

IT WAS NOT POSSIBLE FOR GERMANY TO BUILD AN ATOMIC BOMB DURING THE SECOND WORLD WAR

Shantanu Nagar

Ashoka University, India

The attempt of this academic paper is to prove that Germany would not have been able to build an atomic bomb during the Second World War while the conditions were prevalent for the Allied forces to make the atomic bomb. This argument is supported by referring to various academic papers, books, historical evidences like research papers published by Werner Heisenberg and other eminent scientists. The secret conversations recorded at Farm Hall further support the argument. The paper talks in details about the reasons which led to the failure of The German Atomic Bomb Project. On extensive research, it was found that the German scientists made various technical errors with respect to the concept and technicalities of the atomic bomb. Besides this, the support from Nazi government was minimal towards the project and because of the totalitarian nature of their governance, nuclear science never flourished in Germany. All these reasons led to the failure of The German Atomic Bomb Project. The focus of this paper is to invalidate all the claims made by many historians, scientists and social scientists who claim that it was possible for the Axis powers to successfully build an atomic bomb. Hence, the paper tries to signify that we should not judge history on the basis of morality as it is too random. An ideology or opinion should only be formed by concrete facts, figures and clear evidence.

Keywords: Atomic bomb, Second World War, Allied forces, Germany

Introduction

Michael Frayn's play 'Copenhagen' is an account of a meeting between Niels Bohr and Werner Heisenberg at Copenhagen in 1941. According to the play, the meeting ended on an abrupt note as Bohr thought that Heisenberg had lost his moral values and wanted to make nuclear weapons for the Axis powers led by Adolf Hitler. On the other hand, Heisenberg claimed that he had purposely sabotaged the atomic bomb. This debate is endless as there is no concrete evidence about the reality. To make an atomic bomb during The Second World War there were certain specific requirements without which it was impossible to build a bomb. A strong initial drive by the scientists, an unconditional support from the German government and strong technical expertise were the least requirements. Thus, this paper tries to prove that it was not possible for Germany to build an atomic bomb during the Second World War. This paper further challenges Werner Heisenberg's affirmation of purposely sabotaging the atomic bomb to stall The German Atomic Bomb Project.

Technical and Conceptual Mistakes

The Germans were neither able to recognize Graphite as a moderator nor were able to get Heavy Water which was the alternate source of moderator. There were major mistakes with respect to the technicalities of the bomb. The first mistake was in identifying the use of Graphite as a moderator. In Heisenberg's second paper that he published in 1940, he tried to prove that Graphite was not a good moderator. Walter, another leading physicist in Germany had backed up Heisenberg's claim. Simultaneously, the research performed by Allied powers proved that this was a mistake as the German scientists had done some miscalculations in estimating the absorption cross-section of neutrons. The Allied forces demonstrated this error. They proved that Boron impurities that muddled with Graphite led to some variation in its properties. The use of Boron carbides to manufacture Graphite led to the mixing of Boron impurities with Graphite and thus restricted its use as a good moderator since one atom of Boron absorbed as many slow neutrons as one tenth of a million atoms of Carbon. Thus the Allied forces identified this flaw and achieved a chain reaction using the pure Graphite on 2nd December 1942 while the Germans had to forcefully use Heavy Water as a moderator. Heavy Water can be separated from ordinary water by repeated electrolysis which requires a large hydroelectric plant. The Germans had this plant in Norway, and the courageous Norwegians sabotaged the Heavy Water which was required to build the bomb. "Thus the Germans had only about half the Heavy Water they needed by the end of the war".^[1] Hence a mistake in identifying the moderator and shortage of Heavy Water as an alternative was a major reason that resulted in the failure of The German Atomic Bomb Project.

The German scientists also failed to understand the material properties which were essential for building the bomb. They were not able to find the correct fissionable material required to sustain a stable chain reaction. Heisenberg produced his first technical report on 6th December 1939 to assess "the feasibility of stable reactor using Uranium-235 and the explosive power of a bomb".^[2] In this paper, he only gave a rough description about the bomb. His ideas about Uranium -235 bomb were obscure. He did not have any idea about the use of fast neutrons in a pure U-235 device which was an essential concept to make a bomb. The detailed analysis of captured German documents and American intelligence reports show that there was a flaw in Heisenberg's hypothesis. Heisenberg thought that sustaining a chain reaction using U-235 required the use of slow neutrons but this theory was fallacious. "By Heisenberg's own admission he dismissed from the outset the possibility of producing pure U-235 in significant quantities".^[3] Heisenberg along with other German scientists failed to recognize Pu-239 as an alternative to the Uranium bomb. They did not have any proficiency to bring the sub-critical lumps of Uranium together to initiate an explosion. A team of German scientists under Werner Heisenberg also collected and accumulated Uranium and Heavy Water to build sub-critical assemblies but failed to achieve a sustainable chain reaction. On the other hand, other German scientist named Carl Friedrichs von Weizäcker tried to achieve a sustainable chain reaction using Np-239 in a Heavy Water sub-critical assembly which never attained criticality as Np-239 is considered as a radioactive waste. Weizacker failed to find the use of potent Np-237 which can sustain a chain reaction with fast neutrons with a critical mass of 60 kilograms. The Germans had never measured the reaction cross sections of neutrons and were unable to isolate U-235 and Pu-235. Thus the Germans never identified the correct fissionable material required to build a bomb and were also unaware about the process of isotopic separation required to make a bomb.

Insufficient Understanding about the Critical Mass of the Bomb

Adding on to the two technical errors, The Germans failed to understand the concept of critical mass. Critical mass is the least amount of fissionable material that sustains a chain reaction. The critical mass calculations were not correct and were beyond the correct expression. Heisenberg was not interested in understanding the critical mass which was the minimum mass at which the chain reaction would be initiated. Heisenberg's concern was about the larger mass that would initiate a fast neutron chain reaction and efficiently assure a successful explosion of lowest amount of U-235 before a point would reach at which more neutrons would escape than being internally generated. Heisenberg tried to find the upper

limit for the critical mass of the U-235 bomb instead of its lower limit which on explosion would still contain all the original neutrons within the sphere. This approach was unrealistic and the biggest fallacy was about the attempt to calculate the critical mass for the explosion without wasting a single neutron. The point was to understand and find the critical chain at which the chain of 80 fission generations would still be within the mass but it failed to analyze that the divergent chain of neutrons would have been sufficient to produce an explosion even after the original neutron would have escaped. This understanding was false and erroneous as this calculation would have yielded the upper critical mass while neglecting the true and smaller critical limit of the bomb. Although the understanding of Werner Heisenberg about the upper limit of critical mass was technically correct, it was exigent in its need to cause an explosion. Hence the concept of critical mass was misunderstood by Heisenberg and his German colleagues and this proved as a major technical error.

The Germans failed to calculate the correct critical mass for the atomic bomb. The Germans had calculated the critical mass of U-235 around the order of tons instead of 15-56 kilograms “Heisenberg judged that for a stable reaction, one metric ton of Graphite must be assembled with two to three tons of U-235 and 600 litres of Heavy Water but his estimate about the amount of Uranium needed was offbeat from the real value”.^[4] His misconception was due to the fact that in order to create an explosion, the nuclear reaction would have occurred by creating a superficial condition as a result of building a moderated assembly with Heavy Water and natural Uranium instead of a fast assembly that consisted of metallic U-235 or Pu-235. Paul Lawrence Rose mentions about the Farm Hall Recordings of 1945 where Heisenberg had initially presented the critical mass of a U-235 bomb in order of tons before he corrected himself after a week. “The psychological evidence for this is that Heisenberg clearly presented his earlier incorrect Farm Hall calculation without much thought whereas his later correct argument only arrived after a week of intense thinking”.^[5] It was unfortunate for the Germans that Heisenberg’s contemporaries did not challenge his theories, and the technical misapprehension with respect to the material properties of a bomb and its critical mass proved to be a major loophole. This made it impossible for Germany to build an atomic bomb.

Lack of Support from the Nazi Government

“The failure of German nuclear physics can be attributed to the totalitarian climate in which it lived”.^[6] With a few miscalculations, Heisenberg started to believe that it was an onerous and a demanding task for Germany to make a bomb. While the American government took control and made a concentrated effort to make a bomb, the authority of the project in Germany revolved among different institutions and more than one government agencies. The Nazi regime was a big obstacle in the path of nuclear physics. Their policies and beliefs caused a lot of damage to the German Nuclear Program. “The Nazi State deported numerous Jews and ‘undesirables’ from the universities, labelled theoretical physics as ‘Jewish Science’, dropped its funding, and made it less popular to new students”.^[7] Some of the best German scientists were Jewish and had been in exile while many of them worked for American and British bomb programs. Nazi ideology had only scorn for ‘Jewish physics’ and thus undervalued what theoretical physicists could contribute to the war effort. “Numerically 1145 university teachers in all fields were driven from their posts, many moving to Britain and to the U.S. to eventually find work on the Manhattan Project.”^[8] This helped the U.S. develop the Atomic Bomb. They were responsible for calculating the critical mass of U-235 which was required to initiate an explosion. There was a huge interference of politicians in the matters of science and there was no defined process for selection of top administrative roles because of which people who were incompetent occupied the top administrative posts. The anti-Semitism approaches of Nazis led to the migration and exile of expert scientists. Thus totalitarian nature of governance and lack of vision of German scientist was another cause of the failure of The German Atomic Bomb Project.

The Nazi government did not support The German Atomic Bomb Project. The Germans required manpower and materials for separation of isotopes for a Uranium bomb and Heavy Water production of reactor which was required for Plutonium based bomb. Complex machinery and huge factories were

required to turn out U-235 and Plutonium to make a bomb. The project cost would have been equivalent dollar 30 billion in today's dollars. Initially the Nazis believed that the war would get over by 1943 and were not willing to use their manpower, resources and money in the German Nuclear Programs. It was not only a difficult task but also a big risk as in the later years of The Second World War; Germany did not have the industrial capacity to support such a project. Even if they would have tried to support the project, there would have been a constant threat of possible Allied bombing. It was not possible for the Germans to spend millions of dollars on infrastructure and other support and at the same time deploy around 120000 people during the critical juncture of The Second World War. The Germans invested their money in the weapon programs that could have been completed within that period. Besides this, the scientists themselves did not persuade the government about the possibility of nuclear weapons. Heisenberg had stated that "The project could not have succeeded under the German conditions as they would not have had the moral courage to recommend the government to employ one 120000 thousand people"^[5] while Goudsmit wrote: "They forgot that they themselves had not been very convinced of their own chances of success."^[5] The lack of manpower along with infrastructure was also a major concern in the project. "In the Farm Hall transcripts Heisenberg said that the first time large funds were made available in Germany was in the spring of 1942 after the meeting with Rust when we convinced him that we had definite proof that it could be done."^[9] Heisenberg had said that "The point is that the whole structure of the relationship between the scientists and the state in Germany was such that although we were not 100% anxious to do it, on the other hand we were so little trusted by the state that even if we wanted to do it would not have been easy to get it through".^[10] Heisenberg had foreseen the massive industrial requirement for isotopic separation and Heavy Water production to create the bomb. During the peak time of the war, such an industrial effort was almost impossible to achieve as the resource and human power was not available. It was a big risk to spend a huge amount of money on a project which was difficult to sustain. Thus the lack of support from the Nazi government, lack of infrastructure and manpower and less monetary support were the other major causes of the failure.

Comparison with the Manhattan Project

There were some major contrasts of The German Atomic Bomb Project as compared to the Manhattan Project. These contrasting incidents are essential in understanding the failure of The German Atomic Bomb Project with respect to the successful Manhattan Project. While the German scientists were not able to give direction to the nuclear project, there was a large group of physicists and scientists such as Albert Einstein who wanted to get the project started in the USA. There was a complete contrast in the way governments worked. The USA and UK governments provided an unconditional support to the Manhattan project while the Nazi government was reluctant in providing smallest of support to the German scientists for The German Atomic Bomb Project. USA was one country where research for physics and for making atomic bomb thrived and was given the utmost priority. In contrast to this overconfidence, racism, religious fanaticism led to the expulsion of both prominent Jewish and Non Jewish scientists from Germany. It left Germany with a reduced scientific base, limited expertise and research. Very less priority was given to nuclear physics in Germany because of the totalitarian climate and unavailability of resources. Unlimited industrial resource such as Dupont along with an adequate manpower was made available in USA for the Manhattan project while there were no resources in terms of manpower and infrastructure in Germany. Many brilliant scientists were working on the Manhattan project under Robert Oppenheimer at Los Alamos National Laboratory. In contrast to this, Germany had only countable number of scientists working on the project, which restricted creativity and innovation. The Allied scientists had understood and mastered the process of making a bomb while the Germans completely failed to understand the concept. The Allies were trying to make bombs by using Uranium 235 in a gun-type detonator. The conceptual basis for the atomic bomb was the collision and fusion of two sub-critical masses of U-235 by external explosions into one critical mass. A sphere of Uranium 235 was the main part of the bomb and a section of its inner core of the sphere was removed and placed far

away from its complementary mass. This inner section was surrounded with explosives and when detonated, the blast would have propelled the bullet into its target along with the larger sphere of Uranium. Thus the neutrons would have collided with nuclei from the explosion to obtain the nuclear mass. The other design was based on the fission of Pu-239 to obtain radioactive Polonium and Beryllium. On the other hand, Heisenberg and Weizacker thought of extracting Plutonium from Heavy Water nuclear reactor burning Plutonium but were unaware about the technical difficulties of extracting and separating this Plutonium. Weizacker was mistaken in considering Np-239 rather Pu-239 or Np-239 as possible weapon materials, and even if they had obtained them, they had no idea about the difficulties of bringing a Plutonium bomb to superficiality by Implosion process. Thus the German scientists were not supported by their government, unlike the Allied scientists, which affected the progress of German Nuclear Science.

Conclusion

Thus a lack of technical understanding and technical mistakes with respect to the atomic bomb proved to be a major loophole in The German Atomic Bomb Project. The German government never showed any interest to support the project. Although the German government was reluctant about the project, the German scientists could not win the confidence of German government as they failed to understand the concept of atomic bomb. They also failed to find the correct moderator to meet a chain reaction. These concrete evidences are conclusive of the fact that Germany would never have been able to make an atomic bomb. The debate about Heisenberg personally sabotaging the atomic bomb during The Second World War is endless. According to me, clearly Germany could not have built the atomic bomb and hence it is pointless to argue whether or not Heisenberg wanted to sabotage the bomb or not. The paper clearly signifies that history should be viewed on the basis of concrete facts and evidence.

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