shielding above the reactor. The reactor is usually surrounded by an inert environment of helium and nitrogen, but when the shielding was breached, the gases mixed with air and a massive explosion occurred, followed by a fire as the 1700-ton graphite moderator ignited.

One theory, prominent among Western experts until recently, is that the explosion was preceded by a fire in the nearby turbine hall, but Denton says this theory is no longer fashionable. Soviet delegates at last month's IAEA meeting talked repeatedly of an overpressure of steam in the reactor, followed by the generation of hydrogen and an explosion and fire, he said.

The Soviet delegates also mentioned in conversations at the Vienna meeting that experiments were being conducted at the reactor at the time of the accident, Denton said. But they gave very little information about the nature of the experiments or their contribution to the accident. There has been some speculation in the West, based on no hard evidence, that the experiments might have involved plutonium production for military purposes. Gilinsky says he finds it suspicious that the Soviets have not provided any information about the experiments and suggested that if they had any military implications, "we may never know" the full details of what precipitated the accident.

Whatever started the sequence of events, the containment around the reactor core was evidently breached early in the catastrophe. This has already provoked an intense argument in the United States between the nuclear industry and its critics over the implications for U.S. reactor safety.

Shortly after the accident, spokesmen for the Atomic Industrial Forum, the nuclear industry trade association, stated that the Chernobyl plant, unlike U.S. reactors, had no containment system to isolate radioactive debris from the environment in the event of a major mishap. The clear implication is that such a catastrophic release of radioactivity would not happen here. When Soviet literature on the plant was analyzed, however, it became clear that it did have some containment features. This led the antinuclear Public Citizen, a group founded by Ralph Nader, to take out a full-page advertisement in the *New York Times* claiming that Chernobyl's containment "bears a striking resemblance" to the system used in most boiling-water reactors in the United States.

U.S. experts familiar with the reactor design say that the containment system at Chernobyl is better than nothing—which is what Soviet reactors had prior to about 1980—but it is unlikely to be as effective as U.S. systems. According to one government reactor expert, Soviet engineers added some containment features to the basic design but did not reconfigure the plant itself. "It is a very rudimentary attempt to have some containment functions," he says.

According to an analysis by NRC staff members, the reactor itself is surrounded on the sides by concrete capable of withstanding pressures of 27 pounds per square inch, and the major high-pressure pipes are surrounded by a 57 pounds-per-square inch containment. Both regions are designed to vent through valves into so-called pressure-suppression pools that have been added beneath the reactor. The pools, which are similar to a system used in U.S. boiling-water reactors, are supposed to condense steam, thereby relieving pressure that may build up during an accident. The general consensus among U.S. experts is that the containment system is designed to handle a large pipe break and to keep superheated steam away from the reactor core.

U.S. experts believe that the containment is weakened by the fact that it is penetrated by hundreds of pipes. It is also not clear what the containment is like over the top of the reactor's massive core. A unique feature of the Chernobyl-type reactors is that they can be refueled while the reactor is operating, and the shielding over the reactor has hundreds of plugs that can be removed to take out and insert fuel rods. Robert Bernero, a top safety official at the NRC believes the top of the reactor is the weakest point. "It is very difficult for us to figure out even where the pressure boundary is," he says.

In any case, it seems that the top of the reactor blew apart early in the accident and the subsequent explosion and fire spewed radioactivity into the atmosphere. Just how much was released is a matter of some dispute, in part because the calculations are based on radioactive fallout in European countries hundreds of miles from the reactor. Until the Soviets release data from the region surrounding Chernobyl, the full dimensions of the catastrophe will not be known.

According to calculations by a group at the Lawrence Livermore National Laboratory, perhaps 40% of the reactor's total inventory of radioactive fission products was ejected in the initial explosion and fire, and a further 10% was vented over the following few days. If correct, some 40 million curies of radioiodine and 3 million curies of radioactive cesium were spewed into the environment.

The initial explosion and fire were believed to have been so energetic that a large fraction of the debris was carried very high into the atmosphere. If so, fallout close to the plant in the first day or so may not have been as serious as might be expected from an accident of this magnitude.

George Greenley of the Livermore team says it was "like solving a mystery putting it all together." The group used a computer program originally developed for modeling thunderstorms, which has more recently been used for analysis of the "nuclear win-

Soviets Buy Robots

Under the cover of darkness two Soviet cargo planes slipped into Karlsruhe, West Germany, on Saturday, 10 May. They stayed at the airport only for a few hours—long enough to pick up three specialized robots needed to probe the gutted Chernobyl nuclear power plant. Normally, the sale of such equipment could require a clearance under Coordinating Committee regulations governing the transfer of high technology to Eastern Bloc countries. State Department officials, however, say it appears that this sale was approved on an expedited basis because of the 26 April Chernobyl disaster.

Negotiated over a week's time, the sale is said to be worth more than $10 million to Kerntechnische Helssdienst, GmbH, a nuclear equipment manufacturer located near Karlsruhe. The largest device supplied to the Soviets is a 30-ton camera-equipped shovel loader. Capable of lifting 2.5 tons, the radio-controlled machine has a range of 1 kilometer. A smaller camera-guided and radio-controlled machine with 200-kilogram lifting capacity also was supplied. The third machine also has camera vision, but is cable controlled. About 2 meters long, it has a maximum lifting capacity of 80 kilograms.

The Soviets sought to avoid publicity on the purchase, according to German industrialists and a knowledgeable American scientist. The supplier received little notice prior to the cargo planes' arrival, sources say. The Soviets also declined to receive detailed lessons on the operation of the machines in West Germany. Instead, they reportedly asked the company to send technicians to Moscow to provide training. ■ MARK CRAWFORD