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An Analysis of Success and Failure: The Manhattan Project and German Nuclear Research during the Third Reich

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SENIOR THESIS APPROVAL SHEET

This Honor's thesis entitled

"An Analysis of Success and Failure: The Manhattan Project
and German Nuclear Research during the Third Reich"

written by

Jon Tate Self

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requirements for completion of the

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meets the criteria for acceptance

and has been approved by the undersigned readers

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To Those Thirsty

Fission meant bombs, Germany was the home of the basic discovery, Hitler was determined to rule the world . . . .

INTRODUCTION

Without doubt, the years since World War II have seen a new player on the international scene. Not a person, yet to many, it personifies man's inhumanity to man. Neither is it a nation, yet it wields more power than the most powerful empire or state. Nor is it good or evil in and of itself, but like all fruit of knowledge, it defers to man in its use. The new player is the atom by virtue of its awesome explosive power.

The atom did not burst onto the scene in our context until 1939. That year saw the discovery of fission, which lends itself to the production of great amounts of energy. There were those who lost no time in realizing the applications of such knowledge for power production, and for weapons.

What ensued was the original arms race, not the one between the superpowers teetering on the brink of annihilation, but the race between the conventionally armed Allied and Axis powers. The outcome of the American Manhattan Project is clear--the disappearance of a pair of enemy cities, an unconditional surrender, a brief *Pax Americana*, and another arms race. Yet, what of the other attempts to harness the atom during the war?

Many do not even know that such parallels to the Manhattan Project existed in Great Britain, in France, in the Soviet Union, and even in Japan. Yet, in retrospect, the one most surprising, the one that had the most promise, the one among others that *should* have succeeded, this one lay in the heart of the Third Reich.

The facts are indisputable. The home of the discovery of fission, the possessor of the minds and materials to make it happen, the group with the headstart, the nation headed by a leader who would have used such weapons gleefully--all this describes Germany at the end of the 1930s. Yet, within a few years, the Thousand Year Reich would be a smoldering heap of rubble. No blinding flash of the fury of fission fought for the Fatherland. What then accounts for the discrepancy between logical expectation and reality? Why were London and Washington not destroyed by atomic bombs?

To be sure, to discuss the myriad complex factors contributing to the outcome of WWII is beyond the scope of this work. Within our scope is an examination of the two main competitors in this contest to control the atom--one destined for success and one fated to fail. The world rejoiced in the latter. The jury is still out on the former.

The story of these projects is one of paradoxes. A free and democratic nation produced and used the bomb. A brutal and totalitarian regime did not. The great minds of a people marked for destruction contributed invaluably to a weapon of ultimate destruction. Some saw the bomb as a hope for the future that could move mankind beyond the possibility of war. Our challenge is to cast aside our screen of 'perfect' hindsight and examine this topic in context: fear, war, nationalism, darkness, hope.

Any such examination presents stark contrasts between the sometimes similar German and American nuclear research projects of this time. The same discoveries awaited both sides. Each player pursued the same prize in a different manner. This difference in motivation and organization became what we call history and gave control of atomic power first to the United States.

PREWAR

The structure of the atom unveiled[1]

It is necessary to better understand this paper's central character, the atom. The first definition of the atom came from the Greek philosopher Democritus (460-370 B.C.), who theorized that matter consists of infinitely small, indivisible particles. In addition, the name he bestowed upon these particles, *atomos*, also survives to the modern day.

The character of the atom remained shrouded in mystery for over two millennia, warding off all attempts of alchemy to charm it into gold. Not until the early nineteenth century did a more modern view evolve. At that time Englishman John Dalton proposed his atomic theory, which survives in the same basic form today. He stated that matter consists of small particles called atoms and that an atom of one element is chemically identical to all other atoms of that element. In short, common sense tells us that an atom of gold is the smallest piece of gold that retains all of the unique chemical properties of gold. Nevertheless, this was a breakthrough in the 18th century.

This renewed assault upon the secrets of atomic structure caused a domino effect. Compared to the centuries it took to arrive at a basic understanding, the discoveries that

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[1] Unless otherwise noted, all information found in this section comes from Theodore Brown & H. Eugene LeMay, jr, *Chemistry: The Central Science* (Englewood Cliffs, NJ: Prentice Hall, 1988), 29-38.

followed came at lightning speed. At the close of the 18th century, Frenchman Henri Becquerel discovered radioactivity shortly after the German discovery of X-rays by Roentgen. The following year, 1897, British physicist J.J. Thomson cornered the electron using a primitive ancestor of the television, the cathode ray tube. Contrary to the common belief during 19th century that all great discoveries in science were history, the atom proved to still contain a wealth of secrets. In addition, there proved no shortage of great scientists willing to devote years to finding these secrets.

Further experimentation with radiation to determine how it interacted with matter led Englishman Ernest Rutherford to postulate the existence of the nucleus. Neither the proton nor the neutron remained hidden for long thereafter, thus completing the basic modern picture of the atom. The neutron would come to play a decisive role in the further study of the atom.

The largest question remained: how are these pieces put together? A succession of models preceded Dane Niels Bohr's elegantly simple planetary model, published in 1914, for which he received the Nobel Prize.[2] Though our current idea of the atom has changed and rests on mathematically calculated probabilities, Bohr's idea and its enduring appeal remain a basic tool employed worldwide by scientists and teachers.

By the beginning of our century, science had prodded the basic secrets out of this building block. The search did not stop there, nor has it stopped. Our understanding continues to be refined and restated; this was and is nothing new to science. What was new were the literally earthshattering implications that would accompany further experimentation on the atom. The power to destroy the future of humanity that had lain hidden through the eons awaited discovery.

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[2] Brown, 172.

The Road to Discovery

The road to discovery begins in a spacious suburb of Berlin. In Dahlem, on October 23, 1912, the Kaiser himself dedicated the Kaiser Wilhelm Institutes for chemistry and physical chemistry. By 1914, the number of institutes had grown to seven. Germany had no intentions of losing its edge in the sciences. These institutes served as focal points of discovery in the decades to come.[3]

Also on this road lay World War I. Total war brought a terrifying new dimension to human conflict and a horrible new coldness to man's potential for destruction. The cruelty of biological weapons stung the fighting masses for the first time. Although many cried out against such tactics, there existed those who supported them just as vocally. While some held that such weapons degraded science and scientists, some prominent scientists felt that "a scientist belongs to the world in times of peace but to his country in times of war."[4] *Both* sides developed and employed sinister and deadly gases with the rationalization of ending the war sooner. The greater the weapon, the more lives saved. With this war to end all wars, war and the reasoning that went with it supposedly disappeared. The shattered Western world would not have believed that it could all come again, on an even greater scale, in one generation.

The aftermath of World War I provided fertile soil for seeds of hate. Here the irrational anger of defeat left no scapegoats, not even science. In the 1920s, the rampant anti-Semitism pervading Germany also targeted physics. The Jewish Einstein's continuing success goaded several fading stars in German science. As early as 1922, a former Nobel

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[3] Richard Rhodes, *The Making of the Atomic Bomb* (NY: Simon & Schuster, 1986), 78.

[4] Ibid., 95.

prizewinner, Lenard, hurled abuse on Einstein, his supporters, and his "Jewish physics." The argument evolved to state that truth could only be found in "German physics."[5] Rational thought made the contribution of Einstein and others painfully obvious; unfortunately, decent thought lost ground slowly to madness.

Yet, our understanding of that basic unit, the atom, came further into the light during this time of increasing darkness. The great centers of thought lay not only in Germany, but throughout Europe and even in the United States. In the early 1920s, Bohr received the Nobel prize while also establishing a dream, the Bohr Institute for Theoretical Physics. The opportunity to study under the most influential scientist of the day made Bohr's Institute in Copenhagen a mecca. During this time, Bohr hypothesized that the chemical character of any particular atom or molecule is a result of the electrons in its outer shell. Identifying these valence electrons filled another great gap in our understanding and provided a link between physics and chemistry, thus demonstrating the genius of this Dane.[6]

During the decade of the 20's, a young German began making himself much better known. Werner Heisenberg introduced his famous "Uncertainty Principle,"[7] not only delving into the structure of the atom but also into its components and their behavior. This only began the great role Heisenberg would come to play in physics. Not to be outdone during the interwar period, the U.S. also made its contributions to the growing body of knowledge related to the nuclear realm. In the early thirties, the cyclo-

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[5] Albert Speer, *Inside the Third Reich* (NY: Macmillan, 1970), 273.

[6] Rhodes, 114.

[7] This principle states that it is impossible to know both the momentum and location of an electron in space. Brown, 179.

tron and D_20 both became known.[8,9] Each would come to play a key role in the unfolding drama.

The following year the possible uses of the atom flashed suddenly through the mind of Leo Szilard, a Hungarian emigre in Britain, as he crossed the street in London on a dreary September day. It occurred to him that the energy bound in the atom could be released, possibly to propel man to the stars. The outlet for the human spirit would be limitless and war would end.[10] Fallacious thinking apparently did not disappear after the First World War.

Szilard's interest in the subject led him to pursue the matter and in 1935 to approach the British Government to discuss "the question whether or not the liberation of nuclear energy . . . can be achieved in the immediate future."[11] Szilard's pleas for the need for government secrecy and his sense of urgency almost came to no avail. In October 1935 the War Office turned down his offer of a patent on applications of nuclear energy, citing the apparent lack of its importance! The Admiralty reluctantly took the patent into its safekeeping soon thereafter.[12]

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[8] A cyclotron is a particle accelerator, used to accelerate nuclear particles to sufficient velocities to overcome electric repulsions and bring about a collision and nuclear reaction.

[9] D_2O stands for deuterium oxide, or heavy water. Its importance lies in its use as a moderator in nuclear fission. In other words, it is a necessary brake fluid in studying the atom.

[10] Rhodes, 13, 24.

[11] Spencer R. Weart and Gertrud Weiss Szilard, eds., *Leo Szilard: His Version of the Facts* (MIT Press, 1978), 41.

[12] Ibid., 18.

While Szilard theorized in England, his contemporaries throughout Europe also wasted no time in their pursuits. The legacy of the Curies, who gave radioactivity its name, continued in Paris through their son-in-law, Frederic Joliot-Curie. He produced artificial radiation in 1933, thereby showing that Rutherford's nucleus, when bombarded by a source of radiation, released some of its vast energy by decay. The leading physicists of the day lost no time in extrapolating this discovery into greater applications, suggesting that if the proper material could be found and assembled, an explosion might occur.[13] Interestingly, a relatively minor German chemist, Ida Noddack, suggested the curious idea that the atom could have produced energy by fragmenting. As this contradicted the popular scientific thought of the day, her theory received little attention.[14]

The pieces of the puzzle came together further with the work of Italian Enrico Fermi. His work, begun in Rome in 1934, concerned the results of bombarding uranium, one of the few naturally occurring radioactive elements, with neutrons. Fermi named the species produced transuranics, and scientists everywhere followed his work, trying to ferret out what these mysterious new elements could be. The Kaiser Wilhelm Institute in Berlin-Dahlem, where chemists Otto Hahn and Fritz Strassman worked with physicist Lise Meitner, provided one such site of research.[15] Hahn and Strassman, German by birth, and Meitner, German by Anschluss, honed their analysis of the confusing results of Fermi's work. Their work might have proceeded to quicker resolution had not the ugly affairs of the Reich intervened.

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[13] Rhodes, 200-3.

[14] Hoddeson, 13.

[15] Powers, 45-47. Rhodes, 234. Irving, 20.

The insanity of Hitler's racial laws left no stone unturned and by 1938 had reached even the private Kaiser Wilhelm Institute. So, as had thousands of others, Lise Meitner had to flee the ominous cloud settling over Germany.[16] Perhaps more than any other decision in the coming years, the decision to purge the Jews crippled German society and science. First promulgated in 1933, the laws eventually resulted in the export of one of Germany's greatest assets--a great number of her intelligentsia. The Universities of Berlin and Frankfurt alone lost over one third of their faculties.[17]

The effects of these laws were not limited to the Fatherland; eventually, such bright stars as Hungarian Leo Szilard and Italian Enrico Fermi elected to flee. This proved to be a blessing for the United States and Great Britain, as both acted officially to help these emigres resettle. The Anglo-American academic world received hundreds of top professors, including a number who would play decisive roles in the race to come.[18]

In the midst of such major sociopolitical upheaval and scientific discovery, the pace of change soon accelerated! While the map continued to change because of England's and France's appeasement, which allowed Czechoslovakia to fall to Hitler in his drive for lebensraum, the last major obstacle on the road to discovery gave way. This great insight occurred in the collaboration between Hahn and Strassman in Berlin and Meitner in Sweden. They had continued their work on the transuranic phenomena observed by Fermi, and by the latter half of 1938, Hahn felt painted into a corner.

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[16] Arnold Kramish, *The Griffin: The Greatest Untold Espionage Story of WWII* (Boston: Houghton-Mifflin, 1986), 50-1.

[17] Rhodes, 184-8.

[18] Ibid., 193. Hoddeson, 9.

All of Hahn's results pointed to the existence of barium as a product of uranium bombardment, while all of his intuition told him that was nonsense. Though his technique contained no flaws, this result opposed the conventional knowledge of the day. He hesitated to publish his results, in spite of being sure that the unknown matched barium, saying, "we all know that it can't *really* burst asunder to form barium."[19] The team at the Institute had split uranium and identified the products, using a lab setup which looks like it was made in someone's garage,[20] yet remained in the dark as to their discovery. It took an Austrian refugee woman in Sweden to interpret the data.[21]

Meitner arrived at her momentous conclusion during Christmastime 1938 with the help of her nephew Otto Frisch. On a walk together through the countryside, they hammered out a picture of the splitting of the atom. Frisch would be the one to borrow the term *fission* from biology.[22] The road to discovery had come to an end. The road to the bomb had finally begun.

Fission Revealed

With Meitner's encouragement and the generous assistance of *Naturwissenschaften* editor Paul Rosbaud, Hahn prepared a manuscript for publication. Had Hahn known that Rosbaud went by the codename "Griffin" in all his dealings with the British intelligence community, he might not have rushed to follow Rosbaud's advice to publish.

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[19] Irving, 27.

[20] This author had the opportunity to see the original lab apparati with which Hahn made his momentous discovery. The display resides in the Deutsches Museum in Munich, Germany.

[21] Otto Frisch, *What little I can remember* (Cambridge: Cambridge U Press, 1979), 114-7.

[22] Ibid.

Not a scientist, but neither slow to grasp the possibilities of Hahn's discovery, Rosbaud knew without a doubt that such a discovery did not need to remain in German hands.[23] Had he not seen to it that Hahn's astounding discovery became internationally known, the world might be a very different place.

The published news filtered its way slowly across the continent, reaching Paris by January 26, 1939. Naturally, the Joliot-Curies, shocked and disappointed, realized how close they had come to the same discovery, as had numerous other scientists.[24] The news found its way to the U.S. in the person of Niels Bohr before the published results did. Needless to say, the news spread like wildfire across the states. By the end of January, the *New York Times* and the New York *Herald Tribune* had both published accounts of the discovery; Rosbaud had succeeded in getting the secret out.[25]

Armed with this knowledge, physicists around the globe began an all-out assault on the atom. Scientific breakthroughs began to mount. The news of the Parisian team's discovery of the emission of secondary neutrons from uranium confirmed the possibility of a bomb.[26] Due to the magnitude of the discovery Hahn pondered suicide while others at the KWI in Berlin considered dumping all their uranium into the sea.[27]

That spring a race began. The scientists who had quickly realized the implications of the news just as quickly reacted. Scientists at various universities soon had definite

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[23] Kramish, 50-1.

[24] Rhodes, 271.

[25] Powers, 49-53.

[26] This meant that a uranium atom that absorbs an incoming neutron, in turn, emits neutrons. If more than one neutron is emitted, a sort of population growth occurs, resulting in a chain reaction.

[27] Powers, 54-56.

ideas about the possibility of a weapon.[28] One German emigre in the U.S. immediately envisioned a nuclear pile.[29] By March, Szilard, not content to stay and stir things up in the U.K., and Fermi approached the U.S. government urging immediate action.[30] The following month a program in nuclear research began in France under the Ministry for Economic Affairs.[31] At the urging of several of her scientists, Britain concentrated all future matters relating to the applications of atomic energy in the Air Ministry and began plans to corner the world supply of uranium, most of which came from the Belgian Congo.[32]

Nor was the home of this discovery slow to react. Chemist Paul Harteck wasted no time in writing the German War Office that "the newest developments in nuclear physics . . . will probably make it possible to produce an explosive many orders of magnitude more powerful than the conventional ones. . . .That country which first makes use of it has an unsurpassable advantage over the others."[33]

At the same time, another scientist alerted the Reich Ministry of Education, as it controlled all universities. On April 29, 1939, the Ministry's Reich Research Council held a conference on the uses of atomic energy where Hahn received a browbeating for having let the discovery of fission become known with his publication. Research Council head

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[28] Rhodes, 274-5.

[29] Serber, xxvii.

[30] Rhodes, 292.

[31] Powers, 75.

[32] Margaret Gowing, *Britain and Atomic Energy 1939-1945* (London: Macmillan, 1964), 34-6.

[33] Powers, 10. Irving, 36-7.

Abraham Esau wasted no time either; he banned the export of uranium and began planning a joint research group under his direction composed of Germany's best and brightest scientists. Thus, German nuclear research during the war began as a two-headed dragon.[34]

While the specter presented by the promise of fission alarmed all scientists, those in the U.S. and U.K. sought to pull down a veil of secrecy, while those in Germany reacted by disseminating information.[35] Two such German attempts to spread the word that Germany would pose no atomic threat in the future found a channel out of the Reich through Paul Rosbaud. A spy must get his information somewhere, and some German scientists offered it freely. In May 1939 Rosbaud passed to the British the news of the Germans' April Conference concerning the military applications of fission, while later in the summer he relayed that the German physicists were reluctant to participate.[36]

At this time the situation developed quite differently on both sides. Although initially Germany had all the advantages, such as the discoverer of fission, Czechoslovakian uranium, and a headstart, the Fatherland also inspired a strange sort of ambivalence in a number of its own scientists, evidenced in the information leaks and in a stunning publication of June 1939. This paper by Siegfried Fluegge, entitled "Can the Energy Content of Atomic Nuclei Be Harnessed," put into words the whispers of the last few months. He stopped just short of saying bomb. Though he may have intended this as proof that the Germans had nothing to hide, it produced the opposite effect. The urgency felt in the U.S. and Britain bloomed into a full four-alarm warning.

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[34] Irving, 36.

[35] Weart, 53. Powers, 59.

[36] Powers, 585.

The rapid pace of developments in the Third Reich merited such alarm. Fluegge's article spurred greater interest among German authorities, resulting in action at the War Office. Initially slow to respond to Harteck's letter, the Army finally provided funds for Dr. Kurt Diebner, its expert on nuclear physics, to establish a laboratory in Gottow.[37]

The famous Einstein-Roosevelt letter of August 2, 1939, resulted from this sense of dread. With the threat of war fast approaching, those emigres to America who best knew to dread Hitler carried their argument to the highest office in the land.[38,39] The letter summarized recent developments, stating clearly that "extremely powerful bombs of a new type may thus be constructed."[40] The need to pursue that train of thought received further impetus on September 1, 1939, as Hitler unleashed *blitzkrieg* on Poland.

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[37] Irving, 40-1.

[38] Weart 82-4. Powers, 62-3.

[39] One of the three, Szilard, had first suggested contacting Einstein's friend, the Queen of Belgium, to corner the market on uranium! Ibid.

[40] Ibid., 95.

1 SEPTEMBER 1939-JUNE 1942
BEGINNING TO TURNING POINT

1939

Blitzkrieg inspired horror throughout the West and effectively demolished Polish defenses in a short time. Roosevelt crystallized national sentiments in his speech to Congress on the day WWII began in Europe. He stated that "the ruthless bombing from the air of civilians . . . has resulted in the maiming and the death of thousands . . . and has profoundly shocked the conscience of humanity."[41] Would he have believed possible the amount of destruction that would rain down from American bombers on two Japanese cities in six years?

Beyond prompting such outrage in our President, the outbreak of conflict also made it even more difficult for concerned scientists to reach him. He did not hear about Einstein's letter until October 11, 1939. This made the President the first head of state to receive an authoritative report on the possibilities opened by the discovery of fission. Though no scientist himself, the President wasted no time in grasping the implications; he realized that action would be necessary to prevent a rain of destruction on the West.[42]

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[41] Franklin D. Roosevelt, *The Public Papers and Addresses, VIII* (Russell & Russell, 1939), 454, quoted in Rhodes, 310.

[42] Powers, 11. Rhodes, 310-314.

Action did follow the letter, and on October 21, the Advisory Committee on Uranium held its first meeting. Director Lyman Briggs of the Bureau of Standards and representatives of the Army and Navy met with the emigres who had raised the alarm. The nonscientists present heaped skepticism on the whole issue, but in the end, appropriated $6,000 for related research. The committee report to the President on November 1 narrowly supported the enterprise with an emphasis on power generation. This report also mentioned that should research reveal any promise of explosive applications of uranium, a thorough investigation would be prudent.[43] So, with a whimper, the U.S. government struck off down the road to Hiroshima.

Work in Germany started, on the other hand, with quite a bang. The Army Ordnance Research Department had seen the likelihood of a bomb from Fluegge's explicit June article and wasted no time in further investigating the subject. In early September, the Army ordered the Ministry of Education to cease all investigations into the nature of uranium.

A conference slated for September 16, 1939, included a virtual constellation of Germany's brightest stars in science. Yet, the group lacked its "Northern Star," Werner Heisenberg, the theoretical genius who had made his reputation as a young man and whose genius had not diminished since his Nobel Prize in the mid-1920s. His absence was due to the odor of "Jewish physics" about him due to his defense of persecuted academics and his unwavering adherence to Einstein's ideas.[44]

So, without their leading physicist, the German Army convened its first inquiry. The scientists arrived for the meeting fully expecting conscription. Why else would the

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[43] Irving, 67. Rhodes, 315-7.

[44] Powers, 14-16.

Army have summoned someone to an office in Berlin in 1939? Relief surely followed the revelation of the meeting's purpose, but for some scientists, this relief quickly gave way to dread. Foremost among those with reservations, fission's discoverer, Otto Hahn, again said if his work led to a bomb he would commit suicide. Arguing effectively, other scientists persuaded the group that no harm would result from only studying the problem, particularly the promise of a uranium engine.[45] So, with the eager hope of fully exploiting the nucleus, the German Army's project got underway.

The arguments of several scientists succeeded in including Heisenberg in the project. The War Office's Nuclear Physics Research Group conscripted him on September 20, thereby completing the cast of characters for the German project.[46] Heisenberg came to play a pivotal role in the development of nuclear research in the Third Reich. In short, as the undisputed leading scientist in Germany, he alone could "guide the German atomic research effort into a broom closet, where the scientists tinkered until the war ended."[47]

Perhaps his first act of silent sabotage was his most fatal. Common sense dictated centralized research; therefore, the War Office commandeered the KWI for Physics, envisioning a single research site in the heart of the Reich. Heisenberg emphatically opposed such a move, as did others less vehemently. He effectively argued that researchers would accomplish more at their own institutes. Hesitantly, the government agreed.[48] In one stroke, the Germans had dashed their own chances for success. Just as the

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[45] Powers, 14-16. Irving, 44-5.

[46] Irving, 45.

[47] Powers, 481.

[48] Irving, 49-50.

American decision to centralize resulted in success, so the German failure to do so set them on a course to nowhere.

The collection of scientists varied immensely in their views of the project. Those like Heisenberg felt horrified by the prospect of the Nazis wielding an atomic weapon while those like Diebner and Harteck wholeheartedly desired success. Some idealists even hoped that, armed with progress toward unleashing the power of the atom, Germany's scientists might hold sway over the government.[49] Perhaps the scientific genius Planck's counsel of despair summed up many of the scientists' feelings most concisely--"pointless to protest, insane to intervene, one could only wait."[50]

That fall Heisenberg divided his time between Leipzig and the KWI in Berlin, studying the feasibility of a reactor, as did Fermi at Columbia University.[51] Concurrently, Harteck sought how to isolate the necessary uranium, as did Frisch and Rotblat in the U.K.[52] Soon, the British government would feel motivated to become as active as the Germans.

So, with so strange a mix of scientists, a headstart, and a definite goal, that autumn the Germans got to work. The reverse situation existed in the Anglo-American world. The scientists screamed for action while the governments dragged their feet!

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[49] Ibid., 36, 41. Powers, 20.

[50] Powers, 39.

[51] Powers, 21.

[52] Ibid., 73. Rhodes, 319.

1940

The early part of the year saw the proclamation of the "phony war" by those lulled into a sense of security by the lull in fighting. Hitler would soon change their minds. In contrast, no lull came to nuclear research efforts across the globe. The research would not reach a turning point within the year, but the journey there had certainly begun.

The level of interest in the United Kingdom increased markedly in March with a memorandum from two prominent Jewish emigre scientists working at the University of Birmingham. Otto Frisch, Meitner's nephew who had coined the term fission, and Rudolph Peierls first put together the ideas concerning the practical construction of a bomb. Building on the recent work of other scientists, they concluded that a *deliverable* quantity of uranium could serve as a bomb. Whereas earlier estimates had ranged into the tons of uranium, they accurately predicted a critical mass[53] in the single digit kilogram range. They made their estimate presupposing the use of the lighter isotope[54] of uranium, U235.[55]

In their next step they wrote a memo, summarizing their findings, which radar scientist Mark Oliphant carried to Henry Tizard, chairman of the Committee on the Scientific Survey of Air Defense. The lucid, concise document stressed the massive power of such an explosive and proposed an elegantly simple method of general design. The necessary separation of isotopes would be difficult, but not insuperable.[56] They touched

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[53] Critical mass is that amount of fissionable material necessary for an explosion.

[54] Isotopes are atoms of the same element that differ in weight, meaning that they have the ame number of protons but different numbers of neutrons--isotopes are chemically identical.

[55] U235 is present in a sample of uranium 1:139 with 'regular' uranium, U238.

[56] One scientist in Great Britain summed up the situation when considering the numerous uggested methods of isotope separation. He said you couldn't "spit on the floor without separating

upon the destructive side effects of radiation and included a list of conclusions to make the information easily digestible.

> 1. As a weapon, the super-bomb would be practically irresistible. 2. . . . [It] could probably not be used without killing large numbers of civilians, and *this may make it unsuitable as a weapon for use by this country*[italics added] . . . . 3. . . . It is quite conceivable that Germany is, in fact, developing this weapon . . . . 4. . . . It must be realised that no shelters are available that would be effective and could be used on a large scale. The most effective reply would be a counter-threat with a similar weapon.[57]

The amazing foresight of their thoughts needs no emphasis. In one document, they summarized the entire situation. Though the term Mutually Assured Destruction did not come into existence until long after the guns of WWII had gone silent, the two emigres from the Reich prophesied it in spring 1940. The countries involved in the struggle would not remain the same, but the politics of the bomb would. In retrospect, Frisch clearly stated the reason he was willing to start work toward such a weapon. "We were at war, and the idea was reasonably obvious; very probably some German scientists had had the same idea and were working on it."[58]

Because of this memo, on April 10, 1940, the U.K. formed its own version of the U.S. Uranium Committee which would soon take the name MAUD.[59] This month saw the second meeting of the U.S. committee, which soon gave way to the newly formed

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otopes; the only difficulty was to separate them." Nancy Arms, *A Prophet in Two Countries* xford: Pergamon Press, 1966), 109.

[57] Robert Serber, *The Los Alamos Primer* (Berkeley, CA: U of CA Press, 1992), 79-88.

[58] Frisch, 325.

[59] The story of the committee's name provides an amusing anecdote: in a letter Bohr included eetings to one Maud Ray Kent. British Intelligence, sure that the name stood for an anagram of dium taken, borrowed the name for their central atomic committee. Mrs. Kent was actually a verness who had kept the Bohr children! Gowing, 45.

National Defense Research Council with an expanded budget of $140,000. During this same period, the U.S. and U.K. established their dialogue on atomic matters.[60] Within months, half a world away, the faint stirrings of interest in the atomic bomb reached the shores of Japan. The nation, the first and only victim of atomic holocaust, lost no time in joining the race to the destructive prize![61] In addition, the scientists in the U.S.S.R. began to suspect that the U.S. might be pursuing weapons research due to the apparent veil of secrecy. The Soviets' university-centered research effort, though small, began.[62]

As work continued in Germany, the progress of the war brought the entire situation into a new light. April brought Denmark, and therewith, Bohr under Nazi control. Furthermore, on May 3, Rjukan became the last town in southern Norway to fall to the Germans after ferocious resistance. Small Rjukan's significance lay in the fact that nestled on the edge of its upper ravine stood the world's only heavy water plant.[63,64] Thus, the Germans came yet one step closer to atomic success. Yet, any success would come without the aid of the Fatherland's Axis partner to the south. In May Italian physicists had decided to abandon fission studies, lest Mussolini become interested.[65]

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[60] Rhodes, 334,337-8.

[61] Deborah Shapley, "Nuclear Weapons History: Japan's Wartime Bomb Projects Revealed," *cience*, 13 Jan 78, 152-7.

[62] Herbert York, *The Advisors: Oppenheimer, Teller, and the Superbomb* (San Francisco: W.H. reeman, 1976), 30-1.

[63] Heavy water is composed of oxygen and deuterium, a heavier isotope of hydrogen. The ermans fallaciously believed D_2O to be the only suitable moderator for nuclear research. See ection *1941* concerning Bothe's error.

[64] Kramish, 83. Irving, 53. Powers, 76.

[65] Powers, 165.

The frantic desire of Szilard and the other members of the "Hungarian trio," Wigner and Teller, to keep a tight lid on atomic information in the U.S. once again came to no avail. In May 1940, the *New York Times* ran a revealing front-page story on the possibility of atomic explosives, specifically mentioning the utility of U235.[66] Perhaps if the Germans had read the *Times* more often, their project would have succeeded!

Also, in May, American scientists isolated plutonium for the first time. The importance of this discovery lay in the fact that plutonium would provide another path to the bomb. It is fissionable like uranium, but it is another element and therefore *chemically* separable. The Americans unofficially moved toward closing the gap.[67] The summer saw the establishment of a radiation lab at MIT, while at the same time the U.S. finally took measures to impose censorship on potentially sensitive scientific publications.[68]

The continued success of Hitler's armies granted further favor to the German work. With the blitz of the Benelux countries and the shocking rout of the French, Germany captured not only tons of Belgian uranium ore, but also the prized cyclotron of the Joliot-Curies.[69] The success of the Germans on the warfront did not find parallel in the lab back home. Military success actually had the effect of deprioritizing nuclear research.[70] In June, the promising chemist Harteck's ingenious experimentation with

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[66] Sunday, May 5, 1940.

[67] Powers, 78. Rhodes, 352-5.

[68] Irving, 73 ,94-5. Rhodes, 351.

[69] Irving, 72. Powers, 81-2.

[70] Powers, 82.

frozen CO_2 failed. Heisenberg's stinginess with his uranium supplies had doomed Harteck to failure.[71]

In July, the construction of a new facility began on the site of the KWI in Berlin. Named the Virus House to keep out unwanted guests, the building would serve as the site of innovative experiments. Also, during the latter half of the year, an enterprising technician named von Ardenne found the publications trail toward the bomb. His entrepreneurial skills proved themselves in his requisitioning of funds when he approached and received backing from the Post Office! With German scientist Houtermans, recently released from Soviet prison, von Ardenne's lab came on-line, with surprising success.[72]

The year had seen a mixture of success and failure. The successes and impetus mounted in the U.S. and U.K. The French program simply ceased to exist. Even the Japanese and Russians joined the fray while the Germans continued to shoot themselves in the foot.

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[71] Irving, 64. Rhodes, 343-4.

[72] Irving, 77-9. Powers, 90-7.

1941

1941 began with the largest single blunder of the entire nuclear research effort during WWII. Physicist Walter Bothe at the University of Heidelberg submitted a report to Army Ordnance in January in which he ruled out the use of graphite as a moderator in nuclear research. His projections proved shockingly inaccurate and better attention to detail would have caught the error. The elimination of such an abundant, inexpensive material had far-reaching effects. It left only heavy water as a possibility and created a bottleneck in the German effort. The entire project now depended on the slow trickle of D_2O collected in the rugged valley in southern Norway.[73]

Bothe's diary that day read that he had "been speaking of physics the entire day, while thinking only of you." The "you" referred to Ingeborg Moerschner whom Bothe had met a year earlier on a cruise to New York. She was a spy on her way to the U.S., and thoughts of her sufficiently distracted this leading German physicist on the day he absentmindedly made the most fatal error of the Third Reich's nuclear research effort![74] This mistake provided yet another example that Germany's industry would not fail her, but rather, her scientists. Bothe's prominence ensured that few would challenge his findings; in fact, no German realized his error until 1945.[75]

The following March, the German scientists reconvened to compare work and discuss progress. Together they narrowed their priorities to two problems, those of heavy water and uranium separation. To solve the problem of obtaining enough D_20, they redesigned the concentration process used in Rjukan for greater efficiency. The

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[73] Powers, 98. Irving, 85.

[74] Kramish, 174.

[75] Irving, 85.

difficulties surrounding uranium separation proved more troublesome. Two new methods came into use, isotope-sluice and ultracentrifuge. By the end of the year, the Germans would be attempting seven different methods. These seven did not include the German-invented barrier diffusion method that would prove successful for the United States![76]

April 1941 saw a flurry of activity outside Germany. Foremost, an urgent message smuggled out of the Reich from von Ardenne's assistant Houtermans stressed that Heisenberg and others stalled as much as possible but that the pressure for success was immense.[77] The exchange of information that month was not limited to German espionage; the United States began exchanging information with Great Britain.[78] The U.S., not yet at war, had no doubts about which side to support should involvement arise. Thus began one of the most extraordinary alliances of all history. Not only did two nations cooperate, but they helped one another toward obtaining a weapon of ultimate destruction. Official interest during this time lay not only in the West; Prime Minister Tojo of Japan finally gave orders to pursue a fission weapon.[79]

By the middle of the year, Great Britain had abandoned the Clusius method in favor of gaseous barrier diffusion, which would have promising results by the fall.[80] Concurrently, the U.S. government received the first National Academy of Sciences report concerning nuclear research. Closely echoing its German and British cousins, this report stressed the importance of gaining a leading advantage in the field. Another NAS

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[76] Irving, 88-91.

[77] Powers, 106-7, 585.

[78] Irving, 95.

[79] Shapley, 153.

[80] Rhodes, 345.

report before the end of the year would similarly paint an encouraging picture of the long-term prospects of fission applications without committing to a weapon.[81]

Also, the British began efforts to discover more about German activities in relation to the heavy water plant in Rjukan. Included in the analysis were Peierls and, ironically, Klaus Fuchs.[82,83] A nation that had dedicated itself to monitor its mortal enemy also decided that a bomb would be feasible; Britain had the will to construct a bomb and the July MAUD report gave the go-ahead.[84] A second Einstein letter, this time from the famed scientist to Churchill, also played no small part in the final British decision to commit to the bomb.[85]

The British communicated this to the U.S. and in August sent Mark Oliphant to discover why Briggs and the Uranium Committee seemed to have nothing to say about the issue. Discouraged, Oliphant returned home without any clear answers but with a clear impression of American reluctance. The smartest move he made was convincing leading American scientist Ernest Lawrence of the urgency of the secret report. Oliphant might have left, but he had loosed a cannon on Washington.[86]

Lawrence accomplished his goal well. The message and report worked their way through the bureaucracy and into the hands of Vannevar Bush. Bush had left MIT to

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[81] Ibid., 365, 386.

[82] Fuchs would waste none of his experience with espionage. He would later leak tremendous nounts of information to the Soviets concerning his later work with the Manhattan Project.

[83] Powers, 195-6.

[84] Irving, 95-7.

[85] Ibid., 99. Rhodes, 372.

[86] Rhodes, 372-7.

establish a proper liaison between the military and civilians in weapons development. His efforts resulted in the formation of the National Defense Research Council, thereby giving nuclear fission an independent lobby in the executive branch.[87]

Bush met with President Roosevelt on October 9, 1941. Surveying British calculations and British conclusions, Roosevelt became interested in attaching to the British work. In retrospect, Bush felt the most important outcome of the meeting was the President's interest and lightning quick decision to reserve all future nuclear weapons policy decisions for himself. Thus, without the opinion of the courts or Congress, the President committed the nation to thoroughly exploring the construction of an A-bomb.[88]

The cooperation would grow with the establishment of liaison officers, the first of which was James Conant,[89] who traveled to Great Britain in late 1941.[90] During this time of British commitment and American consideration, the unofficial U.S. project continued. Fermi and his colleagues made further progress toward a chain-reacting pile in Chicago while Seaborg plowed ahead in his extraordinary efforts to produce and study plutonium.[91] Nor had there been any lack of activity in Germany.

The amazing progress of Houtermans at von Ardenne's lab had resulted in a comprehensive picture of a feasible bomb. Particularly, as had Weisaecker before him,

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[87] Ibid., 336-8.

[88] Rhodes, 377-9.

[89] James Bryant Conant had been both president of Harvard and instrumental in the rmation of the NDRC.

[90] Conant, 276.

[91] Rhodes, 395-7.

Houtermans realized the potential of pursuing plutonium.[92] This report circulated among the Uranium Club[93] in August without official response; yet upon reading it, Heisenberg said "we saw in front of us an open road to the atomic bomb."[94] Heisenberg's only reply to von Ardenne attempted to discourage him from further work![95] Another discouraging report at this time, submitted by Weisaecker, detailed America's advantages over Germany in nuclear physics.[96] The work in the Fatherland seemed to be losing its luster.

In response to the developments of the recent months, Heisenberg undertook a trip to visit his mentor and friend Niels Bohr in occupied Denmark. Speculation abounds as to the purpose of Heisenberg's visit. Each man came away from the encounter with a different interpretation of their exchange. Heisenberg wanted to make clear the lines of research being followed in Germany and suggested some sort of scientific bargain in which scientists on both sides could avoid the dreadful results of their work by agreeing not to pursue it further. In short, solidarity equaled safety. Bohr heard Heisenberg loud and clear, but the two failed to speak the same language. Bohr's impression was one of suspicion and distrust. Their old friendship became secondary as he talked to a German physicist working for Hitler. He seemed to hear him say, "We've driven out all those

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[92] Ibid., 371. Irving, 93.

[93] The "Uranium Club" (*Uranverein*) referred to the loosely knit group of scientists working ı German nuclear research.

[94] Irving, 102.

[95] Powers, 134-5.

[96] Ibid., 508.

Jewish physicists and now they're working on a bomb in America--dear Niels, can't you ask them to back off?"[97]

December 1941 proved to be another of those eventful periods in which turning points crowd together, the most obvious changes in the international situation coming from the military theaters. The Japanese Empire launched their surprise attack on the United States at Pearl Harbor, thereby setting into action the course of events that would result in the vaporization of two of Japan's largest cities within four years. The Land of the Rising Sun could not have chosen a more effective method of shocking the American people or galvanizing the nation's will in an all-out effort to crush an enemy. Fear had struck the heartland and Americans would not turn back in the course of the next four years of conflict.

The surprisingly ferocious Russian counteroffensive on the Reich's eastern front provided the other great military turnaround of that month. The altered situation resulted in a directive from Hitler to review all resource-sapping programs, scrapping those holding no promise of success within the coming year. In accordance with this order, the first of three conferences to determine finally the promise of an atomic bomb convened on December 16. The conference resulted in the transfer of the project from the Army to the Reich Research Council.[98]

As the German offensive of June 1941 had almost killed Soviet nuclear research, so the reverse now happened. The Soviet program would eventually begin to recover,

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[97] Ibid., 120-8.

[98] Ibid., 130-5. Irving, 105.

particularly after the first months of 1943. Several German scientists would even add to the work after the war. . . . [99]

1942

Catalyzed by the recent events at Pearl Harbor and encouraged by the November National Academy of Sciences report, which confirmed the findings of the British MAUD report, President Roosevelt granted his only recorded sign of approval related to the eventual realization of atomic weapons with a simple memo attached to a copy of the NAS report. "Jan 19--V.B. Ok--returned--I think you had best keep this in your own safe FDR."[100] During this fateful period in the development of the American project, the direction of the German work also hung in the balance. The first half of 1942 would make or break period for both.

Having recently suffered from the decision to gradually transfer the project from under the Army's supervision to the Reich Research Council, headed by the incompetent Minister of Education Bernhard Rust, the future of nuclear research in Germany still had promise. As evidence of the support given the program, a wealthy, well-connected industrial physicist began a campaign against the self-defeating war on "Jewish physics" by stressing the promise of atomic energy. His efforts did succeed in raising the Reich Research Council's interest in the cast-off research program it had just inherited. In fact, the Research Council chose to schedule a meeting of scientists and high Nazi officials on

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[99] York, 30. Irving, 291. Rhodes, 500-2.

[100] Rhodes, 386-8.

February 26, the same day as a conference of those scientists who had worked under the Army's direction. They hoped to breathe new life into the flailing project.[101]

The German project's comedy of errors, which began with Bothe's incorrect measurement of graphite as a moderator, reached its climax with these conferences. A secretary apparently switched the invitations that included the lecture schedules. Instead of receiving a list of eight general topics, including "Nuclear Physics as a Weapon," the top generals, SS officials, and others guests received the schedule for the parallel, scientists-only conference which featured a full array of complicated lectures on specific, obtuse scientific topics. Not surprisingly, almost all of the high officials found a convenient reason not to attend the conference personally. Once again, the outcome of WWII took a radical turn due to the simple mistake of one person--this time a lowly secretary![102]

Records from the conference indicate that Hahn gave a brief lecture on fission and then Heisenberg proceeded to detail the situation and the hope for a bomb. He gave a blurred and less than encouraging lecture, using complicated examples. Noticeably absent was any mention of critical mass or the difference between a reactor and bomb. Heisenberg did explain the vital necessity of heavy water in any reactor plans and endorsed the idea of pursuing the production of plutonium over uranium separation. Though less than enthusiastic, this conference buoyed the project's chances of further official favor and funds.[103]

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[101] Powers 137-8.

[102] Irving, 105-7. Powers, 137.

[103] Irving, 107-12. Powers, 139-140. Rhodes, 402-3.

Another evidence of the increased interest was the raising of the eyebrows of newly-appointed Minister of Armaments, Albert Speer. In essence, second only to Hitler, Speer could make or break the whole project by himself. One of his actions was to recommend the replacement of Rust with Goering[104] as head of the Reich Research Council, thereby granting it a measure of prestige. Speer awaited the opportunity to learn more about the promises of further research; he did not have to wait long. On June 4, 1942, another conference met at the Harnack House in Berlin.[105]

A similarly decisive conference occurred in the United States on May 23. Interested research leaders assembled with Conant in Washington to decide which paths to the bomb held the most promise. As a result the U.S. chose to pursue all five options: centrifuge, gaseous barrier diffusion, electromagnetic, and graphite/heavy water plutonium-producing piles[106].

No less fateful in its outcome, an Italian emigre began planning a full-scale chain-reacting pile in Chicago that month. So, while the German project teetered between a promising future and oblivion, the U.S. work began inching toward success. The summer 1942 turning point approached.

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[104] Goering was Hitler's powerful Reich Marshal in charge of the Air Force.

[105] Speer, 269.

[106] Rhodes, 406.

SUMMER 1942-POSTWAR
THE ROAD TO HIROSHIMA AND FARM HALL

Latter 1942

The decisive point occurred at a conference at Harnack Haus[107] in Berlin of June 4, 1942. Approximately fifty people gathered there, including Speer, his top military and civilian advisors, generals, field marshals, and admirals, not to mention Hahn, Diebner, and Harteck. Another Heisenberg lecture echoed throughout the room, painfully unclear on the promise of plutonium. This time, though, a general asked how nuclear physics could result in a bomb. The excitement in the room was obvious, as most present had never considered this possibility. Heisenberg's estimate that a bomb "as large as a pineapple" could destroy London peaked interest further. Heisenberg explained the theoretical possibility of a fission weapon, but said it would take years until success, even if accorded top priority.

He wasted no effort in detailing the immense difficulties involved and pointing out all the Germans' disadvantages, including the limited use of only one cyclotron while the Americans had numerous, larger cyclotrons with which to work. When Speer offered the resources to match American facilities, Heisenberg feebly replied that Germans lacked

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[107] The accounts of the conference are found in: Powers, 146-52; Irving, 118-22; Speer, 270-1.

the knowledge to build large cyclotrons. When asked how much funding they would require for the whole project, the scientists proposed a figure of 40,000 DM.

Speer, discouraged by the meeting, expressed his displeasure at having been encouraged to waste his time on a proposal requiring such a ridiculously low amount of money. Though the German project survived the meeting and received further funding, by autumn it had, in effect, been scuttled based on the advice of the physicists.[108]

Nothing could have been more devastating to those scientists who, unlike Heisenberg and several others, had pursued the promise of atomic energy wholeheartedly. Especially disappointed were Paul Harteck and his team of physical chemists at Hamburg, who had made early progress using ingenious techniques. Harteck had improved the D_2O concentration scheme in Norway and it was he who had come so near to success with his ultracentrifuge. Now, he not only had to deal with the threatened loss of funding, but he would soon come under the direction of an unenthusiastic new director.[109]

Within three weeks Speer reported to Hitler "very briefly"[110] on the conference. Hitler failed to grasp the full extent of the news but "was plainly not delighted with the possibility that the earth under his rule might be transformed into a glowing star."[111] Plagued by his own policy of not developing weapons unless the Fatherland had a proper countermeasure and his revulsion at "Jewish physics," Hitler simply passed over the earthshattering potential of the bomb. Speer did not doubt Hitler would have used it and

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[108] Speer, 272.

[109] Irving, 127-9.

[110] Speer, 271.

[111] Ibid. This refers to the theory at the time that a fission weapon might ignite the mosphere--obviously, experience would prove this wrong.

there is little doubt that if anyone could have convinced the Fuehrer to pursue the bomb, it was Speer.[112] But, no one had convinced Speer on that June day at the Harnack Haus.

Ironically, the same day that Speer reported to Hitler, Heisenberg's promising work in Leipzig came to disaster. His L-IV spherical pile, on which he and a colleague had been working for months, exploded. The ingenious design incorporated concentric layers of uranium and heavy water and had yielded promising results. On June 23, it began to leak hydrogen, caught fire, and exploded. Heisenberg and his co-workers barely escaped.[113] That month, the German project went up in smoke, both literally and figuratively.

That summer as Germany forced a turning point conversely saw great progress in the U.S. At Berkeley, American physicist J. Robert Oppenheimer assembled his "luminaries"--a group of scientists including several of the future participants in the Manhattan Project. During that long, hot summer they discussed bomb theory and future work. Pooling all available information from centers throughout the U.S. and the U.K., they succeeded in clarifying basic ideas, problems, and more fully realized the size of any undertaking to build a bomb. Subsequently, the circle of discussion expanded to include the work at the University of Chicago, and the universities of Purdue, Stanford, Cornell, Wisconsin, Minnesota, and California. It soon became apparent that an overarching structure would be necessary to order the disorganization.[114]

The promising results of the Berkeley summer sufficiently impressed the top brass in Washington. Not only did an atomic bomb seem possible, but the "luminaries" in

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[112] Ibid.

[113] Irving, 122-3. Powers, 153-5.

[114] Hawkins, 3-4.

California had even presented the option of a hydrogen superbomb. The government committee's endorsement, which found its way to the Secretary of War, felt that "success in this program before the enemy can succeed is necessary for victory."[115] Thus, in June 1942, the U.S. took the first step toward the hydrogen bomb.

The project demanded quick action and organization which followed in the person of General Leslie R. Groves, the man who had overseen the construction of the Pentagon. There had been doubt as to the best form of project organization, but clearly, divided between the OSRD and the Army Corps of Engineers it might come to nothing. The program needed was a strong leader, and that is exactly what it got. On September 17, 1942, General Somervell of the Army Services of Supply informed Groves of his new assignment saying, "if you do the job right, it will win the war." Groves remembered only too well his response at the historically significant moment. "Oh."[116]

Groves moved immediately. He found and bought the 1250 tons of uranium-rich ore that had stood undisturbed on Staten Island since 1940. The Belgians had shipped it there to keep it out of German hands and had been trying to alert the U.S. to its presence for six months. He also granted the Manhattan Engineer District, as it had been recently dubbed, a War Production Board first-priority AAA rating. On September 19, he authorized purchase of Site X, the 52,000 acres of Tennessee that would become Oak Ridge. Within the week, his promotion to brigadier general came, and with that extra weight of authority, he set out on a fact-finding tour of the vital project which he had inherited.[117]

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[115] Rhodes, 421.

[116] Ibid., 424-5.

[117] Ibid., 425-7.

He visited the three main sites of American work to date: Fermi's chain-reacting pile work in Chicago, gaseous diffusion U235 separation at Columbia University, and electromagnetic separation at Berkeley. Groves made an unfavorable first impression. The new general felt that scientists were impractical, undisciplined and stuck on themselves; the scientists, on the other hand, found themselves confronted with their unlikable, brusque new boss. So here began what would become the ongoing struggle between the scientists' desire for free discourse and the military's love for compartmentalization and secrecy. Groves knew how he wanted things: secret, successful and all-American.[118] He was soon to find that the scientists had their own opinions.

The first salvo in this battle for the organizational soul of the Manhattan Project came from none other than Leo Szilard. When necessary, this tenacious Hungarian had proven himself quite the gadfly. Apparently, he felt it necessary during the fall of 1942. On September 21, his first round of ammunition blasted the work at Chicago with his question, *What is Wrong at the Chicago End*? He stated that "the trouble at Chicago arises out of the fact that the work is organized along somewhat authoritative rather than democratic lines. There is a sprinkling of democratic spots here and there, but they do not form a coherent network which could be functional. This is partly due to a compartmentalization of information."[119] The lack of quick action resulted in another sharp opinion stated November 25 in which Szilard fumed that "compartmentalization of information poisons the discussion."[120]

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[118] Powers 175-81.

[119] Weart, 156.

[120] Ibid., 160.

The balm for this potentially destructive debate proved to be Robert Oppenheimer. He had met Groves during the latter's infamous fact-finding tour, and, surprisingly, the two seemed to have an affinity for one another. By October 19 Groves had decided Oppenheimer would direct the scientific work. It so happened that his view pleasingly concurred with that of Groves. Oppenheimer testified after the war:

> I became convinced as did others that a major change was called for in the work on the bomb itself. We needed a central laboratory devoted wholly to this purpose, where people could talk freely with each other, where theoretical ideas and experimental findings could affect each other, where the waste and frustration and error of the many compartmentalized experimental studies could be eliminated, where we could begin to come to grips with chemical, metallurgical, engineering, and ordnance problems that had so far received no consideration.[121]

So with this idea, Oppenheimer took on his important role as the facilitator, compromiser, and organizational wizard who would so contribute to the success of the American project. Ironically, his German counterpart's objection to centralization had early crippled their chances for success.

The last months of 1942 saw the U.S. project finally begin to gain speed. One of the most momentous achievements of the century occurred on December 2, 1942, in an old underground squash court at the University of Chicago. Months of feverish work culminated in the success of Fermi's pile as the U.S. reached the second great milestone.[122] The Germans had discovered fission; the Americans first controlled it. Now it was a race to effectively harness its power and the Germans no longer appeared the favorites.

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[121] USAEC, *In the Matter of J Robert Oppenheimer* (Washington, USGPO, 1954), 12.

[122] Hoddeson, 33.

Further information from Germany motivated the Allies to action during this year. Four summer intelligence leaks, through Denmark, Italy, and Norway, all stressed that the Germans wanted nothing but a reactor and posed no threat to the Allies. Again, the well-intentioned Germans who leaked this information had only served to further convince the Allies that the Nazis were up to something, and also that they were trying to throw the U.S. off the trail. These four leaks combined with yet another information leak that Heisenberg had been appointed Director *at* the KWI in Berlin.[123,124] Any notion of Germany's greatest brain at the central research site surely caused the U.S. and the U.K. worry.

The Reich Research Council's hold on the project continued to be nebulous. On November 24, Professor Esau wrote the Council's general director demanding, at last, strong centralization of the uranium project. This resulted in Goering's appointment of Esau as Plenipotentiary for Nuclear Physics, in charge of the Nuclear Physics Research Group. Though impressive-sounding, this development did not streamline the entire project. Rather, Esau's unpopularity and the addition of yet another facet to the uncoordinated German work only caused trouble.[125] Now there was one more mouth to feed and just not enough uranium and heavy water to go around.

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[123] Powers, 585-6.

[124] Heisenberg had to be appointed Director *at* the Institute because the Director *of* the ıstitute had fled to the US without officially resigning. The German insistence on order that ecessitated this shortcut fortunately did not carry over into the project as a whole.

[125] Irving, 152-4.

1943

Not without some successes, but without increasing fortunes, German nuclear research continued slowly, scattered about a nation in the process of being bombed. The war's outcome seemed inevitable, and finally put its stranglehold on the Fatherland. The Germans had designed nuclear pile experiments, were attacking more technical problems, and finally had achieved industrial capacity to process the necessary uranium. At this potentially promising juncture, Bothe's error came back to haunt the project. In the course of events, the dependence on heavy water became a potential bottleneck. In 1943, it would bring work to a near standstill.

Rjukan, having been the prime target of the Germans in their invasion of Norway, now became a target for the Allies in their quest to deny the Nazis an A-bomb.[126] The first Allied attempt to destroy the Norsk-Hydro Works at Vemork/Rjukan ended in disaster. Poorly planned, Operation Freshman consisted of sending paratroops into southern Norway to meet an advance team to sabotage the plant. On November 19, 1942, the gliders were lost; the Germans executed the 14 survivors.[127] Obviously, the Germans could easily have figured out what the Allies wanted; logic dictated that if the Allies knew enough to try to deny the Germans heavy water, they knew enough to be working on their own bomb.

The second attempt, named Gunnerside, went into action in February 1943. A small group parachuted into Norway and met the same advance team who had survived the fierce Scandinavian winter. They had received special training, working with details of the plant supplied by the original designers. On the 27th, they skied across the rugged

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[126] Irving, 157-65; Powers, 195-200; Rhodes, 455-7.

[127] Irving, 138-9.

landscape and began their mountain-climbing assault on the fortress-factory which resulted in a resounding success. Their careful training paid off as all of the concentration cells suffered severe damage, inflicting a massive delay on the German research. The most vital element of German nuclear research during WWII had lain poorly guarded, even though there had been an attempt at sabotage only three months earlier.

To the Americans' surprise, the plant went back on-line by April and produced again by June.[128] The estimates of a yearlong delay obviously had been optimistic.[129] The Germans proved themselves not totally disorganized. Yet, the revived threat of heavy water production would not go unattended for long.

In others matters, the German work continued its tradition of mixed success and stagnation. Using leftover uranium plates, Dr. Kurt Diebner continued his work under the auspices of the Nuclear Physics Research Council at Gottow. He achieved the most promising results to date in Germany using a heavy ice pile incorporating cubes. Diebner's success and the progress of the other scientists took center stage at a conference on physics hosted by the German Academy of Aeronautical Research on May 6, 1943.[130]

Not surprisingly, few military or political leaders attended. Heisenberg spoke of atomic explosives and the success of Harteck's U235 separation methods. Hahn stressed fission's importance while Bothe expounded on the progress in cyclotron construction. Once again, all the necessary ingredients for a successful German effort had been in one

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[128] Irving, 186.

[129] Rhodes, 457.

[130] Irving, 174-7.

room and no one stirred the pot. An explicit 80-page report on the proceedings went to press, slated for circulation. Aghast, Speer nipped that foolish move in the bud.[131]

While the Germans floundered in the early months of 1943, the Americans moved ahead resolutely. They had produced a chain reaction, become acquainted with the physical and chemical properties of uranium and plutonium, and were completing designs for Pu production and attacking U235 separation. On February 25 Oppenheimer received a directive from Bush, Director of the OSRD. The letter detailed the objective of the "special laboratory in New Mexico" and explained the envisioned mix of civilian scientists and military oversight. The control of the project would ultimately rest with the President's Military Policy Committee, composed of military and civilian leaders. The letter outlined Oppenheimer's duties to maintain secrecy, facilitate research, and keep both General Groves and James Conant informed. Finally, the directive called for the "closest cooperation" among members of the team.[132]

Armed with these orders, Oppenheimer began the difficult task of recruitment. He relied on

> the interest, urgency, and feasibility of the Los Alamos mission. . . . The prospect of coming to Los Alamos aroused great misgivings . . . . The notion of disappearing into the New Mexico desert for an indeterminate period and under quasi-military auspices disturbed a good many scientists . . . . Almost everyone knew . . . it might determine the outcome of the war . . . it was an unparalleled opportunity . . . a part of history. This sense of excitement, of devotion and of patriotism in the end prevailed. Most of those with whom I talked came to Los Alamos.[133]

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[131] Ibid.

[132] The letter is reprinted, in full, in Hawkins, 495-7.

[133] USAEC, 12-13.

Thus, in the spring of 1943, a city in the middle of the desert sprang up. The site, chosen in the last months of the previous year, fulfilled the criteria for a large area with remoteness from both attack and espionage.[134] As Nobel prize winners, European emigre scientists, and their families disappeared into the wilds outside Santa Fe, construction teams mired in mud struggled to throw together housing and lab space.[135]

By April, construction at Los Alamos had progressed to the point that it could host a series of five lectures. Combined in a small booklet and distributed to each newcomer, the 24 mimeographed pages summarized all that the U.S. knew about how to make a bomb, including information received from Great Britain. The lectures, entitled the "LA Primer," by Oppenheimer student Robert Serber, left no doubts as to the group's mission. "The object of the project [was] to produce a *practical military weapon* in the form of a bomb . . . ."[136] The gap between the American and German projects could not be more clearly stated. The remainder of the primer details the useful properties of uranium and plutonium, the rudiments of chain reaction, crude bomb designs, and projected damage effects. These general ideas offered nothing new, but the American commitment to making these theories into reality was new; that would be the difficult part.

Across the country, work also progressed at Oak Ridge, TN, and Hanford, WA. These two sites, particularly Oak Ridge, would consume most of the estimated

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[134] Hawkins, 4-5.

[135] Ibid., x.

[136] The lectures and Serber's annotated commentary are found in Serber, 3-63 passim.

$2,000,000,000 spent on the Manhattan Project.[137] Acquired in September 1942 and sealed off from the outside world on May 1, 1943, Oak Ridge played host to U235 separation efforts.[138] The two methods employed both attempted the almost impossible task of physically separating the isotopes of uranium based on their minute difference in mass. One system, gaseous diffusion, relied on the two isotopes' different diffusion rates across a porous barrier. This small difference necessitated a cascade of several thousand barrier tanks, in volume up to 1,000 gallons each. Each arm of the U-shaped building housing this processing machinery approached half a mile in length![139] The other system at Oak Ridge relied on electromagnetic separation of the two isotopes. This method worked because atoms of different masses arc through a magnetic field separately. Vaporous ions containing uranium traveled through such a field in curved vacuum tanks and collected in metal pockets at the end of the thousands of tanks.[140]

The work at Hanford concerned plutonium, which had to be manufactured as it does not occur naturally. DuPont built the necessary nuclear reactors alongside the Columbia River in Washington state. The nuclear processes of neutron capture and decay result in the transformation of uranium to neptunium and finally to plutonium. The site also included the massive chemical separation plants necessary to extract the plutonium from the irradiated slugs removed from the reactors.[141] Begun at approxi-

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[137] Serber, 14.

[138] Rhodes, 486-7.

[139] Serber, 14-5.

[140] Ibid.

[141] Ibid.

mately the same time as Los Alamos, Hanford would not come on-line until December 1944, still in time to provide the plutonium for Nagasaki.[142]

The final establishment of a centralized research site was only the beginning of the complexities, as Oppenheimer soon discovered. The sudden birth of a city demanded great attention and consumed a great deal of Oppenheimer's time dealing with organization. He divided scientific and administrative responsibilities into groups such as experimental physics, theoretical physics, chemistry, and metallurgy. These leaders, a few others, and Oppenheimer together constituted the Governing Board which, in the first few months, dealt with a full array of troubles: housing, construction, transportation, security, morale, salaries, and promotions. The decision to host weekly colloquia in which all researchers could assemble raised the eyebrows of the military, still fanatical about secrecy. Los Alamos and the Hanford/Oak Ridge sites, the University of California, and the MET Lab in Chicago established liaisons. All in all, Los Alamos came to stand on more solid ground. President Roosevelt's vote of confidence echoed this sentiment in a June 29 letter to Los Alamos: "Whatever the enemy may be planning, American science will be equal to the challenge."[143]

Luckily, the Germans continued to be less than equal to the challenge throughout the remainder of 1943. The year saw five more information leaks conversely reporting dim chances for German success and the threat of nuclear bombs. One leak in May through Switzerland reported that "the Kaiser Wilhelm group purposely raised difficulties

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[142] Rhodes, 560.

[143] Hawkins, 29-33.

to slow down work on the project."[144] True or not, the existence of the leaks themselves paints a picture of the German project as a less than sound vessel.

Numerous Nazi scientists acknowledged this weakness. The most vocal, naval researcher Werner Osenberg, bitterly complained about the "unfit leadership and the chaotic confusion" plaguing the work. In response to Osenberg's vocal outcries, the SS became involved in April, resulting in a memo dated May 8, 1943, which clearly stated the U.S. was pursuing uranium bombs and that the Reich should correct its deficiencies in this area. Evidently, Goering felt impressed because in June he appointed Osenberg to reorganize the Reich Research Council. As will become evident, this move affected no major change in the direction of the German effort, though Osenberg's emphasis on the vital place of research during wartime did eventually result in the release of 5,000 scientific personnel from the front.[145] It is clear that not everyone was blind to the sorry state of German research.

The remainder of the year saw the various German groups continue their decentralized research. As the destruction of Germany increased, groups slowly began their moves south and west. In July, Harteck's ultracentrifuge separation project not only had to contend with leaking joints and exploding drums, but also suffered heavy damage in an RAF raid. He moved south to Freiburg; others would soon follow.[146] Especially indicative of the depths to which the priority of nuclear research had sunk, in August

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[144] Powers, 586.

[145] Irving, 178-9, 255-6.

[146] Ibid., 178.

Speer released 1200 tons of uranium ore for use in artillery shells, as substitute for a crucial import cut off from Portugal.[147]

In mid-October a conference convened and it came to light that an arrangement of uranium in cubes, as Diebner preferred, rather than plates, as Heisenberg preferred, proved much more favorable. Heisenberg told Harteck that he insisted on plates for his upcoming large reactor experiments because of the simpler theory.[148] This strangely echoed Fermi's reasoning only a few years earlier.[149] The gap between experimental and theoretical scientists had again reared its ugly head.

On November 16, 1943, 155 USAF Flying Fortresses attacked Rjukan. Once again, the Germans had to contend with the fatal bottleneck caused by their dependence on heavy water. This holdup coupled with increasing incidents of destruction due to bombing raids combined to bring the Germans' work to a near standstill by the end of the year. The only major development was the final replacement of the unpopular Esau as head of the Reich Research Council with Walther Gerlach who had a pronounced lack of zeal in pursuing nuclear energy.[150] Instead of promoting the aims of the war with science, he promoted the aims of science with the war.[151]

With Los Alamos off to such a good start, the Los Alamos Review Committee gave its stamp of approval. Their May 10, 1943, report to Groves approved all of the nuclear physics research groups, recommended the pursuit of the hydrogen bomb on a

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[147] Speer, 272.

[148] Irving, 188-9.

[149] Weart, 25.

[150] Irving, 193, 198-99.

[151] Ibid., 231.

lower priority than the fission bomb, established that final plutonium processing should take place at Los Alamos, and echoed Oppenheimer's significant suggestion that ordnance research take place parallel to nuclear physics research. The last recommendation established a vital characteristic of Los Alamos, the close relationship of nuclear and engineering research. Finally, the committee approved Oppenheimer as Director and counseled care to maintain the "special kind of atmosphere that is conducive to effective scientific work."[152]

American and British cooperation reached new heights over the course of the summer, resulting in the eventual incorporation of the British work into the Manhattan Project. This came about as a result of a renewed pressure campaign to impress upon Churchill the dire situation concerning the possibility of a German lead in this area. Earlier in the year, there had been a scare that the Germans could use radioactive bombs against the British. With this threat looming and news of the great strides made in America, a Britain desperate to attain victory threw her lot with the U.S.[153]

In June, the two together made an unsuccessful attempt to corner the world market on uranium. This move developed into the Combined Development Trust after an August conference between Roosevelt and Churchill.[154] The Quebec Agreement, "Articles of Agreement Governing Collaboration between the Authorities of the U.S.A. and the U.K. in the matter of Tube Alloys," also emerged from that conference.[155] This

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[152] Hawkins, 23-5.

[153] Ibid., 26-28. Irving, 180-5.

[154] Rhodes, 500.

[155] The full text of the agreement is found in Gowing, 439-40. "Tube Alloys" was the British odeword for matters relating to uranium.

short document states the logic of combining research and that neither party will ever use the bomb against one another nor use the bomb against or share information with a third party without the other's consent.

With this agreement came a British delegation. They arrived to find that the Americans had not lain idle since the whirlwind of activity in the spring. The major developments of the summer included the beginning of spying on the German work.[156] They also established the future Alsos[157] information gathering mission.[158] In late summer, work with prototype bombs began[159] and major engineering progress resulted in the idea of a successful gun assembly for the bomb.[160]

Significantly, with the British came Niels Bohr, who had finally fled the Nazis in September.[161] Not only did the British bring new ideas, but Bohr, as a giant in physics and something of a philosopher concerning the atomic bomb, brought a new focus to the Manhattan Project. He encouraged a back-to-basics approach since the physicists had become bogged down in the innumerable, inevitable, small problems of the work.[162]

Thus, the end of 1943 approached. The changes in momentum wrought by the turning points in June of the previous year increased. The American/British research

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[156] Powers, 217-8.

[157] Named using the Greek word for grove due to Groves' leadership, Alsos scoured Europe fter the Allied victory to gather any and all information related to the German project.

[158] Ibid., 249.

[159] Rhodes, 478.

[160] Ibid., 467-8.

[161] Powers 234-6. Hawkins 26-28.

[162] Hawkins, 26. Powers, 248.

picked up steam and became a concrete reality in the middle of the New Mexico desert. The Germans, on the other hand, let the year pass without major results.

1944

Though the Allied effort made tremendous progress in the preceding year, not everyone felt satisfied with the state of matters. The gadfly Leo Szilard stepped in again. Expressing his views to Vannevar Bush, his notes provide a particularly useful insight into the workings of the Manhattan Project. We see that although successful, the Project was far from perfect. Dated February 28, 1944, the notes looked back to the beginnings of the project when the U.S. was ahead and lamented the presumable loss of that lead. He stated that the scientists' work was "crippled from the start by a mistaken attitude on the part of the administrators . . . from which many evils have derived . . . . The free interchange of views between different groups working on uranium along related was prohibited beginning the fall of 1940 . . . ."[163]

Szilard's views also questioned the situation at Oak Ridge. He called both methods employed "clumsy" and said "if the competent men who [were] working for the Government . . . had been given enough information . . . we would now have much faster, simpler, and cheaper methods." He also included reference to the tenuous relationship between the researchers and the contractors such as DuPont.

The February 28 barrage continued with the blunt statement "The Scientists without Representation." Here, Szilard included bitter words about the lack of the "official recognition of a group of competent scientists" who should have had a voice in the work. Such an advisory committee had been formed in 1940 but "the first meeting of this

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[163] The excerpts here are found in the fully printed text in Weart, 164-79 passim.

committee was, however, also its last meeting, since . . . it might lead to criticism . . . that Government funds were expended at the recommendation of this committee which included men *who were not American citizens of long standing*[italics added] . . . ." He concluded this section,

> it will therefore be necessary to discuss whether or not this compartmentalization of information is justified from the point of view of maintaining secrecy so that we may see whether the gain in secrecy, if any, can compensate for the very great damage which this compartmentalization causes . . . .[164]

How then did the Manhattan Project not dissolve into civil war between the scientists and the administration? Again, Oppenheimer proved to be the single greatest factor. Others viewed him as a "superb leader . . . often able to achieve a consensus . . . through a remarkable art of analysis and reformulation . . . ."[165] The progress at Los Alamos moved so quickly that by March 1944 they had already begun planning a full-scale test, codenamed Trinity.[166]

A prime example of the importance of internal communication occurred during this time. An independent naval researcher raised Oppenheimer's attention concerning the value of thermal diffusion for uranium separation. The Navy work had worked since November 1943 in a Philadelphia shipyard. Unable to reach Los Alamos through official channels, Abelson resorted to clandestine operations. He passed his information through a man who would be traveling to New Mexico. When Oppenheimer understood Abelson's argument to enrich larger quantities slightly and then feed these enriched quantities into the processing equipment at Oak Ridge, he immediately contacted Groves.

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[164] Ibid.

[165] Hawkins, xiii.

[166] Ibid., 170.

It happened. The subsequent increase in uranium separation might never have occurred had one American scientist not leaked some information. Luckily, such clandestine transfers of information worked to America's advantage, and stayed inside the country![167]

Other developments of the period included the operations of the Alsos mission. As the Allied armies pushed north through Italy, the information gathering operation moved alongside. It soon became apparent that the Italians who had chosen not to pursue a bomb in 1943 knew next to nothing about German nuclear research. Though not exceptionally fruitful, the first Alsos mission did allow those involved good preparation for what was to come. Alsos II would be on the heels of the Normandy invasion.[168]

While Alsos scoured Italy in the first half of 1944, military disaster repeatedly struck the Germans. As one raid destroyed Heisenberg's work in Leipzig, so another visited itself upon the KWI for Chemistry in Dahlem. The home of Hahn's great discovery went up in smoke. The physicists and chemists who could have changed the course of history spent the evening fighting fire and saving paperwork; as the world of their Jewish colleagues had been turned upside-down a decade earlier, so were the lives of those who had remained in the Reich. The bombing of Dahlem was no accident but part of the Allies' deliberate strike at the heart of German nuclear physics.[169]

Within a week of the Institute fire, the part played by Norway and its heavy water finally ended. In response to the Allied bombing of November 1943, the Germans elected to remove all remaining stocks of heavy water to the Fatherland. The Allies could not allow this, and there followed yet another movie-style covert operation. A

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[167] Rhodes, 551-2.

[168] Powers, 300-1.

[169] Ibid., 336-9.

remainder of the sabotage team from the previous year plotted to destroy the shipment en route at its most vulnerable juncture during a ferry ride across an incredibly deep Norwegian lake.[170]

On February 20, 1944, the Hydro sank on schedule when the carefully prepared saboteur's explosives detonated. The deaths of 23 Norwegians etched this incident deeply into the Norwegian memory of World War II, prompting reexamination after the war. Had it been worth the loss of life, the bombings, Norwegians killing Norwegians, and the sabotage? Knowing the sorry state of German research and the Allies' excessive estimates thereof, who would not ask such questions? The controversy continues even until the present day. This year an eyewitness came forward claiming that contrary to official history the shipment had lain poorly guarded at the railway station the night before the ferry trip.[171] At any rate, the valor of those involved is unquestionable and, according to Diebner, the lack of heavy water "was the main factor in our failure to achieve a self-sustaining atomic reactor before the war ended."[172]

The summer of 1944 saw a hodgepodge of uncoordinated efforts related to the German project. Unlike the Allies, the Germans had little success in attaining information through espionage. In June, Gerlach's concern over possible research in America led to a meeting of the central agency concerned with foreign scientific intelligence. The group whose agents had never found anything substantive concerning the Manhattan

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[170] Irving, 203.

[171] *Rjukan Arbeiderblad,* translator Vegard Kiellend (Rjukan, Norway) May 26 1993.

[172] Irving, 211.

Project would not succeed now either. Attempts to collect information through Switzerland, Spain, and American scientific periodicals resulted in a paltry file.[173]

In other matters, the KWI continued, almost to completion, its gradual and piecemeal move out of bombed-out Berlin. In Hechingen in southwestern Germany, Heisenberg established an Institute for Physics in a former textile factory.[174] Meanwhile, the destruction had become so severe in Berlin that Gerlach searched the craters with a Geiger counter to see if the bombs had been atomic.[175]

Harteck continued his role as the achiever of the group with his plans for replacing the heavy water production lost in Norway and finally gave greater attention to uranium separation. The success of Bagge's isotope sluice provided one pleasant surprise, but had to immediately move south to safe obscurity. At the same time, von Ardenne hit upon the idea of electromagnetic separation, not unlike the process used at Oak Ridge. The Russians gladly adopted his ideas in the coming years. Also, Wirtz remained in Berlin and with Diebner planned a large-scale pile in a massive bunker. At long last, scientists came together to work but it was too little, too late.[176]

With the D-Day invasion came the second Alsos mission. Arriving in Paris on August 24, Alsos scientist Goudsmit found Joliot with his precious cyclotron, and heard his sincere opinion that the Germans had little chance of developing an atomic bomb.[177] Subsequent information gathered in Belgium and Strasbourg lent weight to Joliot's

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[173] Powers, 345-6.

[174] Ibid., 335-6.

[175] Irving, 226.

[176] Ibid., 227, 234-5.

[177] Ibid., 247.

opinion and began to create a picture of the formerly ominous German project as nothing more than a disorganized research effort still years from a weapon.[178] Thus, within the year, Roosevelt would know without a doubt, due to the continued work of Alsos, that the Germans clearly did not have an atomic weapon of any sort. Still, the President wanted the weapons ready in case a change in the war necessitated their use on Germany; otherwise, they would be available for Japan.[179]

The continued progress at Los Alamos made it almost certain that the bombs would become a reality in time to influence the outcome of the war. The emphasis had shifted from theory to ordnance engineering; the bomb began to take a real shape. To facilitate operations at the site, Oppenheimer instituted another reorganization, replacing the Governing Board and creating an interdivisional committee to coordinate the activities of groups concerned with designing and testing a bomb.[180]

As the year came to a close, victories began to mount in New Mexico. They found an effective tamper[181] and streamlined bomb design as the test date approached. The victories for the Alsos continued to mount in Europe. City by city, man by man, the German research project began to fall into American hands.

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[178] Powers, 362-9.

[179] Ibid., 404.

[180] Hawkins, 156-7.

[181] Tamper refers to the neutron reflective layer around the core of the bomb. Rhodes, 541.

1945/POSTWAR

The first part of the final year of fighting finally saw the grotesque comedy of errors that had plagued German nuclear research throughout the war come to an end. In a cave in a small southwestern German town, Heisenberg and his team desperately attempted to construct a chain-reacting pile. Dr. Wirtz had finally proven that ubiquitous graphite would have served well as a moderator--Bothe's blunder thus came full circle, fortunately, too late.[182] No matter though, for soon the scientists would have more to worry about than physics.

February brought with it the continued ferocious firebombing of Japan's paper and wood cities, while the devastation in Germany reached new heights with the utter destruction of Dresden. The Allies closed the pinchers on Germany and steadily approached the Japanese Empire. As Europe lay in ruins, Los Alamos flourished. With the bombs rapidly approaching completion, Project Alberta took form. This group held responsibility for the actual delivery of the bomb and made use of specially prepared B-29s. Los Alamos made ready for whatever the President might order.[183]

As Alsos swept through conquered areas, information, supplies, and men fell into their hands. Most of the scientists simply gave up working and sat awaiting the arrival of the Americans. First came Heidelberg with Bothe and his cyclotron. Then Alsos captured the Haigerloch pile. April was a race against the clock and the advancing French and Russians. In one fell swoop, the U.S. denied France the German scientists and their ore while also bombing into the ground sites in eastern Germany that might

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[182] Irving, 275.

[183] Hawkins, 247.

have fallen into Russian hands.[184] Suddenly that month Franklin Roosevelt died leaving Vice President Truman to make a fateful decision the following summer concerning the use of an awesome weapon against a bitter enemy.

On May 3, Alsos placed Heisenberg under arrest at his mountain home in Bavaria.[185] Four days later the guns lay silent; Germany had surrendered. The men who could have made the Nazis an atomic bomb found themselves prisoners, and the labs in which they could have made such a weapon lay smoldering. Even their experimental uranium fell into the victor's hands and found its way into the heart of a bomb destined for Japan.

The relief that Germany had capitulated and had no fission weapons swept over Los Alamos like a joyful wave. Several scientists naively believed that now the bomb would not be used.[186] But, others felt differently. Four years of grueling battle across the Pacific had instilled in many Americans a burning desire to completely crush the Japanese. The heated debate had two sides, as concisely stated by then Secretary of War Stimson:

> Japan has no allies. Her navy is nearly destroyed and she is vulnerable . . . . We have inexhaustible and untouched industrial resources . . . . We have great moral superiority through being the victim [of the other's] first sneak attack. On the other hand, the Japanese are highly patriotic and certainly susceptible to fanatical resistance . . . .[187]

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[184] Powers, 411, 417-9. Rhodes 281-90.

[185] Powers, 429.

[186] Rhodes, 638.

[187] Henry Stimpson and McGeorge Bundy, *On Active Service in Peace and War.* (Harper and ros.,1948), 620, quoted in Rhodes, 683-4.

Unfortunately for Hiroshima and Nagasaki, the thought of unconditional surrender and the potential loss of the Emperor made surrender unthinkable.

In Europe, the German scientists remained under guard outside Paris until July 3, 1945, at which time they arrived in England. Using a special provision in British law allowing anyone's detention at the monarch's pleasure, the British placed the leaders of German science under arrest and detained them at Farm Hall where they remained for several months.[188] They became well acquainted with this country estate during the coming months and were there on July 16, 1945.

The sun rose twice over the New Mexico desert that fateful day as the project Trinity test bomb successfully detonated. Mankind would never be the same, neither would the future politics of war. Within a month two Japanese cities disappeared in fireballs of unimaginable destruction. This news struck the German scientists like a thunderbolt with shock, disbelief and thoughts of suicide. It was all recorded in the bugged rooms of their comfortable prison.[189]

His work done, Oppenheimer resigned soon after the war's end, only to be branded a traitor[190] in the years to come by the nation whose future he had struggled to save. Los Alamos continued as a center for U.S. atomic research, today hosting the Los Alamos National Laboratory. The Germans returned home on January 3, 1946, six months to the day after their arrival on the Emerald Isle.[191] Heisenberg survived to help rebuild German science from the rubble of the Third Reich.

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[188] Powers, 428.

[189] Ibid., 444-6.

[190] Oppenheimer came under suspicion as a communist during the 1950s.

[191] Ibid., 453.

CONCLUSIONS

Did the Germans fail simply because of their disorganization, while the opposite occurred in the United States? Clearly, organization alone cannot account for the outcomes of the two efforts, but it did sign the death warrant for the German work. Had the Germans pursued a bomb at a centralized location like Los Alamos, the lovesick Bothe's error would not have gone unseen. Had the Nazis corralled their scientists, the numerous information leaks would not have occurred. Had the government enforced a hierarchy on the researchers, they would have found their vigorous competition muted. Had they centralized their control, they might have prevented their heavy water disaster.

On the other hand, better organization in the Third Reich might simply have produced a better organized failure. According to what Rhodes calls the shadow history of the German project, that mosaic constructed of memories, recollections, and letters, the German scientists very likely would have still sabotaged their own work. Does this place certain German scientists on some higher moral plane than their Allied counterparts? No, this author feels that the scientists on each side pursued what they viewed as moral. This resulted in the paradox of some choosing nationalism over the state, while others chose the state over nationalism. In hopes of a brighter future, those like

Heisenberg worked against the state to preserve their nation, while many emigres shed their former nationalities to embrace the U.S. and its fight for freedom.

Numerous similarities exist between the German project and its American counterpart. In both nations, small groups of scientists raised the alarm. Both saw a mix of interest and disinterest on the part of the authorities. Work began in university-related labs and industry played a vital part. Both sides even handicapped themselves somewhat in passing over human resources, the U.S. by its reluctance to employ foreign nationals and Germany by the disastrous persecution of its own Jews.

Then where did the paths diverge? Why did the projects produce such different results? The great turning point clearly occurs in the summer of 1942. The Nazis bungled in their failure to grasp the full potential of the atom's power; Germany's scientists played no vocal role in its explanation. While the faltering German effort waned, the American project waxed. The voice of the scientists, though not strong enough to suit some, won major concessions in the battle of organization. Freedom of discussion at Los Alamos in the middle of a desert was a boring spot culturally, but creative intellectually. This atmosphere combined with America's resources and the Allies' desperation could not fail.

Walker in his thesis dismisses as absurd the idea of Heisenberg as a sort of spy. This school of thought points to the danger of the German A-bomb myth as a convenient revision of the past that implies that a degree of innocence, and even superior morality, on the part of the scientists involved. While hindsight does indeed color our view, the evidence does point to some sort of clandestine activity on Heisenberg's part. The picture is cloudy to be sure, but it is a picture nonetheless. Yet, Walker makes the important argument that the respective success and failure of the American and German projects cannot be attributed only to science and technology. It also rested greatly upon politics, ideology, culture, and economics.

Could the Nazis have had a fission weapon? Could they have won the contest of minds, resources, and industry? This author thinks yes. Speer demonstrated his genius in keeping the German war machine running and probably could have provided the necessary materials. Had Heisenberg and Speer had the conviction of Oppenheimer and Groves, had the German scientists convinced the authorities early, had the Nazis imposed the freedom-within-hierarchy used by the Allies, Hitler could have had his superweapon and the postwar world would have been unimaginably different. Thankfully, the Nazis never gathered together in one place long enough to figure that out.

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