A Private Electron Storage Ring: Big Science Goes Commercial

Deep in the heart of many a scientific administrator lies the unvoiced hope-against-hope that the hundreds of millions of dollars needed to build the largest accelerators for high energy physics somehow will pay off in the way that nuclear physics research in past decades culminated in nuclear reactors and weapons. If a recently launched California venture is successful, an impact somewhat more modest than that of nuclear power, but nonetheless substantial, may result from one kind of accelerator—the electron storage ring. A company was formed last June in San Francisco to build such a device for the purpose of providing synchrotron radiation for proprietary research and production. One goal is to enter into joint venture agreements with, for example, microelectronics manufacturing companies that would use the synchrotron radiation in the fabrication of integrated circuits, projected to be a $4-billion-per-year business in 1978.

The Electron Storage Ring Corporation (ESRC) intends, pending the success of an effort to raise $10 million in capital, to construct during the next 3 years a 700-million electron volt electron storage ring to provide synchrotron radiation in the ultraviolet and "soft" x-ray regions of the spectrum. The ring, rather modest by high energy physics standards, will be about 10 meters in diameter and will be capable of serving more than 15 users simultaneously.

Initial plans include the renting of access time to the radiation in a secure environment suitable for proprietary research for about $120 per hour, but this plan is intended only to recover operating expenses and is not expected to be more than a small fraction of the company's business. As potential users increase and commercial applications become apparent, the belief is that it will be possible to work out cross-licensing and joint venture agreements for the use of synchrotron radiation in the manufacture of microstructures of all kinds, in photochemical processes, in x-ray microscopy, and possibly in exotic new devices such as a tunable, high power laser. Other activities envisioned by company officials include development of specialized products and services, such as x-ray lenses, filters with submicrometer pores, and chemical analysis, which the company itself could market. And the construction of additional storage rings for customers, such as large electronics companies that could advantageously make use of an entire ring, is another possibility.

Strictly speaking, an electron storage ring is not an accelerator. In essence, it is an evacuated doughnut or torus in which electrons previously accelerated to relativistic energies by a synchrotron or a linear accelerator can circulate for many hours before gradually dropping out of the beam by colliding with residual gas molecules in the ring. High energy physicists study collisions between these electrons and positrons (anti-electrons) in a counter-circulating beam because the collisions provide the energy needed to make many of the new elementary particles that have so enthralled physicists the past 3 years.

Electrons following curved trajectories continuously emit electromagnetic radiation—synchrotron radiation—over a wide range of wavelengths that varies with electron energy. The electron energy characteristic of today's storage rings (up to 4 billion electron volts) is so large that the most intense radiation is in the ultraviolet and x-ray wavelengths. In the last few years, biologists, chemists, and physicists have rushed to use this remarkable source of radiation for a vast array of spectroscopic and x-ray diffraction studies. Where once the accelerator designer regarded synchrotron radiation as a headache (because the energy lost in radiation had to be given back to the electrons by expensive, power-consuming radio-frequency devices and because of cooling problems), now the Department of Energy and the National Science Foundation are supporting the construction of electron storage rings dedicated solely to the production of synchrotron radiation (*Science*, 8 July 1977, p. 148).

In parallel with the veritable explosion of interest in the use of synchrotron radiation has been an increasingly strong belief that x-rays may provide the means by which the features of ultraminiature devices of all kinds, but principally integrated circuits such as computer memories and microprocessors, can be made even smaller than they are now. (Miniaturization, with its effect of drastically reducing the cost of electronic devices, has been the fuel of today's much touted "electronics revolution.") At present, the patterns that delineate the features of microelectronic devices are obtained by shining near-ultraviolet light through a mask onto an optically active polymer overlaying the electronically active semiconductor, usually silicon, from which the device will be made. This process is called photolithography. Ultimately, diffraction effects limit the minimum dimensions of patterns obtained in this way; by going to x-rays, which have much smaller wavelengths, diffraction effects are made correspondingly smaller. Although numerous problems with x-ray lithography are yet to be fully overcome, according to one recent projection, commercial implementation of this process could begin in 5 years.

One of the problems is the low intensity of available conventional x-ray sources, so that it may take minutes to expose a pattern. The intensity of synchrotron radiation is so high that exposure times of a second or less are possible. Although not necessary for research, such short exposures could spell the difference between an economical or an uneconomical production schedule. The technical feasibility of using synchrotron radiation has already been demonstrated. Two years ago, Eberhard Spiller, Dean Eastman, Ralph Feder, and their colleagues from the IBM Yorktown Heights laboratory journeyed to the DESY synchrotron near Hamburg and were able to replicate features with widths as small as 500 angstroms. Similar experiments are now being pursued by others. Minimum sizes found in today's integrated circuits are about 4 micrometers (40,000 angstroms).

ESRC, which plans to turn this conjunction of storage ring and x-ray technologies into a profit-making enterprise, is the brainchild of three Californians: Lee Hecht, Melvin Schwartz, and Herman Winick. Hecht, who is president of the new company, is best described as a businessman. He is president of an investment and consulting firm and a member of the board of directors of each of three other organizations. In the past, he first founded, then later sold, a computer services company.

Schwartz, of Stanford University, is best known for his research in high energy physics, but this is not his first venture into the realm of private enterprise. He is also the founder and president of his own electronics firm. Schwartz is vice president of ESRC and chief scientist and will be responsible for all research and development activities of the company.

Winick, as deputy director of the Stanford Synchrotron Radiation Laboratory,

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is the person most familiar with storage rings and synchrotron radiation. He is vice president of ESRC and will be responsible for the design, construction, and operation of the company's facilities. Prior to coming to Stanford, Winick had been assistant director of the Cambridge Electron Accelerator, where the first large electron storage ring in the United States operated briefly before being closed for budgetary reasons.

There is a six-man board of directors. One of the directors is Burton Richter of the Stanford Linear Accelerator Center, who had a hand in building the very first electron storage ring and who was the driving force in getting the remarkably productive SPEAR storage ring at Stanford into operation 6 years ago.

According to Hecht, the company currently has three kinds of activity going on in parallel, financed mainly by the personal investments made by the three principals and the other directors. Most important is obtaining the capital (at least $6 million, but preferably $10 million) needed to construct the storage ring and begin operations. At present, four corporations, each large enough to finance the project on its own, are said to be seriously interested, and, says Hecht, whether the company will get off the ground should be known by this spring.

The company is also pursuing the formation of relationships with future users and partners. At present there is a group of more than a dozen firms that constitute the first "user's group."* For now, group members have no financial commitment to the company, but they make a major contribution in advertising the credibility of ESRC just by having their names on a list. A third activity involves developing ideas for use of synchrotron radiation and applying for patents when appropriate.

A company considering buying time

*The group includes Bell Laboratories, General Electric, Hewlett-Packard, IBM, Rockwell International, Signetics, Chevron, Exxon, Monsanto, Boeing, Hughes Aircraft, and Northrop.

Proprietary Research: DOE Says, "We Can Be Very Friendly"

Synchrotron radiation has proved to be such a successful research tool that an increasing number of companies are considering using it for such purposes as x-ray lithographic production of microelectronic circuits and x-ray structural studies of catalysts. The rub is that the only existing U.S. synchrotron radiation laboratory that can provide x-rays has as its source the SPEAR electron-positron storage ring, which is a Department of Energy (DOE) supported facility at the Stanford Linear Accelerator Center—although the laboratory is sponsored by the National Science Foundation (NSF). In years past, companies have avoided proprietary research at DOE facilities because of requirements that patent rights to inventions made during the research be turned over to the government and that all experimental data be made public. This policy no longer rigidly holds, and DOE now says it is worth coming in and talking about proprietary research.

The agency's policy on proprietary research—that is, secret research, usually paid for by the company—dates back to a predecessor, the old Atomic Energy Commission, which made no distinction between research done under government contract and that done at company expense at government facilities. Over the years, written regulations have not changed, according to James Denny, DOE patent counsel, but the agency is now utilizing a long-neglected authority to waive the patent and publication conditions on a case by case basis. Companies can, for example, retain exclusive commercial patent rights, although they must grant the government a free license for use of any invention and must license other firms to use a discovery if the discoverers fail to commercially develop the invention themselves. So far, only a few instances exist in which private concerns have received such waivers. But Denny says that the rigidity people used to see in the AEC no longer exists and that arrangements can readily be made to accommodate proprietary research subject to whatever technical requirements the particular DOE facility being used may have.

This open-armed attitude may be hard to apply at the Stanford Synchrotron Radiation Laboratory, however, because the three institutions involved (DOE, NSF, and Stanford University) have different points of view. People have not been encouraged to attempt proprietary research at the Stanford laboratory, in part because of the old patents and publication policy and in part because officials at Stanford view proprietary research as contrary to the ideals of a university. Moreover, NSF has yet to establish its own policy on the matter. As a result, no special machinery now exists for handling requests to do proprietary research there beyond the existing panel that evaluates all proposals for their scientific merit.

But a recent proposal may change the situation. According to Robert M. Friedman and D. Ray Stultz of Monsanto, their company would like to study the structure of some proprietary catalysts, using an x-ray technique (extended x-ray absorption fine structure, or EXAFS) that is best done with the high-intensity x-ray flux available with synchrotron radiation. The company further proposes to retain patent rights and has not disclosed the composition of the catalysts. Friedman and Stultz say that all parties involved regard the proposal as a welcome test case.

The more flexible DOE policy on proprietary research is probably mainly the result of years of complaint by industry, together with threats that needed research may never get done if companies have to sign away patent rights and disclose their secrets. In the case of synchrotron radiation, there are at least two other factors. The first is that in the early 1980's there will be four U.S. synchrotron radiation centers capable of supplying x-rays (one supported by DOE and three by NSF). In the early years, industrial research could be very welcome because there may not be enough funding available for academic researchers to fully utilize these facilities.

The second factor is that governments in Europe and Japan are taking a more aggressive attitude than that in the United States. The West Germans, for example, will soon be building a $21-million storage ring in Berlin, and about 25 percent of its running time will be expressly for proprietary research by German firms such as Siemens, which has been a vigorous supporter of the project. The French government has also recently agreed to permit proprietary research at its LURE laboratory in Orsay. If it gets off the ground, the proposed privately owned storage ring (see story) could take up the slack, but neither the government nor U.S. industry would care to be faced with a synchrotron radiation "gap."—A.L.R.

from or entering into a joint venture with ESRC might seem to have two other alternatives. The first would be to use existing government-operated facilities. By the early 1980's, there will be at least four synchrotron radiation centers in operation in the United States with x-ray capability. The second alternative would be, especially for a large concern, to build its own storage ring; the cost is not that outrageous.

Hecht argues that neither alternative is a viable one. In the first case, existing government policy has seemed to discourage proprietary research (see box), and in any event it is hard to see how a secure, production environment could be maintained at a public facility. In the second case, storage ring technology is exotic, to say the least, and the number of people in the world who can build one is limited; ESRC expects to employ a sizable fraction of those who can.

Actually, there is a third alternative: not to use synchrotron radiation at all. A quick survey of researchers active in just one potential application, x-ray lithography, found none who would unequivocally say yes or no to the question: Is it cheaper to use synchrotron radiation? Hecht, Schwartz, Winick, and their associates are betting that the coming years will reveal the development of a compelling need to use the wonder radiation and that their company will be the beneficiary.—ARTHUR L. ROBINSON

Speaking of Science

The Fatted Calf (II): The Concrete Truth About Beef

Cattle raising often seems to be more art than science. Serendipity provides as many improvements in cattle-fattening techniques as does applied scientific research. A case in point is the recent discovery that the addition of cement kiln dust to cattle feed decreases the amount of feed required by the animals and improves the quality of their meat. Meanwhile, continuing tests on another serendipitous discovery, a plastic vaginal insert, have confirmed that it has much the same effect.

The effect of the dust was first observed more than a year ago by three Georgia cattle ranchers. They were liming their pastures with dust from a cement kiln and, on impulse, dumped some of the dust into their cattle feed. The cattle ate the feed readily and gained more weight than expected. The astonished ranchers reported their observations to William E. Wheeler and Robert R. Oltjen of the U.S. Department of Agriculture's Beltsville Agricultural Research Center. Wheeler and Oltjen were skeptical, but they obtained 14 steers and fed half of them a diet containing 3.5 percent cement kiln dust. To the investigators' surprise, after the animals had been fed the dust diet for 112 days, they gained 28 percent more weight than animals fed a control diet; they also consumed 21 percent less feed. Analyses showed that the extra weight was all meat and that the animals were apparently quite healthy. Their meat was also of a higher quality than that of the controls.

Wheeler and Oltjen observed much the same phenomenon with a second group of 32 steers. Similar results were also obtained in a study with 60 lambs. Even laboratory rats showed a 23 percent increase in weight when fed a diet containing 1 percent cement kiln dust.

The dust itself is a complex, calcium-rich mixture of minerals that is entrained when hot air is pulled out of the cement kiln; it does not contain the alkalis and hardeners necessary for cement to set. About 30 percent of its effect, Wheeler says, results from a simple buffering action in the gastrointestinal tract. The other 70 percent, he speculates, might arise because the dust contains some element that has not yet been recognized to be an essential nutrient for cattle. Another possibility is that the intense heat of the kiln causes the minerals in the dust to behave in some manner that is beneficial to the cattle. Still another possibility is that the small size of the particles allows them to be absorbed from the gastrointestinal tract more easily than conventional mineral supplements.

The vaginal insert, known as the Hei-Gro device, has been tested in more than 250,000 head of cattle since its introduction some 2 years ago (*Science*, 6 February 1976, p. 453). Users have consistently found that the device produces a 13 to 22 percent faster growth rate among foraging heifers and a 5 to 10 percent faster rate in feedlots. The net effect is a $15 to $20 reduction in the cost of feeding each heifer, according to Wade Dickinson, president of Agrophysics Inc., the device's manufacturer. Studies have shown, he says, that the effects of the device are primarily hormonal. The device is not strictly a contraceptive, but it suppresses estrus and minimizes sexual activity. In the absence of sexual agitation, the heifers grow faster and use less feed.

While testing the device, Dickinson and his colleagues made a second interesting discovery. Both steers and heifers gain weight more quickly if males and females are kept sufficiently far apart so that they cannot smell each other—a distance of at least 15 meters. This fact appears to have been grasped intuitively by some cattle ranchers, but there seems to be no written description of this practice. Dickinson first noticed the effect when erratic results were obtained in some feedlot tests. Close examination showed that when heifers fitted with the device were upwind of steers, their weight gain was greater than that of similarly fitted heifers that were downwind. Erratic results were also obtained when heifers fitted with the device shared a pasture with steers. Similar but somewhat smaller effects were observed for heifers that were not fitted with the device. It appears that pheromones from the steers cause estrus in the heifers to be expressed more intensely, and the resulting sexual agitation causes them to require more feed. This stimulation negates the effect of the device.

In many feedlots the sexes are already separated, so this discovery will probably not have a great impact. An increasing number of ranchers and feedlot operators use the Hei-Gro device because it substantially increases the profit on heifers. It would not be greatly surprising, moreover, if some cement kiln dust is already finding its way into cattle feed. Some 30 million kilograms of dust are collected daily at cement kilns in the United States, so it is readily available. According to a spokesman for the Food and Drug Administration, there are no laws restricting its use in cattle feed, although the ranchers could face legal action if dust residues appeared in meat. A rapid explanation of the phenomenon should thus prove beneficial to both ranchers and consumers.—THOMAS H. MAUGH II

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