since. With six orders and commercial credit, the finances of the company appear to be stabilizing, although it is still operating at a loss. Because the parts alone cost millions of dollars, the company has not yet kept a computer for its own use.

To remedy the Cray-1's principal sales handicap, the company is building up its programming group. ("We now spend as much money on software as on hardware," Cray says.) The staff size has gone from 35 to about 200 in the last year through the addition of programmers and assemblers as well as service engineers and sales people. To coordinate the growth of the company, a young MIT engineer, who is a graduate of Harvard Business school, has been made president. Cray is the chairman of the board and the centerpin of the operation.

* * *

In an office overlooking the snowy parking lot of Spickler's recreational vehicle outlet, Cray is asked how one goes about designing a supercomputer. Except for a certain shyness, his manner and appearance belie his reputation. He is a large, handsome man, carefully dressed in leather moccasins, light blue corduroys, a plaid shirt, and a matching light blue sweater. He speaks of big computer building in an offhand manner, as if everyone has to have a job and that happens to be his.

"There is not much to designing really," he says, implying that anyone could do it if he practiced a little bit. He does not talk to other computer designers, although he says he reviewed the problems of other supercomputers. He does not use a computer to design a computer. He does not use any graphic aids to keep track of the pathways in his machine. Computer building is an abstract exercise, he says, for which his only aid is 8½ by 11 inch quadrille-ruled paper. The only peculiar preference is for "faintly ruled ¼-inch quadrille," and during the intense labor of creating a new machine he uses "about a pad a day." About his sources of creativity, Cray is vague. He implies computer building just requires attention to detail. Couldn't one say the same thing about designing sailboats? "I design computers about the same way I design sailboats," Cray replies. How is that? "For simplicity."

Those who know him say that Cray apparently builds a visual concept of an entire new computer in his head. There are no intermediate steps. He simply conceives it and then draws it. The result is the electronic organization of the whole machine: the wiring, the placement of each integrated circuit, and the design of the 113 different types of printed circuit boards used in the Cray-1. The logic behind this organization—the architecture of the computer—is the key thing, and Cray's success lies in the fact that he has consistently been a little more daring and aggressive than anyone else. He was the first to concentrate on the facets of computer architecture needed for science and he is a "genius at compaction," according to Sid Fernbach, who for years has been buying machines designed by Cray for use at the government's Livermore laboratory.

Rather than incorporate many specialized features in his machines, Cray concentrates on the basics. Whereas an IBM computer might be designed with a large set of instructions it could execute in order to have something to favor every sort of computer user, Cray's computers have a rather limited set of instructions optimized for scientific purposes. Anything that could slow down the machine is suspect. He reportedly once wanted to discard a standard error-checking feature widely used in the industry because it would slow the machine by 5 percent. Much of the architecture of super-

Briefing

Lederberg New President of Rockefeller University

After a search that lasted almost a year and a half, the board of trustees of Rockefeller University on 17 January elected Nobel laureate Joshua Lederberg to succeed Frederick Seitz as president. Seitz is retiring after more than a decade in the Rockefeller presidency (*Science*, 21 January 1977). Lederberg has been chairman of genetics at Stanford University School of Medicine since 1959. He also is professor of computer sciences.

The election of Lederberg, who has had virtually no administrative experience, comes to the surprise of many of his colleagues in biomedical research nationally. Even William O. Baker, president of Bell Laboratories and head of the search committee, acknowledges that choosing Lederberg is an "inventive and different move." According to Baker, whose committee collaborated with a faculty search group headed by Maclyn McCarty, the trustees will look to Lederberg more for his "intellectual contribution" to the university than for his skills as an administrator or fund raiser of proven talent. Reflecting the desire of the board to see Rockefeller concentrate its efforts on areas of genetics and molecular biology and virology in which it was long preeminent, Baker, in a telephone interview, cited Lederberg's "keen sense of strategy in developing new insights in highly traditional fields," as one of the qualities that make him attractive to the board. "We are looking for a new era of ingenuity at Rockefeller," Baker said, pointing out that Lederberg is not only strong in genetics but is also knowledgeable about computers and their application in biology and chemistry.

In 1958, Lederberg shared the Nobel prize for his discovery of the mechanism of genetic recombination in bacteria and has taken a consistently conservative stand on the recent furor over recombinant DNA research, arguing that it is being too restricted. At Stanford, he has coupled his work in bacterial genetics with an interest in life in outer space (he is said to have coined the word "exobiology"). He was instrumental in convincing the space agency to quarantine the moon rocks that were brought to earth on Apollo 11 in 1969 (no living organisms were discovered) and he had a hand in planning biological experiments on the Viking mission.

Lederberg's appointment at Rockefeller becomes effective 1 July.

Schmitt to Seek Commission on All Hazardous Research

During the past session of Congress, in the middle of unsuccessful efforts to pass legislation governing recombinant DNA research (*Science*, 20 January), freshman Senator Harrison (Jack) Schmitt (R–N.M.) took things one logical step farther when he introduced a bill ad-

0036-8075/78/0127-0406$00.50/0

computers is designed to cope with the vector mathematics that occurs often in scientific problems, and the organization of the Cray-1 for vector problems is excellent. (Vector problems require the computer to repeat the same arithmetic with lengthy sets of numbers. The basic speed of a computer can be multiplied as much as tenfold by an architecture designed to anticipate the regularity of vector problems and to facilitate the processing of successive numbers.)

Cray claims that he does not know how to build a computer that is not simple, and this tendency is evident in the choice of basic components. In the entire Cray-1 there are only three kinds of integrated circuits—one for memory, one for logic, and one for addressing instructions. Other supercomputers have many more.

Throughout his career, Cray says that he has been "designing computers to do a better and better job of solving one problem." That problem is the numerical simulation of the physical effects of moving fluids. It is at the root of weather prediction, aircraft design, and many nuclear research problems. He makes no apology for the limitation, saying that "Cray Research is intended to stay in a narrow market" supplying specialized computers to large research institutions. But computational power is stilll insufficient to solve the problem fully. His computer designs, from the CDC 6600 to the Cray-1, have been intended to keep improving the solutions, first expressed in one dimension, then in two dimensions, and perhaps in three dimensions. Conceiving of fractional dimensions is difficult for many people, but computer users do not hesitate. Cray says that progress has been made to the point that "we are now about at 2½."

The problem that Cray has been tailoring computers to solve, at least in one of its realizations, is a central problem of the postwar era. Ironically, the detonation of a nuclear weapon is a problem in fluid simulation. It is a thought dark enough to cast a pall, even over Chippewa Falls, and Cray has considered it and come up with a simple and surprising justification. "The ability to test bombs on a computer seems to me to be the vehicle that led to the Test Ban Treaty," he says, "and as long as we can keep it on a computer no one will get hurt." Diplomats might contest the argument, wanting to take at least some of the credit for their treaties. And it puts a novel twist on the arms race—if computers could neutralize weapons, the Soviets might be parading computer printouts through Red Square on May Day. In fact, just the opposite is true. Supercomputers (Cray's in particular) are considered such an essential ingredient of the arms race that it is doubtful the company could export to any country other than Britain.

What will the future offer in the way of supercomputers? Still more power, Cray thinks. Historically, performance has been improving fourfold every 5 years, and Cray does not see any signs that this trend is flattening. True to his instincts, he does not place his hopes for future improvements on exotic innovations such as Josephson junctions (being studied by IBM) or other cryogenic technologies. He is even skeptical about magnetic bubble memories, which have been developed in prototype for many years. The big advance that has occurred in the last 5 years is in the number of components that can be packed onto a single integrated-circuit chip. The techniques of large-scale integration have reduced the cost of an equivalent number of transistors by a factor of 10, and that is the advance that computer designers will have to use in the future to improve their machines. (The Cray-1 did not use large-scale integration.) The semiconductor

Briefing

dressed to all "potentially hazardous research activities," not just recombinant DNA. The Schmitt bill—the first of its kind—calls for creation of a "National Science Policy Commission," to be composed of representatives of science, academia, business and the public interest, whose job would be to review all kinds of basic research.

An aide to Schmitt reports that the Senator introduced his bill out of concern for the narrowness of the recombinant DNA arguments. A scientist by training, Schmitt says he wants to "protect the public and foster scientific responsibility," without "unreasonably restricting the conduct of scientific research," hence his proposal for a national commission to formulate a comprehensive policy for research across-the-board.

Although the bill did not come up for hearings or discussion last year (it was introduced in November), Schmitt, a member of the subcommittee on science and space, intends to bring it up again during the session of Congress that has just been convened.

Firing of NIMH Head Brown Holds No Portent for NIH

The recent firing of National Institute of Mental Health (NIMH) director Bertram Brown for the ostensible reason that years on the job is long enough (*Science*, 20 January), has raised questions about whether Health, Education, and Welfare (HEW) Secretary Joseph A. Califano, Jr., will also ask for the resignations of long-term directors of the individual institutes of the National Institutes of Health (NIH). One director has been on the job for 15 years; another for a decade. Several others have held their positions for 4 to 5 years, so it is no surprise Califano's statement that "It is my policy that it's for the good of the government and the good of individuals for us to turn over these posts when people have been in them for a number of years," has left some people feeling a bit insecure. The prospect of applying such seemingly arbitrary management principles to institute directorships is particularly tricky in light of the fact that in recent years NIH has had increasing difficulty in recruiting individuals for the posts which pay considerably less than comparable positions in academe.

But the Brown episode apparently is not a portent for NIH. Julius Richmond, assistant secretary for health, says that rumors that Califano is thinking about personnel changes at NIH are "pure hokum, spun out of thin air." "The institute directors," Richmond told *Science*, "are [NIH director Donald S.] Fredrickson's responsibility. He hasn't requested any changes and we haven't asked him for any."

Souces close to the Brown ouster report privately that his dismissal came about as much because of the wishes of his immediate boss Gerald Klerman, new director of the Alcohol, Drug Abuse and Mental Health Administration of which NIMH is a part, as because of any general length of service policy of Secretary Califano's.

Barbara J. Culliton