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NAZI SCIENCE

MYTH, TRUTH, AND THE GERMAN ATOMIC BOMB

MARK WALKER

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Hitler's Bomb

The 1941 meeting between Bohr and Heisenberg is controversial because it is part of the debates surrounding "Hitler's Bomb." During the war both Germany and the United States investigated the economic and military potential of applied nuclear fission. The American effort, otherwise known as the Manhattan Project, built the bombs which fell on Hiroshima and Nagasaki. Obviously the Germans did not manufacture nuclear weapons before Germany surrendered. But ever since the end of the war, scientists and non-scientists both inside and outside of Germany have argued over *why* the Germans failed, and whether the word failure is an appropriate description. This chapter will survey the German uranium project in the context of science under National Socialism.

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Physics and Politics in Weimar Germany (1919–1932) Today it is clear that science in general and physics in particular can be politicized, but science has not always been so susceptible to external influences. An irreversible politicization of science took

place in Germany during the first half of the twentieth century, beginning with the exceptional publicity given to Albert Einstein's theory of relativity and ending with the race for nuclear weapons. Although physics had been temporarily politicized at different times and in different places, since 1945 governments have seen this science as a potential source of political power.

Einstein was a respected scientist even before World War I. But the unusual popularity his theory of relativity enjoyed during and after the war, combined with his unconventional personal style and political stance, transformed him into a cultural and political icon during the Weimar Republic. The experimental verification of relativity in 1919 and the subsequent public fascination, if not obsession with Einstein made the pacifist, democrat, and Jew a cultural and political symbol that transcended his physics and incurred the wrath of both political conservatives and scientific opponents. This political and scientific opposition to Einstein and his theory of relativity created an ideological struggle between "Aryan" and "Jewish physics during the Third Reich.[674]

Opposition to Einstein and modem physics was fueled by the political and economic aftermath of World War I in Germany. The lost war was a catastrophe for the conservative majority of academic scientists. They often reacted by asserting that science and scholarship were all that Germany had left as a world power,[675] an attitude which accelerated and deepened the politicization of physics.

The weak economy and hyper-inflation ruined the endowments of many scientific institutions—not to mention the savings of scientists—and forced researchers to compete for the ever-shrinking amount of available funding and to become more dependent on the generosity of the central government and German industry. This shortage of funds forced the scientific community to work with the government to create the modem peer-review system of science funding. Institutions like the govemmental Emergency Foundation for German Science and the private Helmholtz Foundation relied on expert committees to decide which scientists would receive

A small group of senior German physicists like Max Planck dominated the expert committees within the peer review system and thereby influenced, if not controlled, which research was funded. The major beneficiaries of this system included the creators of quantum mechanics, including Max Bom, Wemer Heisenberg, Pascual Jordan, and Erwin Schrodinger. In contrast, the conservative scientists who rejected modem physics did not have a large share in the new funding system.

Perhaps most important, the politically conservative scientists who opposed the Weimar Republic and rejected the political stance of liberal colleagues like Einstein were often the same researchers who were unable or unwilling to accept quantum mechanics and relativity.[677] Similarly, Einstein's non-scientific political opponents used his controversial theory of relativity as a means to attack him. Einstein's physics and politics thus merged into a single target for political and scientific conservatives. The political and economic upheaval following Germany's defeat thus made modem physics—roughly speaking quantum mechanics and relativity theory—at once both the pride of German science and the target of scientists and laymen who opposed a liberal, democratic worldview.

Two German physicists and Nobel laureates, Philipp Lenard and Johannes Stark, vigorously opposed the Weimar Republic, and felt betrayed by the lack of recognition given to them by their colleagues and government. They were professionally opposed to (in each case, different) elements of modem physics. Such sentiments were common in Germany between the wars, but they went further. By 1933 both scientists were channeling their personal and professional discontent into the virulent anti-Semitism so common on the political right and public support of Adolf Hitler. When the National Socialists came to power in **1933,** Lenard and Stark gained access to political power and influential friends in the new regime.

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Nazification and Militarization (1933–1939) When the Allies defeated the Third Reich and the National Socialist leader-

ship was dead or being tried for war crimes, there was a general consensus outside of Germany that the German people had to be "denazified." But if the Germans had to be denazified after 1945, then they must also have been nazified sometime between 1933 and the end of the war. Nazification can be defined as follows: the effective, significant, and conscious collaboration with most—but not necessarily all—of National Socialist policy. Since the attitudes, assumptions, and actions of German scientists vaned greatly during the Third Reich, so did the form and course of their interactions with National Socialism.

For German politics, **1932** was a tumultuous year. Adolf Hitler's National Socialist German Workers Party had emerged from obscurity to become the largest political party in Germany. Ironically, when German President Paul von Hindenburg appointed Hitler Reich Chancellor in January **1933,** the National Socialists were on the way down; they had peaked the previous year and were struggling to hold their political movement together.

Hitler had been helped into power by an intriguing circle of industrialists, aristocrats, and senior military officers who hoped to use the National Socialist leader for their own ends. Hitler proved to be the more skillful politician and exploited the collaboration of Germany's old elites to help his radical, racist, and ruthless movement eliminate step-by-step all opposition during the first few years of the Third Reich. The old elites retained a little autonomy until the eve of World War II, when Hitler purged the Army leadership. Personal scandals were exploited or manufactured for Field Marshall von Blomberg and Army Commander-in-Chief General von Fritsch, two officers who had expressed concern that Germany was not yet ready to fight. They were eased out of their posts and replaced by more pliable men. In addition, fourteen senior generals were retired and forty-six others required to change their commands. Hitler personally took over as Commander-in-Chief of the Armed Forces.[678]

Both the purge of the German civil service[679] and of German science at the start of the Third Reich are well known.[680] The

so-called seizure of power[681] by the National Socialists dramatically and decisively affected all parts of German society, including science. But both scientists and historians of science have sometimes failed to recognize that the purge of scientists was not a conscious National Socialist policy against science *in particular* and, at least for academics, was an automatic result of the greater civil service purge.

The National Socialist leadership was hardly concerned enough about any particular science, or even science itself, to single it out for special treatment. Education *in* general and university education in particular were priorities for Germany's new rulers, but in this regard physicists were treated no differently from their non-scientific colleagues.

Albert Einstein, perhaps the most famous scientist purged by the National Socialists, represents the exception that proves the rule. Hitler's movement singled out Einstein for wrathful special treatment precisely because his public stature represented a real political threat. However, the thorough and ruthless purge of the civil service effectively "cleansed" the universities and state-funded research institutions (like the Kaiser Wilhelm Society) of Jewish, leftist, and other elements incompatible with the new Germany, thereby striking a heavy blow to all branches of German science.

It is important to recognize *how* the National Socialist purge and reorganization of German society functioned, why it was successful, and what *pattern* it followed. First, Hitler and his followers needed and received assistance from influential members of Germany's conservative elites—including scientists. Second, and most important for this subject, the purge was neither centrally planned, coordinated, nor implemented. Instead the seizure of power was characterized by uncoordinated and often unsolicited pressure from National Socialist rank-and-file party members and SA. This violent and often unsolicited pressure was then exploited by the National Socialist authorities to eliminate all opposition.[682]

Such unsolicited, yet often welcome, attacks from below by the masses making up the basis of Hitler's movement were often

subsequently used by the National Socialist government to justify further repression from above by blaming the victims for inciting the violence.[683] But since the National Socialist leadership also wished to present an image of a peaceful, orderly society under their control, such "revolution from below" eventually became counterproductive. *On* **6** July **1933** Hitler publicly called for "evolution, not revolution," a thinly veiled threat to his own followers.[684] When the **SA** leadership persisted in its calls for a "second revolution" which would have benefited in particular the lower levels of the National Socialist movement, Hitler purged his own movement.

In the summer of 1934 German President Otto von Hindenburg, one of the few remaining checks on Hitler's government, was dying. Hitler intended to merge the office of president into his own position of Chancellor, but that required the blessing of the Armed Forces, the only remaining part of the German state which could launch a putsch against him. The Army feared the SA, and with good reason. Its leadership wanted to turn the **SA** into a political army and to absorb the armed forces in the process. The SS was also involved, because it technically was still a subsidiary of the SA and wanted greater independence. Pressure on Hitler from the Army leadership and the SS finally forced his hand. On 30 June Hitler personally supervised the arrest of Ernst Röhm and the majority of the SA leadership. Most were subsequently murdered by the SS with Army logistical support. This bloody "night of the long knives" permanently silenced calls for a second revolution.[685]

The nazification of German science in general and physics in particular followed this SA model and its four stages, although recalcitrant scientists were disciplined, not murdered: (1) revolution from below, uncoordinated and unsolicited attacks in the name of National Socialism; (2) evolution, not revolution, the National Socialist government orders that henceforth all change will be directed by the responsible authorities or occur through official channels; (3) second revolution, the National Socialist rank-and-file nevertheless continues its agitation; and (4) finally the National Socialist revolution devouring its own children, purging

or disciplining its undisciplined followers.[686] The physics equivalent of the SA was the *Deutsche Physik* movement, which called for a more "Aryan" and less "Jewish" science.[687]

The followers of Lenard and Stark wanted to achieve a second revolution in German physics which would go beyond the initial purge of the civil service and would ensure that they would henceforth receive the best university appointments. Their weapon was a very effective campaign of character assassination. However, by 1936 Stark and his allies were beginning to get in the way of other, more influential forces within the National Socialist movement, including officials within the Ministry of Education and the leadership of the SS.

Deufsche Physik was first opposed and then neutralized by other and stronger parts of the National Socialist movement because the long-standing goals of the former conflicted with the new ambitions of the latter. In contrast to the scientifically sterile *Deutsche Physik,* the established physics community could and did effectively contribute to rearmament and the war effort by training scientists, engineers, and technicians for the armament industry as well as developing new weapons and industrial processes.

This increase in German military strength and initial military successes in turn increased public support for the Third Reich and facilitated the most extreme and murderous National Socialist policies: the creation of a racially pure society in Germany; cultural imperialism; geographic expansion through military aggression; and finally genocide. Although the *Deutsche Physik* movement failed in its efforts to make German physics more National Socialist by attacking modem physics and certain physicists, ironically the successful struggle by the established physics community against *Deutsche Physik* and the consequential collaboration with the National Socialist state it entailed did.

Why was German physics nazified in this way? The adherents of *Deutsche* Physik simply tried to expand their influence within the German physics community any way they could, and initially their strategy appeared successful. The established German physics community could easily find influential and sympa-

thetic patrons within the sometimes chaotic and contradictory political structure of the Third Reich. This support was sometimes given for reasons of principle, sometimes as a cynical, tactical stance within the shifting politics of the National Socialist state, but no matter why these patrons chose to side against *Deutsche* Physik, some of them were *in* a very strong position to do *so*.

But why did the overwhelming majority of German physicists ally themselves with, or submit themselves to forces within the Third Reich and portions of National Socialist policy? Obviously because when compared to the ideological threat represented by *Deutsche Physik,* this course seemed less objectionable because it would provide more professional autonomy. However, this apparent gain in autonomy was misleading. The established physics community had rid itself of *Deufsche* Physik, but now had to demonstrate both loyalty and usefulness to the Third Reich. One of the most controversial and potentially dangerous collaborations between German physicists and the National Socialist state was the uranium project, research into the military and economic applications of nuclear fission.

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Nuclear Fission (November 1938–August 1939) Otto Hahn and Fritz Strassmann, two chemists working at the Berlin Kaiser Wilhelm Institute for Chemistry, made a discovery in late 1938 which, in time, changed the world. When they bombarded uranium, the heaviest natural element, with neutrons (nuclear particles without charge but with mass) they found barium, an element half the mass of uranium. Their Jewish physicist colleague Lise Meitner helped make the initial discovery possible, but had fled Germany earlier in **1938** after the Third Reich had absorbed Austria, which ended the protection her Austrian passport had once provided.

When news of Hahn's and Strassmann's striking result reached Meitner in Sweden, she encouraged her former colleagues. When she subsequently met her physicist nephew Otto Frisch in Denmark, they solved the riddle together: the uranium nucleus

had split in two like a liquid drop. Although Frisch and Meitner were among the first scientists to extend the Berlin results, it is perhaps more significant and important that *so* many different researchers in different countries carried out the same experiments, achieved the same results, and came to the same conclusions: when uranium nuclei split, they released both energy and more neutrons.

Scientists around the world took up this research immediately and raced to be the first to explain, expand, and apply this phenomenon. Personal and professional ambition as well as the obvious potential of nuclear fission ensured that long before scientists began withholding their results in the shadow of World War II, their publications had already demonstrated that uranium fission released great amounts of energy as well as enough neutrons to make possible energy-producing and exponentially increasing nuclear fission chain reactions.

It was only a very short step from these results to the realization that nuclear fission had consequential economic and military applications: a controlled chain reaction could be used to generate electricity; an uncontrolled chain reaction would represent a powerful new explosive. Scientists went to the responsible military authorities in almost every country and passed on the same message, that it might be possible to harness nuclear fission both as *nuclear* explosives of hitherto unknown power and as nuclear energy. They noted that enemy countries were probably already working on uranium; the government had to support a research program in order to determine whether nuclear weapons could be built, how they would be built, and whether they should be built.

Even though researchers throughout Europe and North America went to their governments with this same message, historians and scientists who have studied "Hitler's Bomb" have often distinguished between the German scientists who enlightened their military and their colleagues in other countries who did the same. While American, French, and British scientists are praised for these efforts, their German counterparts are criticized. Indeed, this distinction plays an important role in the persistent

fascination with Hitler's bomb. There is an important difference here, but it is not in what the scientists did, rather in what sort of regime they were serving.

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Lightning War (September 1939–November 1941) The German uranium project did not progress until after the invasion of Poland in September 1939. These two events were connected. The overwhelming majority of Germans and German scientists rallied to the flag once the war had begun, including many individuals who opposed or at least did not wholeheartedly support National Socialism. War also made it both more attractive and easier for Army Ordnance to become involved with scientific research projects which promised powerful new weapons,

Finally, a fundamental transformation in National Socialists' attitudes towards science and science-based technology began during the middle thirties with rearmament and accelerated with the outbreak of war. Military and economic power took precedence over ideological purity. Scientists who could offer something useful for the war effort could now eclipse their colleagues who were ideologically correct but scientifically inferior.

The quality of the German uranium effort can best be judged when compared to its Allied counterpart. During the Lightning War phase the two projects ran astonishingly parallel. With a few exceptions, the Germans and the Americans examined the same subjects, used the same methods, asked the same questions, and found the same answers. There were many different reasons why German scientists chose to participate in the nuclear power project: scientific interest, careerism, financial and material support, exemptions from military service, patriotism, nationalism, and National Socialism—in other words, with the exception of the last point, the same motivations as in other countries.

But motivation and scientific ability alone do not tell the whole story. The political and military leadership was in *control* of the research and had the power of decision. In Germany it was Army Ordnance, and not the academic scientists. The situation in

the United States during the war and in the Soviet Union after the war was no different. The scientists actually carrying out the research could not and did not decide whether the research was begun, whether and how it was continued, and if successful, what would be done with the new weapons once they had been created.

These decisions were made by governmental and military officials. Moreover, in Germany Army Ordnance not only had the power of decision-making, it also had its own competent and loyal scientists, who could well judge the technical and scientific side of the project. The influence of the research scientists over the project, let alone their ability to control it, was limited—although these scientists very often deluded themselves and believed that they were really in charge.

The German uranium research must also be seen in the context of the ever-changing state of the war and, in particular, of the Lightning War which ran from 1939 to the winter of 1941–1942. Germany used the tactic of massive sudden attacks to overwhelm an opponent, strip the conquered country of resources, and use these resources to launch the next attack. The secret reports gathered by the SS Security Service describe how the combination of military success and skillful propaganda combined perpetually to convince most Germans that the war was almost over. Thus in the summer of 1940 it appeared that the war would be over by Christmas. By Christmas it seemed likely that the war would be over by the spring, etc.

Throughout the Lightning War the overwhelming majority of Germans (and most likely German scientists as well) believed that the war would soon end with victory. "Wonder weapons" were not needed. Army Ordnance was in no hurry to have weapons which would not be ready until after the war, and the scientists were under no great pressure to deliver them. Indeed, some of the scientists may well have believed that they were exploiting the Army and National Socialist government for their own ends by receiving both exemptions from military service and research support for something irrelevant to the war being waged.

Postwar claims by project scientists such as Werner Heisenberg that he had been convinced from the very beginning that Hitler would lose the war do not ring true.[688] Heisenberg may well have believed that in September 1939, and it is very likely that after the war he chose to remember his feelings and beliefs in this way. But it is very difficult to fathom that between the summer of 1939 and the autumn of 1941, when German armies inexorably attacked, conquered, and occupied most of Europe, Heisenberg could have believed anything other than what the overwhelming majority of his countrymen did: that the war would soon be over, with a German victory.

It is extremely difficult to judge the motivations of these German scientists during the first phase of the war. Any such judgment should really attempt the impossible and try temporarily to forget the Holocaust that began in the fall of 1941 and the unconditional surrender of German armed forces in the spring of 1945. During the Lightning War these scientists could and did work without great pressure, secure in the knowledge that the war would end with victory before any such nuclear weapons would be needed.

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The War Slows Down (November 1941–November 1942)

The German offensive ground to a halt short of Moscow in the winter of 1941–1942. The subsequent counterattack by the Soviet Red Army pushed back the German forces for the first time in the war and brought the Lightning War to a definitive end. The Japanese attack on Pearl Harbor and Hitler's subsequent decision to declare war against the United States decisively altered the balance of power and drastically changed the political context for uranium research. The Lightning War was now replaced by a war of attrition, where natural resources, industrial capacity, and manpower would determine the victor as the two sides tried to wear down each other. This was a type of warfare which the United States and the Soviet Union were in the best position to win, not Germany. But even though it was now clear that the war would last much

longer, most Germans still believed that they would eventually be victorious.

The responsible science policy officials in Germany and the United States independently reviewed their respective nuclear fission research programs with one fundamental question in mind: could nuclear weapons be manufactured soon enough to influence the outcome of the war from either side? Since Germany obviously needed a more efficient and better organized war economy, Army Ordnance asked its scientists for the first time whether they could expect nuclear weapons soon. American officials asked their scientists similar questions at almost the same time.

Although the hard scientific results were practically the same on both sides, the political, economic, and ideological perspectives were decisively different. In the United States Vannevar Bush, science policy advisor to President Roosevelt and head of the Office for Scientific Research and Development, decided that nuclear weapons might be produced in time, so that the Americans and their Allies *had* to try. In Germany Erich Schumann, head of the research section of Army Ordnance, decided that neither side could produce nuclear weapons in time, so that the Germans *must not* waste valuable resources and time by trying. But as will be discussed below, the meaning of even the word "try" is not as clear-cut as it might appear.

The response by the German uranium scientists can best be appreciated when compared both to its American counterpart and to the selling of the German rocket effort. The German uranium scientists' report was practically identical to that of their American counterparts. There was a great difference between Berlin and Washington, but it lay in perception of the decision-makers, not science. Whereas the American leadership assumed that it would take four to five years to wear down the Third Reich, German political, industrial, and military leaders reckoned with a war of only two or three years more—win or lose. Thus the same scientific results meant that in the United States nuclear weapons could win the war but in Germany could only divert resources away from the immediate war effort.

Schumann's negative decision on nuclear weapons can be better understood when it is compared with his previous decision in **1939** to support the rocket research of Walter Domberger and Wernher von Braun. When Schumann asked the nuclear scientists whether atom bombs could be manufactured in time to help win the war, they responded that nuclear weapons were certainly possible in principle, but in practice they would require such huge investments in manpower and resources that they were irrelevant to the conflict Germany was fighting.

In other words, the German uranium scientists never pushed nuclear energy or weapons. Moreover, their caution was very prudent. It was dangerous in the Third Reich to promise what could not be delivered. In contrast, when Schumann asked von Braun and his colleagues whether rockets could influence the outcome of the war, they merely replied that if the authorities would give them enough support, they would succeed.[689]

The different decisions reached in Berlin and Washington had corresponding consequences. The Germans pushed the rocket project to murderous extremes, using slave labor drawn from Soviet prisoners of war and concentration camp inmates. They swallowed up huge resources on the scale of what the Americans invested in the Manhattan Project, which was used ruthlessly if ineffectively against civilians in Belgium and England. The rockets caused terror, but were so inaccurate that they were a strategic failure and a waste of resources. Rockets became an effective weapon only after their accuracy was improved and they were coupled with nuclear weapons.[690]

Similarly, although the nuclear research programs in America and Germany had been comparable up to January **1942,** this situation quickly changed. Between January and June 1942, the Americans made the huge and obviously necessary investments of manpower, money, and materials and set off on the road to the atom bomb; the Germans did not. By the summer of 1942 the Americans had accomplished what the Germans had almost, but not quite achieved by the end of the war: a nuclear reactor which could sustain an energy-producing nuclear fission chain reaction

and the complete isotope separation of a tiny amount of uranium; in other words, the manufacture of a very small amount of nuclear explosives.

But this stark contrast between the German and Allied achievements should not obscure the fact that the German researchers simply carried on with their research at the laboratory level and continued to investigate all possible applications of nuclear fission, including military uses. In particular, despite the claims to the contrary made by Heisenberg and others after the war, the responsible authorities never made a decision or gave a command henceforth to research and develop only the "peaceful" applications of nuclear fission and make it useful for humankind.[691] Instead Schumann made a "non-decision." The research would not be shifted up to the level obviously necessary for the wartime manufacture of nuclear weapons, but the research program would also continue without change or interruption. Everyone agreed that the great future potential of nuclear fission justified further research, even if it would not decide the war.

Heisenberg's postwar claims that he and his colleagues had kept control of the research in their hands were either disingenuous or at best naive.[692] There is one compelling explanation why Heisenberg and some of his colleagues chose to exaggerate and misrepresent the amount of influence they held over the German uranium project: before they could claim that they had resisted Hitler by denying him nuclear weapons, they first had to convince their listeners that they had been in control.

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The War Is Lost (November* 1942–April *1945) The German catastrophe at Stalingrad decisively altered the German position yet again and simultaneously began the period of wonder weapons. German forces had captured Stalingrad with a great deal of effort, but were soon put on the defensive when the Red Army counterattacked and encircled the city. Although the German forces could have broken out, Hitler ordered them to stay and fight. After his men suffered a high rate of casualties, the German

commander nevertheless surrendered and took his remaining men into Soviet captivity. Very few of them ever returned to Germ a n ~ . ~ ~ ~

The surrender of the German forces shattered the myth of Hitler's infallibility. Perhaps most important, Josef Goebbels' propaganda machine, which had continued to claim that the conflict was going well, was forced to announce the "hero's d e a t h of hundreds of thousands of troops and suffered an irreparable loss of credibility. After Stalingrad the first real doubts about the outcome of the war took root in the German population, and most probably also among German scientists. These doubts were starkly reinforced by the continual deterioration of the war, as the front receded and the Allied bombing of Germany began in earnest.

The worse the war became, the louder and more desperate the search for wonder weapons which could turn the apparent defeat into sudden victory. Ironically, applied nuclear fission was one of the few recent scientific discoveries that were not considered. That possibility had already been investigated and discarded. Despite the ever-worsening state of the war, the bombing attacks that destroyed their institutes and threatened their lives, etc., the uranium scientists continued working with ever greater, if not desperate efforts.

There was no hint of defeatism, rather an enhanced determination to reach their relatively modest goals: building a nuclear reactor which could sustain a controlled chain reaction, and separating out small amounts of uranium isotope **235,** a nuclear explosive. Ironically, the German scientists involved with uranium assumed that they were ahead of their rivals in other countries in the race to harness nuclear fission. For them reaching their goal was also being the *first* to do *so,* an accomplishment which would have obvious professional rewards, no matter who won the war.

Moreover, the very goals of the German uranium project changed over time. Once Army Ordnance had effectively frozen the program at the laboratory level, the progress of the research was limited by the immediate effects of the war: scientists were called up; laboratories were destroyed by bombs; materials and

apparatus were in short supply or unavailable; and the scientists were forced to evacuate from the larger German cities to the relatively peaceful countryside. From the fall of Stalingrad to the end of the war the modest goal of the uranium project was to build a nuclear reactor which could sustain a nuclear fission chain reaction for a significant amount of time and to achieve the complete separation of at least tiny amounts of the uranium isotopes.

The threat of impending doom also provoked a perhaps natural human reaction among the scientists to lower their heads and bury themselves in their research. The closer the bombs and fronts came, the harder these scientists worked. By now none of them believed that their work could bring a German victory, although a few administrators did flirt with disaster by dangling such prospects before prospective patrons in the National Socialist state. Thus work on applied nuclear fission in Germany had none of the moral overtones which appeared in the United States after the successful atom bomb test in the New Mexico desert and everywhere else after the attack on Hiroshima. Moreover, the postwar claims by Heisenberg and others, that this moral question dominated their thinking during the war, also do not ring true.[694]

But it is not enough merely to investigate the *scientists'* motives. Why was the National Socialist leadership willing to continue to support their work? For years, many of the uranium scientists, together with allies in industry and the Armed Forces, had tirelessly stressed with considerable success the military importance of modern physics in general and of nuclear fission in particular. Some of the scientists did begin to downplay nuclear weapons in the last years of the war, during the desperate search for wonder weapons, but the various military and governmental officials had hardly forgotten their earlier lesson. The National Socialiststate and Armed Forces were more than willing to encourage the uranium project—so long as it did not interfere with the war effort—because they recognized that such powerful new weapons would be very useful after the war.

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Purgatory (April 1945–1953) The unconditional German surrender in May 1945 was followed by the occupation of Germany by the four victorious powers: Britain, France, the Soviet Union, and the United States. This postwar period is very important for an understanding of the interaction between German science and National Socialism because the manner in which German scientists now dealt with Hitler's legacy reveals a great deal about how these scientists had perceived their work during the Third Reich. Although most scientists were happy that the war was finally over, they were ambivalent about what lay ahead. The Allies' announcement that they would strictly control scientific research and both denazify and demilitarize Germany threatened the scientists' future.

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Denazification The military effort against Germany had been portrayed during World War II as a struggle against the evil of National Socialism. But after the fall of the Third Reich, the victorious allies could only agree on their *intention* to purge public life entirely of National Socialist influence. From the very beginning the four powers' fundamentally distinct perceptions of the causes and supporters of National Socialism created grave differences with regard to the timing and scope of denazification.[695] In the Soviet zone denazification played an important role in the construction of a new social order based on the Soviet model. In the western zones denazification was essentially restricted to a comprehensive political purge of personnel and left the economic sphere basically untouched. Finally, whereas denazification was a pillar of American occupation policy, it was much less important for the more pragmatic British and the French.

The occupying forces initially ran the denazification themselves, often with catastrophic consequences for public administration and the economy. Mere membership in the NSDAP or an ancillary organization could be grounds for dismissal pending denazification, a policy which had the predictable effect of forcing

solidarity in the face of this blanket threat—including among scientists. However, denazification was quickly turned over to the Germans themselves, both in order to save money and because only Germans were in a position to make the necessary differentiated judgments of conduct under National Socialism. Denazification was now recast as a judgment of personal responsibility, not mere membership in a political organization, and was transformed into a "Factory for Fellow Travelers."[696]

When the four powers decided to wrap up denazification by early 1948, only part of the German population had been investigated. Many entrepreneurs, bureaucrats, and professionals were temporarily exempted from the process in order to facilitate the reconstruction of Germany. Other individuals with money or influence managed to have their cases delayed or appealed. Denazification was thus effectively stopped at a point where most of the "little Nazis" had been through the process, but the big fish escaped relatively unscathed. In retrospect, denazification seems to have been doomed to failure. Without the agreement and cooperation of the Germans, a political purge like denazification could be administratively ordered from above, but not effectively carried out.[697] Of course, this statement holds just as well for the purge of German society by the National Socialists.

Since the western zones were on their way to becoming democracies, their politicians had to cater to the majority will, which was hardly enthusiastic about denazification or self-critical with regard to conduct during the Third Reich. The universities and research institutes were burdened with anti-democratic elements which long outlived National Socialism. This ideological baggage was a serious problem, for democracy can hardly work well when a large portion of those voting are essentially anti-democratic.

Perhaps the fundamental question is the *meaning* of denazification: did the allies intend to neutralize the threat of a National Socialist revival, or to punish previous conduct? In any case, scientists and in particular physicists were nothing special in this regard. Just like scientists had been subjected to the 1933 National

Socialist purge because they were part of the civil service, if they wanted an academic career after the war, then they had to endure the general denazification of the universities.

The denazification which began in 1945 was as much of a political purge as was the nazification that had started in 1933. No one asked in 1945 whether these scientists were good physicists or qualified teachers: they were judged by *political* criteria. Far fewer physicists were purged after 1945 than 1933. There was a severe shortage of physicists in Germany after World War II, so that pragmatism is one part of the explanation. This difference is also due in part to the fact that the dismissals and expulsions of 1933 were sometimes *racial* in nature, a criterion not employed after 1945. But this factor does not suffice to explain the stark contrast between 1933 and 1945.

Apologia can help illuminate this process. According to the usual postwar party line of the established German physics community, German physics remained apolitical during the Third Reich but had fallen behind American science because the National Socialists had ruined German science. However, there was a contradiction here, for the same scientists also asserted that the German physicists who were in place after the dust of denazification had settled were of high quality. Obviously if the National Socialists ruined physics, then some of the many physics professors who began their careers after 1933 and held positions after 1949 should be incompetent political appointees. Conversely, if the postwar physics community was of such high quality, then how could the Third Reich have ruined German physics?

In fact, when attrition due to aging and the postwar employment of physicists by the victorious powers are taken into account, the very small group of physicists purged after 1945 is practically equivalent to the equally small number of former adherents of *Deutsche* Physik. It is no surprise that denazification barely touched physics—it barely touched almost everything—but that in no way explains why only *Deutsche* Physik was purged. No other subset of German physicists, including former SS physicists, was punished so thoroughly and zealously.

A crucial portion of the new party line ran as follows: the physicists who had rejected *Deutsche* Physik, almost no matter what else they had done during the Third Reich, were now practically portrayed as resistance fighters; while the former supporters of *Deufsche* Physik, almost no matter what else they had done under Hitler, were branded "Nazis." But the latter were hardly the only physicists who had collaborated with National Socialism.

The political charges levied against the former followers of Lenard and Stark were usually accompanied by often unfair criticism of their scientific ability. In fact, although they were certainly not the best German physicists, they were also not all incompetents. Thus the final piece of postwar apologia fell into place. Whereas the competent and talented "real" physicists had resisted *Deutsche* Physik and thereby Hitler, only the followers of Lenard and Stark, who hardly deserved the name of scientist, had served National Socialism.

After the war the former followers of Lenard and Stark naturally tried to defend themselves when attacked and to avoid part or all of the punishment headed their way. They hoped to hold on to their positions and pensions, and to avoid fines or, in the most extreme cases, imprisonment. The occupying powers in turn were most interested in the utilitarian value of German physics, not in denazification. Just like influential actors in the National Socialist state had sided with modern physics because it promised to further their political and military goals, the occupying powers chose to back the same scientists because they might be able to help win the Cold War.

But why did the established physics community consciously create and consequently use Deutsche Physik as a scapegoat? Heisenberg, who had never joined a National Socialist organization and in postwar Germany enjoyed the status of a "victim of the Nazis," had a great deal of influence as the author of "whitewash certificates," written testimonials designed to help an individual pass unscathed through the process of denazification. Heisenberg, for instance, helped the convinced National Socialist physicist Pascual Jordan[698] and the SS physicist Johannes Juilfs[699] receive

university appointments. In contrast, when Johannes Stark was tried for denazification, Heisenberg went out of his way to condemn his elderly colleague.[700]

By asserting that only *Deutsche Physik* had been politicized under National Socialism, the established physics community could kill several birds with one stone. First, they appeared to be participating wholeheartedly in the denazification of their profession, to be putting their own house in order. Second, they managed to avoid the purge or punishment of the overwhelming majority of their colleagues. Finally, by coupling scientific incompetence with service for the National Socialists, both of which they restricted to the *Deutsche Physik*, they tacitly asserted that their profession was inherently apolitical and a trustworthy servant worthy of generous support.

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Demilitarization When the occupying powers called for denazification, it was in the context of denazification *and* demilitarization. Physics and science had certainly been militarized during the Third Reich, indeed this transformation was an inevitable consequence of the strategy the established physics community had employed in order to defeat *Deutsche Physik*. However, German demilitarization proved just as ambiguous as denazification. Did the allies intend to neutralize German militarism or to punish previous militarism? To stop all German contributions to militarism or to demilitarize the German nation?

The demilitarization of German science was fundamentally and perhaps inevitably hypocritical.[701] Each of the four victorious powers hunted down German scientists and engineers as intellectual reparations. The Soviets called their researchers "specialists," a fitting name which underscored how the former allies perceived and treated their former enemies. The armorers of the National Socialists were now judged by what they could do for their new employers, not for what they had done for Hitler.

German specialists contributed significantly to the postwar science of all four victorious powers, although these countries have

only grudgingly acknowledged that Germans worked for them, let alone that these specialists played an important role. Work for a foreign power obviously had its disadvantages, especially if it was coerced, but these researchers benefited as well. Their working conditions and compensation were relatively good, they could continue their work at a time when such research was often banned in Germany, and they did not have to go through denazification or justify their past political conduct.

Denazification and demilitarization had an important effect on German science, but not necessarily what had been intended. After World War II the victorious powers as well as the two new German states were in complete agreement with their scientists. If physics was useful, and what is more useful than powerful new weaponry, then physicists would be used. Physicists were seen first and foremost as tools, and tools do not need to be denazified or demilitarized. Physics in both the East and the West was materially rebuilt in order to serve one of the *two* sides in the Cold War, By the fifties, German physics in general was a solid and well-integrated, if subordinate part of the international scientific community.

Nazification and militarization had an unforeseen long-term effect on German science: it provided a push towards the "Big Science" so typical of the post–World War II period. Academic scientists were compelled to work in interdisciplinary research teams and closely with the government, the Armed Forces, and German industry. *On* the other, more negative side, a generation of physicists had been lost through the neglect and politicization of the education system as well as the terrible war. Science also suffered during the destructive chaos at the end of the war and immediate postwar period.

The overwhelming majority of scientists passed through denazification unscathed, but with the need to justify their previous work under Hitler. The denazification and demilitarization of German scientists and engineers had a profound effect on their self-image and postwar myths. Service for a victorious power—whether voluntary or not—retrospectively justified previous work

for the National Socialists and facilitated apologia.[702] After all, how could a researcher's work during the Third Reich be criticized, when the Soviets or Americans wanted these same scientists and engineers to continue their work in the Soviet Union or the United States?

Did the Germans *try* to build atom bombs? If under *try* one understands the obviously necessary investments worth billions of dollars, the construction of huge factories, the development of suitable detonation devices, etc., then they *did not* try. But if under *try* one understands the manufacture of substances which were known to be potential nuclear explosives, and indeed the efforts to manufacture them as quickly and on the greatest scale possible without hindering the war effort, then they *did try*. The question perhaps most often asked, did the Germans *try to build an atom bomb, has no simple answer.*

9

The Crucible of Farm Hall

Why didn't Hitler get the bomb? Traditionally this question has been answered by scientists and historians alike in a black-or-white fashion. Either the team of German scientists were incompetent National Socialist collaborators or they had resisted Hitler by denying him nuclear weapons. Both claims are problematic. Once again, the truth lies somewhere in the middle.

One of the most controversial parts of the history of "Hitler's Bomb"[703] is the long-running debate over the mysterious and elusive "Operation Epsilon" recordings. These conversations, which have only recently been released, were recorded immediately after the war and without the knowledge of ten German scientists detained after the war at Farm Hall, an English country house near Cambridge.[704] General Leslie Groves' Now It Can Be Told, the immodest memoirs of the former head of the American atom bomb project, revealed in 1962 that the conversations of the Farm Hall scientists had been recorded, and that transcripts of these conversations existed.[705] But Groves provided only brief excerpts from the transcripts. In retrospect, the naturalized Ameri-

Farm **Hall, 1945.** (From **the** National **Archives** and **Records** Services.)

can physicist Samuel Goudsmit apparently used the Operation Epsilon report when writing **his 1947** book *Alsos*.[706]

Samuel Goudsmit and the Alsos Mission came to Germany in the wake of the advancing Allied armies in order to determine and neutralize the threat of German nuclear weapons. When the investigation was finished, the Alsos Mission had seized or destroyed most of the material and scientific reports it found and arrested ten German scientists: Erich Bagge, Kurt Diebner, Walther Gerlach, Otto Hahn, Paul Harteck, Werner Heisenberg, Horst Korsching, Max von Laue, Carl Friedrich von Weizsacker, and Karl Wirtz. They were brought to Farm Hall after brief stops in France and Belgium.

Since all but one of these scientists had been active in the German uranium project, they rightly assumed that they had been arrested because of their research. Ironically, they also falsely assumed that they were ahead of the Allies. Two concerns preoc-

Samuel Goudsmit, date unknown. (Courtesy of the AIP Emilio Segrè Visual Archives.)

cupied the guests: they were troubled by their inability to communicate with the families they had been forced to leave behind and they had no idea when or if they could go home.

In time, the Farm Hall detainees also confronted themselves with five fundamental questions:

1. Was I a "Nazi"?
2. Did we know *how* to make atom bombs?
3. Could Germany under National Socialism have produced nuclear weapons?
4. Did we *want* to make atom bombs?
5. What about our future?

Erich Bagge, 1945 at Farm Hall. (From the National Archives and Records Services.)

Here we will examine these questions and the answers these scientists reached in the context of the Third Reich and postwar Germany. Unless otherwise designated, all of the comments made by the Farm Hall detainees were private conversations, not statements to their jailers. Although the ten German scientists could have suspected that they were being monitored, it appears that they did not.

Kurt Diebner, 1945 at Farm Hall. (From the National Archives and Records Services.)

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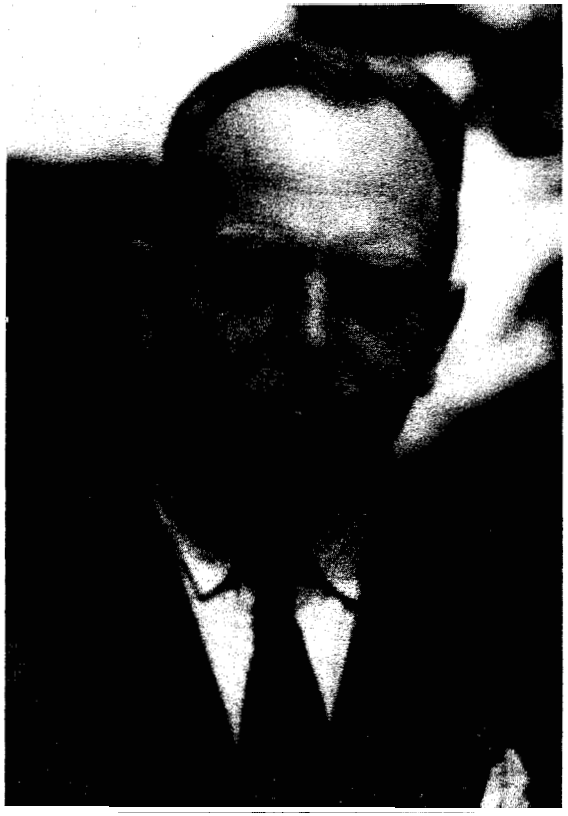
Was I a "Nazi"? The first question to trouble the scientists was whether they bore personal responsibility for part or all of the excesses of National Socialism. In other words, who were the "Nazis" among them? Only Erich Bagge and Kurt Diebner had been members of the National Socialist Party, but only Otto Hahn, Werner Heisenberg, and Max von Laue had not joined some



Otto Hahn, 1945 at Farm Hall. (From the National Archives and Records Services.).

National Socialistorganization.[707] Diebner, a civil servant in Army Ordnance, had held far more responsibility than his younger colleague Bagge, so that it was no surprise that he acted defensively at Farm Hall.

First, Diebner said that he only stayed in the Party because if Germany had won the war, then only NSDAP members would have been given good jobs. Next he argued that he had suffered under National Socialism. He had never voted for Hitler during

Walther Gerlach, 1945 at Farm Hall. (From the National Archives and Records Services.)

the Weimar Republic. In 1933 he became a Freemason in opposition to National Socialism. Once this information became known, Diebner claimed, he had experienced difficulties, at the university institute he was affiliated with and at Army Ordnance, where his promotion to civil servant was delayed. Furthermore, Diebner claimed that he had prevented the German looting of the physics institute in Copenhagen[708] and the arrest of Norwegian colleagues

during the war, thereby tacitly coupling the responsibility he had as a Party member in Army Ordnance with the ability to restrain National Socialist excesses.[709]

Diebner's colleagues at Farm Hall were not *so* understanding. Otto Hahn pointedly remarked that being in the NSDAP had not done him any harm. When the scientists subsequently were considering drafting a written statement which would claim that their group had taken an "anti-Nazi" stance during the Third Reich, both Walther Gerlach-one of Diebner's few defenders—and Werner Heisenberg said that they could not conscientiously sign any such statement if Diebner had signed it as well. Diebner himself had no illusions about his future. He feared that when he returned to Germany, everybody would label him a Party member.[710]

For his part, Erich Bagge argued that he and the rest of the young assistants had been pressured into joining the University Stormtroopers, and that he had entered the NSDAP unknowingly. When someone asked his mother in the autumn of **1936** whether Bagge had wanted to join, she thought that it was a good thing and sent in his name. A few months later Bagge received his Party book which falsely said that he had been in the Party since 1 May 1935 and had sworn an oath to Adolf Hitler.[711]

Bagge generally was treated much more sympathetically by his colleagues than was Diebner. Heisenberg explained to a visiting English colleague and friend that Bagge had come from a proletarian family, which was one of the reasons why he joined the NSDAP, but that Bagge had never been a "fanatical Nazi." However, Gerlach rejected the suggestion that anyone had to join the Party, thereby stirring **up** considerable animosity. Once Gerlach had left the room, Bagge remarked that Gerlach had been protected from political attacks because he knew Goring personally and had a brother in the SS. Indeed Gerlach's jailers believed that he was particularly concerned to distance himself from National Socialism. Perhaps, they speculated, he had a guilty conscience.[712]

But there was more to being a "Nazi" than Party membership. The British wardens detected the lingering effect of National Socialist ideology. Bagge expressed grave concern at the fact that Moroccan French soldiers had been billeted in his house. Bagge was not alone. When the detainees were lent a copy of *Life* magazine containing articles on the atom bomb and a number of photographs of scientists, von Weizsacker remarked that of course they were mostly German, even though this statement was in fact untrue. The British commander reacted by reporting the conceit of the Germans who, with the possible exception of von Laue, still believed in the Master Race.[713]

Finally, the scientists expressed very different opinions about the worst excesses of the National Socialists. Bagge argued that if the Germans had put people in concentration camps during the war—he did not do it, knew nothing about it, and always condemned it when he heard about it—and if Hitler had ordered a few atrocities in concentration camps during the last few years of the conflict, then these excesses had occurred under the stress of war. In contrast, Karl Wirtz stated flatly that he and his countrymen had done unprecedented things. In Poland Jews were murdered. The SS also drove to a girls' school, Wirtz added, fetched out the top class and shot them simply because the Polish intelligentsia was to be wiped out. Just imagine, he asked his colleagues, if the Allies had arrived in Hechingen, the small town where Wirtz's institute had been evacuated during the last years of the war, driven to a girls' school and shot all the girls! That's what "we" Germans had done, he said.[714]

Perhaps the most interesting aspect of this moral question, who was a "Nazi"? is that this discussion practically vanished once these scientists heard the news of Hiroshima. Other questions now preoccupied their minds.

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Did We Know How to Make Atom Bombs? When Goudsmit (and the others who have subsequently taken up his arguments) asserted after the war that Heisenberg did not understand how an atom bomb worked,[715] there were three parts to his supposed lack of understanding: (1) Heisenberg had not realized that plutonium

was fissionable material suitable for a nuclear explosive; (2) that nuclear weapons used fast-neutron chain reactions; and (3) only relatively small amounts of fissionable material were needed. Put these three together and you get Goudsmit's claim that the Germans in general and Heisenberg in particular mistook the nuclear reactor they were building for an atom bomb.

There is ample evidence that Heisenberg understood during the war that uranium 235 and plutonium were fissionable materials suitable for nuclear explosives and that such nuclear explosives used fast-neutron chain reactions.[716] The Farm Hall transcripts also corroborate Heisenberg's consistent understanding of these two areas.[717] All that was left was the matter of critical mass for a bomb.

Fortunately, a comprehensive February 1942 Army Ordnance report on the German uranium program includes the statement that the critical mass of a nuclear weapon lay between 10 and 100 kilograms of either uranium 235 or element 94.[718] There was no mention of who had made the estimate, and there was no reference to a scientific report which contained the calculation of the estimate. It seems most likely that Heisenberg would have been entrusted with this task, but he may have delegated the assignment, like he did many others.

Arguably it does not matter who made the estimate of critical mass or how it was made. German Army Ordnance decided in January or February of 1942 not to mount the industrial-scale effort which would have been needed to build nuclear weapons. The important question is: was the Army decision based on accurate information, comparable to that used in the United States? Or did German scientists mislead their military by exaggerating the difficulty of building the bomb?

In fact the German estimate of critical mass of 10 to 100 kilograms was comparable to the contemporary Allied estimate of 2 to 100. Thus the decision made by Army Ordnance was based on accurate information. The German scientists working on uranium neither withheld their figure for critical mass because of moral scruples nor did they provide an inaccurate estimate as the result of a gross scientific error. Instead the Army decision should be

attributed to the differences in context between the Germans and the Allies: for example, how long each of the two sides assumed the war would last, the availability of raw materials and manpower, and the effect of the fighting on the war economy.[719]

The Operation Epsilon transcripts tell us what these scientists knew about nuclear weapons. On 6 August 1945 the detainees learned of the detonation of an American atom bomb.[720] At first they did not believe their English wardens, but after hearing the official announcement later in the evening they realized that the news was true. Hahn immediately asserted that the Allies must have managed to separate the isotopes of uranium, thus producing pure uranium 235, a nuclear explosive. But his colleague Paul Harteck, who used centrifuges during the war in an effort to achieve uranium isotope separation, reminded Hahn that another nuclear explosive, the transuranic element 93, could be manufactured in a nuclear reactor.[721] They did not yet know how the Allies had built their bomb.

This exchange also illustrates one reason why the brief excerpts from the Farm Hall recordings published by Groves have been misinterpreted. Even though all concerned had already demonstrated their knowledge of the fact that 93 decays within 2.3 days to a stable element 94 (plutonium), in their informal conversation the Germans usually used the term 93. The explanation for this apparent sloppiness in terminology may be traced back to the fact that during the war Kurt Starke, a young scientist working in Hahn's lab, had succeeded in separating out and analyzing 93, but though they were certain element 93 would produce 94, neither he nor his senior colleague had managed to produce plutonium.[722]

Heisenberg was one of the most skeptical scientists with regard to the Allied atom bomb. At first he did not believe a word of the report, but hastened to add that he could be wrong. Then he made a curious remark: it was perfectly possible that the Americans had ten tons of enriched uranium, but not ten tons of pure uranium 235.[723] Hahn immediately questioned Heisenberg's statement. During the war the physicist had told Hahn that only a

Carl Friedrich von Weizsacker, **1945** at Farm Hall. (From **the National** Archives and Records Services.)

relatively small amount of uranium 235, 50 kilograms, was necessary; why was Heisenberg now saying that tons were needed?

Heisenberg responded by saying that for the moment he would rather not commit himself. He did say that if the bomb had been made with uranium 235, then the Germans should be able to work out exactly how it had been done. It just depended on the order of magnitude, whether it was done with 50,500, or 5,000

Karl Wirtz, **1945** at Farm Hall. (From the National Archives and Records Services.)

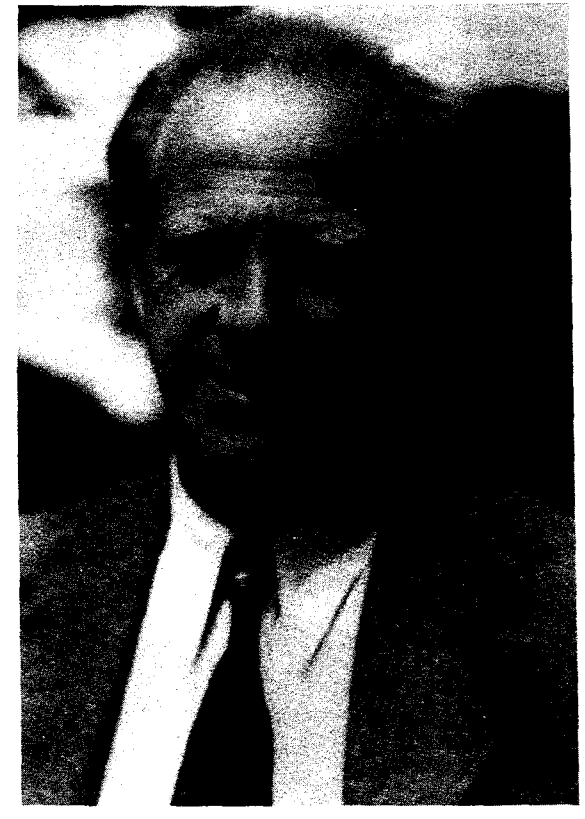
kilograms of fissionable material. He went on to say that the Germans could at least assume that **the** Americans had some method of separating isotopes, even if the scientists at Farm Hall did not know what that method was.[724] Heisenberg did return to this question of critical mass before he left Farm Hall.

Carl Friedrich von Weizsacker and Karl Wirtz debated whether the Americans had used plutonium for their nuclear

explosive.[725] Von Weizsäcker in fact had brought the potential use of transuranic elements as nuclear explosives to the attention of Army Ordnance in 1940.[726] Wirtz was skeptical, but not because he was ignorant of what needed to be done to manufacture plutonium. Von Weizsäcker agreed. The Allied scientists who had captured them in Germany had showed much more interest in isotope separation, so that von Weizsäcker assumed that they had used the same method.[727]

The official announcement at 9:00 in the evening stunned the Germans because they now realized that the news was genuine. Harteck asserted that the Allies had managed to make a bomb either by using electromagnetic uranium isotope separation on a large scale—and of course the Americans did use this process along with other methods—or some photochemical isotope separation process.[728] Harteck's suggestion illustrates another reason why the Farm Hall transcripts have been misinterpreted. Although these scientists were aware that transuranic fissionable material could be manufactured in a nuclear reactor, most of them now assumed that the Americans probably used isotope separation to make uranium 235, and not a nuclear reactor to make transuranics, in order to make their nuclear explosives.

Thus Hahn remarked that the Allies seemed to have made a nuclear explosive without first perfecting the nuclear reactor.[729] This assumption was accepted by many of his colleagues as well, apparently because it allowed them to hold out hope (for at least a little while longer) that they had outperformed their British and American competitors in at least one area. Considering the newspaper accounts of the enormous scale and cost of the Allied effort, Harteck speculated that they must have used a huge number of mass spectrographs, since if they had had a better method, then it would not have cost so much. Even though Horst Korsching and Wirtz, both younger physicists with experience in isotope separation research, doubted that spectrographs had been used, Heisenberg and other senior scientists accepted Harteck's theory. This suggestion was plausible because the Germans knew that this



Werner Heisenberg, **1945** at **Farm** Hall. (From the National **Archives** and Records **Services.)**

technology was both available and could produce pure uranium 235.[730]

When they were alone, Hahn pressed Heisenberg again on the actual size of the atom bomb. If the Allies had set up a hundred thousand mass spectrographs, Heisenberg said, then they could produce 30 kilograms a year of uranium 235. Hahn responded by asking whether the Americans would need as much as that for a

bomb? Heisenberg's answer to Hahn's question is illuminating: yes, he thought that the Allies would certainly need that much fissionable material, but quite honestly, he told Hahn, he had never worked it out.[731]

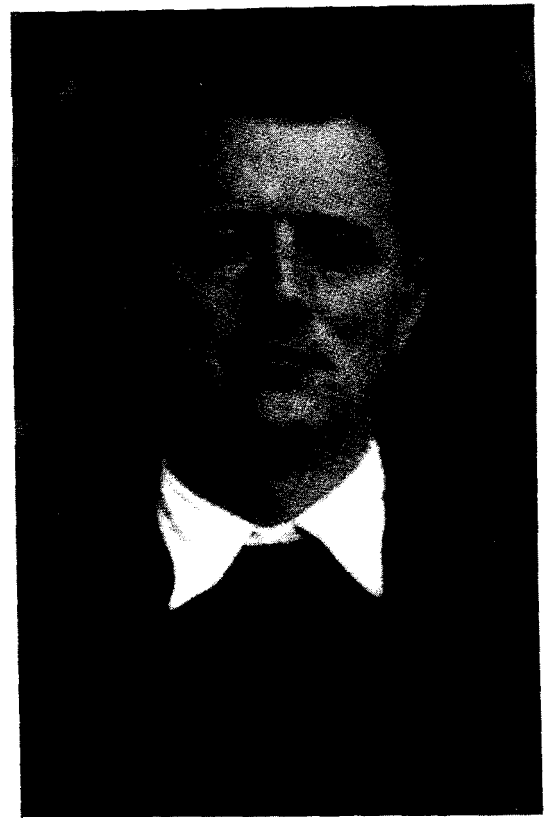
Hahn then asked how the bomb exploded? Heisenberg first responded with a rough argument using the mean free path of a fast neutron in uranium 235 to get an improbably large estimate of the radius of critical mass: 54 centimeters, which would mean a ton of 235. But he immediately went on to say that the Allies could have done it with less, perhaps a quarter of that quantity, by using a fast neutron reflector or tamping around the critical mass. In 1943 the young German physicist Karl-Heinz Höcker had worked out the theory for a nuclear reactor using a lattice of uranium spheres, calculating both the diffusion of fission neutrons in a spherical mass of fissionable material and the probability that the surrounding spherical layer of moderator would reflect neutrons back into the sphere. Moreover, it is known that Heisenberg followed Höcker's work

Hahn also asked Heisenberg how the Americans could have taken such a large bomb in an aircraft and be certain that it would explode at the right time? His physicist colleague replied that the bomb could be made in two halves, each of which would be smaller than the critical mass. The two halves would then be joined together to ignite the chain reaction.[733]

In response to a subsequent question from Gerlach, Heisenberg also speculated that perhaps the nuclear explosive was merely enriched uranium, some mixture of the isotopes 235 and 238.[734] Heisenberg was certainly aware that pure 235 would be better than any mixture, and in 1939 he had told Army Ordnance that pure 235 was needed for such an explosive.[735] He was apparently so skeptical at Farm Hall that the Allies could have succeeded in total uranium isotope separation that he was willing to consider the possibility of using enriched uranium in an atom bomb—a strategy which would not have worked.

On 8 August 1945 the detainees read in the newspapers that the Americans had used "pluto" in a bomb, and there was immediate speculation as to whether this new element was element 94. This newspaper account provoked another illuminating remark from Heisenberg. The Germans had not even attempted to research fast neutron reactions in 94 because they did not have this element, and saw no prospect of being able to obtain it.[736]

The following day the newspapers mentioned that the atom bomb weighed 200 kilograms, prompting a conversation between Harteck and Heisenberg. Harteck asked whether this was the true



Paul Harteck, 1945 at Farm Hall. (From the National Archives and Records Services.)

weight of the bomb or whether the Americans were merely trying to bluff the Russians. This latest piece of information worried Heisenberg, because it suggested that his estimate of critical mass was too large. He decided to take another look at the problem.

An important part of his previous calculations was the multiplication factor of fission neutrons: how many neutrons would each nuclear fission release? Heisenberg had been using a conservative multiplication factor, 1.1, the value they had observed during their own uranium machine experiments. When Heisenberg substituted a factor of 3, he found that the radius of the critical mass was comparable to the mean free path, roughly 4 centimeters, which made the critical mass considerably smaller.[737]

Harteck and Heisenberg then reconsidered the possibility of using 94 as a nuclear explosive. Heisenberg pointed out that the use of 94 would mean that the American uranium machine had been running since 1942. Moreover, the chemical separation of 94 from uranium would be fantastically difficult. Harteck, an accomplished physical chemist, agreed with Heisenberg that it was highly improbable that the Allies had succeeded with 94.

The detained scientists continued to discuss how their Allied colleagues had managed to manufacture an atom bomb. Eventually Heisenberg was asked to give a lecture on the subject. Such talks were common at Farm Hall. The detainees entertained themselves and kept busy by holding an informal series of scientific lectures. The presentation, which was punctuated by questions and lively debate, took place on 14 August 1945. By this time, Heisenberg asserted that they (in other words, he) understood very well how the atom bomb worked.[738]

Heisenberg now assumed that 2 to 2.5 neutrons were released per fission. He used a diffusion equation for neutron density, assumed that there was a neutron reflector surrounding the fissionable material, and calculated a critical radius of between 6.2 and 13.7 centimeters for the atom bomb. Heisenberg was still dissatisfied, because the newspaper article claimed that the whole explosive mass only weighed 4 kilograms, but the sphere with a 6.2 centimeter radius would weigh 16.

In his Farm Hall lecture Heisenberg went on to discuss a possible detonation mechanism for the bomb. Two hemispheres, each slightly smaller than the critical mass, would be placed in an iron cylinder, actually a gun barrel, such that one hemisphere would be shot at the other. Indeed the Hiroshima bomb did use such an arrangement. Finally, Heisenberg speculated on the effect of the nuclear blast. The first 10 meters of air surrounding the bomb would be brought to a white heat. The surface of the uranium sphere would radiate about 2,000 times brighter than the sun. It would be interesting, he added, to know whether the pressure of this visible radiation could knock down objects.

Four days later, one of the English officers showed the detained scientists the British White Paper on the atom bomb, an official publication which effectively cut off all further speculation by the Germans on the technical aspects of Allied nuclear weapons. Apparently the wardens at Farm Hall were now confident that the Germans had revealed everything they knew about nuclear weapons. Heisenberg now noted that the physics of it was actually very simple. It was an industrial problem and it would never have been possible for Germany to do anything on that scale.[740] Thereafter the Germans spent their time worrying about their future and trying to get back home.

The transcripts of Operation Epsilon also provide additional evidence for dismissing the postwar claims by Heisenberg and others that Bothe's "mistake"—he had measured the diffusion length of thermal neutrons in carbon-slowed down the German effort by diverting their efforts away from the use of graphite as neutron moderator towards heavy water.[741] There is absolutely no mention of graphite as a moderator in the Farm Hall transcripts. Only after Heisenberg and others had read the official American publication[742] on the atom bomb, and thereby learned that the Americans had used graphite, did they begin to use Bothe as a scapegoat, the one German scientist whose error had handicapped their efforts. In fact Army Ordnance had considered using graphite as a moderator, but chose heavy water because it appeared less expensive.[743]

The postwar accounts by Groves and Goudsmit of Farm Hall are sometimes distorted. Statements from the Operation Epsilon transcripts are often taken out of context and other remarks, which would make clear what these Germans did and did not know, are passed over in silence. Goudsmit describes how the detainees debated what the "plutonium" mentioned in the newspaper accounts meant, but does not also say that the Germans had been discussing the transuranic elements 93 and 94 and their properties throughout their captivity.

The question for Heisenberg, Hahn, Harteck, and the rest of their colleagues was whether the Allied plutonium was what they knew as 94, and subsequently the Germans reached a consensus that it was. Similarly, Goudsmit tells us that Heisenberg and the others speculated whether perhaps the Allies had used the radioactive element protactinium as an explosive, but without making clear that this speculation was in the context of either uranium 235, or plutonium, or protactinium as an explosive.[744]

Groves is sometimes unfair in his handling of Heisenberg. He faithfully reproduces Heisenberg's statement admitting both ignorance of how the Allies succeeded and the disgrace he felt that they did not know how their British and American colleagues had done it. But Groves does not tell the reader that Heisenberg's statement is preceded by a long and surprisingly accurate speculation on exactly how the Allied atom bomb worked.[745] Finally, Goudsmit makes several claims that are simply wrong and for which there is no supporting evidence in the Farm Hall transcripts: (1) that the Germans believed that the Americans had dropped a complete nuclear reactor on Hiroshima; (2) that at first the Germans had not understood that the plutonium used as an explosive is produced in the reactor; and in short (3) that the Germans had failed to realize that there is a difference between a reactor and an atom bomb.

But the most controversial technical aspect of the Farm Hall recordings has always been Werner Heisenberg's apparently confused conception of an atom bomb. His understanding that fast neutron chain reactions in pure uranium 235 and plutonium constituted nuclear explosives had been demonstrated during the war

and is reinforced in the Operation Epsilon report as well. The one unclear point is critical mass of the weapon: how much was needed for the bomb to go off?

In contrast to Groves and Goudsmit, both R. V. Jones' and Charles Frank's accounts from memory of the Farm Hall recordings were quite accurate. The British scientist Jones remembered Heisenberg's first "back-of-the-envelope calculation" for critical mass, whereas his countryman Frank in turn remembered Heisenberg's subsequent sophisticated calculation using a "rather polished version of diffusion-and-multiplication theory."[746]

During the war Heisenberg most probably made a rough estimate which was comparable to contemporary Allied estimates, but more importantly was good enough for German Army Ordnance to decide not to attempt the industrial-scale production of nuclear weapons. At the time the German researchers had been unable to separate out uranium 235 or to sustain a chain reaction in a uranium machine. Even this relatively small critical mass must have appeared out of reach until after the war.[747] Heisenberg himself admitted at Farm Hall that he had never made a more precise calculation of critical mass, not because he was incapable of it, but because there was no point. R. V. Jones has even speculated that Heisenberg made an accurate calculation in 1942, but had forgotten it by the summer of 1945.[748]

Groves' and Goudsmit's assessments were probably colored by their desire to "prove" that the Germans had been incompetent and thus saw in these transcripts what they wanted to see. But they also called Heisenberg's scientific abilities into question for a specific reason: to explain why the Germans did not make an atom bomb. If the Farm Hall recordings make anything clear, it is that Heisenberg's temporary confusion with regard to critical mass had nothing to do with the scale, tempo, or success of the German efforts to harness the military applications of nuclear fission. Anyone who wants to know why the world never saw National Socialist nuclear weapons will have to look far beyond Farm Hall.

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Could Germany under National Socialism Have Produced Nuclear Weapons? It is important to separate the question, did the German scientists *know how* to make atom bombs, from two other questions: (1) *could* the Third Reich have manufactured nuclear weapons before the end of the war; and (2) did these scientists *want* to make atom bombs for the National Socialists? The press reports of the attack on Hiroshima and Nagasaki touched off a heterogeneous reaction among the scientists, a reaction which moreover changed over time.

Karl Wirtz was one of the few detainees to simply and flatly say that he was glad that they did not have the atom bomb.[749] Otto Hahn's reaction was similarly unambiguous: he would have sabotaged the war effort if he had been in a position to do *so*. When he was privately told the news before the rest of his colleagues, it shattered his composure. He told his warden that he had originally contemplated suicide when he realized the destructive potential of his discovery of nuclear fission, and that he now felt personally responsible for the deaths in Hiroshima. Several alcoholic drinks were required to calm Hahn down sufficiently to let him rejoin his colleagues.[750]

The reaction of Walther Gerlach, who had been in charge of the uranium research during the last eighteen months of the war, was quite different. He went up to his bedroom and began to cry, despite the efforts of Paul Harteck and Max von Laue to comfort him. Gerlach's British captors saw him acting as a defeated general and contemplating suicide. Hahn subsequently asked him why he was *so* upset. Was it because Germany did not make an atom bomb or because the Americans could do it better than the Germans?[751]

Gerlach insisted that he was not in favor of inhuman weapons like the atom bomb. In fact he had been afraid of it and had not believed that the bomb could be made so quickly. But he was depressed because the Americans had demonstrated their scientific superiority. He realized during the last years of the war that the bomb would eventually be developed, and was determined to

exploit the potential of uranium for Germany's future. Thus he told Colonel Geist, Minister of Armaments Albert Speer's right-hand man, and Fritz Sauckel, Plenipotentiary for Labor Development, that he who could threaten the use of the bomb could achieve anything.[752]

Heisenberg later explained to Hahn that Gerlach was taking the news so badly because he was the only one of the Farm Hall scientists who had really wanted a German victory. Although Gerlach had known and disapproved of the crimes of the "Nazis," he felt that he was working for Germany. Hahn replied that he, too, loved his country, and that as strange as it might seem, that was why he had hoped for her defeat.[753] Gerlach himself went further, tacitly criticizing the Allies by arguing that, if Germany had had a weapon which would have won the war, then Germany would have been in the right and the others in the wrong. Moreover, conditions in Germany were not now better than they would have been after a Hitler victory.[754]

Gerlach was not the only one to criticize the Allies. Von Weizsacker called the American atom bomb attack on Japan madness. Heisenberg objected that one could equally say that using nuclear weapons had been the quickest way to end the war, whereupon Hahn added that that thought was what consoled him.[755] Wirtz was horrified by Hiroshima and argued that it was characteristic that the Germans had discovered nuclear fission but the Americans were the ones who used it.[756]

When the news of Hiroshima began to settle in, several of the scientists began to argue that they could not have made atom bombs. Von Weizsacker pointed out that, at the rate they had been going, they could not have succeeded during the war. Even the scientists involved with the research had said that it could not be done before the end of the conflict.[757] Although Bagge rejected von Weizsacker's comment at the time, he subsequently admitted that none of the scientists had forcefully pushed the project.[758]

Heisenberg put this question into the context of science policy during the Third Reich. In the spring of 1942, when the fate of the uranium research was being decided, he would not have had

the moral courage to recommend that 120,000 men be employed—like in America—to move from research to development on the industrial scale. The entire German uranium project involved at most a few hundred workers. The relationship between the scientist and the state under National Socialism, Heisenberg explained, was at fault. Although he argued that he and his colleagues were not 100% eager to make atom bombs, the scientists were so little trusted by the state that it would have been difficult to accomplish even if they had wanted to do it.[759]

Kurt Diebner, who had been responsible for much of the administration of the uranium project, agreed, stating that the officials had been interested only in immediate results and did not want to pursue a long-term policy like the Americans had obviously done.[760] Harteck first argued that they might have succeeded if the authorities had been willing to sacrifice everything towards that goal, but upon reflection said that the Germans never could have made a bomb, but certainly could have created a working nuclear reactor. He was very sorry that they had failed to achieve the latter, no doubt because of the national and professional prestige it might have meant.[761]

Von Weizsäcker also speculated at first that, if they had gotten off to a better start, then the Germans might have had nuclear weapons by the winter of 1944–1945. Wirtz pointedly replied that then Germany would have obliterated London, but would still not have conquered the world, and then Allied atom bombs would have fallen on Germany. Von Weizsäcker agreed that it would have been a much greater tragedy for the world if Germany had had the atom bomb.[762]

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Did We Want to Build Atom Bombs? The real controversy surrounding the Farm Hall recordings has not revolved around whether these ten German scientists *could* have made atom bombs, rather whether they *would* have. The transcripts from Farm Hall demonstrate that von Weizsäcker did indeed eventually argue that, because they had not wanted to make nuclear weapons,

they did not. But these arguments were hardly a simple cover-up, rather a concerted attempt to persuade himself and his colleagues to revise their own memories in order to put a better face on an increasingly problematic past.

Von Weizsäcker began this reinterpretation by stating his belief that they had not made an atom bomb because all the physicists did not want to do it on principle. If they had all wanted Germany to win the war, then they would have succeeded. Hahn immediately rejected this suggestion,[763] and later Bagge privately said that it was absurd for von Weizsäcker to say that he had not wanted the thing to succeed. That might have been true in his case, Bagge allowed, but not for all of them.[764]

Von Weizsäcker's next step was to argue that, even if the German scientists had gotten all the support that they had wanted, it was by no means certain that they would have gotten as far as the Americans and British did. After all, the German physicists were all convinced that the thing could not be completed during this war. Heisenberg interjected that von Weizsäcker's interpretation was not quite right. Heisenberg had been absolutely convinced of the possibility of making a nuclear reactor, but never thought that the Germans would be able to make a bomb. Moreover, he admitted that at the bottom of his heart he was glad that only a reactor and not a bomb appeared possible. Here Heisenberg was being disingenuous. He was well aware that an operating nuclear reactor was perhaps the most important step towards making nuclear weapons.

Von Weizsäcker then pushed the point, arguing that if Heisenberg had wanted to make a bomb, then he would have concentrated more on isotope separation and less on a nuclear reactor. Otto Hahn left the room at this point, perhaps because he did not want to hear any more. Von Weizsäcker went on to argue again that they should admit that they did not want to succeed. Even if they had put the same effort into it as the Americans and had wanted it as badly, the Allied aerial bombardment of German factories would have doomed their efforts.[765]

This question, whether these scientists had *wanted* to succeed, was couched more and more in terms of moral principles. Heisenberg argued that, if the German scientists had been in the same moral position as the Americans, who felt that Hitler had to be defeated at all cost, then they might have succeeded. But Heisenberg and his colleagues had considered Hitler a criminal.[766] Indeed earlier at Farm Hall, when Heisenberg first learned of the agreement reached at the Potsdam Conference and the probable cession of German territory to Poland, he remarked that it would have been infinitely worse if Germany had won the war.[767]

But Heisenberg was clearly changing his mind with regard to his own past intentions. In a subsequent conversation with Hahn they both agreed that they had never wanted to work on a bomb and had been pleased when it was decided to concentrate everything on creating a nuclear reactor.[768] In fact no such decision was ever taken. Rather than dictating to the researchers that they would henceforth work on a reactor and not a bomb, Army Ordnance merely decided not to boost the research up to the industrial level.

This minor distortion of the historical record is important, for it forms a basic part of the postwar myths surrounding Hitler's bomb.[769] Still later, after Heisenberg had seen the British White Paper and thus knew a great deal about how the atom bomb had been achieved, he stated flatly in a conversation with his old friend and British colleague Blackett, who was visiting Farm Hall, that the Germans had been interested in a kind of machine, but not a bomb.[770]

But the most striking comment made in Farm Hall came from von Weizsacker, who said that history would record that the Americans and English made a bomb, and at the same time the Germans, under the Hitler regime, produced a workable nuclear reactor. In other words, the peaceful development of the uranium machine was made in Germany under the Hitler Regime, whereas the Americans and the English developed this ghastly weapon of war.[771] The author Robert Jungk interviewed von Weizsacker in

1954 and subsequently wrote a similar passage in his book *Brighter than a Thousand* ***Suns:***

> It seems paradoxical that the German nuclear physicists, living under a saber-rattling dictatorship, obeyed the voice of conscience and attempted to prevent the construction of atom bombs, while their professional colleagues in the democracies, who had no coercion to fear, with very few exceptions concentrated their whole energies on production of the new weapon.[772]

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What about Our Future? These scientists were not most concerned about who among them had been "Nazis," whether they had known how to build or could have built a bomb, or even whether they had wanted to do *so*. Instead, they were by far most interested in their professional future in the postwar environment they foresaw: strict control of science in Germany in general and of uranium research in particular, and tension if not war between the United States and the Soviet Union.

Several of the detained scientists feared that, when they returned to Germany, they would be considered traitors for denying Germany the nuclear weapons it had needed to win the war. Gerlach stated flatly that they would not remain alive long there.[773] Von Weizsacker subsequently agreed that it would be a long time before he and his colleagues could clear themselves in the eyes of their own countrymen.[774] But when Harteck still later expressed a similar sentiment, that the German masses would consider them traitors, Heisenberg pointed out that the inevitable postwar Allied control of German science would make it look as if the Germans were forced to continue their work under wicked Allied control which, he added, they would have to accept with fury and the gnashing of teeth.[775] He was confident that the Allies and the German people would support German science.

Any fear the Farm Hall detainees might have had of their own countrymen was dwarfed by the deep mistrust they felt towards the Soviet Union. Early on in their captivity, Kurt Diebner became

Horst Korsching, 1945 at Farm Hall. (From the National Archives and Records Services.)

frantic at the thought of his wife and son falling into Russian hands. When he finally learned that they had been saved by the western Allies, he asked to *go* to church, apparently a rare step.[776] Otto Hahn went out of his way to emphasize repeatedly their profound distrust of Stalin and fear of the Soviet Union.[777] Von Weizsäcker argued that if the Americans and British were good imperialists, then they would attack the Soviet Union immediately, before Stalin

got nuclear weapons. Instead the western Allies would probably use the atom bomb as a political weapon, which von Weizsacker agreed was good, but which also meant that there would be peace only until the Soviet Union had such weapons, when there was bound to be war.

For Heisenberg, the Soviet threat meant that German science was more bound up with the Americans and British than ever before; the nature of Stalin's regime meant there was no real possibility of switching over to the Soviets even if they wanted to do so.[778] He suggested to Horst Korsching that a United States of Europe might be far better than Germany being part of the Russian Empire.[779] Such sentiments echoed one of Heisenberg's most infamous statements during the war: the choice lay between German or Russian domination, and Germany would be the "lesser

The scientists' fear of both their own countrymen and the Soviet Union was balanced out in part by a hope that the work they had done on uranium would make their collaboration an attractive prospect to the western powers. The Farm Hall detainees were very optimistic at first that their services would fetch a high price, but that optimism came at a time when they were fairly ignorant of the extent of the Allied achievement. The more they learned about the clear superiority of the American and British work, the more depressed and humble they became.

From Gerlach's perspective, negotiations with the Allies over German nuclear power could have begun even before the war had ended. If they had had a nuclear reactor by the summer of 1944, he told Heisenberg, and it had been properly handled from the point of view of propaganda ... But his colleague cut him off. That might have been a basis for negotiation, Heisenberg said, for any other German government, but not for Hitler. Heisenberg blamed Hitler for the fact that the discovery of nuclear fission had been taken away from Germany.[781]

Gerlach for his part was quick to argue that his main goal during the Third Reich had been to save German physics and German physicists, Heisenberg immediately tried to cheer up Gerlach by suggesting that German physics would be able to

collaborate as part of a greater western group.[782] Indeed Gerlach's argument, that he had worked within the system in order to save German physics, became one of the most important justifications made after the war for past collaboration with the National Socialist government.[783] But the nationalism Gerlach exhibited at Farm Hall tarnishes this noble goal. For example, when Sir Charles Darwin visited the detainees and asked what they were going to do in light of the atom bomb, Gerlach replied that he doubted that there would be free science from then on,[784] apparently not realizing the irony of his remarks, coming as they did from the man who oversaw physics research during the last terrible years of Hitler's dictatorship and the murderous SS Empire.

At Farm Hall Heisenberg returned again and again to his fervent hope that there was some part of the uranium problem for which the Germans had outdone the Allies and would have something to offer them. The uranium business would give the Americans and British such tremendous power that Europe would become a block under Anglo-Saxon domination. The fact that the Germans had concentrated on uranium might give them the chance of collaboration.[785] Heisenberg hoped that if the Americans had not gotten as far with nuclear reactors as the Germans had done—later revealed to be a false hope—then there might be a chance of making money.[786]

Heisenberg was by no means alone in his wishful thinking. For example, von Weizsäcker chose to interpret a remark in a newspaper that the Allies had been unable to control the energy in an atom bomb as proof that the Americans did not yet have a nuclear reactor and that the German work was still of considerable value.[787] Indeed much of the confusion found in the Farm Hall recordings arguably has more to do with the Germans' desperate desire to believe that they had not been completely outdone than with any lack of understanding of technical issues on their part.

Paul Harteck was the most forthcoming on the subject of collaboration. He wanted to work as closely as possible with the west,[788] and indeed Harteck was the only one of the Farm Hall scientists to emigrate, moving to the United States during the

fifties.[789] Heisenberg argued that since it now appeared likely that the Americans and British would dominate Europe, the German scientists could work with them with a better conscience. Indeed he argued that that was the sensible thing to do.[790]

When Heisenberg and von Weizsäcker discussed future international scientific cooperation at Farm Hall, they seemed to consider international physics as being almost synonymous with work under the leadership of their senior Danish colleague Niels Bohr. The hope of collaboration led the Farm Hall detainees to speculate about a new international technocracy with physicists—in other words, themselves—in charge. In fact it is striking how quick almost all of the detained scientists were to overrate their own political influence in the postwar world. Von Weizsäcker told Darwin that either every physicist in every country should refuse to hand over the secret of nuclear fission to any government—which all present agreed was impossible—or the scientists had to lead the governments themselves.[791]

Heisenberg argued that all scientists were too dependent on their governments and had to try and get political influence.[792] But this revelation appears to have been caused more by Hiroshima and the postwar political climate than the legacy of the Third Reich. This attitude also explains much about Werner Heisenberg's ill-fated science policy efforts in the Federal German Republic, including the short-lived German Research Council and his failed attempt to bring the first West German nuclear research center to Munich.[793]

Similarly, when Gerlach subsequently asked Heisenberg whether he would cooperate in order to make the bomb useful for humankind,[794] he responded that it was unlikely to occur in that form. Useful for humankind now meant only that the Soviets should not get the atom bomb, but that could not be prevented. Heisenberg believed that the Allies would try to work with the Soviet Union to establish international control over the manufacture and use of fissionable material. He had no objection to taking part in such an organization in order to ensure that Germany had a share in this control.

Heisenberg envisioned this control being exerted by a technocratic organization embracing all the nuclear physicists from around the world,[795] a vision which sounds very much like part of the postwar myths that grew up around his controversial wartime visit with Niels Bohr. In essence Heisenberg told Bohr four things in 1941: Bohr should collaborate with the German occupation authorities in Denmark because Hitler would win the war; the Germans were working on nuclear weapons; Heisenberg knew that such weapons could be built; and finally, that Heisenberg personally had mixed feelings about the prospect.

After the war Heisenberg, von Weizsäcker, and others argued that the purpose of their 1941 trip to Copenhagen was to secure international control of nuclear power in the hands of the physicists and thereby forestall the creation of all nuclear weapons. When the Farm Hall recordings are combined with the other sources for Heisenberg's and von Weizsäcker's trip to Denmark, the evidence strongly suggests that the two German physicists had not been concerned with international scientific control during the war. It was the shock of Hiroshima and the threat of the looming Cold War, and not the specter of National Socialist atom bombs, that awakened their interest in controlling nuclear weapons.

Finally, any description of the eagerness on the part of some of the Farm Hall detainees to work with the western powers would be incomplete without a discussion of the deep ambivalence they also felt toward the Americans and British, and especially the bitter personal resentment caused by their imprisonment. This resentment clearly faded quickly once they finally returned to Germany, but it had existed all the same.

The British wardens found that their German guests showed complete lack of appreciation of the fact that they were nationals of a conquered nation.[796] The general attitude expressed by the detainees was that World War II had been a misfortune forced on the Germans by the malignancy of the western powers, who by now should have forgotten it. The German scientists certainly seemed to have done so.

Moreover, the detainees were prone to make thoughtless and disturbing remarks. For example, both Karl Wirtz and Carl Friedrich von Weizsäcker argued that the Allied war with Japan was engineered by President Roosevelt, who deliberately allowed the attack on Pearl Harbor to take place without giving the due warning that these German scientists were certain he could have provided.[797] Even if these scientists had shown any knowledge of being overheard, which they did not, such remarks are neither defensible nor understandable.

Despite his eagerness to cooperate with the Americans and British, Heisenberg also let fall a few disconcerting and unflattering remarks. With regard to their continuing imprisonment—the most sensitive issue—Heisenberg argued that while some Americans were favorably disposed toward the Germans, there were those obstinate people, those American Heydrichs and Kaltenbrünners, who believed that the best thing the German scientists could expect from them was to stay locked up.[798] Such a comparison of American officials to the two heads of the infamous SS Security Service seems misplaced.

Perhaps most interesting, however, is Heisenberg's speculation concerning what might happen if they tried somehow to force their release. Their (unnamed) opposition would then use that opportunity to bring forth all its hatred of Germans and argue that the German scientists did try to help the "Nazis." Although Heisenberg and his colleagues did not achieve an atom bomb, their enemies would argue that if they had done so, then they naturally would have given it to Hitler.[799] Heisenberg thereby anticipated the content of the most influential and damning attacks he and his colleagues experienced in the postwar era, spearheaded by Samuel Goudsmit.[800]

In the end, however, the mood of the detainees brightened considerably once it was clear that their release was imminent. Indeed Heisenberg practically dictated where he wanted to return to, the University of Göttingen, one of the few intact universities in the American or British zones.[801] The Americans forbade any return to the French zone of occupation.[802] The British occupation

authorities subsequently made great efforts to make Heisenberg and his colleagues as comfortable as possible in postwar Germany as part of their policy to use Germans to rebuild Germany.[803] *On* 7 December **1945** the official order was given for the detainees' return to Germany.[804]

The British wardens had quite often been both amused and exasperated by the conduct of their charges, so that it was with considerable humor that they described how Karl Wirtz hauled down his colors. Even though they had all cursed their warden, Wirtz admitted, it would be wise to stay on his good side. They did not know when they might have another use for him.[805]

The ten German scientists imprisoned at Farm Hall neither collaborated to build nuclear weapons for Hitler nor resisted him. The Farm Hall recordings provide unprecedented insight into how these German scientists dealt with the horrific revelations caused by the fall of National Socialism and the bombing of Hiroshima. At first the scientists asked themselves whether they were "Nazis," and decided that the answer was no. The one possible exception, Kurt Diebner, was redefined as more of an administrator **than** a scientist.[806] In fact, none of these scientists were convinced National Socialists, but they all made concessions to the Third Reich. In short, their conduct places them all in the gray areas somewhere between "Nazi" and "anti-Nazi."

The second question, were the German scientists competent, was answered with a resounding yes. Any arguments that Germany could not have created nuclear weapons were based on limitations of the war economy or failure by the National Socialist leadership, not the individual expertise of the detained scientists, Indeed few of the Farm Hall scientists were even willing to follow Horst Korsching's lead and flatly state that their American colleagues had been superior.[807] The German uranium scientists were indeed competent, even if their achievement appears modest when compared to the Manhattan Project.

The third question, would these Germans scientists have made atom bombs for Hitler to use, had no clearcut answer at first. Instead a consensus was gradually built up, by Carl Friedrich von

Weizsacker in particular, that the ambivalence they had all felt when faced with providing such weapons to the National Socialists was the reason why they had not succeeded in making an atom bomb. But all too much emphasis on von Weizsacker in this regard is misplaced, for none of his colleagues was forced to accept his arguments, just as no one has been forced to believe the postwar myths surrounding the German atom bomb. However, such "what if" questions have no definitive answer. No one knows or can know for certain what they ***would*** *have* done, least of all the scientists themselves.

The final problem facing these scientists was how best to ensure a bright professional future. Here the Farm Hall recordings show their true value, for these transcripts of overheard conversations make clear that what these scientists felt they needed most were *myths.* Fundamental portions of the postwar apologia were all forged in the psychological crucible of Farm Hall. This included the myth that Gerlach and others had worked on nuclear weapons merely in order to save German physics and free science; that it was Heisenberg's experience during the Third Reich that had taught him that scientists had to play an active role in politics; and most strikingly, that in 1941 Heisenberg and von Weizsacker had been striving to create an international cooperation (if not technocracy) of physicists to control nuclear power and save the world from nuclear weapons.

10

The Myth of Hitler's Bomb

The myths created at Farm Hall are still with us today. They have even taken on a life of their own. No amount of historical research or analysis of what the German uranium scientists did or did not do during the Third Reich has been able to dispel them.[808] This chapter will investigate exactly how these myths have evolved and why they are so persistent.

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The Apologetic and Polemic Theses The German atom bomb is like the unicorn. It never really existed, but during World War II many people thought that it did, or that it might. Since the war very many people have argued about whether it could have existed, whether it would have existed, and if it had existed, what would have been done with it. Thus the controversy surrounding this mythical weapon is about what certain people might have done if things had been different, and what consequences their action or inaction might have had.

The controversy surrounding "Hitler's bomb" can best be explained by breaking it down into its constituent parts. First, there are two pronounced and polarized sides to this debate, the "apologetic" and "polemic" theses. The apologetic thesis can be traced from Carl Friedrich von Weizsäcker's archetypal arguments at Farm Hall through Werner Heisenberg's adaptation in the immediate postwar years and Robert Jungk's popularization during the fifties, up to the recent book by Thomas Powers, *Heisenberg's War.*

The thesis itself runs as follows. There was no chance of making a German atom bomb. But if there had been such a chance, then a small group of German physicists would have done whatever was necessary in order to make sure that such terrible weapons never made it into the hands of Adolf Hitler and the rest of the National Socialist leadership. This thesis is apologetic in the sense of "apologia," *not* apology. It is an apologia neither for building a bomb nor for not building one, rather an apologia for being willing to work on the economic and military applications of nuclear fission for the National Socialist government during World War II, in other words, for being apolitical, irresponsible, and, some might add, amoral.

The polemic thesis can be traced from Samuel Goudsmit's archetypal statements and publications in the immediate postwar period, through the memoirs of General Leslie Groves, the former head of the successful American nuclear weapons project, and culminating in the recent book by Arnold Kramish, *The Griffin.* Goudsmit was a Jew and a former member of the Allied scientific intelligence mission that had investigated the German uranium project.[809] This assignment also revealed to him, shortly after reaching Europe, that both his parents had died in the death camp at Auschwitz.

The polemic thesis itself runs as follows. There was no chance of making a German atom bomb. But if there had been such a chance, then the German scientists involved would have done whatever was necessary in order to make sure that Germany not lose the war. This thesis is polemic because, in order to explain why there was no German atom bomb, it makes an objectively false

assertion: the claim that the German project suffered from gross scientific incompetence. It should be noted here that, when scientists attack each other on political or other extra-professional grounds, they very often couch their critique in terms of professional competence. When Goudsmit publicly accused Heisenberg and his colleagues of scientific incompetence, he could not have hurt them more.

Of course the apologetic and polemic theses contradicted each other—that was the intention of Goudsmit on one hand and Heisenberg and von Weizsäcker on the other. But what is striking and yet interesting is the significant similarities and commonalities between them. Heisenberg, von Weizsäcker, and Goudsmit all employed a decidedly ahistorical philosophy of science. All of these physicists—like very many scientists, then and now—assumed that science is reducible to the actions and intentions of a few great scientists. For example, either the German work was a success because of Heisenberg and a few close colleagues, or it was a failure because of Heisenberg and a few close colleagues. The possibility that the success or failure of a research effort could depend on external factors or, more importantly, on the cooperative efforts of a large number of scientists, engineers, and administrators, was not even considered.

Both theses used an inaccurate black-and-white picture of scientists under Hitler in order to bolster the apolitical image of their profession and to further their respective political agendas. Goudsmit arbitrarily and unfairly labeled some scientists as politicized incompetents, while implying that the competent majority of German scientists had remained apolitical. In his interpretation, the National Socialist system had placed a small number of incompetent scientists into positions of authority and responsibility and had instituted tight controls over German science.

Since German research had obviously been damaged by National Socialism, he argued, it was clear that the United States could not afford strict controls over scientific research. But by singling out a few supposed incompetent "Nazi" scientists, Goudsmit also implied that the majority of "real" scientists had

remained apolitical, which fitted his implicit argument that most scientists—American and German—were impartial, trustworthy

Heisenberg arbitrarily and unfairly labeled a few scientists as politicized incompetents as well—although Goudsmit and Heisenberg disagreed over exactly who fell into this category—in order to place all blame and responsibility on their shoulders for the ideological perversion of German physics. According to Heisenberg, the followers of Lenard and Stark were the culprits. Thus the great majority of German physicists who had rejected *Deutsche* Physik were competent, had acted responsibly during the Third Reich, and should not be disciplined further. The few incompetent "Nazi" scientists had already been ostracized by the German physics community and punished. This apologia was the scientific version of a general theme running throughout the denazification and reeducation of Germans in general after 1945. Many Germans hastened to place all blame and responsibility on a very small number of dead or already prosecuted individuals, so that the rest of the German people could get on with their lives and avoid any further punishment.

Both the apologetic and polemic theses were products of their times. Heisenberg's mythical attempts to forestall nuclear weapons and keep them out of the hands of Adolf Hitler became a symbol for the resistance of German scientists and science against National Socialism. In particular, this type of analysis cannot be limited to Heisenberg, von Weizsacker, and their intimate circle. Although the apologetic thesis was perhaps the creation of only a few scientists, once it had been publicized, many other German scientists embraced it as gospel, indeed with the fervor of the newly converted.

In America, scientists and especially physicists were engaged in an important debate during the postwar years over the future of nuclear research in the United States, that is, whether there should be civilian or military control. Goudsmit's use of the German uranium project as an example of secrecy ruining science was meant to play a role in this debate. By using a distorted interpretation of the scientific and technical shortcomings of the German effort and contrasting it with the successful American project, Goudsmit implied that future American science might fail just as miserably as he claimed Heisenberg and his colleagues had if restrictive controls were placed on postwar nuclear research. In fact, this motivation may well have been more important to Goudsmit than his understandable rancor toward Germans.

The connection between the apologetic and polemic theses was grounded in a common desire to portray science as apolitical. Scientists try hard to assert their immunity from political influence and the objectivity of their profession. Both of these theses have remained influential and virulent to the present day precisely because of the black-and-white portrayals by Goudsmit on one hand and Heisenberg and von Weizsacker on the other. A complex situation was thereby simplified and distorted such that it could be brought before a much larger, lay audience, which was exactly what the best-selling author Robert Jungk did.

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Probation (1953–1957) In 1953 West Germany regained its sovereignty over scientific research. The door was now open to nuclear R and D and neither the government nor Germany's scientists wasted any time in making ambitious plans to catch up with the rest of the industrialized world. The continuing controversy surrounding the German atom bomb must be seen in this context, for the specter of National Socialist nuclear weapons cast a long shadow over any West German ambitions to develop the economic or military applications of nuclear fission. Scientists like Heisenberg and von Weizsacker faced a dilemma: how to generate generous public support for West German nuclear research without stirring up the ghost of "Hitler's bomb"? Two mutually reinforcing publications did the trick Robert Jungk's 1956 bestseller *Brighter Than a Thousand Suns,*[811] a history of the American and German efforts to build atom bombs, and the so-called "Gottingen Manifesto" of 12 April 1957.[812]

In 1957 eighteen leading German scientists, including many who had played an important role in the wartime German uranium project like Otto Hahn, Heisenberg, von Weizsacker, and Karl Wirtz, published an open letter to West German Chancellor Konrad Adenauer and thereby bit the hand that had been feeding them. Both Adenauer and his ambitious Defense Minister Josef Strauss had been generous supporters of the massive wave of state investment in a new generation of big science research centers, but now also appeared to have military ambitions with regard to nuclear weapons.

Adenauer and Strauss had made disingenuous remarks in public, implying that nuclear weapons were not very different from other weapons and that there were effective defenses against nuclear attack. The scientists' manifesto contradicted their government by explaining that there was neither a limit to the destructive potential of strategic nuclear weapons nor a way to protect large population centers from them. Instead, they argued that the Federal German Republic should voluntarily renounce the possession of nuclear weapons.

But the Gottingen eighteen were careful about what they were criticizing. *On* one hand they announced that under no circumstances would they be willing to participate in the production, testing, or use of nuclear weapons in any way. On the other hand, they hastened to add that it was of utmost importance to promote in every way the peaceful use of atomic energy, and that they intended to continue this task as in the past.

Von Weizsacker subsequently clarified his position: he did not ask about the responsibility of science *for* the atomic age, but about its responsibility *in* the atomic age. In other words, the Germans did not want to talk about how or why atom bombs had been created, rather about what should now be done with them. Furthermore, von Weizsacker added, the Germans had had no influence on the development of nuclear weapons since 1945.[813]

Jungk's book was most influential publicity for the apologetic thesis and vital to disseminating the myth of "Hitler's bomb." The controversy was thereby broadened from interested scientists to

intellectual circles in Britain, Germany, and the United States. At the heart of Brighter is a juxtaposition of German scientists who conspired to deny nuclear weapons to Hitler and American and émigré scientists who created atom bombs and placed them into the waiting hands of the American president. The intended message was clear: German scientists had conspired successfully to deny nuclear weapons to Hitler and for this reason were morally superior to their counterparts in America.

Jungk's most compelling "proof" of his thesis was the mythical journey taken in September 1941 by Heisenberg and von Weizsacker to Copenhagen in order to speak with their teacher and colleague Niels Bohr.[814] Perhaps no event in the history of recent science has generated as much controversy as this visit, revolving around the infentions Heisenberg and von Weizsacker took with them to Copenhagen. Adherents of the apologetic thesis argue that this journey was aimed both at helping Bohr (and the other scientists at his institute) and saving the world from nuclear weapons—all'such weapons, not only German. In contrast, the supporters of the polemic thesis claim that Heisenberg and von Weizsacker wanted to help the National Socialists exploit Bohr and, in particular, to get intelligence from him about Allied nuclear weapons.

Rumors of the Copenhagen visit began shortly after the end of World War II. For example, in 1946 the émigré physicist Rudolf Ladenburg passed on to his colleague Samuel Goudsmit what Niels Bohr had told him several years before: when Heisenberg and von Weizsacker came to Copenhagen in 1941, they expressed their hope and belief that if the war would last long enough, then nuclear weapons would win the war for Germany.[815] Heisenberg's side of the story was circulating among scientists as well. In the spring of 1948, the Dutch mathematician Bartel van der Waerden, who had spent the Third Reich teaching at the University of Leipzig and who now was in the United States, heard rumors about the Copenhagen trip from Fritz Houtermanns and Richard Courant.[816]

In the same year Heisenberg himself told van der Waerden that, when he had spoken with Bohr in Copenhagen, he had asked

him whether a physicist had the moral right to work on nuclear research during the war. Heisenberg recalled that Bohr asked in return whether he believed that a military application of nuclear fission was possible, whereupon Heisenberg answered yes. When Heisenberg repeated his question, Bohr surprised him by arguing that in all countries the military use of physicists was unavoidable and therefore justifiable. Heisenberg explained to van der Waerden that Bohr had obviously considered it impossible that physicists from all peoples would band together against their governments.[817]

The 1941 conversation between Bohr and Heisenberg remained a topic of gossip for scientists until Jungk brought it before a much wider audience. According to Jungk, Heisenberg's visit was the key part of a conspiracy: Heisenberg and von Weizsäcker traveled to Copenhagen in order both to help their mentor and with Bohr's help to arrange an international "strike" among physicists of all nations to forestall the creation of such weapons of mass destruction.[818] Jungk's description also implied that the German scientists would deny nuclear weapons to Hitler, no matter what.

Jungk interviewed von Weizsäcker before writing his book. His first contact with Heisenberg came in early 1955, once he had started his manuscript. He approached Heisenberg through one of the physicist's former neighbors in Leipzig, asking him if he would be willing to help him with his book. But Heisenberg declined to meet Jungk, explaining that it had been his experience that another person could not correctly express his side of the story.[819]

However, Heisenberg's reaction when Jungk sent him a complimentary copy is illuminating. Heisenberg went out of his way to deny Jungk's interpretation that the physicist had resisted Hitler, noting that on the contrary he had felt ashamed in comparison with the conspirators of 20 July who attempted to assassinate Hitler in 1944. Heisenberg had been friends with a few of these men who sacrificed their lives through truly serious resistance. However, although Heisenberg gave Jungk detailed and thorough criticism of several claims made in *Brighter Than a Thousand Suns*, the physicist offered no comment whatsoever with respect to Jungk's

portrayal of a conspiracy centered around Heisenberg to deny nuclear weapons to the National Socialists, or to the clear implication that the German scientists were morally superior to the émigrés and Americans. Rather Heisenberg praised Jungk for capturing very well the general atmosphere among the atomic physicists.[820]

But Heisenberg did more than merely refrain from criticizing the conspiracy theory. Jungk had asked him for more information concerning his 1941 visit to Copenhagen. In the first edition of Jungk's book, the author had implied that this meeting represented a conspiracy by the German scientists to forestall nuclear weapons. Heisenberg told Jungk that he had tried to enlist Bohr's help in an effort to create an international agreement among the world's scientists not to work on the atomic bomb, because such weapons would be very expensive, and because of the obvious moral concerns.[821]

The 1958 English translation of Jungk's book and all subsequent German editions have contained an excerpt of a letter from Heisenberg to the author which implicitly confirmed Jungk's conspiracy theory.[822] Heisenberg explicitly confirmed the conspiracy theory in his unpublished correspondence with Jungk. Unfortunately, Jungk did not make clear in his book that Heisenberg supported the conspiracy theory. *Brighter Than a Thousand Suns* was a commercial success—it is still in print in Germany and the United States—and it brought the myth of "Hitler's bomb" to the attention of the public inside and outside of Germany.[823]

Jungk's book and the Göttingen Manifesto are connected in at least three important ways. The Göttingen eighteen were genuinely concerned about the arms race and Germany's precarious position in central Europe, but there is more here than meets the eye. The West German nuclear policy threatened to call public attention to the unsettling truth that such research led inevitably down two different paths. The Göttingen scientists were afraid that too much emphasis on West German nuclear weapons would evaporate public support for nuclear research. They intended to combat this threat by simultaneously renouncing nuclear weapons

while pushing for nuclear research. Jungk's book also tacitly argued that the military and peaceful applications of nuclear research were separable and indeed had even been kept apart under Hitler's dictatorship.

The scientists' 1957 description of their motives and intentions also parallels the motives and intentions that Jungk had ascribed to the wartime conspirators. The Göttingen Eighteen appeared merely to be continuing consequently the same ethical conduct they had begun during the Third Reich—of course, in contrast to their American colleagues, who during the forties and fifties created both the atom and hydrogen bombs.

Brighter Than a Thousand Suns was clearly influenced by McCarthyism and the Cold War. Jungk was understandably disillusioned by the witch hunts in the United States and the use of American economic, political, and military muscle after World War II. In other words, his portrayal of German scientists under Hitler as being morally superior to their American and émigré colleagues had as much to do with criticism of postwar American domestic and foreign policy as any desire to rehabilitate Heisenberg, von Weizsäcker, and their colleagues. Just like the original apologetic and polemic theses, Jungk's conspiracy theory was a product of the times.[824]

Two publications by von Weizsäcker, one before and one after the publication of Jungk's book, illustrate the effect of *Brighter Than a Thousand Suns*. In a letter dated 14 October 1955 and reprinted shortly thereafter, the physicist gave the following account. The German nuclear scientists had not been forced to decide whether they wanted to make bombs or not. If they had been forced to decide, then different scientists would have reacted differently. A few would have certainly wanted to make bombs, others just as certainly not.

Von Weizsäcker regretted most that he and his German colleagues had not communicated to their counterparts on the other side the information that they were not making bombs. Nuclear weapons would have been developed in any case, von Weizsäcker argued, but perhaps not at such a forced tempo, which

of course had been powered most of all by the fear of German nuclear weapons. The bombing of Hiroshima and Nagasaki might thereby have been avoided. It had never occurred to von Weizsäcker and his German colleagues that the Americans would seriously try to build atomic bombs. Rather they were completely surprised by the news of Hiroshima.[825]

After *Brighter Than a Thousand Suns* and the Göttingen Manifesto, von Weizsäcker subtly changed his account. Instead of merely saying that the Germans had never been in a position where they had to decide whether or not to make atom bombs, he now coupled such statements with the claim that the German scientists had been aware of the moral dilemma they faced and had discussed whether or not they *should* work on nuclear weapons. In other words, after Jungk's book von Weizsäcker couched his statements in moral terms, thereby implying that moral considerations had played a role in their wartime work and perhaps had even forestalled the German atom bomb.

For example, von Weizsäcker now said that after the discovery of nuclear fission a small group of German scientists raised the same question among themselves as had their counterparts in America: could secrecy protect humankind from the advent of atomic bombs? However, it was already too late. Although at that time a worldwide, universal understanding among physicists might have done the job, von Weizsäcker argued, the German scientists were not ready for a step of such wide political scope.

During the war the German uranium scientists were spared the last, hard decision. They saw that they were unable to make nuclear weapons and were happy about it. But they had overestimated the difficulties and underestimated the means at the disposal of American physicists. They had been convinced that the Allies would also be unable to build the bomb. This was a grave error, for otherwise von Weizsäcker and his colleagues would probably have made a desperate effort to inform the West that the Germans were not making nuclear weapons.

Von Weizsäcker was careful not to criticize American military policy. He made no moral judgment on the wartime decisions

by American military leaders to drop bombs on Japan. But the physicist also believed that it would be very valuable if the use of atomic weapons could be prohibited by international agreement, and if this prohibition could be implemented by actual destruction of such weapons.[826] In fact, von Weizsäcker became a very active participant in the international effort by scientists to stop the nuclear arms race during the Cold War.

Von Weizsäcker's 1958 statement differs from his 1955 letter in an important respect: the former implies that there was a potential conspiracy, that is, that a group of individuals were preparing or considering a conspiracy to deny nuclear weapons to Hitler and to all governments. But who is originally responsible for the conspiracy theory? There are two explanations: (1) the conspiracy was Jungk's idea and it influenced von Weizsäcker's subsequent accounts; or (2) the conspiracy was von Weizsäcker's idea but he only began to use it cautiously in public after he had encouraged Jungk to publish it and take the heat.

Although Heisenberg's and von Weizsäcker's descriptions of their visit to Copenhagen are the best known, there is more than one side to this story. One of the few published accounts of Bohr's side is found in an article his son Aage wrote for a 1967 Festschrift in honor of his father. Aage Bohr, who was also in Copenhagen in the autumn of 1941, rejects Jungk's conspiracy theory as a fiction. He flatly states that there was no mention of any plan aimed at preventing the development of atomic weapons through a mutual agreement with colleagues in Allied countries, and notes on the contrary that the very scanty contact the Danes had with the German physicists during the war only strengthened the impression that the German authorities attributed great importance to the military applications of nuclear fission.[827]

In 1985 the American author Arnold Kramish took this interpretation even further and published an account of the visit with Bohr that portrayed Heisenberg and von Weizsäcker as spies. They traveled to Copenhagen in Hitler's service in order to pump Bohr for information on the Allied atom bomb project.[828] The most recent publication to take Bohr's side appeared in the former Soviet

Union. According to the Russian physicist Eugene Feinberg, Bohr made a 1961 visit to the Soviet Union and described while there how Heisenberg had tried in 1941 to enlist him in the cause of German cultural propaganda.[829]

Heisenberg published his memoirs in 1969, and implied in his book, like in his published letter to Jungk, that this trip was part of an attempt to forestall the creation of all nuclear weapons.[830] Eleven years later, Heisenberg's widow published an impassioned defense of her husband. Although Heisenberg had not discussed matters of secrecy like nuclear fission or the motives behind his visit to Copenhagen with her during the war,[831] she nevertheless argued that Heisenberg wanted to convince Bohr that Heisenberg and his colleagues would not make atom bombs, in the hope that all such weapons would thereby be forestalled.[832]

It is unclear who was responsible for the conspiracy theory. Today Jungk feels that he has been misled by Heisenberg and von Weizsäcker. While he was researching *Brighter Than a Thousand Suns*, German physicists revealed to him that not even the dictatorship of the Third Reich had been able to force its researchers to contribute to a project they had rejected. In particular, Jungk insists that von Weizsäcker told him that the German scientists had consciously attempted to hinder the construction of a German atom bomb; they had not been "activists," rather "pacifists." Subsequently Heisenberg corroborated this statement to Jungk.

When Jungk's book appeared in the autumn of 1956 and immediately generated a great deal of attention and praise, Heisenberg and von Weizsäcker made no protest. Instead Jungk learned they were very pleased that, in the eyes of the international public, their secret resistance against efforts to construct a German atom bomb had liberated them from any suspicion of complicity with Hitler's regime.

But when an English translation of *Brighter* appeared in America, Jungk's portrayal of the German physicists was sharply criticized and von Weizsäcker began to distance himself from what he had told Jungk, at first cautiously, then ever more decisively. The physicist now emphasized that he and his colleagues would

not have built the bomb because they lacked the necessary resources, not because of moral considerations. At first, von Weizsäcker claimed that Jungk had been naive. However, when Jungk did not immediately defend himself, von Weizsäcker went further and claimed that the conspiracy theory had been Jungk's idea, even though Jungk has witnesses who say von Weizsäcker had made this claim years before he met Jungk.

Jungk does not absolve himself from responsibility for the conspiracy theory of pacifist resistance he publicized. Heisenberg once told Jungk that decent people would not have been able or willing to work on such a horrible weapon and Jungk believed him. But Jungk does feels guilty of having believed what he wanted to believe. As he now recognizes, unfortunately true history is not a history of pious legends and upright heroes.[833]

Von Weizsäcker has also recently spoken out on his role in the German uranium project in general and on the 1941 visit between Bohr and Heisenberg in particular.[834] He in turn has little respect for Jungk, whom he criticizes for writing biased history in order to make a political point.[835] But there is an apparent contradiction in von Weizsäcker's statements. On one hand, he criticizes Jungk for creating the conspiracy theory:

> In his book ... Jungk argued that the German physicists would have decided, in a sort of conspiracy, not to build the bomb. This [argument] did a great deal of damage to Heisenberg in the eyes of his western colleagues, because some of them believed that Heisenberg was now using someone else to propagate this fable. However, that is absolutely false, it was Jungk's own idea. I have never claimed that we would have decided to hinder the construction of the bomb ... Rather I have always said we were happy when we realized that we could not do it.[836]

On the other hand, in a statement published almost simultaneously, von Weizsäcker also said: "the true goal of the visit by Heisenberg with Bohr was ... to discuss with Bohr whether physicists all over the world might not be able to join together in order that the bomb not be built."[837]

These two last statements can be reconciled if the historian does what Heisenberg and von Weizsäcker have not done, and makes an unambiguous and systematic distinction between *intention* and *action*: (1) Heisenberg, von Weizsäcker, and some of their colleagues were troubled by the destructive potential of nuclear fission; (2) Heisenberg, von Weizsäcker, and some of their colleagues contemplated and perhaps discussed the desirability of international cooperation among scientists to forestall the creation of the first nuclear weapons; (3) before Heisenberg, von Weizsäcker, or any of their colleagues took any action (or inaction) in order deliberately and consciously to slow down, divert, hinder, or forestall the development of nuclear weapons, the decision by the responsible authorities in Germany not to invest the huge amounts of money, materials, and manpower required[838] made any such action or inaction moot.

Why have Heisenberg and von Weizsäcker been unable or unwilling to distinguish clearly between their actions and intentions? The reasons for their suggestive ambiguity could range anywhere from a subconscious repression of the fact that they did not actively resist Hitler, to a conscious and therefore deliberate desire to deceive. In any case, it is clear that Jungk and many other people have listened to Heisenberg and von Weizsäcker explain their *intentions* not to help the National Socialists but went away with a conviction that the two physicists had *actively* fought against Hitler and thereby spared the world the specter of National Socialist nuclear weapons.

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Counterattack (1957–1962) American and émigré colleagues often got the same message from Jungk's book and the Göttingen Manifesto: an implied condemnation of the American, British, and émigré scientists who had helped create atom bombs while threatened by the specter of National Socialist nuclear weapons. A 7 July 1958 article in *Newsweek* noted that many of Jungk's

critics saw "his book as part of the worldwide attempt to discredit the U.S. as an atomic power on moral grounds." It quoted Samuel Goudsmit (who helped ghostwrite the article): "the historical record shows that they [the German uranium scientists] tried hard and failed."[839]

When Leslie Groves, former head of the Manhattan Project, published his immodest memoirs in **1962,** *Now It Can Be* ***Told,*** he decisively altered the debate surrounding "Hitler's bomb by selectively reprinting a few choice remarks from the Farm Hall recordings.[840] These excerpts, which revealed the existence of these recorded conversations for the first time, counterattacked Jungk's conspiracy theory and began three decades of rancorous debate and persistent efforts to force the release of the transcripts. Many people struggled so hard to obtain these transcripts because they assumed that these conversations would "prove" his or her interpretation, that is, either the apologetic or polemic thesis."

Goudsmit's book *Alsos,* a polemic account of how National Socialism had ruined German science, also reported what the interned scientists had said at Farm Hall. Goudsmit's portrayal of his colleagues was not kind. The Germans had been shattered by the news of Hiroshima, which left them with an intense feeling of despair and futility. They reproached each other with bitter words, suffered from hysteria, and were bewildered when faced with the Allied achievement.

Most important, Goudsmit insisted that the Germans had not understood the difference between a nuclear reactor and an atom bomb. Eventually, Goudsmit explained, some of the younger men at Farm Hall hit upon a brilliant rationalization of their failure to make nuclear weapons. They would deny that they had ever tried to make nuclear weapons, rather would stress that they had been working only on a nuclear reactor and forget that they had thought this would lead directly to the bomb. They would tell the world that German science never, never would have consented to work on a horrible thing like nuclear weapons.[842]

Both Goudsmit and Groves used the Farm Hall transcripts to argue that the German scientists did not create nuclear weapons

because of scientific incompetence, not moral scruples. In other words, if it could be demonstrated that these Germans had made grievous scientific errors, it would be easy (or at least easier) to dismiss the postwar claims or insinuations that certain German physicists slowed down and diverted their work away from military applications because they had recognized the immorality of giving atom bombs to Hitler.

For thirty years, adherents of the apologetic thesis have hoped that the Farm Hall transcripts would reveal that Heisenberg was competent and thereby prove (although the argument is illogical) that von Weizsacker had been telling the truth, i.e., there had been a conspiracy against Hitler. In turn, supporters of the polemic thesis have hoped that these transcripts would reveal Heisenberg's incompetence and thereby prove (although this argument is illogical as well) that moral concerns played no role. This debate was finally ended by the sudden release of the transcripts in 1992. Both camps have been disappointed.

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The Immortal Myth of "Hitler's Bomb" Forty years of the apologetic and polemic theses have taken a toll on the history of "Hitler's bomb." Many recent accounts have been journalistic, historically inaccurate, and seem intended more to fight old battles, defend or attack the reputations of individuals now dead, than to shed new light on the German atom bomb and its myth. Since **1962** the overwhelming majority of the authors who have studied "Hitler's bomb" have accepted and advocated either the polemic or the apologetic thesis.[843] Very few individuals have been willing to consider that neither one extreme nor the other might be true.[844] For almost three decades, the *two* groups have been talking past each other.

There are many recent examples of such literature, but only two authors will be examined here, one for each thesis: Thomas Powers as apologist and Arnold Kramish as polemicist. Thomas Powers' recent book, *Heisenberg's War: The Secret History of the German Bomb,* represents both the logical development and an

extremely virulent interpretation of the apologetic thesis. Despite Jungk's and von Weizsacker's recent disavowals, Powers revives Jungk's 1956 conspiracy theory and indeed goes beyond it: "Heisenberg did not simply withhold himself, stand aside, let the project die. He killed it."[845] Powers believes a second-hand account that Heisenberg "falsified the mathematics" in order to kill the German atom bomb "comes very close to the truth."[846]

Unfortunately, Powers systematically misreads evidence that runs counter to his interpretation. For example, Powers tries and fails to explain away both Heisenberg's February 1942 lecture before Party and military leaders, where the latter emphasized that uranium 235 and plutonium would be explosives of "utterly unimaginable effect,"[847] and the recently released Farm Hall Transcripts, in which Heisenberg admits that he never thought that nuclear weapons could be created before the end of the war.[848]

Powers demonstrates in his book that the Allies made plans to kidnap and assassinate Heisenberg in order to halt the German uranium project. Indeed these plans may explain why Powers champions Jungk's conspiracy theory. Powers amplifies Heisenberg's resistance in order better to emphasize the injustice and paranoia of the Allied efforts against him. The real aim of Powers' book is to argue that, if the truth had been known about the German atom bomb, then this "might have contributed a note of caution to debate about the Russian danger at the outset of the Cold

The apologetic thesis is so persistent because it facilitates the rehabilitation of German scientists who, like all Germans, have had to wrestle with the legacy of National Socialism. This thesis can also play a role *in* contemporary science policy. Assertions that even during the Third Reich responsible German scientists were able and willing to control their science and its repercussions (for example portrayals of Heisenberg as the man who saved the world from National Socialist nuclear weapons) can lend support to the German nuclear power industry.[850] If German scientists had done the right thing and denied nuclear weapons to Hitler, then the

public should trust them with nuclear research and nuclear energy now.

Arnold Kramish's recent book, *The Griffin,* represents both the logical development and an extremely virulent interpretation of the polemic thesis. Kramish portrays Heisenberg and von Weizsacker as willing tools of the "Nazis," but does so either through undocumented claims or by using only a small number of historical documents, thereby ignoring the wealth of evidence which contradicts his interpretation. For example, a letter from von Weizsacker to Minister of Education Bernhard Rust concerning the advantage which American physics held over its German counterpart—part of a campaign to increase the funding, independence, and prestige of German science during the Third Reich—is misinterpreted by Kramish to portray von Weizsacker as a spy, receptive to passing on Allied secrets.

Although Kramish is willing to give most German physicists the benefit of the doubt, he portrays Werner Heisenberg and Carl Friedrich von Weizsacker as loyal collaborators of Adolf Hitler. Thus the seeds sowed by Samuel Goudsmit in his book *Alsos* come to fruition, for it was Goudsmit's arbitrary black-and-white portrayal of German science, and in particular his singling out of Heisenberg and von Weizsacker as scapegoats, that came to be dogma. Kramish is fighting the battles that Goudsmit once fought, or at least he is fighting the battles he thinks Goudsmit fought. But the idea of Heisenberg or von Weizsacker as intelligence agents or loyal followers of Hitler is no more plausible than the assertion that they had conspired to deny the National Socialist leader nuclear weapons.[851]

The polemic thesis is just as persistent as the apologetic. It provides an outlet for Germanophobia. In addition, it justifies the successful American effort to create atom bombs. The fear of National Socialist nuclear weapons had been the driving force behind the Manhattan Project. In fact the Germans did not develop atom bombs. However, if it could be shown that the German scientists failed because of incompetence but would have made

nuclear weapons for Hitler if they could have, then the weight of guilt for Hiroshima is lessened.

The unfortunate legacy of the apologetic and polemic theses is a lack of objectivity. Both Goudsmit and Heisenberg gave biased accounts of the truth when respectively asserting the apologetic and polemic theses, but their battles are still being fought today. The greatest danger embodied by the apologetic and polemic theses has not been that they were false, but that they have taken on a malevolent life of their own.

Why is the myth of "Hitler's bomb" so persistent? This myth serves as a symbol for the apologia of the German scientific community. Since many Germans still wrestle uneasily with their ambivalent past, it should be no surprise that *so* do some German scientists. A considerable amount of Germanophobia undeniably still exists inside and outside of Germany. The wounds caused by World War II are still open. For historical reasons, Heisenberg and von Weizsacker have been singled out unfairly as scapegoats for the collaboration of scientists with National Socialism, ironically just as they had treated the followers of *Deutsche Physik* after the war.

There also seems to be an irrational fascination with the thought of a Conspiracy, and this fascination has taken two different forms. First, there are those who believe in Jungk's **1956** conspiracy theory. Second, in stark opposition to Jungk, there are those who believe in another type of conspiracy, in particular that, after working wholeheartedly for Hitler, these German scientists now conspired to deceive the rest of the world into believing that they had resisted him. But there was no conspiracy, rather apologia, and the distinction is important. Unwillingness or inability to face an unpleasant reality is not necessarily the same as the deliberate desire to deceive. Finally, many people clearly have a macabre fascination with the dream or nightmare of National Socialist nuclear weapons winning World War 11 for Germany. The myth of "Hitler's bomb" tells us more about our current society than about events forty years ago.

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Heisenberg and National Socialism If Werner Heisenberg had died in an accident in **1930,** how would we remember him? Probably as one of those young geniuses who died tragically before they could fulfill their promise. If during the Weimar Republic Heisenberg had accepted a call to a professorship in the United States, how would we remember him? Probably not even as a German scientist, rather as one of those emigrants who are no longer counted as German because of their absence from Germany, their non-German citizenship, and the fact that they often worked against Germany during World War 11.

But Heisenberg neither died nor emigrated, rather he experienced and survived National Socialism. Let us now examine what dilemmas Heisenberg confronted during and after the Third Reich and how he reacted to them. These problems and reactions, and not his exceptional scientific performance, have molded and determined for many their postwar image of Heisenberg. Before Adolf Hitler's appointment as German Chancellor in January **1933,** Heisenberg's problems were of a scientific nature, challenges which the young physicist met very well. However, after the National Socialists took power, the problems were always, at least in part, of a political nature.

There is one question to keep in mind: whatever Heisenberg did, could he have believed that he was being apolitical or even was resisting Hitler?

1. How did Heisenberg react to the purge of the German civil service and the firing of his Jewish colleagues in **1933?** First, he went to Max Planck for advice. Second, Heisenberg did what Manck suggested (as well as what Planck and Max von Laue also did). Heisenberg attempted to convince Jewish colleagues who apparently would be granted exceptions—for example, Max Born, who had fought at the front during World War I—that they should stay. When this strategy failed, because the colleagues either were not granted exceptions or did not want to remain, Heisenberg

attempted together with Planck, von Laue, and others to fill the vacant positions as quickly and as well as possible.

2. How did Heisenberg react when he was attacked as a "white Jew" and "Jewish in spirit" by Johannes Stark? When Stark published an article in the *Völkischer Beobachter,* the newspaper of the National Socialist movement, Heisenberg answered in the same forum. When Stark repeated his attacks, this time in the SS newspaper *Das Schwarze* Korps, Heisenberg pursued two strategies simultaneously. He went through official channels and demanded action from the Saxon and Reich Ministries of Education. Either Stark was right, and Heisenberg would resign, or Stark was not right, and the ministries had to protect Heisenberg from such attacks.

At the same time Heisenberg also contacted Heinrich Himmler, the head of the SS, and asked for political rehabilitation. The personal answer from Himmler contained an offer as well as a demand. Heisenberg would receive a professorship-though not the Munich position—as well as the opportunity to publish an article in the *Deufsche* Physik journal. In fact, in **1942** he was offered, with the support of the SS, both a professorship at the University of Berlin and the directorship of the Kaiser Wilhelm Institute for Physics.

Himmler demanded in return that Heisenberg make a clear distinction between support given to scientific theories and to scientists. Heisenberg accepted this condition immediately and unconditionally. For example, in his **1943** article in the *Deutsche* Physik journal, he argued that the history of a physical theory was irrelevant, that the theory of relativity would have been invented without Einstein, and that all that mattered was whether a theory was correct, not who invented it.

3. How did Heisenberg react in September **1939** to the invasion of Poland? He regretted that it was war, he hoped that the conflict would come to an end relatively quickly and bloodlessly, and he immediately reported to the Army for service as a soldier.

4. How did Heisenberg react to the invitation he received to help research the possible economic and military applications of

nuclear fission instead of serving his country as a soldier? He took up the work with enthusiasm, energy, and success. In two articles, finished respectively in December **1939** and February **1940,** he worked out the theoretical foundations for nuclear energy and nuclear weapons and immediately passed them on to Army Ordnance.

5. How did Heisenberg react when it became clear to him in the autumn of **1941** that his colleague and former teacher Bohr was threatened in occupied Denmark, and separately, that in principle nothing stood in the way of nuclear weapons? He accepted an invitation to give a talk at a German astrophysics conference at the Copenhagen German Cultural Institute, a center for the cultural and scientific collaboration between native scientists and National Socialism. While he attended the Copenhagen conference, he also visited Bohr and told him: **(1)** Hitler would win the war; *(2)* nuclear weapons were possible; **(3)** the Germans were working on them; and (4) he, Heisenberg, had mixed feelings about it. Moreover, together with Carl Friedrich von Weizsacker, Heisenberg advised Bohr to collaborate with the Germans and in particular with the German Cultural Institute.

6. How did Heisenberg react in February **1942** when Army Ordnance decided that nuclear weapons were not relevant to the war effort and that the uranium project would be transferred to the Reich Research Council in the Ministry of Education, decisions which threatened the financing and support of the project and thereby clearly endangered the security of the individual scientists? He lectured in February **1942** before leading figures in the National Socialist party and armed forces on the theoretical foundation of nuclear fission. This popular lecture made crystal clear both the military significance of nuclear fission in general and of Heisenberg's own work in particular, including the remark that nuclear explosives would have an "unimaginable effect." After a few weeks this information even landed on Josef Goebbels' desk.

7. How did Heisenberg react in **1943,1944,** and 1945 to the ever-deteriorating state of the war? Together with his other colleagues in the uranium project, he worked harder and harder,

desperately attempting to reach the now relatively modest research goals before the end of the war: to build a nuclear reactor which could sustain a nuclear fission chain reaction for a modest period of time; and to manufacture tiny amounts of pure uranium 235, that is, to create tiny amounts of a nuclear explosive.

8. How did Heisenberg react to the end of the war, when his Allied colleagues arrested him? Heisenberg made a distinct impression on them as an "anti-Nazi" and German nationalist.

9. When Heisenberg was interned in Farm Hall in England and heard the radio news of the bombing of Hiroshima, how did he react? He admitted only grudgingly that he had never made the calculations necessary for an atom bomb because he had believed that they would not be able to create them before the end of the war. Subsequently, he worked so intensely on this problem that after a few days he could explain to his colleagues in Farm Hall how the Allies had done it.

Yet what is most important is that over the next few weeks and with the strong encouragement of Carl Friedrich von Weizsacker, Heisenberg began to change his opinion gradually and step-by-step. He said that he had not believed that these weapons were possible, and in his heart he had been glad. At the end, he said that he and his colleagues had not wanted to build nuclear weapons for Hitler and that these moral scruples were the reason why the "Nazis" did not get them.

10. How did Heisenberg react after World War II when his American colleague Samuel Goudsmit polemically attacked him? Goudsmit claimed that the Germans had not been in a position to build nuclear weapons because they had made crude, simple scientific errors. However, if they would have been in a position to do it, then they would have done what was necessary in order that Germany not lose the war. Heisenberg answered with an apologetic thesis co-authored by von Weizsacker. The Germans had not been in a position to build nuclear weapons; but if they would have been in such a position, then they would not have done it. They would have done whatever was necessary in order that these horrible weapons not fall into Hitler's hands.

11. How did Heisenberg react to the denazification of the German physics community after World War II? He sharply criticized the former adherents of *Deutsche Physik* like Johannes Stark, but in contrast wrote "whitewash certificates" for those individuals who had worked against *Deutsche Physik,* almost no matter what else these persons had done during the Third Reich. Thus Heisenberg helped rehabilitate the SS-physicist Johannes Juilfs and the convinced National Socialist and physicist Pascual Jordan.

12. How did Heisenberg react to Robert Jungk's 1956 book, *Brighter Than a Thousand Suns,* which propagated the apologetic thesis and claimed that only a conspiracy around Heisenberg and von Weizsacker had saved the world from National Socialist nuclear weapons? In 1957 Heisenberg explicitly corroborated the conspiracy theory in his private correspondence with Jungk, although in public he always restricted himself to hints and ambiguous remarks which tacitly strengthened the conspiracy theory.

13. How did Heisenberg react when the nuclear politics of Defense Minister Franz Josef Strauss and Chancellor Konrad Adenauer threatened public support for nuclear research and nuclear energy in the Federal German Republic, especially because this policy awakened the specter of "Hitler's bomb?" Together with von Weizsacker and other colleagues like Otto Hahn, Max von Laue, and Karl Wirtz, he sent an open letter to Adenauer which made it clear that they would have nothing to do with the research, development, or stationing of nuclear weapons in Germany.

14. How did Heisenberg react in his later years when faced with his own mortality? In his 1969 memoirs, *Physics and Beyond,* he clearly implied that the conspiracy theory was true. In a 1970 private letter he claimed the conspiracy theory more explicitly than ever before. Together with Hahn and von Laue, Heisenberg had supposedly falsified the mathematical calculations in order to deny nuclear weapons to Hitler. This claim was not only false, it is tragically absurd.

Heisenberg may have resisted Hitler, in his own mind. Heisenberg's behavior was not so different from most of his colleagues in Germany, the United States, or the Soviet Union who

worked on nuclear fission. Almost all of them cooperated with their governments under very different conditions, either out of conviction, ambition, or fear. There was an important difference, but that lay with the political, ideological, and moral nature of the regime, not the scientists.

But the main point here is not to condemn Heisenberg's conduct under National Socialism, rather to criticize activity by him and *so* many others since the end of the Third Reich. Why were myths and legends of active resistance against Hitler created and propagated after the war? Obviously because something is being repressed. Scientific work, exactly like any other occupation, can be politicized. Scientists in general are morally neither superior nor inferior to the general public. Finally, sometimes—for example under National Socialism during World War II—there are neither simple answers nor simple questions.

11

Conclusion

The Scientist as Fellow Traveler

This book began with a distinction between "Nazi" scientists and the scientists who served National Socialism. Yes, some scientists enthusiastically embraced Hitler's movement, but they are only part of the story. The German scientific community and most of its members entered into a Faustian pact with National Socialism, trading financial and material support, official recognition, and the illusion of professional independence for conscious or unconscious support of National Socialist policies culminating in war, the rape of Europe, and genocide.

Ironically, the initial ideological attacks on German science served to drive scientists into the arms of military, industrial, and political allies and thereby into an ever closer collaboration with Hitler's movement. This relationship, in contrast to the discredited and discarded politicized scientific movements like *Deutsche Physik,* was based not on ideology, rather utility. Johannes Stark

Oct 1943) Heisenberg MPI; Coblitz to Heisenberg (18 Nov 1943) Heisenberg MPI.
639. Cassidy, (1991), 466–67.
640. Burrin, (1994).
641. Spielvogel, (1992), 294.
642. See chapters 8, 9, and 10.
643. REM to Heisenberg (17 Jul 1943) Heisenberg MPI; Heisenberg to Deutsches Wissenschaftliches Institut Bucharest (18 Dec 1943) Heisenberg MPI.
644. Deutsche Akademie to Heisenberg (29 Sep 1943) Heisenberg MPI; Deutsche Akademie to Heisenberg (29 Dec 1943) Heisenberg MPI.
645. REM to RUB (29 Dec 1944) Uk. H185 I, 12 HUB.
646. Laue to Kurator der Uni. Berlin (2 Apr 1944) Uk. H185 I, 11 HUB.
647. "Rapport over Begivenhederne under Besættelsen af Universitetets Institut for teoretisk Fysik fra d.6.December 1943 til d.3.February 1944," 1944 or 1945, NBC; thanks to Finn Aaserud und Gro Næs for translating this document.
648. Von Weizsäcker to Heisenberg (16 Jan 1944) NAARS.
649. "Rapport" NBC.
650. Handwritten note by Heisenberg on back of Euler to Heisenberg (8 Jan 1944) Heisenberg MPI.
651. "Rapport" NBC.
652. Heisenberg to Jensen (1 Feb 1944) Heisenberg MPI.
653. REM to Heisenberg (1 Mar 1944) Heisenberg MPI; Deutsche Forschungsgemeinschaft to Heisenberg (28 Mar 1944) Heisenberg MPI.
654. Werner Heisenberg, "Bericht," (27 Apr 1944) Uk. H185 I, 32 HUB.
655. Wiist to Himmler (15 Oct 1937) Hofler BDC.
656. Otto Hofler BDC.
657. SS-Obersturmführer to Himmler (22 Jun 1937) Hofler BDC.
658. Nagel, (1991).
659. Deichmann, (1992), 199–210.
660. Wust to Himmler (15 *Oct* 1937) Hofler BDC.
661. SS-Brigadeführer und Generalmajor der Polizei to dem Reichsführer-SS im Hause (23 Nov 1942) Hofler BDC.
662. Klinger to Heisenberg (28 Jun 1949) Heisenberg MPI.
663. Heisenberg to Klinger (4 Jul 1949) Heisenberg MPI.
664. Heisenberg to Hofler (27 Apr 1944) Heisenberg MPI; Werner Heisenberg, "Bericht," (27 Apr 1944) Uk. H185 I, 32 HUB.
665. Hofler to Heisenberg (12 Jan 1947) Heisenberg MPI.

666. Heisenberg to Klinger (4 Jul 1944) Heisenberg MPI.
667. Werner Heisenberg, "Die aktive und passive Opposition im Dritten Reich," (12 Nov 1947) Heisenberg MPI.
668. REM to Heisenberg (9 Aug 1944) Uk. H185 I, 35 HUB.
669. Powers, (1993), 402.
670. Goudsmit, (1983), 114.
671. REM to Heisenberg (27 Mar 1945) Uk. H185 I, 36 HUB.
672. For the ambivalence towards Heisenberg and von Weizsacker, see Walker, (1989), 204–21.
673. See chapter 10.
674. Kleinert, (1979); Hentschel, (1990); Hentschel, *Studies*, (1992); Hentschel, *Turm*, (1992).
675. Forman, (1973).
676. Forman, (1974).
677. Forman, (1973); Forman, (1974); Forman, "Helmholtz."
678. Noakes and Pridham, (1990), 697–99.
679. Noakes and Pridham, (1990), 220–32.
680. The classic accounts are Ludwig and Beyerchen, (1977), 9–50; also see Mehrtens, (1989) and Geuter (1992).
681. See Kershaw, (1991), 37-86 and the primary documents collected and edited by Noakes and Pridham, (1990), 123–91.
682. Noakes and Pridham, (1990), 123–87, esp. 144–54.
683. Noakes and Pridham, (1990), 146,148–50.
684. Noakes and Pridham, (1990), 170–1.
685. Noakes and Pridham, (1990), 167–87.
686. Renneberg and Walker, in Renneberg and Walker, (1993), 9–11.
687. Richter, (1973); Beyerchen, (1977); Kleinert, (1978); Richter, (1978/1979); Kleinert, (1980), 35–38; Richter, (1980); Kleinert in Olff-Nathan, (1993).
688. Heisenberg, (1973), 206–7.
689. Neufeld in Renneberg and Walker, (1993); Neufeld, (1994).
690. Neufeld in Renneberg and Walker, (1993).
691. Heisenberg, (1973), 214; Heisenberg, (1946), 329.
692. Heisenberg, (1946), 329.
693. Noakes and Pridham, (1990), 83945.
694. Walker, (1989), 209.
695. Vollnhals, (1991).
696. Nietzhammer, (1982).
697. Vollnhals, (1991), 57.

698. See Wise, (1993) and Beyler (1994).
699. Walker, (1989), 198–99,
700. See chapters 2 and 3.
701. Gimbel, (1986); Gimbel, (1990).
702. Albrecht, Heinemann-Grüder, and Wellmann, (1992).
703. See Walker, (1989), and chapter 8.
704. Unfortunately, neither the recordings themselves nor the German originals of the recorded conversations are available; the transcripts have been published, including the two sections available in the original German, as Charles Frank (ed.), *Operation Epsilon*, (1993).
705. Groves, (1983), 333–40.
706. Goudsmit, (1983), 134–9.
707. The information on membership in National Socialist organizations is available in the personnel files of these scientists at the BDC.
708. Also see chapter 7.
709. *Operation Epsilon*, (1993), 39, 42, 54.
710. *Operation Epsilon*, (1993), 54, 215.
711. *Operation Epsilon*, (1993), 51–3.
712. *Operation Epsilon*, (1993), 52–3, 64–5, 189–90.
713. *Operation Epsilon*, (1993), 50,168,171.
714. *Operation Epsilon*, (1993), 50, 55.
715. Walker, (1989), 204–221.
716. Walker, (1989), 21,5658.
717. *Operation Epsilon*, (1993), 72,109,117–21.
718. Walker, (1989), 48–9.
719. Walker, (1989), 46–51, 165–78.
720. *Operation Epsilon*, (1993), 70.
721. *Operation Epsilon*, (1993), 70–1.
722. Walker, (1989), 23.
723. *Operation Epsilon*, (1993), 71–2.
724. *Operation Epsilon*, (1993), 724.
725. *Operation Epsilon*, (1993), 74.
726. Walker, (1989), 23–24.
727. *Operation Epsilon*, (1993), 74.
728. *Operation Epsilon*, (1993), 75.
729. *Operation Epsilon*, (1993), 76.
730. *Operation Epsilon*, (1993), 75–7, 83.
731. *Operation Epsilon*, (1993), 83.
732. Walker, (1989), 96–9.

733. *Operation Epsilon*, (1993), 83-4.
734. *Operation Epsilon*, (1993), 88.
735. Walker, (1989), 21.
736. *Operation Epsilon*, (1993), 116–17.
737. *Operation Epsilon*, (1993), 117–18.
738. *Operation Epsilon*, (1993), 11840; the original German version of this lecture is given on pages 147-64.
739. *Operation Epsilon*, (1993), 143–4.
740. *Operation Epsilon*, (1993), 175.
741. Walker, (1989), 26–7,168,207,209.
742. Smyth, (1945).
743. Walker, (1989), 25–27.
744. *Operation Epsilon*, (1993), 116,119–20.
745. *Operation EpsiZon*, (1993), 117–18.
746. R.V. Jones, Introduction, in Goudsmit, (1983), xv-xvi; also see Frank's introduction to *Operation Epsilon*, (1993), 1–13, especially 5–7.
747. Walker, (1989), 49–51.
748. Goudsmit, (1983), xvi.
749. *Operation Epsilon*, (1993), 72.
750. *Operation Epsilon*, (1993), 70, 82.
751. *Operation Epsilon*, (1993), 79–80.
752. *Operation Epsilon*, (1993), 80.
753. *Operation Epsilon*, (1993), 82.
754. *Operation Epsilon*, (1993), 87.
755. *Operation Epsilon*, (1993), 72.
756. *Operation Epsilon*, (1993), 79.
757. *Operation Epsilon*, (1993), 73, 78, 85.
758. *Operation Epsilon*, (1993), 85–6, 90.
759. *Operation Epsilon*, (1993), 76–7.
760. *Operation Epsilon*, (1993), 78.
761. *Operation Epsilon*, (1993), 80, 85–6.
762. *Operation Epsilon*, (1993), 78.
763. *Operation Epsilon*, (1993), 76–7.
764. *Operation Epsilon*, (1993), 90.
765. *Operation EpsiZon*, (1993), 78.
766. *Operation Epsilon*, (1993), 83.
767. *Operation EpsiZon*, (1993), 67.
768. *Operation Epsilon*, (1993), 82–3.
769. Walker, (1989), 46–51, 205–11.

770. *Operation Epsilon*, (1993), 175.
771. *Operation Epsilon*, (1993), 92.
772. Jungk, (1958), 105.
773. *Operation Epsilon*, (1993), 79–80.
774. *Operation Epsilon*, (1993), 92.
775. *Operation Epsilon*, (1993), 171.
776. *Operation Epsilon*, (1993), 27.
777. *Operation Epsilon*, (1993), 143.
778. *Operation Epsilon*, (1993), 89.
779. *Operation Epsilon*, (1993), 145.
780. See chapter 7.
781. *Operation Epsilon*, (1993), 87.
782. *Operation Epsilon*, (1993), 87–8.
783. Walker, (1989), 192–221.
784. *Operation Epsilon*, (1993), 143.
785. *Operation Epsilon*, (1993), 88–9.
786. *Operation Epsilon*, (1993), 92–3.
787. *Operation Epsilon*, (1993), 92.
788. *Operation Epsilon*, (1993), 211.
789. Walker, (1989), 177.
790. *Operation Epsilon*, (1993), 88.
791. *Operation Epsilon*, (1993), 143.
792. *Operation Epsilon*, (1993), 110,143.
793. See for example Eckert, (1990) and Eckert and Osietzki, (1989).
794. *Operation Epsilon*, (1993), 108–9.
795. *Operation Epsilon*, (1993), 109.
796. *Operation Epsilon*, (1993), 168.
797. *Operation Epsilon*, (1993), 230.
798. *Operation Epsilon*, (1993), 236.
799. *Operation Epsilon*, (1993), 241.
800. Walker, (1989), 204–21.
801. *Operation Epsilon*, (1993), 179–80.
802. *Operation Epsilon*, (1993), 221.
803. Walker, (1989), 179–204.
804. *Operation Epsilon*, (1993), 266.
805. *Operation Epsilon*, (1993), 275.
806. *Operation Epsilon*, (1993), 190.
807. *Operation Epsilon*, (1993), 77.
808. Walker, (1989), 192–221.

809. Walker, (1989), 153-60.
810. Goudsmit, (1983).
811. Jungk, (1956).
812. Cioc, (1988), 43-6, 75–91; an English version of the manifesto was reprinted as "Declaration...," (1957).
813. Von Weizsacker, (1957).
814. See chapters 6 and 7.
815. Ladenburg to Goudsmit (23 Oct 1946) Goudsmit, AIP.
816. Van der Waerden to Heisenberg (18 Mar 1948) Heisenberg MPI.
817. Heisenberg to van der Waerden (28 Apr 1948) AIP.
818. Jungk, (1956), 108–11, esp. 110.
819. Jungk to Heisenberg (10 Feb 1955) Heisenberg MPI; Heisenberg to Jungk (14 Feb 1955) Heisenberg MPI.
820. Heisenberg *to* Jungk (17 Nov 1956) Heisenberg MPI.
821. Jungk, (1958) 101; Heisenberg to Jungk (18 Jan 1957) Heisenberg MPI.
822. Jungk, (1958), 102–4.
823. Jungk, (1958), 81, 91, 102–4; Heisenberg to Jungk (18 Jan 1957) Heisenberg MPI; Heisenberg to Jungk (17 Nov 1956) Heisenberg MPI.
824. After this passage had been written, Jungk corroborated this interpretation; Jungk *to* the author (30 Apr 1989).
825. Von Weizsacker to the editor (14 Oct 1955), in Seelig, 130–33, here 130–31.
826. Von Weizsacker, (1958), 180–81.
827. Bohr, (1967), 193; see chapters 6 and 7.
828. Kramish, (1985), 120,203.
829. Feinberg, (1989); I would like to thank Carl Friedrich von Weizsacker for sending me a German translation of Feinberg's article.
830. Citations are from Heisenberg, (1973), 211–14.
831. Citations are from Heisenberg, (1983), 93.
832. Heisenberg, (1983), 96–103.
833. Jungk, (1993), 298–300.
834. Von Weizsacker, *Welt*, (1991); von Weizsacker, *Spiegel*, (1991); also see von Weizsacker, (1988), 37–83.
835. See von Weizsacker, (1993), 331–60, here 351.
836. Von Weizsacker, *Welt*, (1991), 4.
837. Von Weizsacker, *Zeit*, (1991), 18.
838. Walker, (1989), 47–51.
839. *Newsweek* (7 Jul 1958), 62; Diamond to Goudsmit (5 Jul 1958) AIP.
840. See chapter 9.

841. Groves, (1983), 333–40; see chapter 9.
842. Goudsmit, (1983), 134–9.
843. The latest in this line are Kramish, (1985) and Powers, (1993).
844. David Irving's book, although flawed in other ways, is a notable exception; *see* Irving, (1983).
845. Powers, (1993), 479; the page references here are taken from the British edition published by Jonathan Cape.
846. Powers, (1993), 507.
847. See chapters 6 and 7.
848. See chapter 9.
849. Powers, (1993), 481.
850. See Hermann and Schumacher, (1986), 11–22.
851. Kramish, (1985), 118–9.
852. Kershaw, (1993), 197–217.
853. Gillispie, (1959).
854. Graham, (1993).

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