best nuclear characteristics, with hydrogen and helium standing out among the gases and water—even with its marginal nuclear properties and tendency to corrode uranium—as the best liquid.

During the summer, Moore and his group began planning a helium-cooled pilot pile for the Argonne Forest Preserve near Chicago, built by Stone & Webster, and on September 25 they reported to Compton. The proposal was for a 460-ton cube of graphite to be pierced by 376 vertical columns containing twenty-two cartridges of uranium and graphite. Cooling would be provided by circulating helium from top to bottom through the pile. A wall of graphite surrounding the reactor would provide radiation containment, while a series of spherical segments that gave the design the nickname Mae West would make up the outer shell.

By the time Compton received Moore's report, he had two other pile designs to consider. One was a water-cooled model developed by Eugene Wigner and Gale Young, a former colleague of Compton's. Wigner and Young proposed a twelve-foot by twenty-five-foot cylinder of graphite with pipes of uranium extending from a water tank above, through the cylinder, and into a second water tank underneath. Coolant would circulate continuously through the system, and corrosion would be minimized by coating interior surfaces or lining the uranium pipes.

A second alternative to Mae West was more daring. Szilard thought that liquid metal would be such an efficient coolant that, in combination with an electromagnetic pump having no moving parts (adapted from a design he and Einstein had created), it would be possible to achieve high power levels in a considerably smaller pile. Szilard had trouble obtaining supplies for his experiment, primarily because bismuth, the metal he preferred as the coolant, was rare.

Groves Steps In

October 1942 found Groves in Chicago ready to force a showdown on pile design. Szilard was noisily complaining that decisions had to be made so that design could move to procurement and construction. Compton's delay reflected uncertainty of the superiority of the helium pile and awareness that, engineering studies could not be definitive until the precise value of k had been established. Some scientists at the Met Lab urged that a full production pile be built immediately, while others advocated a multi-step process, perhaps beginning with an externally cooled reactor proposed by Fermi. The situation was tailor-made for a man with Groves's temperament. On October 5 Groves exhorted the Met Lab to decide on pile design within a week. Even wrong decisions were better than no decisions, Groves claimed, and since time was more valuable than money, more than one approach should be pursued if no single design stood out. While Groves did not mandate a specific decision, his imposed deadline forced the Met Lab scientists to reach a consensus.

Compton decided on compromise. Fermi would study the fundamentals of pile operation on a small experimental unit to be completed and in operation by the end of the year. Hopefully he could determine the precise value of k and make a significant advance in pile engineering possible. An intermediate pile with external cooling would be built at Argonne and operated until June 1, 1943, when it would be taken down for plutonium extraction. The helium-cooled Mae West, designed to produce 100 grams of plutonium a day, would be built and operating by March 1944. Studies on liquid-cooled reactors would continue, including Szilard's work on liquid metals.

Seaborg and Plutonium Chemistry

While the Met Lab labored to make headway on pile design, Seaborg and his coworkers tried to gain enough information about transuranium chemistry to insure that plutonium produced could be successfully extracted from the irradiated uranium. Using lanthanum fluoride as a carrier, Seaborg isolated a weighable sample of plutonium in August 1942. At the same time, Isadore Perlman and William J. Knox explored the peroxide method of separation; John E. Willard studied various materials to determine which best adsorbed plutonium;[36] Theodore T. Magel and Daniel K. Koshland, Jr., researched solvent-extraction processes; and Harrison S. Brown and Orville F. Hill performed experiments into volatility reactions. Basic research on plutonium's chemistry continued as did work on radiation and fission products.

Seaborg's discovery and subsequent isolation of plutonium were major events in the history of chemistry, but, like Fermi's achievement, it remained to be seen whether they could be translated into a production process useful to the bomb effort. In fact, Seaborg's challenge seemed even more daunting, for while piles had to be scaled up ten to twenty times, a separation plant for plutonium would involve a scale-up of the laboratory experiment on the order of a billion-fold.