer the question, "How does the Japanese Government persuade the private sector to invest in areas which it believes most advantageous for the national interest?" One way is through the tax laws, where growth is stimulated by reducing taxes through accelerated depreciation of new equipment bought by companies who are on an approved list of industries or who have strong export records. Moreover, another program permits deferral of taxes for new companies developing overseas markets. A second method is through the loan policies of the Bank of Japan. Commercial banks find it easier to get funds from Japan's central bank when their loan policies are in accordance with government priorities; that is, when loans go to companies selected for development.

American semiconductor manufacturers consider this practice, which they call targeting an industry, unethical when used in conjunction with a sheltered home market. They have cause for worry, given Japan's earlier success in applying the strategy to textiles, steel, consumer electronics, and automobiles, because semiconductors are now a targeted industry and because integrated circuits are essential ingredients of equipment in computer systems.

To boost its semiconductor industry, the Japanese government has also provided over the years funds for development of new technologies, which is another source of ire in the United States. Murray Bullis of the National Bureau of Standards (NBS) estimates that from 1966 to 1980, Japanese government semiconductor programs have amounted to about $522 million. Just ended in March was Japan's Very Large Scale Integration project, which cost about $310 million. Forty percent of the VLSI budget was shouldered by the government; 60 percent by private industry. (VLSI is the next stage of development in integrated circuitry; microelectronics is in the fading days of the large-scale integration or LSI era now. The scale of integration refers to the number of devices such as transistors placed on one integrated circuit.)

And the microelectronics bug is catching. A study by Terry Wong of Rockwell International lists the amounts being spent by several European governments in an effort to upgrade their countries' generally sleepy microelectronics capabilities. Great Britain's National Enterprise Board and Department of Industry have several projects totaling $430 million, including one NEB grant for the formation of an all-new integrated circuit company, INMOS, Ltd. (Quite a stir was caused when several key engineers from Mostek, a Dallas-based firm that is the leading producer of state-of-the-art computer memory chips, defected to INMOS.) France is spending up to $300 million, Italy has allocated $135 million, and West Germany has a $100 million-project to develop VLSI technology.

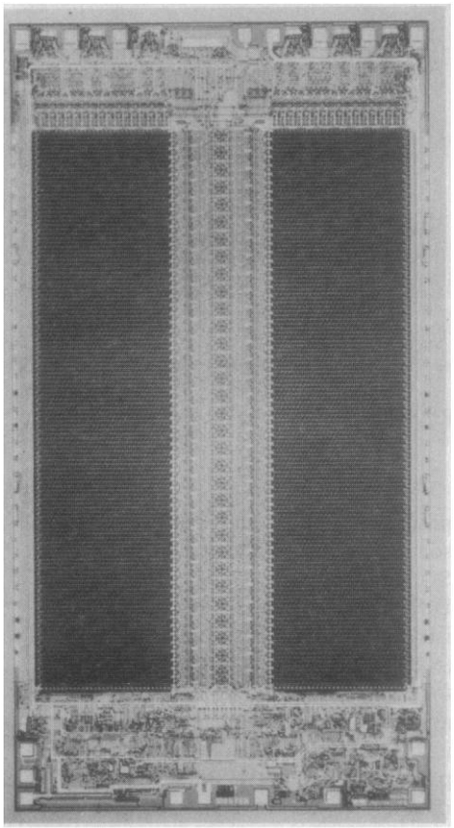
A quicker way to obtain integrated circuit expertise is to buy it, and the European companies are also taking this approach. From less than a quarter million dollars in 1969, European investments in American semiconductor firms rose to $515 million by the end of 1979. Some 14 U.S. integrated circuit manufacturers have been entirely or partially acquired in this way. The most dramatic acquisition took place last spring, when the French conglomerate, Schlumberger, Ltd., took over the Fairchild Camera and Instrument Corporation for $363 million.

Especially galling to U.S. microcircuit makers is that the Japanese VLSI project involved government-mandated close cooperation among five leading Japanese electronics and computer firms, something rarely allowed in the United States. Reportedly under pressure from U.S. firms, however, the Japanese Ministry of International Trade and Industry (MITI), which is the agency responsible for orchestrating the remarkable cooperation between government and industry in Japan that has become known as "Japan, Inc.," recently announced that all patents on developments coming from the VLSI project would be made available to American companies by way of licensing agreements.

Michiyuki Uenohara of the Nippon Electric Company (one of the VLSI participants) has told U.S. audiences several times that the cooperation was only at the level of basic research; when it comes to new products, Japanese companies are as fiercely competitive as Americans. But L. J. Sevin of Mostek said, "Absolute hogwash," when asked if he believed this explanation. Thus, whatever its actual value, to those in the United States the VLSI project stands as a prime symbol of the unfair burden under which America's most innovative and productive industry has to labor.

A less symbolic difference between the United States and Japan has to do with formation of capital for investment in new technology and expanding production. American companies' primary sources of capital are profits on sales and investment dollars from the issuance of stock. Furthermore, domestic integrated circuit manufacturers have been slavish adherents to the experience curve, a doctrine which asserts that production costs decrease a fixed percentage each time cumulative production doubles. To maintain market share, the philosophy goes, prices should follow the experience curve down. Thus profits, as a percentage of sales, are smaller in the semiconductor industry than for American industry as a whole. Capital formation,

*U.S. General Accounting Office, *United States-Japan Trade: Issues and Problems* (GAO Report ID-79-53, 21 September 1979, Washington, D.C. 20548).



Photomicrograph of a 16 K random access memory chip of the type that is in short supply. Bits are stored in the two long rectangular arrays; other circuitry is for controlling input and output of data and for communicating with other chips. [Source: Mostek Corporation]

which depends critically on holding a sizable share of the market, is getting to be a crucial issue for U.S. semiconductor manufacturers, according to industry executives.

The Japanese (and Europeans) have a distinct advantage in this regard, John Welty of Motorola told Senator Adlai Stevenson's (D-Ill.) international finance subcommittee last January. Partly because of government regulations and partly because of business custom, companies in these countries can borrow much more extensively than is possible in the United States. A measure of debt is a figure called the debt to equity ratio. Debt to equity ratios in Japan range from 3 or 4 to 1, whereas in the United States, ratios of 1 to 2 or 3 are more common. Although interest must be paid on the borrowings, the cost of borrowing is less than the cost of capital acquired through the sales of stock, for example. The difference, said Welty, translates into a 4.5 percent reduction in the price Japanese vendors are able to charge as compared to American prices, all other things being equal. Thus, the Japanese seem to have the best of both worlds. Because they have access to low-interest, preferential loans, Japanese companies do not need to start with a large market share in order to generate capital, as do American firms. But because of lower capital servicing costs, they can sell more cheaply and thereby gain a large share of the market.

While they might legitimately ask "What have you done for us lately?" U.S. semiconductor companies have to admit that they have received considerable government assistance, direct and indirect, in the past. The Semiconductor Industry Association, a lobbying group of American companies, counts some $350 million of direct federal aid from 1958, when the integrated circuit was invented, to 1976. A similar amount was provided through sales to government agencies. The two figures together account for about 30 percent of all semiconductor research and development during the period. The Minuteman missile program in particular, says NBS' Bullis, greatly aided the development of integrated circuits by providing a market for the devices when they were just getting off the ground. And several federal agencies, including the Department of Defense, the National Science Foundation, the National Aeronautics and Space Administration, and NBS either have funded or directly carried out research of benefit to the industry.

Nonetheless, say observers, the tendency toward an adversarial relationship between U.S. industry and government and the absence of an export-oriented consciousness in any government agency seems to put a burden on the shoulders of American microelectronics companies that competitors in Japan and other nations do not have to carry. Senator Stevenson said recently, "The Japanese computer industry is organized by government for investment, basic research, and global competition. Back in the United States, the Justice Department is trying to break up IBM." (Curiously, points out Frederick Haynes of the Department of Commerce, the relationship between the U.S. Department of Agriculture and American farmers is quite like that between MITI and Japanese industry, although agricultural products account for only one-fifth of all U.S. exports.)

The other side of exports is imports. A basic semiconductor industry complaint has been that the United States is a free market open to the world, whereas the reverse is not true at all. Member nations of the European Economic Community, for example, levy a 17 percent tariff on integrated circuits produced outside their boundaries. The comparable U.S. tariff is 6 percent. The Europeans also restrict access to certain markets, such as telecommunications, to companies with local manufacturing facilities. Also, electronics equipment moving between nations within the European Economic Community may be subjected to tariffs if it contains more than a small percentage of foreign semiconductors. Thanks to regulations permitting American companies to set up subsidiaries in Europe, however, these obstacles have not been overly burdensome. Moreover, establishing foreign subsidiaries has additional benefits, such as a better relationship with customers. American semiconductor companies account for about 55 percent of European consumption of microcircuits.

In Japan, the situation is not so favorable. The U.S. share of the Japanese market is about 15 percent. The tariff on electronic components there has been 12 percent, although in the Tokyo Round of the Multilateral Trade Negotiations (recently completed in Geneva), the two sides agreed to reduce the tariff in stages over 8 years to 4.2 percent. But most American firms have found it exceedingly difficult to sell their wares in Japan or to set up subsidiaries there. Two conspicuous exceptions are IBM and Texas Instruments, the world's largest computer and semiconductor companies, respectively. IBM still has the most computer sales in Japan, although its share of the market is limited by agreement to 35 percent and has declined with the recent accelerated development of the Japanese computer industry. The price of IBM's 1960 entry was making its computer technology available to Japanese companies by way of licensing agreements. Texas Instruments, according to the most widely told account, forced its way into Japan in 1967 on the strength of extremely strong integrated circuit patents, which the company alleged the Japanese were violating. Company officials have asserted in the press that TI's success in Japan was more the result of hard work than brute force. Other companies have not done so well. Joint ventures by Fairchild and Motorola in the early 1970's were unsuccessful, although observers have differed on ascribing the demise to inadequate effort and a refusal to forego short-term profits for a longer range strategy or to a closed Japanese market. Beginning in 1974, a liberalized policy has slowly been put into effect in Japan, and several leading U.S. semiconductor firms are now said to be setting up or

planning research or production facilities there.

One reason for the gradual opening up of Japan to American electronics companies is an increasing sensitivity in Japanese industry and government to complaints of a closed market, as indicated by progress in trade negotiations. In addition to the difficulty of establishing overseas subsidiaries there, U.S. executives have complained about the practice of Japanese customs officials who value imports at roughly 25 percent over what Americans say they are worth. The Tokyo Round negotiations have resulted in agreement on a customs valuation code to go into effect in 1981, which could deter this practice.

Concern has often been voiced over an official and unofficial "buy Japan" policy. An intensely disliked facet of the policy is that cited by Gordon Moore of the Intel Corporation, California's largest integrated circuit manufacturer. Moore says that MITI has encouraged Japanese purchasers to buy foreign electronics components only when no comparable Japanese product existed, thus protecting home producers from competition while encouraging the flow of new technology into the country. Several anecdotal accounts exist of Japanese customers canceling orders from U.S.

Do the Japanese Make Better IC's?

Representatives of Japanese industry and government have been saying for some time that the reason for Japan's success in international trade is the quality of its products, not unfair trade practices. Up to now hard figures to back up the validity of such claims for Japan's integrated circuits (IC's) have not been available. But at a March meeting in Washington, D.C., sponsored by the Electronic Industries Association of Japan, an executive from Hewlett-Packard dropped what one attendee called a bombshell—a comparison of 300,000 random access memory chips from three Japanese and three American companies showed the Japanese IC's to be consistently freer of defects. Making products of higher quality does not necessarily absolve the Japanese of accusations of unfair trade practices, and there are reasons why the Hewlett-Packard figures may not be completely representative. But the company's findings do seem to underscore what numerous observers have been pointing out—the Japanese have an altogether different approach to quality control than their U.S. counterparts.

"At first glance, the impression is that the Japanese are using low cost and domestic protection as levers to build a strong base for exports. On close inspection, this premise does not hold up. The Japanese semiconductor companies are using superior product quality to gain competitive advantages of enormous magnitude." This is what Richard Anderson of Hewlett-Packard's Data Systems Division told an invited audience of mainly congressional staff people at the Washington meeting. To back up his statement, Anderson presented some numbers. Not a single device from the three Japanese companies failed an inspection of incoming new parts, whereas failure rates from the three American companies ranged from 0.11 to 0.19 percent. In field operation, memory chips from the Japanese firms failed at rates from 0.01 to 0.019 percent, while American chips exhibited failure rates from 0.059 to 0.267 percent.

Are the Hewlett-Packard results representative? The company only reluctantly started buying Japanese memory chips when its American supplier had trouble producing them, and presumably it is an unbiased customer looking for the best product available. In the past, members of the Semiconductor Industry Association have testified before the U.S. International Trade Commission that independent laboratory tests had shown no difference in reliability between Japanese and American IC's. But an informal survey by Benjamin Rosen of Rosen Research, Inc., who follows the industry closely, ended with the conclusion that both users and manufacturers of IC's in the United States agree that Japanese quality is superior, although perhaps not as overwhelming as the Hewlett-Packard statistics suggest. One explanation for the marked superiority of Japanese chips in the Hewlett-Packard tests is that the Japanese may have selected their best products for sale to the company. Such tactics have been alleged to occur whenever Japanese companies want to penetrate a new market.

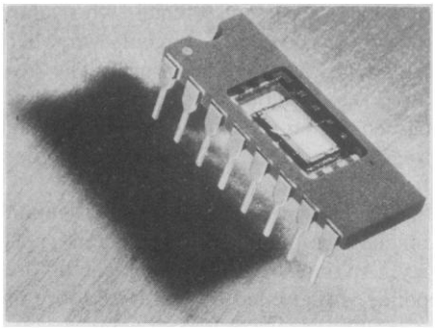
Whether such charges can be supported or not, observers agree that Japanese and American companies have quite different approaches to quality control. A March article in *Electronics* by Tamatsu Goto and Nobukatsu Manabe of the Nippon Electric Company points up the difference, "There are two basic approaches to improving IC reliability. One screens out failures by strict inspections, the other tries not to build failures in the first place. In the U.S., for example, the term quality control is often used as a synonym for inspections, and strict and frequent inspections then come to be regarded as good quality control, although of course they raise costs." But, the authors continue, "Japanese leaders of quality control take the opposite tack. They feel the highest reliability is achieved by building quality in; for if failures are held to a minimum, yields go up, costs come down, and inspection becomes almost redundant."

"The better the quality, the lower the cost?" asked Hajime Karatsu of Matsushita at the Washington meeting. "Many people might think this is too good to be true." American IC makers clearly think so. They accuse the Japanese of achieving higher quality by the expensive practice of double inspection. But other observers think the Japanese are on to something. "What is especially distressing," says Murray Bullis of the National Bureau of Standards, "is that the Japanese have just properly applied procedures developed in the U.S." A succession of American quality control consultants, including W. E. Deming, J. M. Juran, and A. V. Feigenbaum, journeyed to Japan in the early 1950's, when Japanese products had a low reputation for reliability. Apparently their lessons stuck. According to a recent General Accounting Office report (see story), "The defect ratio in product after product is lower in Japan than in the United States." In a case study of the color television industry, the agency found that in one American plant taken over by Japanese managers the defect rate per 100 TV sets packed fell from over 150 to 3 to 4. Sets made in Japan have even lower rates. Perhaps it is time for Americans to practice what they used to preach.—A.L.R.

firms after receiving phone calls from MITI. The policy is said to be changing. In the realm of government procurement, for example, the Tokyo Round of negotiations produced an agreement requiring open bidding from domestic and foreign suppliers, including the use of international technical specifications and publication of selection criteria. But in one important case there has been little progress. The Nippon Telephone and Telegraph Corporation, Japan's national telecommunications company, has not been and still is not open to bids from foreign suppliers.

Where does all this leave the U.S.-Japan competition? On a worldwide basis, American companies' current share of the semiconductor market (just over two-thirds) is of concern because it has been slowly dropping since the beginning of the integrated circuit era in the early 1960's, when it was 88 percent. According to one recent study of bilateral U.S.-Japan trade in integrated circuits, in 1978 the United States exported 220 million devices and imported 100 million devices. The United States therefore has a positive balance of trade. Although both countries have statistics demonstrating that their worldwide balance of trade in integrated circuits is negative, the U.S. deficit is growing and the Japanese is decreasing, according to an International Trade Commission report.†

Pierre Lamond of National Semiconductor, another California firm, argues that the net balance of trade is not the figure of greatest concern at the moment. The dark cloud already well past the horizon is the penetration of Japanese integrated circuit companies into the U.S. market for state-of-the-art computer memory chips. Computer memory chips are important because they are the integrated circuit sold in the highest volume. Often the newest technology appears in memory chips before it does in other types of circuits, such as microprocessors. Profits from sales of memory chips are said to underwrite development of other important, but less popular, devices. Thus, Lamond says that he and his colleagues are greatly worried by the fact that 42 percent of the U.S. market for a memory chip called a 16 K RAM is held by the Japanese. In effect, within a targeted industry, microelectronics, the Japanese are targeting the most important component. (RAM stands for random access memory. 16 K means that the chip can store 16,384 bits of information. Soon to come are 64 K RAM's, which some observers call the first VLSI integrated circuit.)



Encapsulated 16 K random access memory chip in standard 16-pin dual in-line package. A standard configuration allows devices from different manufacturers to be interchangeable. [Source: Ruder & Finn Incorporated for Fujitsu Limited]

While the targeting tactic would be in keeping with past Japanese practice, the argument is flawed in the case of the 16 K RAM because there is a worldwide shortage of capacity to produce these chips right now. Thus, whatever market share the Japanese have attained would seem to be by default more than by design. Reasons for the shortage are multiple. After the 1974–1975 recession, U.S. manufacturers did not invest in new production equipment as much as they, in hindsight, could have. IBM has in the last couple of years become a big drain on the market, soaking up more than 10 percent of all the 16 K devices manufactured in 1979 as it looked for memory chips for its newest computer systems. Some companies, such as Intel, have deliberately chosen not to produce 16 K RAM's in favor of other types of circuits that are more profitable. In fact, Robert Noyce of Intel told Senator Stevenson's subcommittee, the company buys 16 K RAM's from Japan for less than it would cost to make its own. All in all, trying to convict Japan of unfair competition on the basis of 16 K RAM's would seem to be a losing effort.

Nonetheless, industry representatives have been beating a path to Washington in a search for relief from what they see as their biggest challenge, accumulating capital. At a hearing of Representative Charles Vanik's (D-Ohio) trade subcommittee, spokesmen for the Semiconductor Industry Association argued that ways to ease the problem of capital formation include a 3-year depreciation for new equipment as opposed to the current 7 years, and a deferral of capital gains taxes for proceeds from the sales of securities that are reinvested in other securities. To stimulate research and development, it was suggested that there be an investment tax credit for research. Other ideas were a full tax credit up to 10 percent of total company research expenditures for funds provided to a university and a 10 percent additional tax credit for research exceeding a firm's average expenditures in the preceding 4 years. Industry spokesman have also argued for negotiations "at the highest level" between the United States and Japan in order to eliminate practices of targeting that interfere with free trade.

The parade of semiconductor businessmen has had some effect. Several federal agencies have had or shortly will have studies out on some aspect of the U.S. semiconductor industry or on international competition in electronics. The latest, due in late April, is from the State Department. What will come of it all is, of course, uncertain. One initiative, from President Carter's industrial innovation study released last October, is the establishment of so-called generic technology centers scheduled for fiscal 1981. Jointly funded by government and industry, the centers would allow for a certain amount of cooperation between otherwise competing companies. The integrated circuit manufacturers have been sounded out for their interest in establishing such a center. So far their response has been lukewarm, with the prevailing opinion being that such an enterprise could be of value if the government will provide money but stay out of the center's operation, which might cost about $30 million annually.

Interestingly, semiconductor executives have not been seeking a large federal role in supporting research and development or in organizing U.S. industry for exporting. The message the integrated circuit leaders have been carrying is that they feel more than able to compete on their own, if the rules of the game can be made more even.

This is the outcome that seems the least likely, however. A United States government with so limited a role may not be in the cards. The fact is that the American companies did not develop entirely on their own without government support. Now the Japanese and European governments are trying to do the same for their industries. Perhaps the best course of action is to adopt some of the practices of countries such as Japan that help government and industry to work together to develop growing, innovative, high-technology companies that can compete on the world market, while continuing to work towards a world without protectionist trade practices.—ARTHUR L. ROBINSON

†U.S. International Trade Commission, *Competitive Factors Influencing World Trade in Integrated Circuits* (USITC Publication 1013, November 1979, Washington, D.C. 20436).