stage without further presidential authorization. Roosevelt indicated that he could find a way to finance the project and asked Bush to draft a letter so that the British government could be approached "at the top."[19]

Compton reported back on November 6, just one month and a day before the Japanese attack on Pearl Harbor on December 7, 1941, brought the United States into World War II (Germany and Italy declared war on the United States three days later). Compton's committee concluded that a critical mass of between two and 100 kilograms of uranium-235 would produce a powerful fission bomb and that for $50-100 million isotope separation in sufficient quantities could be accomplished. Although the Americans were less optimistic than the British, they confirmed the basic conclusions of the MAUD committee and convinced Bush to forward their findings to Roosevelt under a cover letter on November 27. Roosevelt did not respond until January 19, 1942; when he did, it was as commander in chief of a nation at war. The President's handwritten note read, "V. B. OK—returned—I think you had best keep this in your own safe FDR."[20]

Moving Into Action

By the time Roosevelt responded, Bush had set the wheels in motion. He put Eger V. Murphree, a chemical engineer with the Standard Oil Company, in charge of a group reponsible for overseeing engineering studies and supervising pilot plant construction and any laboratory-scale investigations. And he appointed Urey, Lawrence, and Compton as program chiefs. Urey headed up work including diffusion and centrifuge methods and heavy-water studies. Lawrence took electromagnetic and plutonium responsibilities, and Compton ran chain reaction and weapon theory programs. Bush's responsibility was to coordinate engineering and scientific efforts and make final decisions on recommendations for construction contracts. In accordance with the instructions he received from Roosevelt, Bush removed all uranium work from the National Defense Research Committee. From this point forward, broad policy decisions relating to uranium were primarily the responsibility of the Top Policy Group, composed of Bush, Conant, Vice President Wallace, Secretary of War Henry L. Stimson, and Army Chief of Staff George C. Marshall.[21] A high-level conference convened by Wallace on December 16 put the seal of approval on these arrangements. Two days later the S-1 Committee gave Lawrence $400,000 to continue his electromagnetic work.

With the United States now at war and with the fear that the American bomb effort was behind Nazi Germany's, a sense of urgency permeated the federal government's science enterprise. Even as Bush tried to fine-tune the organizational apparatus, new scientific information poured in from laboratories to be analyzed and incorporated into planning for the upcoming design and construction stage. By spring 1942, as American naval forces slowed the Japanese advance in the Pacific with an April victory in the battle of the Coral Sea, the situation had changed from one of too little money and no deadlines to one of a clear goal, plenty of money, but too little time. The race for the bomb was on.

Continuing Efforts on Isotope Separation

During the first half of 1942 several routes to a bomb were explored. At Columbia, Urey worked on the gaseous diffusion and centrifuge systems for isotope separation in the codenamed SAM (Substitute or Special Alloy Metals) Laboratory. At Berkeley, Lawrence continued his investigations on electromagnetic separation using the mass spectrograph he had converted from his thirty-seven-inch cyclotron. Compton patched together facilities at the University of Chicago's Metallurgical Laboratory for pile experiments aimed at producing plutonium. Meanwhile Murphree's group hurriedly studied ways to move from laboratory experiments to production facilities.

Research on uranium required uranium ore, and obtaining sufficient supplies was the responsibility of Murphree and his group. Fortunately, enough ore was on hand to meet the projected need of 150 tons through mid-1944. Twelve hundred tons of high-grade ore were stored on Staten Island, and Murphree made arrangements to obtain additional supplies from Canada and the Colorado Plateau, the only American source. Uranium in the form of hexafluoride was also needed as feed material for the centrifuge and the gaseous and thermal diffusion processes. Abelson, who had moved from the Carnegie Institution to the Naval Research Laboratory, was producing small quantities, and Murphree made arrangements with E. I. du Pont de Nemours and Company and the Harshaw Chemical