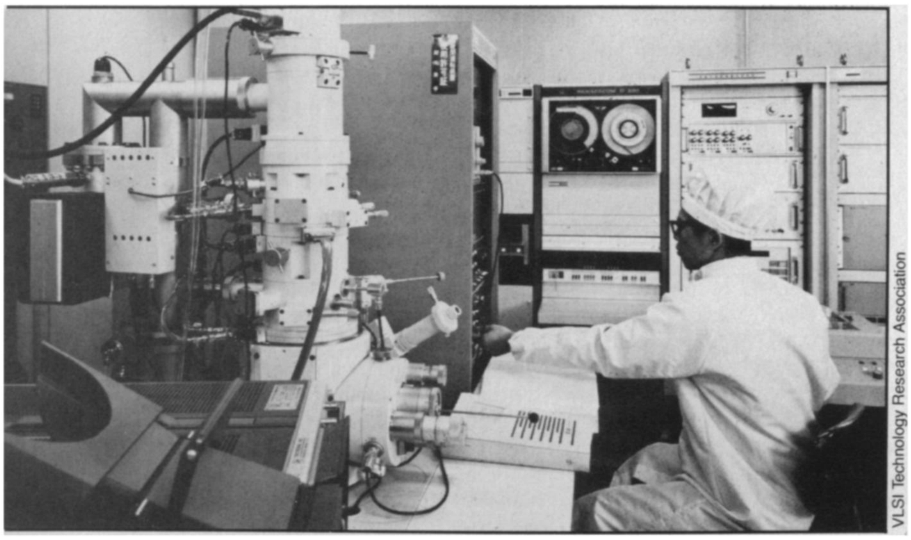
LETTER FROM TOKYO (3):

The Great Computer Race

The next generation of computers may be introduced by Japanese companies, not American ones

BY JOHN H. DOUGLAS



Electron beam apparatus at the VLSI Cooperative Laboratory represents one of the technologies that may contribute to the next generation of computers.

VLSI Technology Research Association

Tucked away in a quiet neighborhood at the far edge of Kawasaki's industrial sprawl, the "Cooperative Laboratory, VLSI Technology Research Association" would appear instantly familiar to any American corporate scientist. Indeed, the only immediate difference that strikes a foreign visitor is that just inside the front door you must exchange your shoes for Japanese-style slippers, whose soft "pat pat" adds a homey touch to the otherwise sterile surroundings.

Yet this laboratory could not exist in the United States. It is a unique creation of "Japan, Inc." — a government-sponsored facility staffed with scientists and engineers on loan from seven private companies. Their purpose: to develop the basic technology needed for Very Large Scale Integration (VLSI) circuitry, the basis of the next generation of computers. And already the word is out — talk shared by engineers over beer late in the night — "This time we can beat the Americans."

By daylight, however, in the formal reception lounge of the Cooperative Laboratory, director Yasuo Tarui pooh-poohs such speculation. He calls recent reports in the American trade press of billion-dollar funding and working goals of million-bit chips by the early 1980s "exaggerated." The total budget for the planned four-year government R&D program is only 70 billion yen, he says, about $280 million at today's rates. As for competing with the United States, he repeats his call to American colleagues, given recently at a professional meeting in Washington: "I hope we can explore the unknown field of microelectronics together." And he pledges to share all "academic results" gained from his laboratory's research with the rest of the world.

At the heart of the VLSI problem is the limitation imposed by today's technology on packing more and more circuits onto silicon "chips." These chips, which became familiar to most people when they led to creation of digital watches and pocket calculators, reduce the calculating time and electrical power requirements of giant computers. Tens of thousands of transistors are now packed onto one chip, but if a way can be found to make that *hundreds* of thousands, another revolution of novel electronic devices and computer applications is foretold.

Although many applications will probably come as a surprise even to today's experts, an impressive number of potential uses are already awaiting development of VLSI circuitry. For example, the ability of single chips to conveniently store and process large amounts of data should permit transmission of pictures over ordinary telephone lines. This development could make picture telephones practical for home use and make facsimile transmission of the printed page cheap enough eventually to bring about "electronic mail."

Combining the powerful chips into computers with unprecedented speed and storage capability should allow scientists to attack whole new categories of problems — such as developing a computerized model of the world's climate. For the average consumer, the new chips will mean that pocket calculators can become pocket computers, and that a home computing center can be tied into a globe-spanning data network.

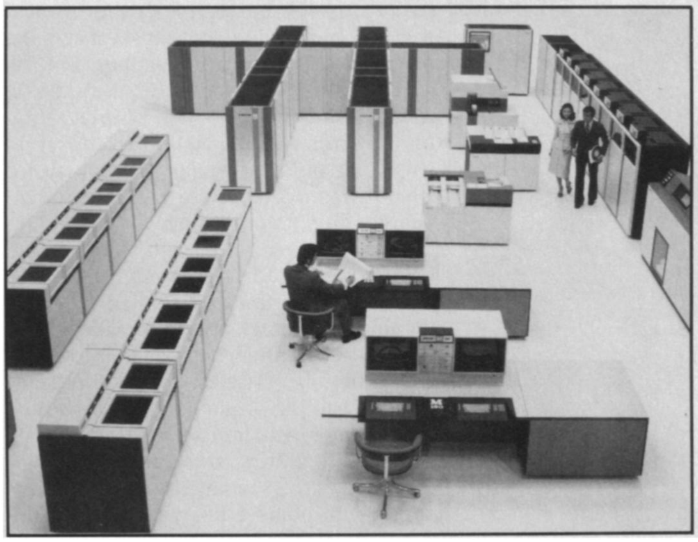
For the Japanese, commitment to having an independent domestic computer industry has meant adapting to a new level of international competition. Although the original technology could be borrowed from abroad, an R&D effort of unprecedented sophistication had to be established at home to keep the Japanese companies from falling behind, particularly in developing the new VLSI circuits.

At first, the chances for success did not look good: Such American giants as the General Electric Co. and the Radio Corporation of America had limped off the computer battlefield, and the three-nation European effort, Unidata, collapsed after only three years. But Japan's Ministry of International Trade and Industry (MITI) took the fledgling industry under its wing, and its success so far has been untarnished.

Fujitsu Ltd./Foreign Press Center

(One of a series of articles on Japan's science and technology by contributing editor John H. Douglas, a Fulbright Research Journalist in Tokyo.)

Photos: Fujitsu Ltd./Foreign Press Center



Japan is the only free-world country whose computer industry is not U.S.-dominated, and the average usage rate of computers in Japan is the world's highest. The M-190 is Japan's largest computer.

To counteract a division of effort among domestic companies that left them at the mercy of International Business Machines' wholly owned Japanese subsidiary — a situation industry observers liked to call "IBM and the Seven Dwarfs" — MITI first encouraged the computer companies to form three loose associations. Each association was to build computers capable of competing with IBM's System/370 series, and each would be based on a different (originally borrowed) technology: Fujitsu and Hitachi would make a series of computers compatible with IBM machines; Toshiba and Nippon Electric Company (NEC) would make a series based on Honeywell technology; and Mitsubishi and Oki Electric would make a series based on Univac technology.

As a result of this effort, Japan is now the only free-world country whose computer industry is not American-dominated. About two-thirds of Japan's installed computers (about 38,000, including minis) is the second largest in the world. And, according to Takeo Shiina, president of IBM-Japan, the average *usage* rate of computers in Japan is the world's highest.

Many Japanese industries, such as automobile manufacturing and steelmaking, are highly automated, using domestically made computers. And a nationwide computer network linking principal banks is effectively allowing Japan to pass directly from cash-and-carry business (checks never really caught on) to a "cashless society" of credit cards and automatic payment of bills through bank accounts.

At present, only about four percent of the world computer market is controlled by the Japanese, but their exports are increasing. The largest Japanese computer maker, Fujitsu Ltd., recently beat out IBM in head-on competition to sell a giant, $36 million computer network to Australia. Earlier, Fujitsu sold its top-of-the-line M-190 computer to the Spanish National Telephone Co., and Hitachi has just received permission to export three large computers to mainland China for meteorological use. (The sale had been held up initially because of fears that the computers were big enough to allow China to design sophisticated nuclear weapons.) Some industry observers predict that the Japanese share of the world computer market could jump to 15 percent within just five years.

But that will mean developing a VLSI capability completely on their own, and for this task MITI has again encouraged individual companies to pool their efforts. This time, two groups of companies will manufacture the final products (Mitsubishi has joined the Fujitsu-Hitachi group and Oki has dropped out). And all the major computer manufacturers, plus two smaller companies, have joined in the common effort to conduct a joint R&D program, forming the VLSI Technology Research Association, under MITI auspices. This association, in turn, shares technical data with another VLSI project, conducted by the Nippon Telegraph and Telephone Public Corporation, with help from the Ministry of Posts and Telecommunications.

Cooperative Laboratory director Tarui summarized for SCIENCE NEWS the current state of the joint research effort. Present integrated circuits are manufactured by photolithography, which involves exposing a light-sensitive resist to light passing through a mask with the circuit pattern etched on it. Most people in the industry believe that a circuit element size of one or two microns is about the best that can be achieved with photolithography. This would limit the amount of information that could be stored on a single chip to about 64 kilobits (64,000 binary digits) — a level the Japanese have already achieved. Tarui and his colleagues are thus concentrating on finding new ways to etch the microcircuits, using electron beams and X-rays, which should eventually produce chips with many times more circuit elements.

Last May, the VLSI Association announced that a variable spot electron beam technique had been developed that would cut the time required to etch a circuit pattern on a chip to one-tenth the time needed previously. Since the time needed for exposure is the main obstacle to commercial application of the expensive e-beam equipment, considerable industry interest was stimulated by this announcement.

Tarui says that experiments are now being conducted to see which type of variable beam apparatus might be most suitable for commercial application — one using two apertures to shape the beam or another that forms the beam using a series of electrostatic lenses. Although these devices have been used to create test patterns on silicon chips, neither has yet been used to make a VLSI.

An alternative approach under consideration, Tarui says, is to expose sensitive materials under a mask to X-rays, which have a much shorter wavelength than light and could thus give finer definition of circuit elements. Current efforts, he says, are aimed at overcoming three major obstacles. First, a more powerful source of X-rays is needed, since present sources require long exposure times. Second, appropriate masks must be found that can be placed closer to the surface to be exposed than those in common use today. Third, aligning the mask and the exposed surface will be a problem, since the elements will be too small for optical inspection.

U.S. companies, of course, are also experimenting with e-beam and other methods of producing VLSI circuits. IBM alone is reportedly spending more on VLSI research than the Japanese association as a whole. Both Japanese and American engineers interviewed agreed that American companies probably still hold a slight lead in R&D related to VLSI technology, but that the Japanese may come out with a computer based on the new circuitry first, mainly because their companies can afford to be more adventurous.

Consider the case of IBM. In 1963 the company introduced System/360 and instantly obsoleted the previous generation of computers. The designer was a brilliant engineer named Gene M. Amdahl, who immediately wanted to push ahead with even more revolutionary machines. Eventually IBM did market the advanced System/370, but Amdahl, not satisfied with the progress, set up his own company in 1970.

His strategy was simple: Get the jump on IBM by using a higher scale of integration on the circuit chips, while the conservative giant plumbed older technology for what it was worth before finally introducing new circuits more slowly. By 1976, Amdahl had largely succeeded in his quest, having produced a computer that was two-and-a-half times faster than the comparable IBM model, and selling for 10 percent less cost. And when he ran into financial difficulty, Amdahl found an eager partner waiting — Fujitsu Ltd. — which received in return for its support the rights to Amdahl's advanced technology.

Now play the scenario again. When IBM announced plans a few years ago to develop a "Future System" of computers, presumably based on VLSI technology, for introduction in the early 1980s, MITI organized the VLSI Technology Research Association to develop the circuits needed to compete. But this time, not only would the Japanese companies have to stand on their own — since access to another Amdahl seemed very unlikely — but by pushing ahead full speed, they just might beat IBM, if the latter took its usual conservative course. Said one influential Japanese financial newspaper, "This is our Apollo project."

As far as an outsider can tell, the Great Computer Race is still wide open: IBM has had second thoughts about trying to introduce another revolutionary system all at once. Customer reluctance and problems with writing the software required for a new system led the company to announce a policy of introducing technology in small stages. On the other hand, IBM has just amassed the largest stash of ready money and marketable securities of any corporation in the country — $5.2 billion. While the company will not say what it plans to do with all that cash, vice-president for finance and planning Dean P. Phypers was quoted in BUSINESS WEEK as saying, "Suppose that there was a tremendous breakthrough in component technology and that, say, we had to write off and retool our component operations. ..." For that, VLSI competition from Japan seems to be the only likely candidate at the moment.

Clearly, the prospect of heightened competition from Japanese computer makers has worried smaller American companies even more. Among other things, the Japanese could sell and lease computers to developing countries on financial terms that the small American companies would have trouble matching. What advantage new technology may not give to Japanese companies, financing by friendly government banks can always supplement. Speculation has thus arisen in the industry that while IBM will not be particularly hurt by the latest Japanese initiatives, smaller American companies may be forced into joint ventures of their own in order to survive.

In addition to sponsoring development of computer systems competitive to IBM's 370, and underwriting research into VLSI technology, MITI is also investing heavily in another computer-related project — pattern information processing. Optical recognition of printed letters, numbers, *kana* (Japanese syllable characters) and *kanji* (the thousands of Chinese ideographs used in Japanese) has reportedly already been achieved. The first practical application of this system is expected within two years, probably at the Japanese patent office, where computers will aid in processing applications. Experiments in voice and handwriting recognition are also being conducted. If successful, this project should give the Japanese companies a strong start toward future consumer applications of computers, such as electronic mail. Says one knowledgeable American observer, "This is what the Japanese really want, where their strength has always been, the vast potential home market."

Officially, the Japanese government has been encouraging the domestic computer industry as a logical extension of its developing economy. As raw material shortages and foreign competition begin to cut into traditional export industries such as steel, the Japanese look toward computers as the key to a new era of high-technology exports (SN: 12/3/77, p. 378). But the prospect of developing a major new technology on their own — putting to rest forever the stigma of being technological "copiers" — is also a major motivation, at least at the level of individual engineers.

After a long evening of unusually frank exchange, I was standing in a subway station with one such engineer. As his train approached, he paused in our light conversation and suddenly turned reflective. "But I must say," he began hesitantly, as if just completing a long-considered thought, "IBM really does make a fine computer." He paused again as the train rumbled by, then smiled as he murmured almost inaudibly under his breath, "And I want to beat them!" □