Nuclear Power in the U.S.S.R.: American Visitors Find Surprises

After years of plodding quietly in the footsteps of the West in its development of civilian atomic power, the Soviet Union has recently begun some bold trailblazing of its own.

On one hand, the Soviet program to develop a large and economical fast breeder reactor, one that produces more nuclear fuel than it consumes, has surged well ahead of similar efforts in the United States and Europe. The two largest fast breeder demonstration plants in the world are both under construction in the U.S.S.R. One is nearly ready to run, 7 years before an American fast breeder of comparable size is scheduled to start up.

At the same time, the Soviet Union has embarked on an ambitious program of building a family of huge, new nonbreeding power reactors of a design that U.S. authorities say represents a "significant departure" from conventional Western technology. In some ways this new reactor resembles nothing so much as a throwback to the old "atomic pile" reactors of a generation ago, in which the first nuclear chain reactions were achieved. But the design has been sufficiently modernized so that Glenn T. Seaborg, the recently retired chairman of the Atomic Energy Commission, considers it essentially a "new approach" to the generation of electricity by atomic power.

New information about the U.S.S.R.'s breeder program, and about its new nonbreeder, was brought back to the United States last month by a delegation of ten scientists and engineers who toured Soviet nuclear facilities in 11 cities from 5 to 19 August. Seaborg led the official delegation.

In interviews and telephone conversations, Seaborg and several other members of the tour described their impressions of Soviet progress in nuclear power development, and they singled out the new nonbreeding reactor as a "surprising" and "puzzling" highlight of the trip.

The new model reactor will produce 1000 megawatts of electricity, only a little less than the planned output for the largest reactors now being built in the United States, and more than twice the capacity of any reactor previously built in the Soviet Union. Pairs of the reactors are planned at sites near Leningrad, Smolensk, Kiev, and Kursk, all in the heavily populated and industrialized western regions of the U.S.S.R.; one reactor is under construction at Leningrad.

The U.S. delegation found the new model's design as noteworthy as its size. In an interview, Seaborg explained that the reactor uses graphite to moderate the speed of neutrons produced in the chain reaction. Uranium fuel rods are embedded in the graphite. Cooling water circulates through "thousands" of tubes inside, instead of bathing a densely clustered core of fuel rods immersed in a steel vessel, as in the pressurized water and boiling water reactors that predominate in the West. Years ago, the United States and other Western countries all but discarded the graphite-moderated reactor as being too complex and costly for commercial power plants. Instead, pressurized water reactors—initially developed for nuclear submarines—became the preferred model for civilian power plants in the United States. A few uranium-graphite reactors were built to produce plutonium for weapons, but by the time the AEC was able to sell American industry on the attractiveness of electric power from nuclear energy, reactor manufacturers were more experienced in building Navy-style reactors than any others, Seaborg said. "It was really industry's choice."

From all appearances, Soviet planners followed the same pattern. They built the world's first industrial atomic power plant with uranium and graphite in 1954, then seemed to swing heavily in favor of pressurized water reactors—first for naval propulsion, then as the standard item for civilian power plants.

Nevertheless, Soviet engineers have revived and modernized the uranium-graphite reactor, and they seem to think their new version is cheaper to build, and safer to operate, than conventional reactors of comparable size.

Although papers outlining the new Soviet 5-year plan for 1971 to 1976, made public in March, briefly described the new reactor, as well as plans for its construction, some members of the visiting U.S. delegation last month were nonetheless surprised. "It was something we hadn't really expected," said Lombard Squires, a consulting engineer in Florida and a member of the Advisory Committee on Reactor Safeguards (ACRS), which oversees the AEC's safety policies. "Certainly a substantial development effort went into this type of reactor that we didn't know much about."

This in itself was surprising, and it suggests either that Soviet officials have been especially coy about this particular project or that American visitors haven't been asking the right questions.

In contrast to the secrecy that shrouds Soviet activities in space, officials of the State Committee on the Utilization of Atomic Energy have enjoyed rather warm rapport since the early 1960's with their counterparts in the AEC. Under a "Memorandum of Cooperation" signed by the two agencies in 1963 and renewed every 2 years, Soviet and American nuclear scientists and engineers have shuttled back and forth across the Atlantic, periodically visiting each others' civilian research facilities and power plants and talking about mutual design problems.

Not Telling Everything

Only last summer, a delegation of AEC reactor specialists spent 2 weeks on an information-gathering junket, looking into Soviet progress in fast breeders and touring all manner of reactor facilities. But somehow they missed seeing or sensing the biggest nonbreeder reactor project of all. Indeed, the group published two reports of its findings, including a 113-page volume titled "Soviet Power Reactors—1970," which asserted that a small and rather ordinary pressurized water reactor similar to those widely used in the United States "is now adopted as the main thermal nuclear station reactor" in the U.S.S.R. A table of existing and planned nuclear power stations in the Soviet Union showed that by 1975 a total of 26 reactors would be producing 6132 megawatts of power. Since no mention was made of uranium-graphite reactors, the table appears to have been several thousand megawatts low in its estimate. "I guess the Russians don't always tell you everything they're doing," Squires commented.

This time, 2 days after the American

Crunch on Cannikin Decision Near

President Nixon must soon decide whether to sanction the 5-megaton underground nuclear blast that the Atomic Energy Commission plans to set off in the early fall on the Aleutian Island of Amchitka.

Opposition to the Cannikin test has been steadily growing among environmentalists, scientists, and members of Congress, and there is evidence that the Administration itself is far from united.

Public debate over the desirability of the blast, whose purpose is to test a nuclear warhead for the Safeguard System's Spartan antiballistic missile, has been hampered by the Administration's refusal to disclose the contents of a top-secret report, which contains the recommendations of seven government agencies and was compiled by a committee headed by Under Secretary of State John N. Irwin. Although no one from the press has seen the documents, it has been reported that only the Department of Defense and the AEC favor going ahead with the blast. The State Department is said to favor postponement until after the Strategic Arms Limitation Talks to be held with Russia this fall. The Environmental Protection Agency and the Council on Environmental Quality are said to oppose the test because of the danger of earthquakes, tidal waves, and the destruction of wildlife.

The Office of Science and Technology, according to reports, believes the warhead to be of marginal usefulness because it was designed as part of the "heavy" Safeguard system rather than the present modified system, which requires a lower yield warhead for the defense of missile sites. This view has been stated by a number of scientists, including Harold M. Agnew, director of the Los Alamos Scientific Laboratory. The Federation of American Scientists, headed by Herbert F. York, flatly claims the weapon is "obsolete."

Forces arrayed against Cannikin suffered two setbacks last month in the District Court of Washington, D.C. One suit, brought by a 33-member congressional delegation headed by Representative Patsy Mink (D–Hawaii), sought to obtain release of the Irwin report but was thwarted by a summary judgment issued by Judge George L. Hart, who explained that "some things have got to be secret."

The second case, decided 5 days later by the same judge, was brought by the Committee for Nuclear Responsibility in conjunction with seven other environmental and antiwar groups. The plaintiffs charged that the AEC's environmental impact statement did not satisfy the requirements of the National Environmental Policy Act and that the nuclear test ban treaty of 1962 might be violated if radiation were vented into the atmosphere. Delay or cancellation of the test, ruled the judge, "might cost our entire liberty."

Appeals on both cases were filed last week in the U.S. Court of Appeals in Washington, D.C.

A $16.5-million appropriation for the test (almost $200 million has already been expended) appears to be making its way safely through Congress, despite attempts by Cannikin's leading Senate opponent, Mike Gravel (D–Alaska), and Senator Daniel K. Inouye (D–Hawaii) to push amendments that could have delayed or canceled the test. Congress was expected to take final action on the appropriation soon after reconvening this week.

Final approval of the test rests personally with President Nixon. Administration spokesmen say he is reviewing the matter, but they will give no clue as to when he plans to announce his decision. The President is under intense pressure from his weapons men, who maintain the test is vital for the national security. Successful detonation of a 6-megaton device last year by the Russians has increased the air of urgency. On the other hand, proceeding with Cannikin is likely to reap a harvest of ill will, not only from Alaskans and other domestic critics, but from Canada and Japan, which have both sent notes of protest to the President and whose sensibilities have already been bruised by the new U.S. economic policy.—CONSTANCE HOLDEN

delegation arrived in Moscow, their Soviet hosts ushered them aboard a private jet, said to be Premier Alexei Kosygin's own, and whisked them up to Leningrad where the Seaborg party became the first group of Westerners to visit the uranium-graphite reactor under construction there. "It was just fascinating," Seaborg said, as he recalled peering into the gleaming metal innards of the plant—the plumbing, pumps, and heat exchangers. He said the first of two reactors is scheduled for completion in a year or two, although last-minute changes in some of the parts have already delayed the project a bit.

Although the visitors generally found the Soviets willing to answer their questions, some of the delegates described the answers to queries about the Leningrad plant design and the reasons for building the new family of reactors as somewhat circumspect.

However, the Soviets did provide figures showing that the new power plant cost far less than other nuclear installations. Edwin E. Kintner, the AEC's assistant director for reactor engineering, said he was told that the entire 2000-megawatt facility at Leningrad, including two reactors and all the generating equipment, would cost 240 million rubles or about $265 million. The usual way of comparing power plant costs is in dollars per kilowatt, which in this case is $132 per kilowatt. By comparison, figures obtained by the AEC tour group in 1970 showed that a similar but much smaller reactor and the world's largest fast breeder reactor —a 600-megawatt giant under construction near Beloyarsk—each cost about $250 per kilowatt.

Some members of the Seaborg party expressed skepticism at the low cost estimate. When they inquired whether the figure included allowances for inflation, overruns, interest, or other ancillary expenses, Kintner said, Soviet officials seemed to find such questions absurd.

Officials questioned by the U.S. delegation conceded that graphite reactors have the disadvantages of being inherently bulky and riddled with complicated plumbing. But the Soviets indicated that apart from lower cost their design offers other advantages over conventional water-cooled reactors. For one, the Soviets think that the graphite reactor may help conserve scarce supplies of high-grade uranium, which ordinary reactors burn very inefficiently. This would work two ways. Plentiful natural

American delegation mingles with Soviet hosts at the Scientific Research Institute of Nuclear Reactors at Melekess. Sculpture in background depicts nuclear fission. From left: Joseph Lewin, Oak Ridge National Laboratory; V. Menshikov, U.S.S.R. State Committee on Atomic Energy; M. Naidionov, State Committee; Lombard Squires, AEC; Rodney L. Cool, Rockefeller University; Robert L. Hirsch, AEC; John J. Taylor, Westinghouse Electric Corp.; Julius H. Rubin, AEC; Robert E. Hollingsworth, AEC; Edwin E. Kintner, AEC; A. Meshkov, State Committee; Glenn T. Seaborg, AEC; O. D. Kazachkovsky, Institute director; S. Patrakeev, State Committee. Not in picture: Robert D. Duffield, director, Argonne National Laboratory.

thorium could easily be loaded into the Leningrad reactor, and others like it, and converted into fissionable uranium-233, a new nuclear fuel. Man-made supplies of this isotope could help relieve the strain on uranium reserves in much the same way as a new process for converting low-grade coal into burnable gas would help save precious stores of natural gas.

The other means of conserving uranium is more complicated. Kintner suggests that the new reactors may be intended to fill a plutonium deficiency in the Soviet Union. Plutonium is the primary fuel for fast breeder reactors, which are meant to make more efficient use of natural uranium by converting it into even more plutonium. Initially, much of the plutonium fuel for breeder reactors—in both the United States and the U.S.S.R.—will come from the exhausted cores of ordinary nonbreeder reactors, where it appears as a byproduct of fission. In the United States, AEC officials expect that by the time the commercial breeders become a reality, in the mid-1980's, there will be more than enough recycled plutonium to fuel them. But the Soviet Union—which is expected to have only about a tenth of the nuclear generating capacity of that in the United States during the next decade—probably will not have sufficient plutonium to fuel the breeders it plans to build. (Indeed, Soviet officials have said they intend to run their breeders on uranium at first, spendthrift as that may be.) Kintner and Squires point out, however, that the Leningrad-type reactor is a "slightly better" plutonium producer than others, and may therefore be a unique "transition" power plant meant to precede the introduction of breeders by initially supplying some of them with plutonium fuel.

Danger Is Reduced

A second major point made by Soviet engineers in explaining their switch to graphite reactors was that this design is less likely than most to suffer a severe loss of cooling water, which could result in a damaging or catastrophic explosion. This is because cooling water flows through many tubes in a graphite reactor, rather than through a few very large pipes as in pressurized and boiling water reactors.

American authorities consider such an accident possible in U.S. plants but highly improbable. To mitigate the consequences of a severe loss of coolant, through a broken pipe for instance, U.S. reactors are equipped with emergency cooling systems. However, the adequacy of these systems has recently been questioned (see *Science*, 28 May and 9 July).

Squires, of the ACRS, called the subdivision of coolant in the Leningrad reactor "an interesting safety feature" that would reduce the possibility of a a major coolant loss and make the consequences of such an accident "less severe" than in other reactors.

Such concerns are unusual for Soviet authorities, who have never seemed deeply preoccupied with reactor safety. AEC officials who have toured Soviet reactor plants in the past have reported, with thinly veiled astonishment, an apparent total absence of the last-ditch accident control devices used on American reactors. They have reported that Russian reactors do not have emergency cooling systems (although the Leningrad plant does have a small one), and that atomic power plants are housed in ordinary factory-like buildings rather than in the massive steel and concrete "containment" shells used in the United States. Unlike U.S. reactors, those in the Soviet Union are sometimes built side by side, the possibility of explosion notwithstanding, to take advantage of common water lines and ventilation stacks. Moreover, Russian reactors have frequently been built within 2 miles of sizable population centers. As AEC officials interpret the Russian safety philosophy, catastrophic accidents are simply "incredible"—that is, not worth worrying about—and the addition of last-resort safety devices only increases a reactor's complexity and decreases its overall safety. Similar views exist in the U.S. nuclear industry.

Seaborg saw no indication that this philosophy might be changing, but Squires and Kintner did. Kintner said that officials acknowledged that "safety requirements will grow with an increase in the population [of reactors]," and that the bigger they are, the more dangerous they are. Squires said he got the impression that the Soviets have "no intention" of putting their large new reactors near major population centers (the Leningrad reactor is near a small town, about 20 miles from the city itself.) Ironically, large new reactors in the United States are being built increasingly close to major eastern urban areas, on the assumption that reliability and safety are improving with time and experience.

In a telephone interview, Squires said "the propriety of our situation in the Soviet Union" prevented asking pointed questions and getting specific answers. Nonetheless he came away with the feeling that Soviet authorities are "moving to lessen the possible consequences of the type of accident we've been talking about all along."

Talks during the 15-day trip touched on support of civilian R & D in nuclear energy, but American officials said that they were unable to compare Soviet and U.S. budgets. "I felt they were genuinely trying to tell us about this sort of thing, but the two systems are so different it's very hard to compare them," Seaborg said. For one thing, the Soviet State Committee, the AEC's counterpart, functions both as the AEC and as an industrial manufacturer, in that it conceives, designs, builds, and delivers power reactors to the Ministry for Power and Electrification, the state utility. Seaborg did, however, hazard an unwilling guess that thermonuclear fusion research receives twice the support in the Soviet Union as here. "But that's not a responsible guess," he insisted.

Conversations during the tour only skirted broad energy policies and such topics as the economic competitiveness of nuclear energy and fossil fuels. It is generally understood, however, that only about 10 percent of new power plants in the Soviet Union are nuclear, whereas the figure is about 40 percent in the United States. Seaborg said that Soviet authorities say that they are currently committed to building about 10,000 megawatts of nuclear power, in contrast to 100,000 megawatts of nuclear power to which U.S. utilities have so far committed themselves. This slower pace is generally attributed to Russia's greater endowment of untamed rivers and untapped reserves of fossil fuels, although in the Soviet Union, as in the United States, concentrations of people and industry are often far from cheap supplies of fuels.

But whatever the pace-setting forces at work, Soviet nuclear authorities were clearly proud of their achievement at Leningrad and seemed anxious to build a good many more reactors like it—perhaps to the exclusion of other types. Seaborg said he sensed a "definite switch to the new design." And Squires concluded that "while they didn't come right out and say they were abandoning pressurized water reactors, that's the impression you get."

—ROBERT GILLETTE

(The Soviet fast breeder reactor program will be discussed in another article.)

The Berkeley Scene, 1971: Patching Up the Ivory Tower

Berkeley, Calif. For 5 of the past 6 years, *Science* has reported on the state of the Berkeley campus of the University of California—not just because reporters seek some relief from the wretched Washington summer climate, but because of the widely held notion that events here serve as a barometer of the student movement and the state of American higher education. This could be the last report in the series. Berkeley may still be a barometer, but its significance now stems from its academic reputation. The revolutionary fervor has vanished. In spite of the years of sit-ins, riots, tear gas, broken windows, shootings, vindictive assaults on the Berkeley campus from Governor Ronald Reagan, budget cuts, and countless predictions of its imminent doom, the campus still stands as an entirely solid monument to the traditional values of academia.

"This has been the quietest year in recent history," remarked one official in the campus administration. Recent history, as most everyone knows, began here in the fall of 1964 with the Free Speech Movement. From then on it was marked by a series of crises, each of them seemingly more critical than the last and each leading to an increasingly harsh backlash from the state's populace and the state government. At times, particularly during the strike for a third-world studies program in the fall of 1968, the period following the bloody battle over People's Park during the spring of 1969, and during demonstrations against the ROTC program in the spring of 1970, the presence of legions of riot-equipped police on the campus became an almost routine event. Such was the popular image of Berkeley as a hotbed of student rebellion that some of the city's more conservative residents displayed bumper stickers reading: "I'm from Berkeley, and I'm not revolting."

Except for one miniriot marking the second anniversary of the People's Park altercation, nothing has happened recently to throw faculty, students, and administration back into their accustomed battle postures. Indeed, this past year was a quiet one on most campuses. But in Berkeley, where the confrontation had almost become institutionalized, you can hear the quiet.

With the demise of political disruptions, faculty and students seem to have rediscovered academic pursuits and embraced them with an almost religious fervor. Decidedly absent is an old disease known locally as Berkeley fever,