

# German wartime nuclear research and the 'Heisenberg myth': A review

By Jim Thomson

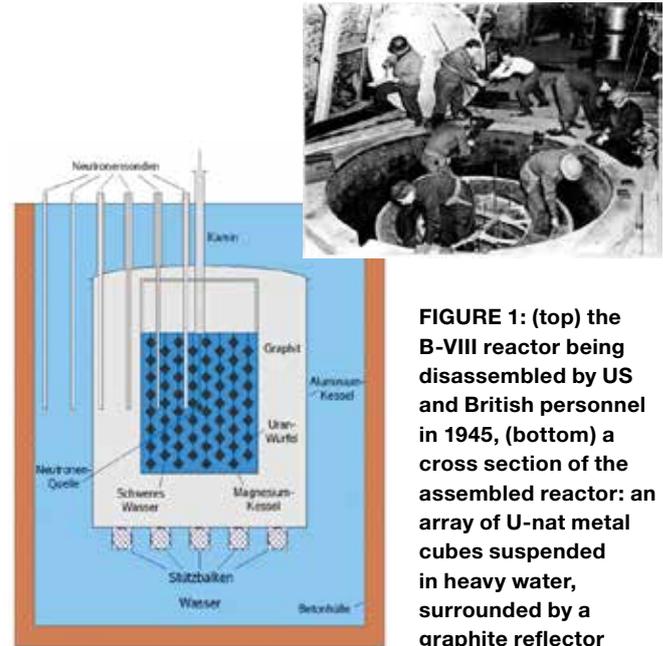
## 1. INTRODUCTION: THE OUTCOME OF GERMAN NUCLEAR RESEARCH IN 1945, AND COMPARISONS WITH THE MANHATTAN PROJECT AND V-WEAPONS PROJECT

**F**ission was discovered in Germany 1938 by Otto Hahn and Fritz Strassmann, with contribution from Lise Meitner (who was by then an emigrée to Sweden). Yet by early 1945, when the Manhattan project was nearing fruition, the principal tangible products of some 6 years' R&D effort in Germany were:

- a sub-critical heavy-water moderated natural uranium 'reactor' (the B-VIII, Fig.1) in Haigerloch in southern Germany
- some experiments led by Paul Harteck in gas centrifuge enrichment at Celle in northern Germany, with limited success
- other sub-critical reactor experiments (led by Kurt Diebner) at Gottow in eastern Germany.

**TABLE 1: A comparison of the outcomes of the Manhattan project and the German nuclear project (Manhattan project details are from Rhodes, *The Making of the Atomic Bomb*)**

|   | Process  | Manhattan project achievements during WW2  | German project  |
|---|--|--|---|
| 1 | Electromagnetic separation of uranium isotopes | Oak Ridge, Tennessee, Y-12 plant: 'Calutrons' which increased enrichment to up to 84% U-235                                  | No. The Germans only had access to a single cyclotron so were relatively weak on cyclotron technology. ('Calutrons' were massive cyclotrons.) |
| 2 | Gas diffusion separation                       | Oak Ridge K-25 plant: Used to take enrichment from 2% to 23% U-235   | Not attempted   |
| 3 | Thermal diffusion separation                   | Oak Ridge S-50 plant: Used to enrich up to 2% U-235  | Experimental only, unsuccessful   |
| 4 | Gas centrifuge separation of U-235             | Experimental only during wartime   | Experimental only, 1-2% U-235 achieved early 1945   |
| 5 | Heavy water production                         | Trail, British Columbia (from 1943)  | Vemork, Norway, until destroyed in 1943   |
| 6 | Uranium-graphite reactors                      | Hanford, Washington 250 MW(th) piles for plutonium production (also the CP-1 pile in Chicago and the X-10 pile at Oak Ridge) | Not attempted because a graphite was considered unsuitable as a moderator.  |
| 7 | Uranium-heavy water reactors                   | CP-3, Argonne, Chicago (critical 15th May 1944)  | B-VIII, Haigerloch, March 1945 (but subcritical)  |
| 8 | Plutonium separation                           | Hanford 'canyons'  | No  |
| 9 | Weapon design and assembly                     | Los Alamos (NM); the Trinity test, Hiroshima and Nagasaki.   | No  |



**FIGURE 1: (top) the B-VIII reactor being disassembled by US and British personnel in 1945, (bottom) a cross section of the assembled reactor: an array of U-nat metal cubes suspended in heavy water, surrounded by a graphite reflector**

The reasons for this comparative lack of progress are manifold and complex, and include technical failures, lack of political will, and the effects of Allied bombing. A comparison of the outcomes of the Manhattan and German projects is presented in Table 1.

The major German accomplishment was the B-VIII reactor, designed and built under a team which included Werner Heisenberg, Karl-Friedrich von Weizsacker and Carl Wirtz. Construction of the B-VIII had begun in Berlin in 1943 but was moved to Haigerloch in 1944 because of Allied bombing. In addition, its design was constrained by the lack of heavy water

|                            | Manhattan project  | V-weapons   | German nuclear project                          |
|----------------------------|--|---|---|
| Cost (wartime US\$ approx) | c. \$2 billion   | c. \$3 billion  | c. \$2 million                                  |
| Personnel and impact       | About 120000 (maximum) were employed in the project. Total mortality estimates for Hiroshima and Nagasaki vary but generally lie in the range 130000 to 230000 | 12000 forced labourers were killed during production. Some 9000 people were killed in V-weapon attacks. | Only a few hundred were employed in the project |

**TABLE 2: Estimates of costs and effort of the Manhattan, V-weapon, and German nuclear projects**

production after 1943, when the Vemork heavy water plant in Norway was destroyed by Norwegian partisans. In March 1945, as the war drew to its close, an attempt was made to take the B-VIII critical, but it proved to be too small. An Italian study of the B-VIII (Grasso et al., 2009) concluded that it “was not too far from being a good working critical reactor”, with a  $k_{eff}$  of about 0.89.

Overall, the German effort into nuclear R&D was much less than the Allies’. However, the Germans probably spent a comparable amount of effort to the Manhattan project in their development and manufacture of the V-weapons (Table 2).

This paper attempts to review, very briefly, the large body of literature which has been written about the motives, ethics and honesty of the German team, with respect to (a) what their wartime intentions were, and (b) how they tried to justify their actions after the war was over. These are very complex issues that are impossible to address fully in a short paper. Hence, an annotated bibliography is presented for those who wish to read further.

## 2. ALLIED CONCERNS DURING WW2 ABOUT POSSIBLE GERMAN PROGRESS TOWARDS A BOMB

From 1940, Allied nuclear development (which later became the Manhattan project) was very largely motivated by fear of the Nazi programme. Einstein’s famous letter to President Roosevelt in August 1939 drew Roosevelt’s attention to recent nuclear research. (This letter was actually drafted by Leo Szilard and only signed by Einstein.) In particular it drew attention to the connection of physicist Carl-Friedrich von Weizsacker to the Nazi government. “.....I understand that Germany has actually stopped the sale of uranium from the Czechoslovakian mines which she has taken over. That she should have taken such early action might perhaps be understood on the ground that the son of the German Under-Secretary of State, von Weizsacker, is attached to the Kaiser Wilhelm Institute in Berlin.....”

Similarly, the famous ‘Frisch-Peierls Memorandum’ outlining a future nuclear development programme (written by Otto Frisch and Rudolf Peierls, two Jewish-German exiles working in blacked-out Birmingham University in March 1940 who would later play major roles in both the Manhattan project and the post-war UK bomb programme) contained warnings about the capability of scientists who had remained in Germany, in particular “.....Dr. K. Clusius (Professor of Physical Chemistry in Munich University), the inventor of the best method for separating isotopes....” Klaus Clusius had in 1939 been the first person to separate the two isotopes of chlorine.

The principal discoverer of uranium fission, Otto Hahn, remained in Germany throughout the war. Although he played

**Replica of the nuclear reactor at Haigerloch museum**



no real role in the wartime nuclear research programme, he had worked with Fritz Haber on the development of poison gases in the First World War. Hahn was afraid of where his discovery of fission might lead. In August 1945, when in detention at Farm Hall in Cambridgeshire, his German colleagues worried about Hahn's mental health after hearing about Hiroshima. Hahn was awarded the Nobel Prize in November 1945.

Paul Harteck had been a co-discoverer of the D-D fusion reaction when working with Rutherford at Cambridge in 1934. (His co-discoverer had been Australian Mark Oliphant, who would later be a 'midwife' of the Manhattan project: he badgered the Americans to initiate the huge investment for the Manhattan project.) In 1939, Harteck was the first to alert the German government to the discovery and potential of fission.

Other notables included Kurt Diebner, Walther Bothe and, of course, Werner Heisenberg, the Nobel Prize-winning golden boy of German physics who was the most high-profile member of the German wartime nuclear programme.

In short, there was a lot of scientific talent in Germany, and throughout most of the war there was serious Allied concern that a significant German nuclear research and development effort might be underway. On the Allied side, it felt like a race to see who could get an atomic bomb first.

In the words of Georgi Flerov, a leading Soviet physicist who worked on the Soviet weapons programme and who also discovered in 1940 the spontaneous fission of uranium, "It seemed to us that if someone could make a nuclear bomb, it would be neither the Americans, British or French but Germans. The Germans had brilliant chemistry; they had technology for the production of metallic uranium; they were involved in experiments on the centrifugal separation of uranium isotopes. And, finally, the Germans possessed heavy water and reserves of uranium. Our first impression was that Germans were capable of making the thing. It was obvious what the consequences would be if they succeeded." (quoted by Rhodes in *Dark Star*)

These concerns helped fuel the massive undertaking that was the Manhattan project. Many of the most significant members of the Manhattan project team were European exiles who were mainly either Jewish or had Jewish connections. Their names are indeed some of the best-known in 20th century science and include Hans Bethe, Enrico Fermi, Otto Frisch, the atom spy Klaus Fuchs, John von Neumann, Rudolf Peierls, Emilio Segre, Leo Szilard, Edward Teller, and Stanislaw Ulam.

These concerns were further stoked by Niels Bohr, who escaped from occupied Denmark in 1943. He told the Allies that, while visiting him in Copenhagen in 1941, Heisenberg had said Germany was developing an atomic bomb.

All of this led to the ALSOS mission in 1944/45 where an effort was made to capture German atomic scientists, and to seize information relating to their wartime developments. By Christmas 1944, it had become apparent that the 'German atomic bomb' was a mirage. Ten leading German scientists were captured and held at Farm Hall, near Cambridge, for several months in late 1945. The rooms had hidden microphones and transcripts were made of their discussions. (The transcripts were not revealed fully until the 1990s - this is discussed further below.) It became clear that the extent of their knowledge fell far short of that required for a successful weapons programme, and in January 1946 they were released.

### 3. POST-WAR DEBATE - THE HEISENBERG MYTH

After his release from internment, Heisenberg wrote a summary account of the German project which was published by the journal *Nature* in 1947. He said production of nuclear weapons in Germany would not have been possible under wartime conditions, due to shortage of raw materials and manpower, and because of Allied bombing. He also wrote that in 1942, when a decision to commit huge resources would have been necessary, the view of the Nazi leaders was that the war was already almost won, so early results would have had to be promised to make it worthwhile. (These statements were seemingly at odds with the Nazi leaders' long-term commitment to the very resource-intensive V-weapons programme.) He said the project team was only interested in making an *uranmaschine* (reactor). Furthermore, and controversially, he implied that the German scientists had procrastinated in order to prevent project progress. However, he also implied the German scientists could have made a bomb if they had wanted to. In short, it read like a post-war attempt to redeem himself in the international physics community.

Heisenberg's implications were developed by Robert Jungk, who formulated the 'Heisenberg myth' in his 1956 book *Heller als Tausend Sonnen* (*Brighter than a Thousand Suns*): "It seems paradoxical that German nuclear physicists, living under a sabre-rattling dictatorship, obeyed the voice of conscience and attempted to prevent the construction of atomic bombs, while their professional colleagues in the democracies, who had no coercion to fear, with very few exceptions concentrated their whole energies on the production of the new weapon." Kramish (*The Griffin*, 1986) wrote "Jungk's book was an early example of the shameful fiction that has now been taken as gospel." Jungk subsequently (1990) distanced himself from the Heisenberg myth, saying "That I have contributed to the spreading of the myth of passive resistance by the most important Nazi physicists is due above all to my esteem for these impressive personalities, which I have since realised to be out of place."

Attempts by Heisenberg and others to suggest there was no wartime intent to produce atomic bombs caused intense irritation amongst some and led to a decades-long debate. Lise Meitner wrote in 1945 "One should force a man like Heisenberg and many millions like him to go to these camps and see the martyred victims. His visit to (Bohr in) Denmark in 1941 is unforgivable." (quoted by Kramish).

Goudsmit, in his 1947 book *ALSOS*, let his hatred for the Nazis (his parents had died in the Holocaust) cloud his judgment somewhat; he wrote off the whole German project team as incompetents - which seems overstated - although his conclusion was probably correct: "The plain fact of the matter is that the Germans were nowhere near getting the secret of the atom bomb. Indeed, at the rate they were going and the direction they were taking, it is anybody's guess if they would have arrived at it at all in any practicable period of time."

Heisenberg's 1941 visit to Bohr in Copenhagen has long been controversial. The two men had been close colleagues over many years and spoke each other's languages, yet their accounts of this meeting were contradictory: Bohr claimed Heisenberg wanted him to join the German nuclear weapons project, while Heisenberg claimed he only wanted to warn the Allies, via Bohr, of German developments. Bohr remained

## The Farm Hall transcripts

In 1992, transcripts of the conversations of the interned German scientists in Farm Hall, Cambridgeshire, were released. Of particular interest were their reactions, in August 1945, to the news of the Hiroshima bomb. They heard the BBC evening news and their heated discussion went on into the night. Some extracts are given below (these are selected from many pages of discussion). Note that Otto Hahn was held at Farm Hall despite having no real involvement in the project, so his barbed comments are a useful counterpoint to the others named below (who were all directly involved).

**HAHN:** "If the Americans have a uranium bomb then you're all second raters. Poor old Heisenberg."....

**HEISENBERG:** "All I can suggest is that some dilettante in America who knows very little about it has bluffed them.....I don't believe a word of the whole thing."....

**von WEIZSACKER:** "I don't think it has anything to do with uranium."....

**GERLACH:** "They've got (*plutonium*) and have been separating it for two years."....

**HEISENBERG:** "I consider it perfectly possible that they have about ten tonnes of enriched uranium, but not that they can have ten tonnes of pure U-235." (*Heisenberg doesn't know the critical mass!*)....

**HAHN:** "But tell me why you used to tell me that one needed 50kg of U-235.....now you say you need two tonnes?"....

**HARTECK:** "You could do it with 100,000 mass spectrographs"....

**von WEIZSACKER:** "I believe the reason we didn't do it was because all the physicists didn't want to do it, on principle. If we had all wanted Germany to win the war we could have succeeded."

**HAHN:** "I don't believe that."

**von WEIZSACKER (after Hahn has left room):** "If we had started this business soon enough we could have got somewhere."..... (*This statement destroys the Heisenberg myth before it had begun!*)

**WIRTZ:** "It is characteristic that the Germans made the discovery and didn't use it, whereas the Americans have used it."..... (*Here is the origin of the Heisenberg myth.*)

**GERLACH:** "When we get back to Germany we will have a dreadful time. We will be looked on as the ones who have sabotaged everything. We won't remain alive long there.....Isn't it a pity that the others have done it?"

**HAHN:** "I am delighted."

The evidence of these transcripts is that there was clear intent to work towards a weapon, although the route to achieve this was at best vague. This conclusion is supported by the discovery, in Soviet archives in 2005, of a 1941 draft patent for an atomic bomb written by von Weizsacker.

annoyed with Heisenberg until his death: unsent draft letters from Bohr to Heisenberg dated 1958 were published in 2002, which showed that Bohr remained extremely annoyed with Heisenberg for allowing Jungk to repeat Heisenberg's version of the Copenhagen meeting and to re-state the 'Heisenberg myth' of German innocence. Bohr wrote: "I carefully fixed in my mind every word that was uttered. It had to make a very strong impression on me that at the very outset you stated that you felt certain that the war, if it lasted sufficiently long, would be decided by atomic weapons. At that time I had no knowledge at all of the preparations under way in England and America, and when I did not reply and perhaps looked doubtful, you told me that I had to understand that in recent years you had occupied yourself almost exclusively with this question and were certain that it could be done. On the other hand, there was no hint on your part that efforts were being made by German physicists to prevent such an application of atomic science.....my alarm was not lessened by hearing from the others at the Institute that Weizsacker had stated how fortunate it would be for the position of science in Germany after the victory that you could help significantly towards this end."

## 4. KEY TECHNICAL FAILURES IN THE GERMAN PROJECT

The German programme became stymied by lack of heavy water. Hence Kurt Diebner subsequently concluded that "the elimination of German heavy water production in Norway was the main factor in our failure to achieve a self-sustaining atomic reactor before the war ended".

No attempt was made to pursue graphite moderation because Walther Bothe, in 1940, had concluded that graphite was unsuitable. This was probably due to boron contamination at the ppm level. (In the Manhattan project, Leo Szilard had recognised that the normal route for manufacturing graphite involved boron carbide electrodes. Hence he got the manufacturers to change the electrode material.)

No serious effort at weapon-scale enrichment was made. In any case, the size of the plant would have been prohibitive; its power consumption would have been huge, it would have been a target for Allied bombing, and (as discussed above) Heisenberg over-estimated the amount of U-235 needed for a bomb. A US report from 1946 concluded that "In comparing the progress with the centrifugal method of separation made by the Germans and by ourselves it is clear that at the end of the war they were far behind where we were in this country at the end of 1943....."

## 5. KEY POLITICAL AND ORGANISATIONAL FAILURES

In a presentation to senior military and political leaders in 1942, Heisenberg infamously stated that "a bomb the size of a pineapple could destroy a city". However, at that time (i.e. pre-Stalingrad), the Nazi leaders thought the war was almost won, and since early results could not be guaranteed, there was no immediate strong military interest.

There was perhaps a lack of courage to recommend, in the situation of Nazi Germany, a project that might require 100000 people, without any guarantee of success. All the senior scientists involved would be aware of the potential personal consequences of failure in such a brutal dictatorship.

After 1942, there was a loss of focus as management of the project was transferred from the military (Herreswaffenamt) to government research (Reichsforschungsrat) (with its notorious bureaucracy), although the project retained sufficient status that the project team were excluded from call-up until very late in the war.

As a symptom of this loss of focus, Heisenberg published a book about cosmic rays in 1943. Others were doing non-project-related work also - Heisenberg and others spent a lot of time in 1943/44 acting as 'cultural ambassadors', giving lectures within Europe. Heisenberg himself visited Holland, Switzerland, Czechoslovakia, and Poland. (Notably, given his subsequent efforts to distance himself from the Nazi hierarchy, his visit to Poland was at the invitation of Hans Frank, Poland's notorious Nazi Governor General, who was an old school friend - and who was later executed at Nuremberg (Bernstein, 2004).)

Thus from 1942 to early 1945, the project moved along at a relatively low level compared to the Manhattan project, while enabling the project members to be spared from the Eastern Front.

## 6. CONCLUSIONS

Until mid-1942, the German team was arguably in the lead. However, until 1942, the Germans thought the war would be over too soon for nuclear research to have any effect. After 1942, the Allied bombing of Germany would have made any major new project very difficult.

Heisenberg, von Weizsacker, Harteck, Diebner and the others might have been able to make an atomic bomb for Hitler in the time available. However:

- The 'time available' was much longer than was expected in 1940, or even perhaps in 1942.
- If the Nazi priority had been the bomb instead of the V weapons, things might have been different.
- The failure to use graphite as a moderator, and the destruction of the Vemork plant, were undoubtedly significant.
- The Germans didn't pursue cyclotrons, or gas diffusion, for uranium enrichment.
- The German scientists will have been concerned about the possibility, and the consequences, of failure if they had 'talked up' the prospects for a successful bomb project.
- There was no panic about 'the other side getting there first', because the German scientists thought they were first. (This was different from the Allied position.)
- They were in a protected project which meant they were not likely to be conscripted.

Any claims that German scientists deliberately delayed developments, as part of passive resistance to the Nazi regime, now seem discredited.

Heisenberg remained enigmatic, but was perhaps at his most candid in a letter to Jungk written in 1956: "With the beginning of the war there arose of course for every German physicist the dreadful dilemma that each of his actions meant either a victory for Hitler or a defeat of Germany, and of course both alternatives presented themselves to us as appalling. Actually, I suppose that a similar dilemma must have existed for the physicists active on the allies' side as well, for once they were signed on during the war, they also were signed on for Stalin's victory and Russia's foray into Europe. Overall, the German physicists acted in this dilemma as conservators of sort of that which was worthy and in need of conserving, and to wait out the end of the catastrophe if one was lucky enough to still be around." But even this seemingly candid paragraph contains retrospective self-justification.

The German scientists failed to produce any tangible successful outcome from their wartime research. This was at least partly due to bad decisions. After the war, they were happy that their failed efforts were presented as morally-justifiable procrastination. However, this duplicity was eventually revealed in 1992 by the publication of their conversations at Farm Hall in August 1945.

As a final comment, a book by Rainer Karlsch, first published in 2005, made new and bizarre claims that German atomic weapon tests had taken place in Germany in late 1944 and early 1945. The evidence for this seems non-existent, although there may have been fusion experiments using high explosives. These will have failed, although Karlsch claims there were a large number of fatalities. Karlsch did, however, discover in Soviet archives the von Weizsacker atomic bomb patent from 1941.

## Bibliography with commentary

(\* = Recommended books)

- ◆ **\*Jeremy Bernstein (2nd Ed., 2001), *Hitler's Uranium Club: The Secret Recordings at Farm Hall, Copernicus, New York.* This includes the full conversation after the interned German scientists heard about the Hiroshima bombing.**
- ◆ David Cassidy (1991), *Uncertainty, The Life and Science of Werner Heisenberg*, WH Freeman, New York. This is a detailed biography which addresses the enigmatic behaviour of Werner Heisenberg.
- ◆ Samuel Goudsmit, (1947, republished 1996) *ALSOS*, American Institute of Physics, New York. This is a good light read, and it captures the raw emotions and paranoia of 1945. Goudsmit's parents had died at Auschwitz and, as a result, some of his judgment seems clouded.
- ◆ Werner Heisenberg, (1947), *Research in Germany on the technical application of atomic energy*, Nature, 160, 4059, pp 211-214. This brief paper reads like a post-war attempt by Heisenberg to redeem himself to the international scientific community.
- ◆ David Irving (1967), *The Virus House*, William Kimber, London. (This was published in the USA as *The German Atomic Bomb*.) This book gave the first good technical account of German wartime nuclear research. It was based on interviews with some of the German scientists, and on research into files held in the USA. However, Irving is well-known as a Nazi sympathiser and Holocaust-denier. (Notably, in a libel action in London in 2000, which he lost, the judge said "Irving has for his own ideological reasons persistently and deliberately misrepresented and manipulated historical evidence; that for the same reasons he has portrayed Hitler in an unwarrantably favourable light, principally in relation to his attitude towards and responsibility for the treatment of the Jews; that he is an active Holocaust denier; that he is anti-Semitic and racist, and that he associates with right-wing extremists who promote neo-Nazism".) Hence his writings should be treated with circumspection – although this does not appear relevant to *The Virus House*. A pdf of this book is available free from Irving's website <http://www.fpp.co.uk/books/index.html>
- ◆ Robert Jungk (1956), *Heller als Tausend Sonnen*, published in English in 1958 as *Brighter Than A Thousand Suns*, Harcourt Brace, New York. This book formulated the Heisenberg myth of passive resistance.
- ◆ Rainer Karlsch (2005), *Hitler's Bombe* (in German) translated into French (2007) as *La Bombe de Hitler*, Calmann-Lévy, Paris. This is an unlikely 'history' focussing on Diebner's alleged activities in Göttingen in 1944/45. He makes unsubstantiated claims for successful reactor operation and weapons testing. Despite the lack of evidence, Karlsch's claims attracted publicity, helped by his co-authorship (with Mark Walker) of a paper entitled 'New light on Hitler's bomb' in *Physics World* (June 1st, 2005). Fantasy.
- ◆ Arnold Kramish (1987), *The Griffin*, Macmillan, London. This gives a fascinating account of the life of Paul Rosbaud, editor of the journal *Naturwissenschaften*, and a British spy. This account includes interesting details about the German nuclear programme.
- ◆ Thomas Powers (1993) *Heisenberg's War: The Secret History of the German Bomb*, Penguin. This continued the Heisenberg myth (despite the prior publication of the Farm Hall transcripts).
- ◆ Richard Rhodes (1986 and 2012), *The Making of the Atomic Bomb*, Simon and Schuster, London. This is a highly readable and thorough history of the Manhattan project.
- ◆ Paul Lawrence Rose (1998), *Heisenberg and the Nazi Atomic Bomb Project*, University of California Press. This is an outspoken critique of Heisenberg's and Powers' accounts.
- ◆ **\*Mark Walker (1989), *German National Socialism and the Quest for Nuclear Power 1939-1949*, CUP. This is a detailed history, based on Walker's PhD thesis at Princeton.**
- ◆ Mark Walker (1995), *Nazi Science – Myth, Truth and the German Atomic Bomb*, Perseus. This book re-works much of Walker's earlier book.

## Electronic media and video

- ◆ A presentation which formed the basis for this article is available on the author's website: [http://www.safetyinengineering.com/FileUploads/German%20WW2%20nuclear%20research\\_1423497296\\_2.pdf](http://www.safetyinengineering.com/FileUploads/German%20WW2%20nuclear%20research_1423497296_2.pdf)
- ◆ A BBC Horizon film *Hitler's Bomb* (1992) is available on YouTube and contains fascinating interviews with Carl-Friedrich von Weizsacker and Erich Bagge, although this makes the programme too sympathetic to the 'Heisenberg version' <http://www.youtube.com/watch?v=eV-ElwRwDIM>
- ◆ *Copenhagen*, a stage play by Michael Frayn (1998), presents a fictional account of the meeting between Heisenberg and Bohr in 1941. The BBC version with Daniel Craig can be seen on YouTube: <https://www.youtube.com/watch?v=S4BVcUjSpag&list=PLTV6WqjPIHvSa5WtJm7wau4JLwUaEQsq>
- ◆ The movie *Denial* (2016, dir. Mick Jackson) presents an account of the 2000 trial of Irving vs Penguin Books, in which Deborah Lipstadt, a Holocaust scholar, was sued for libel by Holocaust denier and author David Irving. Irving lost and was forced into bankruptcy. See the above bibliography regarding Irving's book *The Virus House*. DVD is available on Amazon, [https://www.amazon.co.uk/Denial-DVD-Rachel-Weisz/dp/B01N6R3ZQ2/ref=sr\\_1\\_1?crid=36TNUNU5PTVY&dchid=1&keywords=denial+dvd&qid=1587898990&s=dvd&srprefix=denial%2Caps%2C203&sr=1-1](https://www.amazon.co.uk/Denial-DVD-Rachel-Weisz/dp/B01N6R3ZQ2/ref=sr_1_1?crid=36TNUNU5PTVY&dchid=1&keywords=denial+dvd&qid=1587898990&s=dvd&srprefix=denial%2Caps%2C203&sr=1-1)

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- ◆ Bernstein, J., *Heisenberg in Poland*, Am J Phys, 72 (3) 2004
- ◆ Grasso, G., Oppicci, C., Rocchi, F., and Sumini, M., (2009), *A neutronics study of the 1945 Haigerloch B-VIII nuclear reactor*, Phys. Perspect., 11, 318-335
- ◆ Rhodes, R., (1995 and 2005), *Dark Star – The Making of the Hydrogen Bomb*, Simon and Schuster, New York



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