

## **Part 8**

# **The German Bomb**

### **The Uranium Club**

In September 1939, Werner Heisenberg was expecting to be called to active duty. He told his American friends he had to return to Germany for "machine gun practice" to keep up his combat training, but instead of joining his mountain infantry unit, he was ordered to report to the Army Weapons Bureau in Berlin. Several of his fellow physicists had been recruited to research the possibility of making a nuclear bomb. Heisenberg was relieved that he did not have to fight and delighted that he could continue his research. He was given the task by Kurt Diebner – a colleague and loyal Nazi – of inventing a "uranmaschine" to sustain a nuclear chain reaction. The next month, Otto Hahn and Hans Geiger joined the Uranverein, or Uranium Club to work towards a bomb. Hahn said if a bomb was created, he would kill himself.

Heisenberg, who also coordinated research at the Kaiser Wilhelm Institute for Physics in Berlin, did not believe an atomic bomb was possible, but was eager to return to his laboratory in Leipzig where he and his associates began working out the details of a nuclear reactor using natural uranium.

As with Fermi and Szilard, they had determined that fission occurred with slow neutrons and that some way of moderating their energy was needed; the possibilities were paraffin, graphite or heavy water. Heavy water was scarce at the time, so their first experiments used paraffin. The reactor in Leipzig (L-1) and the Berlin reactor (B-1) were constructed of alternating layers of uranium and paraffin, and both failed. Even with six tons of uranium, the second iteration, B-2, failed to increase neutron production and it was concluded that paraffin would not work as a

moderator. Meanwhile, Walther Bothe was in Heidelberg studying the properties of heavy water and graphite. His experiments indicated that heavy water would work and that graphite, in theory, an excellent choice, absorbed too many neutrons. Thinking it may be contaminated, Heisenberg ordered "pure" graphite, which was even worse. By early 1941, paraffin and graphite had been abandoned and in all subsequent experiments, heavy water was used as a moderator, but it was hard to get, and the work was slow.

In June, 1940, Germany occupied Norway and the Vemork hydroelectric plant at Rjukan, which produced heavy water, and it appeared that this moderator would be easily available. Despite efforts by the allies to disrupt production some still flowed to Germany, but the quantities were far below what Heisenberg's research required and his German overseers demanded.

Isotope separation was also an early part of the Uranium Club's mandate. At first there was great hope that  $U^{235}$  could be separated using thermal diffusion. Klaus Clusius and Gerhard Dickel had invented the process by separating isotopes of chlorine gas, but when uranium hexafluoride was tried, the effort produced only a one percent enrichment in seventeen days. The experiment ended in 1941 but work continued on centrifuges to separate the heavier and lighter ions. By the end of the war, only a small amount of uranium had been enriched and any hope of a bomb from pure  $U^{235}$  was gone.

Carl Fredrick von Weizsäcker was accustomed to reading scientific articles on the Berlin subway and in the summer of 1940, he learned that two Berkeley physicists had discovered a new element, atomic number 93. He concluded that the new element was unstable and would decay to element 94, which could, possibly, be used to make a bomb. Element 94, which would soon be named plutonium, could be produced in a uranium reactor, but Heisenberg's research on the uranmaschine had stalled.

## **Hitler Puts on the Brakes**

In 1941, the Wehrmacht appeared invincible and on June 22, Germany invaded Russia. At first, things went well for the Nazis, as one Russian city after another fell under their control, but at the gates of Moscow, their momentum slowed; then it started to rain. Mud froze as an early winter approached and they were bogged down for weeks.

The second week of December in 1941 was not a good week for Adolph Hitler. On the fifth, the Russian Army began their winter offensive and the frozen German army began to retreat; six days later, Germany declared war on the United States. It was quickly clear that Germany now faced a much wider and more difficult war and that the economy had to be restructured and priorities re-evaluated.

On December 16, members of the Uranium Club met with Army Ordinance officials. When asked about the timing of an atom bomb, Heisenberg was unclear and the Army concluded that his research could not help the war effort in the foreseeable future. The German Army needed miracle weapons in a matter of months, not years and made the decision to withdraw from nuclear research and transfer the uranium project to the Reich Research Council. The army, however, continued modest funding for Kurt Diebner's work on the bomb. On the same day that Hitler put the brakes on the German atom bomb project Roosevelt decided go full speed ahead with America's nuclear program. If he had known that the Nazis were unlikely to produce a bomb, perhaps there never would have been a Manhattan Project or an atom bomb.

## **Heisenberg, Diebner and the Uranmaschine**

On February 26, 1942, Heisenberg addressed a meeting of Reich ministers to sell his on-going nuclear research. He told of the wonders of nuclear power, hinted at a bomb and alluded to "absolute, definite proof that it could be done." No one was quite sure if he was referring to a reactor or a bomb, but Heisenberg's new

employer, the Reich Research Council increased his funding. Work on the bomb was not dismissed, but was put off until they had a successful reactor.

At a June 4 meeting, Heisenberg was again looking for funding. Albert Speer, who was convinced that the only way Germany could win the war was with an atomic bomb, asked him how much money he wanted, and Heisenberg requested only a pittance. Although he spoke of the surety of producing a weapon, he only asked for money enough for reactor research. Heisenberg would not commit to make a bomb or ask for the funds to do so. If he had failed to produce one, he would have been shot.

In Leipzig, heavy water, still in short supply, had replaced paraffin in the L-4 reactor, which showed signs of neutron multiplication before it exploded, destroying the laboratory and scattering powdered uranium and heavy water. On the same day, Speer informed Hitler that there was no possibility of a nuclear super-weapon. Despite these supposed setbacks, Heisenberg was pleased. He did not have to build a bomb, but had funding to continue his nuclear power research. He would not be drafted into the infantry and his reactor project, now using heavy water, was on the right track, but, in spite of his optimism, there was still a fly in his ointment.

British Intelligence had been planning sabotage raids on the Vemork heavy water plant for nearly a year, when in February, 1943, a small team of commandos blew up the electrolysis cells and poured the stored heavy water down the drain. In Germany, shortages continued. Although the plant was back in operation in April, Allied heavy bombers finally destroyed it in November, 1943.

Despite all the disruptions, there was enough heavy water in Germany for research to continue. Heisenberg was now immersing plates of uranium in heavy water with modest results and Diebner was using cubes of the metal suspended from wires with more success, but there were still delays. Due to heavy bombing raids, it took nearly a year for Heisenberg's orders for uranium plates to be delivered. Once he got them he decided that Diebner's lattice arrangement was superior and sent them

back to the factory to be cut into cubes. At Gottow, Diebner's smaller G-2 lattice reactor was multiplying neutrons at a much greater rate than the L-4 did before it exploded. During the repeated delays, Heisenberg worked on his quantum mechanics research, publishing several papers.

In late 1944, Heisenberg had finally obtained the uranium cubes, a ton and a half of heavy water, and began assembling B-7, the largest reactor experiment to date. The magnesium vat containing the heavy water was surrounded by graphite to reflect neutrons and shield the scientists. In its first test, it showed the best neutron multiplication yet, but in January, 1945, with the Russian army fast approaching Berlin, B-7 was hastily disassembled and loaded onto trucks.

Heisenberg rented a small cave used to store beer under the castle church in the southern German town of Haigerloch and reassembled the reactor, now called B-8. Experiments started in March, and by April, neutron proliferation was the highest they had seen. As they filled the vessel with heavy water, the count shot up and up, but at the end, it leveled off. The B-8 reactor was still too small to produce a chain reaction.

When they heard that American troops were in a nearby town and were looking for them, the physicists buried the uranium cubes in a nearby field and secreted away the heavy water. When Engineers, assigned to the Alsos<sup>1</sup> mission, arrived, they found the reactor and soon located the uranium and heavy water as well. Soon the members of the Uranium Club were in British Army custody.

<sup>1</sup> The Alsos mission to secure German nuclear assets was part of the Manhattan Project

## **Farm Hall**

No one would confuse the four men on the well-kept lawn for athletes. Three of them were gleefully hitting a ball across a volleyball net, the fourth sat on a chair,

looking up from his newspaper from time to time. They were having a good time exercising outside in the clear air; they considered their stay at Farm Hall to be a sort of holiday. Each of them would take turns serving the ball over the net. They did not seem to care that no one returned their serve. As the ball gyrated wildly through the air they would laugh. It seems that rather than a round ball appropriate for the game of volleyball, the players were given an oblong rugby ball.

The newspaper-reading spectator was Otto Hahn while the volleyball players were Werner Heisenberg, Carl Friedrich von Weizsäcker and Karl Wirtz. Heisenberg had won a Nobel Prize in 1932 and Hahn got his in 1944, even though he could not be located to receive it. The players were four of the ten members of the Uranium Club captured by the American Alsos mission. They were in British custody because an American General offered to have them all shot. As far as anyone knew, they had been working on the German bomb since 1939.

Farm Hall, a sprawling Georgian manor house not far from Cambridge, had everything needed for the German scientists' comfort including a personal servant for each of them. The food was excellent, there was a radio, and each had their own room, but no one could leave; the mansion also included microphones throughout and an office where everything they said was monitored and recorded.

Just before dinner on August 6, 1945, Otto Hahn was informed that the Americans had dropped an atomic bomb on Hiroshima, Japan. He was overwhelmed and, as the "discoverer" of nuclear fission, felt responsible for all the devastation and death. Calmed by alcohol, he went to dinner and spread the news. The conversation ranged widely throughout the night. Heisenberg: "I don't believe a word of the whole thing." Weizsäcker: "I think it's dreadful for the Americans to have done it. I think it is madness on their part." "...we will soon find out how to do it if we go on working." Hahn: "I didn't think it would be possible for another twenty years." Wirtz: "I am glad we didn't have it." They went on to cast blame for their failure: too few researchers, too little money, too much competition, too little moral courage, too much moral courage, too little perseverance. They were glad they had

not made a bomb; they were devastated that the Americans had beaten them to it. So as not to show their anxiety to the Englishmen, they played cards until after midnight.

Regardless of all their blaming, once the Russians began to push the Germans back from Moscow, and America joined the war, the German bomb was no longer possible, if it had ever been.

On January 3, 1946, the Farm Hall detainees were returned to the British sector of Germany. Werner Heisenberg returned to his position as director of the Kaiser Wilhelm Institute for Physics (soon to be renamed after Max Planck) and remained until 1970. Otto Hahn became a major force in the revival of German science and an advocate against nuclear weapons. Carl Fredrick von Weizsäcker continued his career as a theoretical physicist at the Max Planck Institute and became a Christian pacifist. No one at Farm Hall ever had any more to do with atomic weapons.