and left. The ones remaining accept the Wilson style, if not uncritically. That management style as it affects both staff and visitors will be discussed in a second article.

Although Wilson and his staff run the lab with a generous measure of self-determination, their powers are by no means unlimited. The major premise is that the lab shall operate as a national facility. URA, the AEC contractor, is a consortium of universities (now numbering 52) that was organized to sponsor the new accelerator and to guarantee that it would operate without favoritism.

Most formal power over the lab is held by a board of trustees. The board is empowered to hire and fire the director and, as one observer put it, "with Wilson that's about the end of their authority."

The board has delegated management responsibility to the URA president, a part-time post so far always occupied by a university physicist. For most of the life of URA, the job has been held by Norman F. Ramsey of Harvard. According to observers, Ramsey, Wilson, and Goldwasser have had a working relationship that makes it possible to settle virtually all questions, save on major policy issues, without bothering the board much.

The remarkable degree of autonomy practiced at Batavia would not, of course, be possible without the cooperation of the AEC. The project, at the start, had the sympathy and interest of the AEC commissioners, who were relieved when Wilson came along and said he could build the accelerator for the $250 million available. And much credit is given to AEC officials on the scene who were willing to take a nonbureaucratic approach as long as Wilson's methods brought results.

Much of the flexibility in the lab's operations has depended on management's powers of discretion in using funds remaining from the $250 million in construction funds. About $30 million was available for work to improve the performance of the machine. After this year that whole sum will have been obligated.

With the "kitty" depleted, there will no longer be a cushion for the operating budget, whose rate of growth is lagging behind the rate projected as necessary for the lab to operate effectively. The operating budget was $28.4 million last year and is expected to be $36 million this year, instead of the $48 million projected. Despite this shortfall, FNAL has received relatively favored treatment in the high energy physics budget at large (*Science*, 23 August, Research News).

A major question at Batavia is about future funds for expansion. There is a sort of Daniel Boone effect in high energy physics; when physicists achieve a new energy level they pine to move on to the next frontier. This is true at Batavia. Part of the kitty is being used to build a prototype section of a superconducting magnet ring which could be used as an "energy doubler" in the same tunnel as the main ring. Using the present ring as a booster, the FNAL designers estimate that it would be possible to reach 1000 Gev.

There are other options for expansion, notably a proposal for a super superconducting ring 10 miles in circumference. Technically it would appear that the horizons are virtually unlimited for high energy physics, but fiscally this is far from true. The AEC, which has been a faithful patron of the discipline, faces a major reorganization, which could very possibly send high energy physics looking for a new guardian. And the federal budget situation in the next few fiscal years is unlikely to be very hospitable to basic research.

At Batavia an exhilarating atmosphere has been created and a new range of scientific opportunities opened up, but what may be just as important for the next phase in high energy physics is the Wilson style of doing more with less.—JOHN WALSH

Nuclear Fuel Reprocessing: GE's Balky Plant Poses Shortage

The General Electric Company helped put men on the moon, but GE seems to have met its technological Waterloo in the mundane field of nuclear fuel reprocessing. In one of the more spectacular failures of the nuclear age, GE has disclosed that the Midwest Fuel Recovery Plant which the company spent 6 years and $64 million building near Chicago does not work and will have to be virtually scrapped.

GE executives have told the Atomic Energy Commission that redesigning and rebuilding the chemical plant—which was to have been one of three operating in the United States by 1979—will take at least four more years and an additional $90 million to $130 million. The company's disclosure has shocked the utility industry, which is beginning to worry about an imminent national shortage of fuel reprocessing capacity. Some government authorities, moreover, see in GE's predicament a critical lesson for the energy industry as a whole: that the perils of pushing new technologies too fast are great and costly.

Reprocessing plants form the penultimate link in the nuclear fuel cycle. They receive used or "irradiated" fuel rods from nuclear power stations, chop the rods up into sausage-size pieces, and chemically extract the remaining uranium and its by-product plutonium for later recycling in new reactor fuel. Left over are intensely radioactive isotopes of cesium, strontium, and other elements that build up in fuel rods as they are used. These isotopes form the final waste of nuclear power generation.

The chemical processes used in such plants (mainly a solvent extraction method) have been around since World War II. Their development, in fact, is one of the heroic tales of the Manhattan bomb project. In a stupendous leap in scale during 1943–45, the project's engineers used chemical studies performed on half a milligram of plutonium as the basis for designing a massive, remotely operated processing plant at Hanford, Washington, that soon was extracting tens of kilograms of plutonium from the fuel of military production reactors. It was a "staggering" gamble, Henry D. Smyth later wrote in his official report of the Manhattan Project, and one that "in peacetime no engineer or scientist in his right mind would consider making. . . ."

General Electric took a similar gamble in the mid-1960's, although it was somewhat less daring and apparently blessed with none of the Manhattan Project's good fortune.

By 1964, GE researchers had devised a new fluorine-based technique that promised to simplify nuclear fuel recovery and reduce some of the associated problems of pollution and safety.

The company called the new process Aquafluor and said it would virtually eliminate radioactive liquid effluents from reprocessing plants. Moreover, GE believed, the process would be efficient and compact enough to be used in small facilities that could be built near nuclear power stations. This would reduce the need for trundling highly radioactive and massively shielded spent-fuel bundles over highways and railroads.

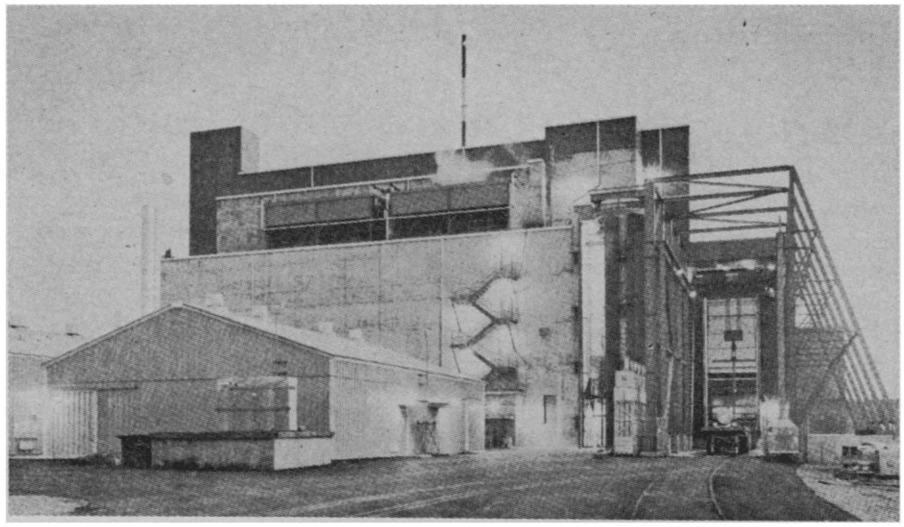
In 1968, the company broke ground at a 25-acre site near Morris, Illinois, south of Chicago, for a demonstration plant to process 300 tons of uranium a year. Its cost was set at $36 million, and the deadline for completion was July 1970.

What happened? By all accounts it was a highly imaginative facility that posed engineering problems which were never solved. Records placed on file in the AEC's public documents room in Washington, D.C., show a long, dismal succession of equipment failures during 2 years of testing with "cold," or only slightly radioactive, uranium. Plumbing clogged and parts broke down with numbing regularity.

Last March, with costs running nearly twice as high as anticipated, GE's chief executive, Reginald H. Jones, ordered a review of the situation. The resulting 50-page report was submitted to the AEC in July.

According to the report, plumbing problems had been expected, but the "special designs" worked out to solve these problems had only exacerbated them. Morever, equipment which would be so radioactive under normal operating conditions that it could never again be touched by human hands turned out to be repairable only by human hands. The study found that the Morris plant might be able to process 50 to 100 tons of fuel a year, but in the likely event of a major breakdown it could be closed for "years."

The company's internal review concluded last month that "even with long design and development programs, it is difficult to see solutions for many of these problems." The only feasible answer, GE has decided, is a drastic redesign of the plant that would involve a "complete departure from the original approach."



General Electric's Midwest Fuel Recovery Plant. [*Source:* Nuclear Industry]

Whatever that means, it won't be easy. The heart of the plant is a massive, windowless, ten-story concrete box that does not readily lend itself to remodeling. To make matters worse, GE executives are concerned that new security and waste disposal policies contemplated by the AEC may impose additional design changes. The company has not ruled out the possibility of simply abandoning the reprocessing field.

The GE report offers little explanation of how a major, R & D-oriented corporation could work itself into such a fix. Indications, however, point to overconfident engineering and a failure to test the new process fully in intermediate stages. Bertram Wolfe, who became GE's nuclear division chief after the crucial decisions had been made, says that if the company had it to do over again, the new technology would have been tested at full scale before being cast (literally) in concrete as a production plant.

"What we underestimated," Wolfe told *Science*, "was the difficulty of going from a laboratory environment—where you have access to equipment—to a remotely operated production plant."

One energy authority in the government, who asked not to be identified, said that chemical engineering failures of this magnitude "have not been uncommon here and in other countries" in the past several years.

"Expensive plants that work at only a fraction of their [designed] capacity are not uncommon these days, although no one speaks about them," this source said. One possible explanation is that competitive pressures are forcing engineers to scale up the size and increase the efficiency of new technologies much too rapidly.

And therein may lie a lesson for proponents of crash programs to develop shale oil and synthetic oil and gas from coal.

For the nuclear industry, the main problem posed by the GE plant's failure is what to do with all the fuel it was supposed to process. Sixty tons of irradiated fuel are already waiting at the plant, and a lot more will arrive before 1980, the earliest that GE could have a remodeled facility running. A larger plant, being built by Allied Gulf Nuclear Services, is expected to start up at Barnwell, South Carolina, by 1977 and an older commercial plant near Buffalo, New York, shut down for expansion in 1972, will reopen in 1979 or later. By then, according to the trade journal *Nuclear Industry*, the nation will have a backlog of about 2300 tons of used but unprocessed reactor fuel.

Storage capacity at nuclear power plants is limited, and the AEC may have to come to the rescue. The commission is looking into the possibility of providing storage space or opening its military reprocessing plants to commercial use. "Fortunately, we have some time," says one AEC expert. "It's not an emergency, but we do have work to do."—ROBERT GILLETTE