Company of Cleveland to produce hexafluoride on a scale sufficient to keep the vital isotope separation research going.

Lawrence was so successful in producing enriched samples of uranium-235 electromagnetically with his converted cyclotron that Bush sent a special progress report to Roosevelt on March 9, 1942. Bush told the President that Lawrence's work might lead to a short cut to the bomb, especially in light of new calculations indicating that the critical mass required might well be smaller than previously predicted. Bush also emphasized that the efficiency of the weapon would probably be greater than earlier estimated and expressed more confidence that it could be detonated successfully. Bush thought that if matters were expedited a bomb was possible in 1944. Two days later the President responded: "I think the whole thing should be pushed not only in regard to development, but also with due regard to time. This is very much of the essence."[22]

In the meantime, however, isotope separation studies at Columbia quickly confronted serious engineering difficulties. Not only were the specifications for the centrifuge demanding, but, depending upon rotor size, it was estimated that it would require tens of thousands of centrifuges to produce enough uranium-235 to be of value. Gaseous diffusion immediately ran into trouble as well. Fabrication of an effective barrier to separate the uranium isotopes seemed so difficult as to relegate gaseous diffusion to a lower priority (the barrier had to be a corrosion-resistant membrane containing millions of submicroscopic holes per square inch). Both separation methods demanded the design and construction of new technologies and required that parts, many of them never before produced, be finished to tolerances not previously imposed on American industry.

In Chicago, Compton decided to combine all pile research by stages. Initially he funded Fermi's pile at Columbia and the theoretical work of Eugene Wigner at Princeton and J. Robert Oppenheimer at Berkeley. He appointed Szilard head of materials acquisition and arranged for Seaborg to move his plutonium work from Berkeley to Chicago in April 1942. Compton secured space wherever he could find it, including a racket court under the west grandstand at Stagg Field, where Samuel K. Allison began building a graphite and uranium pile. Although it was recognized that heavy water would provide a moderator superior to graphite, the only available supply was a small amount that the British had smuggled out of France. In a decision typical of the new climate of urgency, Compton decided to forge ahead with graphite, a decision made easier by Fermi's increasingly satisfactory results at Columbia and Allison's even better results in Chicago. In light of recent calculations that cast doubt on the MAUD report's negative assessment of plutonium production, Compton hoped that Allison's pile would provide plutonium that could be used as material for a weapon.

By May 1942 Bush decided that production planning could wait no longer, and he instructed Conant to meet with the S-1 section leaders and make recommendations on all approaches to the bomb, regardless of cost. Analyzing the status of the four methods of isotope separation then under consideration—gaseous diffusion, centrifuge, electromagnetic, and pile—the committee decided on May 23 to recommend that all be pushed as fast as possible. This decision reflected the inability of the committee to distinguish a clear front-runner and its consequent unwillingness to abandon any method. With funds readily available and the outcome of the war conceivably hanging in the balance, the S-1 leadership recommended that all four methods proceed to the pilot plant stage and to full production planning.

Enter the Army

The decision to proceed with production planning led directly to the involvement of the Army, specifically the Corps of Engineers. Roosevelt had approved Army involvement on October 9, 1941, and Bush had arranged for Army participation at S-1 meetings beginning in March 1942. The need for security suggested placing the S-1 program within one of the armed forces, and the construction expertise of the Corps of Engineers made it the logical choice to build the production facilities envisioned in the Conant report of May 23.

By orchestrating some delicate negotiations between the Office of Scientific Research and Development and the Army, Bush was able to transfer the responsibility for process development, materials procurement, engineering design, and site selection to the Corps of Engineers and to earmark approximately sixty percent of the proposed 1943 budget, or $54 million, for these functions. An Army officer would be in overall command of the entire project. This new arrangement left S-1, with a