The grandfather of the hydrogen bomb?: Anglo-American intelligence and Klaus Fuchs
Author(s): MICHAEL S. GOODMAN
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MICHAEL S. GOODMAN*

The grandfather of the hydrogen bomb?: Anglo-American intelligence and Klaus Fuchs

> The thing that people forget now about Klaus Fuchs is that he was working very hard for this country.
>
> Norris Bradbury, Director
> Los Alamos National Laboratory.[1]

DR KLAUS EMIL Julius Fuchs was an infamous spy of the cold war. Yet, more than fifty years after his arrest the true significance of his espionage is still hotly debated.[2] The consensus, that Fuchs played an integral role in the development of the Soviet atomic bomb, is no longer in doubt. As regards the Soviet hydrogen bomb however, the traditional viewpoint is that Fuchs could have played no important role because at the time he left Los Alamos, research into the H-bomb was erroneous. Nobel physicist Hans Bethe has argued that what information Fuchs did pass across could only have impeded Soviet efforts.[3]

This traditional view has, however, been challenged by Russian physicist German Goncharov, head of the Theoretical Division of Arzamas-16 (the Russian nuclear research center). In the light of recent archival-based research, Goncharov has persuasively demonstrated that Fuchs played a very significant role in the Soviet hydrogen bomb program. This article supplements Goncharov's findings by elucidating Fuchs' contributions and considering them in relation to the American and British nuclear weapons programs.

* School of History and School of Politics, University of Nottingham, Lenton Grove, Nottingham, NG7 2RD, England. (ahxmsg@nottingham.ac.uk). I am grateful to the AHRB for research support and to the School of History and the School of Politics, University of Nottingham, for a small grant to purchase the FBI "Foocase" material. I also thank Kate Pyne, Arnold Kramish, Gregg Herken, Richard Aldrich, Chapman Pincher, and Sabine Lee.

The following abbreviations are used: *BAS, Bulletin of the atomic scientists;* DDRS, Document Declassification Reference System; DOE, US Department of Energy Reading Room, University of New Mexico; Foocase, Ferenc M. Szasz Papers, Center for Southwest Research, University of New Mexico; LHCMA, Liddell Hart Center for Military Archives, King's College, London; PRO, Public Record Office, London.

1. Interview Transcript, 16-17 Mar 1986. LHCMA, "Nuclear age," 11/13.
2. When the PRO released a series of MI5 files on the Fuchs case, *The Guardian* headlined, "How MI5 cracked nuclear traitor," and *The Independent,* "MI5 unable to prove guilt of Soviet agent," both on 22 May 2003.
3. Hans A. Bethe, *Memorandum on the history of thermonuclear program* (28 May 1952). Available at www.fas.org/nuke/guide/usa/bethe-52.htm.

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The debate about Fuchs has serious implications for the performance of intelligence estimates of the Soviet nuclear weapons program. These concern the operation of the McMahon Act and the failure to predict the first Soviet test in August 1949. This article places the assessments by the British and American intelligence communities of Fuchs' espionage within the context of assessments on the Soviet nuclear weapons program. The recent opening of archives on both sides of the former Iron Curtain have made a detailed re-examination possible.

In early 1950 Klaus Fuchs was convicted of "communicat[ing] to a person unknown information relating to atomic research which has calculated to be, or might have been, or was intended to be, directly or indirectly, useful to an enemy."[4] In the west, much to the dismay of Whitehall, the case became huge news, offering a simple explanation for the relative speed by which the Soviet Union had managed to break the American atomic monopoly. In the east, however, any knowledge of Fuchs was vehemently denied.[5]

Fuchs' was released from a British prison in 1959 and employed in an East German nuclear research center. Two years before his death in 1988 the Soviet Union informed him of the value of his contributions; in 1989 he received public recognition in a television documentary.[6] Now Fuchs' contributions are far more widely acknowledged. His portrait hangs in the museum at the Russian nuclear research center Arzamas-16 and a page is devoted to him on the official website of the SVR– one of the successor organizations to the KGB.[7]

When Klaus Fuchs left Nazi Germany for England in the 1930s he was a committed communist. That did not prevent his enrollment in the British atomic bomb program after he had completed a doctorate at Bristol University. As with other foreign scientists about to be engaged in governmental scientific war work, his security clearance was processed in record time; as General Bill Donovan head of the Office of Strategic Services (the forerunner to the CIA), later described his policy, "I'd put Stalin on the OSS payroll if I thought it would help defeat Hitler."[8]

Fuchs began by assisting Rudolf Peierls in intelligence assessments of the German atomic program. At the end of 1943 Fuchs joined the British Diffusion Mission in New York where he remained until transferred to Bethe's Theoretical Division at Los Alamos in August 1944. He remained at Los Alamos after the war, primarily because the new Director, Dr Norris Bradbury, had insisted that he con-

4. "Hearing, before the Lord Chief Justice, Lord Goddard, at the Old Bailey on 1 Mar 1950, of the case against Klaus Emil Julius FUCHS, arraigned on indictment (four counts) under the Official Secrets Act, 1911, Section 1;" FBI Foocase File 65-58805, Serial 899.
5. Yuli Khariton and Yuri Smirnov, "The Khariton version," *BAS, 49:4* (May 1993), 22.
6. Markus Wolf, *Memoirs of a spymaster* (London, 1998), 227-232; Wladimir Tschikow and Gary Kern, *Perseus: Spionage in Los Alamos* (Berlin, 1996), 432. Many KGB officers believed that Fuchs never received due credit. Nikolai Dolgopolov, *Oni ookrali bomby dlya sovetov* (Moscow, 2000), 105.
7. Sig Hecker, "Return to Russia," *Los Alamos news bulletin* (12 Jul 1996), 2; http://svr.gov.ru/history/fx.html Klaus Fuchs.
8. Robert C. Williams, *Klaus Fuchs: Atom spy* (London, 1987), 49.

tinue work on the "Navy Test"– the "Bikini" series of weapons trials in 1946.[9] Fuchs left Los Alamos in the summer of 1946 to become head of the Theoretical Division at the Atomic Energy Research Establishment (AERE) at Harwell, where he remained until his arrest in early 1950.[10]

The release of the VENONA documents by the west in the 1990s—the codename given to the Anglo-American breaking of some wartime Soviet cipher traffic—provided the first indications of how Fuchs had been caught.[11] Given the urgent need to keep the VENONA secret intact, it proved to be crucial that Fuchs admitted his espionage to Harwell's security officer Henry Arnold. Fuchs was tried on March 1, 1950 and in proceedings that lasted only ninety minutes, confessed to four counts of espionage, and received the maximum sentence of fourteen years imprisonment.

1. FUCHS AND FISSION
Los Alamos and Harwell

An important facet of intelligence is to learn what the enemy knows about you. In this respect the Fuchs case offered an information feast to the intelligence services.

The FBI, following acrimonious discussion with the British Security Service MI5, became the body through which the rest of the U.S. intelligence establishment communicated with Fuchs after his conviction. However, the FBI and its director J. Edgar Hoover were more concerned with identifying Fuchs' American handler "Raymond" (who proved to be Harry Gold) than with exploiting the case for atomic intelligence purposes. The Atomic Energy Commission (AEC) and the CIA cared more for intelligence than for Gold. This disparity became increasingly clear with the distribution of the report written by Hugh Clegg and Robert Lamphere, the two FBI agents who interrogated Fuchs in London. Arnold Kramish, an AEC intelligence analyst at the time, commented: "I recall our frustration in the AEC upon reading the Clegg/Lamphere report. Neither was in the least familiar with elementary nuclear matters…in other words, both we and the British lost the opportunity to extract better information from Fuchs." And to make matters worse the FBI did not release all it knew to the AEC.[12] Instead the AEC thus had to piece

9. Norris E. Bradbury to James Chadwick, 5 Feb 1946, in Robert C. Williams Papers, 2:2B, Niels Bohr Library, American Institute of Physics, College Park MD.
10. Williams (ref. 8); Norman Moss, *Klaus Fuchs: The man who stole the atom bomb* (London, 1987); Christopher Andrew and Vasili Mitrokhin, *The Mitrokhin Archive: The KGB in Europe and the West* (London, 2000).
11. John E. Haynes and Harvey Klehr, *VENONA: Decoding Soviet espionage in America* (London, 1999); Nigel West, *VENONA: The greatest secret of the cold war* (London, 1999); Christopher Andrew, "The VENONA Secret," in K.G. Robertson, ed., *War, resistance and intelligence: Essays in honor of M.R.D.Foot* (Barnsley, 1999), 203-226.
12. Personal communications, 26 June 2002 and 12 Feb 2003.

together what information Fuchs could have passed to the Soviet Union by a close study of Fuch's activities in the United States and Britain.

Fuchs was originally part of the British gaseous diffusion team at Oak Ridge. The Americans had consulted him in England and regarded his expertise so highly that they brought him to the U.S. late in 1943.[13] He began with work on the production of fissionable uranium but soon became involved with the plant's overall design. He moved to Los Alamos with Peierls, whom Hans Bethe, the leader of the Theoretical Division, had asked to replace Edward Teller as head of the T-1 group working on the hydrodynamics of the implosion mechanism. Peierls agreed on condition that his assistants, Tony Skyrme and Klaus Fuchs also be invited. Fuchs arrived in Los Alamos in August 1944.

The American official history of the Manhattan Project asserts that the contribution of the British Mission was "in no sense vital and actually not even important. To evaluate it quantitatively at one percent of the total would be to overestimate it."[14] By contrast, Hans Bethe recognized the British role as "absolutely essential."[15] It certainly was to Soviet espionage.

A crucial aspect of Fuchs' intelligence value to Moscow was the positioning of the British party within the Los Alamos hierarchy. The British Mission were cleared to read any document or report in the Los Alamos library, to attend the weekly colloquium, to enter the "technical area" where discussion was relatively free from security restrictions.[16] The British Mission was on the whole less compartmentalized than their American colleagues.[17]

Fuchs was considered a vital member of Bethe's theoretical division. As former Los Alamos Director Harold Agnew comments, "clearly he was a first class scientist or Bethe would not have worked with him."[18] Compartmentalization would not have kept material away from Fuchs. As General Groves testified in the Oppenheimer hearings in 1954, "it is important to realize [that] if we had limited [overall information] to a small group, say just the top people, Fuchs might still have been in that group."[19] The FBI investigators noted that Fuchs "was inclined

13. Williams (ref. 8), 67.
14. *Manhattan Project: Official history and documents* (Washington, D.C., 1977), Reel 10: Diplomatic history of the Manhattan Project (Jan 1948). British Library, London.
15. Cited in Dennis C. Fakley, "The British Mission," *Los Alamos science* (Winter/Spring 1983), 189.
16. Personal communications from Don G. Marshall, 5 Nov 2002, Anthony P. French, 22 Nov 2002; Marshall and French were members of the British Mission.
17. Edward Teller, "The work of many people," *Science, 121* (25 Feb 1955), 270. Nigel West has alleged that Fuchs' access to secret materials was enlarged on the orders of J. Robert Oppenheimer, whom he accuses of being a Soviet spy. "Treason still shadows J.R. Oppenheimer," *Insight on the news* (15 Oct 2002). See http://www.insightmag.com/main.cfm?include=detail&storyid=285748.
18. Personal communication from Harold M. Agnew, 16 Nov 2002.
19. *In the matter of J.Robert Oppenheimer. Transcript of hearing before personnel security board* (Washington, D.C., 1954), 175.

to associate more frequently with persons in the top level."[20] Fuchs' ongoing value to the project can also be inferred from Bradbury's request that he continue at Los Alamos to work on the atomic tests of 1946. His value had also been realized by the British for as Peierls wrote Fuchs, "I am glad to hear that you are not likely to stay on beyond June at Los Alamos…there is much to do here already and by the time you get here there will probably be more."[21]

Fuchs returned to England in the summer of 1946 to head up the Theoretical Division at the AERE. Since the AERE concentrated mainly on civilian uses of atomic energy, Fuchs' appointment may appear puzzling. His successor, Professor Lord Brian Flowers, explains the reasoning, "the only honest-to-God theoretical group was the Harwell one—Cockcroft [as Director] would have demanded that – and Fuchs was obviously the man to lead it."[22] Despite his location, Fuchs continued to be involved with weapons work.[23] His frequent absences from Harwell caused some concern among his group about his leadership qualities.[24]

Fuchs the scientist worked hard and conscientiously for the United States during the war.[25] According to John von Neumann, Edward Teller and Otto Frisch, he was an extremely good physicist. Bethe described him as "one of the most valuable men in my division, one of the best theoretical physicists we had," while Cockcroft thought him indispensable.[26]

The Soviets

Distribution of material gained through espionage was strictly limited within the Soviet atomic program. The Soviets took compartmentalization further than the Americans, which helps explain why Western intelligence had such difficulty penetrating their program. The vast majority of Soviet scientists had no idea of the

20. Notes on an interview with Fuchs' LASL colleague Richard W. Hamming, Foocase File 65-58805.

21. Peierls to Fuchs, 29 May 1946. PRO AB 1/574. This letter predates the British decision to produce an atomic bomb. See Richard Rhodes, *Dark sun: The making of the hydrogen bomb* (London, 1995), 259.

22. Michael S. Goodman, interview with Lord and Lady Flowers, 23 Sep 2002.

23. Margaret Gowing, *Independence and deterrence: Britain and atomic energy, 1945-1952*. Vol. 2 – *Policy execution* (London, 1974), 144; Brian Cathcart, *Test of greatness: Britain's struggle for the atom bomb* (London, 1994), 99.

24. Ref. 22. It appears that Fuchs' staff did not know the reason for his absences.

25. John Manley, as reported in Sam Roberts, *The brother: the untold story of atomic spy David Greenglass and how he sent his sister, Ethel Rosenberg, to the electric chair* (London, 2001), 78; also Norris Bradbury (ref. 19), 494.

26. Neumann, in ref. 23, 652; interview with Edward Teller, www.gwu.edu/~nsarchiv/coldwar/interviews/episode-8/teller1.html, p. 1; interview with Hans Bethe in *The Washington Star* (5 Feb 1950); cited in Fletcher to Whitson, 13 Feb 1950, Foocase File 65-58805, Serial 205; Otto Frisch. *What little I remember* (Cambridge, 1979), 200; Cockcroft, in Gowing (ref. 23), 145, and Cathcart (ref. 23), 101.

intelligence contribution. Rather than provide it, the scientific leader of the program, Igor Kurchatov, would secretly use it to check Soviet scientists' calculations.[27]

Fuchs began to pass information to the Soviet Union in 1942, and by 1943, it is claimed, was also providing information about the research of other people, including German scientists in the intelligence he was assessing.[28] By 1943, according to Kurchatov, Fuchs' reports had become indispensable; "obtaining them has immense, indeed invaluable importance for our state and science."[29] Kurchatov made a similar evaluation at the end of 1944. In February 1945 Fuchs disclosed the implosion method for detonating the plutonium bomb, a concept so novel that there did not exist a word in Russian for it![30] By all accounts, the most important information that Fuchs gave the Soviets was the virtual blueprint for the Trinity device in New Mexico in July 1945.[31]

Between 1941 and 1943 Fuch's provided more than 570 sheets of "valuable material" to the Soviets.[32] Yuli Khariton, the Chief Designer at Arzamas-16 later commented, "the design of the first Soviet atomic bomb was based on a rather detailed diagram and description of the first American bomb, which the Soviet Union obtained through the efforts of Klaus Fuchs and Soviet intelligence."[33] Intelligence officer Vladimir Barkovsky stated that Fuchs "was our very valuable asset," a statement echoing the views of his London KGB controller Alexander Feklisov.[34] Despite the importance of the material Fuchs and others passed to the Russians, it alone could not have been useful to anyone but well supported and well trained physicists.[35] Soviet scientists not only had to replicate Fuchs' information using Soviet materials for American specifications, but also had to solve problems not addressed in the blueprint.[36]

27. German A. Goncharov and Lev D. Ryabev, "The development of the first Soviet atomic bomb," *Physics-Uspekhi, 44:1* (2001), 71-93.
28. Tschikow and Kern (ref. 6), 85.
29. Pavel Sudoplatov, *Special tasks: The memoirs of an unwanted witness* (London, 1994), 446. Despite the ridiculous claims made by Sudoplatov, the inclusion of espionage documents in the appendices make the book invaluable.
30. Yuli A. Yudin, ed., *Manuscript on the history of the Soviet nuclear weapons and infrastructure*, www.ransac.org/new~web~site/ccc/history-manuscript eng.pdf; Yudin (ref. 35), 58, 60; *Secrets, lies and atomic spies* (NOVA Transcript #2904), www.pbs.org/wgbh/nova/transcripts/2904 venona.html, p. 4.
31. Yudin (ref 30), 63-65.
32. Vladimir Lota, *GRU i atomnaya bomba* (Moscow, 2002), 55-107, quote from 102.
33. Khariton and Smirnov (ref. 5), 22.
34. Vladimir Barkovsky, lecture on Soviet atomic espionage during World War II, delivered to Los Alamos, Nov 1994, available at www.bombshell-1.com.
35. "Juli Chariton: Mitglied der Akademie der Wissenschaften," in Wladimir Gubarew, ed., *Arsamas-16: Wissenschaftler der geheimen russischen Atomstadt brechen das Schweigen* (Berlin, 1992), 44; Yuli B. Khariton and Yuri N. Smirnov, *Mifi i realnost sovyetskovo atomnovo proekta* (Arzamas-16, 1994), 8.
36. Arkady Brish, "We copied the charge design, not the bomb itself," *Literaturnaya Gazeta*

The importance of Fuchs' material can best be illustrated by the nature of the first Soviet atomic bomb. Until early 1945 the Soviets knew only the gun method, through Fuchs and by independent research. Following further information from Fuchs and re-calculation and verification of his information, Kurchatov chose the plutonium implosion bomb as his primary goal.[37] He would pursue it along identical lines to the wartime Anglo-American project. Probably, as Yuli Khariton has suggested, Fuchs' information influenced Stalin's wartime decision to launch the Soviet atomic project.[38]

Kurchatov opted to copy the American bomb not only to decrease the risk of failure, but also to obtain experimental data on the potential effects of the Anglo-American weapon.[39] But the paramount concern was to develop an atomic bomb in the shortest possible time; "any other decision would have been unacceptable and simply frivolous."[40] However, some commentators have argued that the decision to copy the American bomb retarded the Soviet program. It reduced the emphasis on research into the indigenous atomic bomb which, when tested in 1951, produced an explosive yield twice as powerful as the American-sytle one from a device half the size.[41]

2. FUCHS AND FUSION

The Soviet bomb

Fuchs' most valuable contribution to the Soviet weaspons program concerned the hydrogen bomb. The idea of a hydrogen bomb arose from discussions between Enrico Fermi and Edward Teller in 1941. From 1943 Teller lectured at Los Alamos on what he called the "super."[42] In the summer of 1945 Teller persuaded Fermi to present a series of lectures detailing the current state of research into thermonuclear weapons.[43]

In September 1945 Fuchs passed a synopsis of these lectures to the Soviets. The importance of this material lay not so much in the information, but in the

36 (7 Sep 1994), 10; www.fas.org/news/russia/1994/jptnd019-94033.htm; Igor N. Golovin, "Hurry comrades," *Wissenschaft and Frieden, 2* (Jul 1995), www.uni-muenster.de/Pealon/wut/wf-95/9521201m.htm.

37. Goncharov and Ryabev (ref. 27), 85-86.

38. Khariton and Smirnov (ref. 5), 16.

39. Yudin (ref. 30), 84.

40. Khariton and Smirnov (ref. 5), 22.

41. Richard Rhodes, "The myth of perfect nuclear security," *The New York Times,* 24 Jul 2000; Victor Shamberg, *The Soviet atomic bomb* (Colorado, 2001), 45; www.dtic.mil.net.

42. Anne Fitzpatrick, *Igniting the light elements: The Los Alamos thermonuclear weapon project, 1942-1952* (PhD Thesis LA-13577-T, Virginia Polytechnic Institute, 1999), 105. This is a crucial addition to the thermonuclear literature as the author had access to classified archives.

43. "Summary of Notes on Lectures by E. Fermi," G.P. Thomson Papers, Trinity College, University of Cambridge, J84.

knowledge that the United States had embarked on thermonuclear weapons research.[44] But the information was not trivial: it included, for example, details about the properties of tritium.[45] Kurchatov commissioned a group of leading Soviet physicists to consider the possibility of making a superbomb.[46] The resultant report, "Utilization of the nuclear energy of light elements," contained some original ideas but mainly confirmed material in Fermi's notes.[47] Thus Fuchs' spying initiated the Soviet hydrogen bomb program by instigating a feasibility study.[48] What more did he contribute? Some Soviet experts say "little," because other material he provided did not have much value.[49] Others however, notably German Goncharov, say "a great deal," and their view is beginning to prevail.

After his return to England in mid-1946, Fuchs was not again in touch with Soviet intelligence until September 1947, when his controller confimed the Soviet interest in thermonuclear weapons. In response Fuchs provided details of the "ongoing theoretical superbomb studies in the US under the direction of Teller and Enrico Fermi at the University of Chicago."[50] Since under the American McMahon Act Anglo-American atomic co-operation had ceased, Fuchs would not have had routine access to the results obtained by Teller and Fermi. Perhaps Teller told him privately. Fuchs was very close to Teller at Los Alamos, and while there Fuchs had worked on thermonuclear weapons. As Teller later recalled, "he [Fuchs] talked with me and others frequently in depth about our intensive efforts…it was easy and pleasant to discuss my work with him. He also made impressive contributions and I learned many technical facts from him."[51]

However Fuchs obtained the information, it energized the Soviets to direct new intelligence activities against research in Chicago. Within weeks "Moscow received a remarkable intelligence report;" though not from Fuchs, it was initiated

44. German A. Goncharov, "The 50th anniversary of the beginning of research in the USSR on the potential creation of a nuclear fusion reactor," *Physics-Uspekhi, 44:8* (Aug 2001), 857-858. This article includes a diagram taken from Fermi's lectures but which is not included in the copy of the notes in the Thomson papers. I am grateful to Gregg Herken for a copy of the original Soviet archival page that includes the diagram and Russian translation of the notes.

45. German A. Goncharov, "On the history of creation of the Soviet hydrogen bomb," *Physics-Uspekhi, 40:8* (Aug 1997), 860.

46. Yuri A. Romanov, "A memoir of the teacher," *Physics-Uspekhi, 39:2* (Feb 1996), 179.

47. Goncharov (ref. 45). A copy of the report can be found in *Physics-Uspekhi, 34:5* (May 1991), 445-446.

48. German A. Goncharov, "American and Soviet H-bomb development programs: Historical background," *Physics-Uspekhi, 39:10* (Oct 1996), 1043. AU: FULL PAGES.

49. Yuli B. Khariton, Victor B. Adamskii, and Yuri N. Smirnov, "On the making of the Soviet hydrogen (thermonuclear) bomb," *Physics-Uspekhi, 39* (Feb 1996), 185-189; Victor B. Adamskii and Yuri N. Smirnov, "Once again on the creation of the Soviet hydrogen bomb," *Physics-Uspekhi, 40:8* (Aug 1997), 855-858.

50. German A. Goncharov, "Thermonuclear milestones," *Physics today* (Nov 1996), 51.

51. Cited in Stanley A. Blumberg and Gwinn Owens, *Energy and conflict: The life and times of Edward Teller* (New York, 1976), 228.

following his disclosures.[52] In February 1948 the Soviet Union formally began its hydrogen bomb program. A month later Fuchs again met with Feklisov, an event which "played an exceptional role in the subsequent course of the Soviet thermonuclear bomb program."[53] At the meeting Fuchs handed over documents that dealt with the hydrogen bomb, at least one of which provided new theoretical data.[54] According to Russian accounts based on privileged access to this material, the documents consisted of information pertaining to the initiation system of the "Classical Super" – the hydrogen bomb as it was known at the time Fuchs left Los Alamos.

Just before leaving the United States in April 1946, Fuchs (and James Tuck and Egon Bretscher of the British Mission) participated in the "Conference on the Super" or on the "big, big boy," as one American put it.[55] The conference provided an account of the current state and future progress of work on thermonuclear weapons.[56] In May, Fuchs and John von Neumann filed a patent application on the Classical Super, the contents of which he dutifully passed to the Soviet Union.[57]

The Fuchs-von Neumann patent (FVNP) is still highly classified because of its importance and value in the development of a thermonuclear weapon.[58] The patent deals with the principle of radiation implosion—the method of using a gun-method atomic bomb to ignite a thermonuclear reaction; in the words of Goncharov (who has seen the patent), it was "remarkable for its wealth of novel ideas, well ahead of its time."[59] In August 1946 Teller produced an alternative design called the "Alarm Clock," thereby suspending development of the "Classical Super."

In April 1948 Fuchs' notes were sent to Stalin, Molotov, and Beria, who interpreted them to mean that the Americans had "made considerable progress in the development of nuclear weapons."[60] They decided to enlarge their program. That same April several top scientists including Khariton were asked to assess this in-

52. Joseph Albright and Marcia Kunstel, *Bombshell: The secret story of America's unknown atomic spy conspiracy* (New York, 1997), 185. The authors suppose that the disclosure came courtesy of Ted Hall.
53. Goncharov (ref. 50), 52.
54. Yudin (ref. 30), 96.
55. Louis Slotin to Frisch, 15 Apr 1946, in Otto Frisch Papers, 8:136A, Trinity College, University of Cambridge.
56. *Prima facie proof of the feasibility of the Super* (LA-551, 15 Apr 1946) and *Report of conference on the Super* (LA-575, 12 June 1946). I thank Gregg Herken for providing both documents.
57. The (unfinished) patent, S-5292X, was "Improvements in methods and means for utilizing nuclear energy." Gregg Herken, *Brotherhood of the bomb: The tangled lives and loyalties of Robert Oppenheimer, Ernest Lawrence, and Edward Teller* (New York, 2002), 374, note 92.
58. Arnold Kramish, personal communication, 5 Jul 2002.
59. Goncharov (ref. 48), 1034.
60. Ibid, 1037-8. Their reasoning was odd since they knew that Fuchs had left the U.S. in 1946.

telligence coup. Investigations into Fuchs' material germinated into a project known as the "tube"– the Soviet analogue of the "Classical Super."[61]

The physicist in charge of the tube was Yakov Zel'dovich. His group had worked on liquid deuterium as a thermonuclear fuel, Andrei Sakharov instead proposed using alternate layers of deuterium and tritium in what became known as the "Sloika" (layer cake) design or the "First Idea."[62] Both designs continued to be developed simultaneously and at the end of 1950 Khariton wrote a report detailing the status of all hydrogen bomb programs. Subsequently Fuchs' configuration was dropped in favor of a less complicated design by Zel'dovich.[63] Goncharov argues that Fuchs' design was too advanced; since the apparatus necessary to assess its complex physical processes did not exist in the Soviet Union, "it was never subjected to mathematical analysis." Zel'dovich "referred to Fuchs' scheme as a more elaborative alternative." Goncharov concludes that Soviet physicists misunderstood Fuchs' design when they dropped it in 1950.[64]

Goncharov states that the information Fuchs passed in 1948 was "*probably* consistent, by and large, with information set forth in the Fuchs-von Neumann patent." Historian Gregg Herken suggests that the information was only "based in part" on the FVNP.[65] In his book *Brotherhood of the bomb,* Herken includes a diagram of the thermonuclear weapon design passed by Fuchs to Feklisov in March 1948.

Dr Conrad Longmire, a physicist who worked at LASL on the American hydrogen bomb tests in 1951 and who has recently viewed the FVNP again has noted that "the drawing appears to show a *continuing* fixation on igniting the classical Super."[66] The diagram does not represent a workable hydrogen bomb. Nonetheless, it concentrates attention on the question of *ignition*, as the FVNP discusses.[67] This emphasis is indicated by the gun mechanism, since at that point implosion bombs were too large to offer a practical solution.

Although it tested a device that employed thermonuclear reactions in 1953, by early 1954 the Soviet Union had reached an impasse in developing a high-yield, efficient thermonuclear weapon.[68] Sakharov found a solution, the "Third Idea," analogous to the Teller-Ulam configuration in the U.S. Desperate for a solution, Soviet physicists turned back towards their earlier papers. Goncharov: "Zel'dovich and Sakharov connected the commencement of work on the principle of a Soviet

61. Yuli Khariton, Victor Adamskii, and Yuri Smirnov, "The way it was," *BAS, 52:6* (Nov/Dec 1996).
62. Andrei Sakharov, *Memoirs* (London, 1990), 102-104; Goncharov (ref. 61), 53. This was the Soviet analogue of Teller's "Alarm Clock."
63. Goncharov (ref. 50), 56-57.
64. Goncharov (ref. 45), 862-865, quotes on 863.
65. Goncharov (ref. 50), 52, emphasis added; Herken (ref. 57), 187).
66. Personal communication, 29 Oct 2002; emphasis added; Longmire based his observations on a recent look at FVNP; they are not fifty-year-old memories.
67. Longmire, personal communication, 24 Oct 2002.
68. Sakharov (ref. 62), 182.

analog of the Teller-Ulam configuration with research on a two-stage initiator for the Tube, functionally similar to the two-stage initiator mentioned in Fuchs' materials…it cannot be ruled out that Fuchs' 1948 document could have helped in the discovery of the Third Idea."[69] As another Soviet veteran observed that although "the conceptually related studies by the Zel'dovich group [did not] produce tangible results…they were undoubtedly instrumental in forming the backbone of the Soviet physics community with fine qualifications for tackling the supreme complexity of the domestic thermonuclear weapons program."[70] If Fuchs' information helped lead the Soviet Union to a workable thermonuclear weapon, it did not do so on its own: the transmission was indirect.

Information from other spies within the American program, most notably Ted Hall, also helped.[71] Physicist Lev Feoktistov mentions that in late 1953 or early 1954 he was shown a diagram from a model devised by mathematician Stanislaw Ulam, which could not have arrived via Fuchs. By this time, Feoktistov wrote, "we understood far more and could interpret tip-offs and hints. I cannot escape the feeling that we were extended a helping hand once in a while, although quite inconspicuously."[72]

The American bomb

The "Conference on the Super" of April 1946 built upon and discussed a previous study, *Prima facie proof of the feasibility of the Super,* which cautioned that "any argument for the feasibility of the super is open to one general objection, that no guarantee can be given that all pertinent physical phenomena have been thought of and properly evaluated – nor even that all pertinent effects are known."[73] The conference concluded that a super very possibly could be constructed," though it also emphasized the complexity of the problems that would be faced.[74] Not all the participants concurred. They had the satisfaction of seeing the original design, the"Classical Super," dropped in favor of the "Alarm Clock"– so called to wake physicists up to the idea of thermonuclear weapons. According to Teller, the "Alarm Clock" was a simpler design along the lines of the classical model; among its advantages was that it required less tritium, which had proved both expensive and difficult to produce in large enough quantities.[75]

In order to ignite the thermonuclear component of a hydrogen bomb, a very efficient fission bomb is needed. In the immediate postwar years not enough was

69. Goncharov (ref. 45), 862, 864. Gorelik mentions that Zel'dovich was annoyed at himself for not having recognized Fuchs' ideas earlier. Gennady Gorelik, *Andrei Sakharov: Nauka i svoboda* (Moscow, 2000), 235.
70. Romanov (ref. 46), 179.
71. Albright and Kunstel (ref. 52).
72. Lev P. Feoktistov, *Nukes are not forever* (Moscow, 1999), 73, 74 (quote).
73. LA-551 (ref. 56), 1.
74. LA-575 (ref. 42), 45.
75. Fitzpatrick (ref. 53), 123-124, 194.

known about the processes in an exploding fission bomb to comprehend the energy transfer necessary.[76] Carson Mark, the post-war head of the Theoretical Division at Los Alamos, identified the difficulty in the need for a calculation of "unprecedented size and complexity."[77] This problem was compounded by the lack of efficient, powerful computers.

Research continued on both fission and fusion weapons, but at a far slower pace than during the war, a consequence in part due to the smaller number of theoretical physicists based at Los Alamos.[78] The explosion of the Soviet bomb in 1949 and the revelations of the Fuchs case in 1950 brought a new impetus to the hydrogen bomb program, and in January 1950 President Harry Truman authorized a crash-start program.[79] Research into the Super was then not going well; "probably Los Alamos scientists were never less sure of thermonuclear feasibility than early in 1950."[80]

Ignition remained the key problem. Fission bombs could create a temperature high enough to trigger fusion, but the blast would cool before it could ignite a mass of gaseous deuterium.[81] Calculations by Ulam revealed that the weapon would not work—calculations that drove Teller to "tears of frustration."[82] He continually complained of the slow progress of thermonuclear weapons research. Before Truman's decision, the first U.S. test of a hydrogen bomb was planned for 1958 at the earliest—a date set in part on intelligence estimates for the first Soviet atomic bomb.[83]

According to Ulam, Teller "kept insisting on certain special approaches of his own....I became irritated by his insistence."[84] After showing that the Super would not work, Ulam began to consider how to make fission bombs more efficient. He deduced that the compression involved in the implosion fission bomb would produce a "bigger bang" than a gun-method bomb could. At the end of 1950 Ulam discussed with Carson Mark the great compression that would be produced. In the

76. J. Carson Mark, *Thermonuclear weapons: Period 1946 to January 1950,* 4 (DOE). This is a draft of the classified version LA-5647-MS. Mark's *A short account of Los Alamos theoretical work on thermonuclear weapons, 1946-1950* (1 Oct 1954), is a revised, specially declassified edition. See also Herbert York, *The advisors: Oppenheimer, Teller and the superbomb* (San Francisco, 1976), 25.
77. J. Carson Mark, "A maverick view," in *Behind tall fences: Stories and experiences about Los Alamos at its beginning* (Los Alamos, 1996), 161.
78. Fitzpatrick (ref. 42), 272-273.
79. Truman learned about the Fuchs case the day after authorizing the hydrogen bomb. Peter Galison and Barton Bernstein, "In any light: Scientists and the decision to build the superbomb, 1952-1954," *HSPS, 19:2* (1989), 310-312.
80. Frederick C. Alexander, Jr., *Early thermonuclear weapons development: The origins of the hydrogen bomb* (May 1969), 14 (DOE).
81. Atomic Energy Commission Information Research Division, *History of the early thermonuclear weapons: Mks 14, 15, 16, 17, 24 and 29* (June 1967), 13 (DOE).
82. Stanislaw M. Ulam, *Adventures of a mathematician* (New York, 1976), 216.
83. Fitzpatrick (ref. 42), 208.
84. Ulam (ref. 82), 213.

"Classical Super," radiation carried away heat from the thermonuclear fuel faster than the thermonuclear reactions could replace it (known as the Inverse Compton Effect). Nevertheless Teller had rejected compression as a method of conserving heat. The idea had not re-surfaced because until a better understanding of the fission process had been attained, only chemical explosives could achieve the necessary pressures, and they were otherwise inadequate for the job.

In conversations with Ulam early in 1951 Teller gradually became convinced that staged compression would work and proposed that the radiation escaping from the primary would offer a more efficient method of ignition. Thus the fabled Teller-Ulam configuration was born.[85]

Recently questions have been raised about the originality of the Teller-Ulam designs. The Fuchs-von Neumann patent had been concerned with the ignition of the "Classical Super." It had suggested using the x-ray radiation emitted from an exploding fission device to implode the thermonuclear fuel.[86] Radiation implosion was thus not a new idea in 1951.

Following Truman's announcement in January 1950, officials decided that the upcoming nuclear weapons trials in 1951– codenamed *Greenhouse*– should include some sort of thermonuclear experiment. While ignition of a sufficient amount of thermonuclear fuel was still unachievable at this point, it was thought possible that "if ignitable, D-T [deuterium-tritium] could in turn ignite deuterium, thus proving in principle that the Classical Super would work." The D-T mixture was to be ignited by using the escaping radiation from a fission device. The subsequent successful test—shot *George*—in May 1951 therefore indicated that radiation-induced implosion worked.[87]

Carson Mark has recalled that *Greenhouse George* was a "rather vague scrambling together of ideas. It was the pattern that Edward [Teller] had favored. It turned out that it was very much the pattern of the 1945 [should be 1946] Fuchs-von Neumann patent."[88] Teller emphasized that the "main principle of radiation implosion was…stated in a conference on the thermonuclear bomb in the spring of 1946."[89] Other physicists, who worked on the first thermonuclear weapons tests, have connected the *George* shot to the FVNP. Marshall Rosenbluth: "my impression is that while not at all a direct discovery of radiation implosion, it at least could have been an important precursor to the *Greenhouse George* experiment."[90]

One of the most important results of the *George* shot was information about radiation-induced implosion. This information brought Teller to his elaboration of Ulam's initial idea: "The planning of the *Greenhouse* experiments, at least in my

85. Rhodes (ref. 21), 462-469.
86. Lorna Arnold, *Britain and the H-bomb* (London, 2001), 7.
87. Fitzpatrick (ref. 42), 157 (quote), 160-161.
88. Quoted in Rhodes (ref. 21), 456. See also Goncharov (ref. 48), 1035.
89. Quoted in Fitzpatrick (ref. 42), 227-228. Bradbury made a similar assertion in a news conference in September 1954. Post-Presidential Files, Name File: Gordon Dean, Box 65, Harry S. Truman Presidential Library, Independence MO.
90. Personal communication, 22 Oct 2002.

opinion, led Teller to the idea of radiation implosion." Carson Mark explained why Teller rather than Ulam hit on the solution: "the fact that Edward thought of radiation was natural because he had been involved in much more detailed work on the George shot than had Ulam."[91] A 1952 Department of Defense memorandum clearly defined this line of progression:[92]

> [W]e are informed by competent authorities, including those at Los Alamos, that Klaus Fuchs possessed…a full understanding of the Los Alamos thermonuclear weapon feasibility report of April 1946. As you know, this report contained all the essential ideas which led to the Greenhouse George shot in May 1951. The George shot in turn demonstrated the principle…which greatly increased the probability of a practical and economical thermonuclear weapon and thus precipitated our current redirected development program.

Edward Teller has traditionally been claimed as the "father of the hydrogen bomb." Physicist Frank Shelton made Teller the father and Ulam the midwife.[93] Russian physicist and historian Gennady Gorelik recalled saying within the American physics community, that "Teller may be the father of the H-Bomb, but Ulam surely slept with the mother." Gorelik observed that whatever the parentage of the Soviet H-bomb, Klaus Fuchs must be its grandfather.[94]

The British bomb

Until the passing of the 1946 McMahon Act, the British had full access to the work at Los Alamos. Therefore Fuchs' sharing of knowledge with his British colleagues was entirely legitimate. When it became clear however that such exchange would end, Sir James Chadwick, as head of the British Mission to Los Alamos, ordered members to take note of their and everyone else's research before leaving.[95] Fuchs had been an especially valuable member of the Mission because he had tried to comprehend the state of research in every area at Los Alamos—an effort facilitated by his amazing memory.[96] Also at Chadwick's direction Fuchs visited the Chalk River site in Canada, to "see how things were going."[97] Chadwick

91. Quoted in Rhodes (ref. 21), 469, 470.
92. Memorandum by the service secretaries to the Secretary of Defense, 27 Mar 1952, *Foreign relations of the United States, 1952-1954*. Vol. 2 *Atomic energy; arms control* (Washington, D.C., 1984), 880.
93. Frank H. Shelton, *Reflections of a nuclear weaponeer* (Colorado, 1988), 3-27.
94. Gennady Gorelik, *A Russian perspective on the father of the American H-bomb*; http://people.bu.edu/gorelik/Minnesota_02_web.htm 8-9.
95. Williams (ref. 8), 96; Bretscher to Frisch, 7 June 1950. Frisch Papers, (ref. 55), Box F22.
96. Cathcart (ref. 23), 105.
97. Chadwick to Fuchs, 24 Jan 1946, PRO AB1/444.

asked his team to compile an encyclopedia on nuclear work for the benefit of British scientists.[98]

While working at Harwell, Fuchs frequently visited the weapons research laboratory at Fort Halstead. His participation in its programs became especially important as the decision was taken to replicate the plutonium implosion bomb that had been dropped on Nagasaki, just as the Soviet Union had done. Throughout the late 1940s Fuchs continued to write summaries of work in the U.S. and devoted a large amount of his time to weapons research. Any act of espionage he then committed had little importance: Fort Halstead had far more to learn from Fuchs than Fuchs from Halsted.[99] Hence, despite questions of security, the British continued to employ Fuchs because of "the growing confidence felt in him by his colleagues and by the outstanding contribution he himself was making to the atomic energy project."[100] A recently released document from MI5 reads: "it has been decided that the advantages gained by Harwell through the undoubted ability of Dr Fuchs outweigh the slight security risk."[101]

Fuchs' arrest in 1950 came as a blow to the British nuclear weapons program. Three weeks after his imprisonment, William Penney, the head of the British nuclear weapons program, wrote in a memorandum about improving plutonium production: "knowing the position as I do, I can say that there are only four people in this country who have the knowledge and ability to discover within three to four years what these major improvements are. One of the four is now in prison, two of the others are university professors who are unwilling to do more than give advice. The fourth is myself."[102] Fuchs' notebooks had to substitute for their author. In March 1950 Penney met with Cockcroft to discuss them.[103] Derrick Littler searched through Fuchs' papers at Harwell. They were not extensive, but contained some information on the hydrogen bomb and details of the research of other scientists.[104] Nothing of importance was found in Fuchs' safe, for as his successor Lord Flowers has testified, "What he did with his Top Secret documents, which is what the safe was for, God only knows."[105]

Most of Fuchs' top-secret papers came from or were deposited with Penney. That would have removed the Harwell security officer, Henry Arnold, from the loop. As an MI5 officer noted, "the distribution of all Top Secret papers at Harwell takes place through Arnold…Fuchs probably does receive documents direct from Penney at Fort Halstead and over these Arnold has no control."[106] In any case,

98. Joseph Rotblat, personal communication, 26 Sep 2002. See also correspondence in Rudolf Peierls Papers, Bodleian Library, University of Oxford, Box D57.
99. Cathcart (ref. 23), 103-104, 106.
100. Gowing (ref. 23), 149.
101. J.S. McFadden, Ministry of Supply to R.A.A. Badham, MI5, 14 Aug 1948, PRO KV 2/1245.
102. Quoted in Cathcart (ref. 23), 107.
103. Arnold (ref. 86), 38.
104. Personal communication, 15 Oct 2002.
105. Ref. 22.
106. J.C. Robertson, 10 Oct 1949; PRO KV 2/1247.

Fuchs' papers, ordered in a hundred folders, were deposited in Penney's safe in 1950. At some time before 1963 the papers were destroyed at Penney's request, opening "a gap in our 'scientific history' [that] cannot be filled."[107] Penney, shortly before his death, also ordered that his own papers be burned. The reason for his house-cleaning is not known.

At the end of May 1952 Penney requested permission from MI5 to visit Fuchs in prison. The reason for it, according to a letter from Sir Freddie Morgan, Controller for Atomic Energy, to Guy Liddell of MI5: "Dr Penney has recently been combing over once more Fuchs' work up to the date when he was arrested. As far as can be discovered Fuchs was never asked how much of his Harwell work, if any, was passed on to the Russians…in the light of recent developments, it is highly important that this particular aspect of Fuchs' matter should be cleared up."[108] Liddell's response showed that MI5 thought that Fuchs had made a comprehensive statement concerning his espionage to Perrin. MI5 reluctantly agreed to the interview and also the participation of Eric Welsh of MI6 in it.[109] Why did Penney feel it necessary to re-interview Fuchs?

Given that by June 1952 the first British fission bomb was en route to its test site in Australia, it is far more plausible that Fuchs was consulted about the hydrogen bomb. Penney and Cockcroft had been asked to produce a paper on the hydrogen bomb in time for a meeting of the Atomic Energy Board on May 15, 1952.[110] Were the "recent developments" that Morgan mentioned to Liddell on May 28 the decision by the British Government to begin an inquiry into the hydrogen bomb?

Penney and Welsh met with Fuchs on at least one occasion, as one former member of Eric Welsh's atomic intelligence unit recently recalled.[111] In *Spycatcher* Peter Wright describes reading [the deleted] MI5's "Klaus Fuchs File."[112] Wright learned that the only people who had visited Fuchs in prison were Penney and three of Fuchs' scientist friends: Peierls, Nicholas Kurti and Herbert Skinner.[113] But perhaps there were more. "Fuchs is continuing to collaborate in various other matters," as we learn from a letter from Morgan to Penney dated February 9, 1953.[114]

107. John Corner to Group Record Storage Officer, 29 Nov and reply, 4 Dec 1963. PRO ES 1/494.

108. F. Morgan to G. Liddell, 28 May 1952. PRO KV 2/1258. MI5 knew in 1950 that Fuchs had passed on information about Harwell, and it would be odd if that knowledge had not filtered back to Penney. See J.C. Robertson, "Indications of a Russian espionage source, other than Fuchs, at Harwell,"1 Feb 1950, PRO KV 2/1250.

109. See the correspondence in PRO KV 2/1258.

110. Kate Pyne, "Turning on the light: The UK discovery of the H-bomb principles," *British nuclear history study group seminar*, Mountbatten Center for International Studies, University of Southampton, 16 May, 2002.

111. Private communication.

112. Peter Wright, *Spycatcher: The candid autobiography of a senior intelligence officer* (Victoria, 1987), 237.

113. Michael S. Goodman, interview with H. Chapman Pincher, 24 Jul 2002.

114. Morgan to Penney, 9 Feb 1953. PRO ES 1/493.

Fuchs had had many discussions with John Corner and Herbert Pike (two of the leading scientists in Britain's nuclear weapons program), who had worked on the "Classical Super" for six months in the late 1940s, but had concluded it was both too expensive and impractical.[115] Despite this, however, it does appear that a thermonuclear weapons program was in Penney's mind, for the Aldermaston site was chosen in order to accomodate a cryogenics facility—compulsory for a program based on the design of the Classical Super. Corner and Pike's discussions with Fuchs may have included information about the hydrogen bomb that Fuchs had obtained from Teller in 1947.[116] Fuchs was not an exclusive informant. He said that he passed information to the Soviet Union to ensure that atomic weapons would not be the sole possession of one country; apparently he followed the same reasoning in trying to expedite the British program.[117]

According to historian Lorna Arnold, when Britain decided in July 1954 to develop a hydrogen bomb, the only information available came from work done at Los Alamos up to 1946 and from snippets provided by the Americans to enable British physicists to analyze debris from Soviet tests.[118] With this limited knowledge, science administrators were uncertain about the nature of a hydrogen bomb; the chairman of the Working Party on the Operational Use of Atomic Weapons wrote in September 1954 that "the H-bomb is merely a large re-designed A-bomb with a large booster, still further boosted by tritium."[119] At the ministerial level, officials noted "the prevailing state of general ignorance with regard to the so-called hydrogen bomb...we must, in the first instance, strive to arrive at some definition of the general term 'hydrogen bomb'."[120]

The uncertainty in the science has made it difficult to reconstruct the history. As the recent official account puts it: "Penney…produced a series of ideas and frequently changing sketches. But where the essential ideas came from, how they were brought together, and how the design really evolved is something of a mystery." During two weeks in early 1956 the British found the scheme that became the basis of the Grapple thermonuclear tests of 1957; how it was done remains a mystery. As the official history questions: "If Fuchs' information was of such

115. Gowing, (ref. 23), 443; Cathcart (ref. 23), 104; Arnold (ref. 86), 41.
116. In 1958 the murderer Donald Hume was released from Wakefield prison. He had been a neighbor of Fuchs and had had long and detailed conversations with him. Hume dictated his notes of these conversations to the *Daily express*. Evidence that would not have been available then corroborate the notes, for example Hume's statement that Fuchs passed information on the mechanics of triggering a hydrogen bomb in 1948. I thank Chapman Pincher for a copy of these notes.
117. Statement to the FBI and William Skardon, 26 May 1950, Foocase, File 65-58805, Serial 241.
118. Arnold (ref. 86), 40-1.
119. "Future Program—Memo by the Chairman, Working Party on the Operational Use of Atomic Weapons," OAW/P(54)9, Sep 1954, PRO DEFE 7/22008.
120. Anon., Memorandum, Aug 1954, PRO AVIA 65/876.

value to Soviet scientists, how much did he also give to the British and how important was it?"[121]

3. INTELLIGENCE ESTIMATES

Despite good Anglo-American relations in atomic intelligence and the collaboration of the FBI and MI5, the two sides did not share their evaluations of Fuchs' disclosures. The Americans wanted to prevent a leak of information prohibited by the McMahon Act, while the British did not want the Americans to know what they and the Russians had learned about work at Los Alamos. According to Arnold Kramish, the AEC was annoyed that the British would not reveal much about Fuchs' espionage after leaving the U.S., and that in fact "the British were very coy, indeed reticent, about what Fuchs might have revealed on the British program."[122]

British

Michael Perrin, Deputy Controller for Atomic Energy within the Ministry of Supply, concluded from interviews with Fuchs that he had sincerely tried to recall and relate the information he had given to the Soviets. That included material on the origins of the British effort and of the American gaseous diffusion project. In February 1945 Fuchs shared with the Soviets the report he had written summarizing "the whole problem of making an atomic bomb as he saw it." A subsequent report on the same topic followed in June, together with relevant files from LASL and the design to be tested at Trinity. After returning to England, Fuchs refused to answer Soviet questions on the size of the U.S. stockpile or about the British fission program. Concerning the hydrogen bomb, Fuchs said that he had given "the Russian agent the essential nuclear physics data and the general picture as far as it was then [in mid-1947] known to [me] of how the weapon would work."[123] This statement provides a further indication that Fuchs knew about then-recent American research.

The unexpected early success of the Soviet atomic weapons program could easily be explained by Fuch's treason. Cockcroft and other top scientists held this view.[124] The Joint Intelligence Committee (JIC) agreed, and made the connection between espionage and early detonation a prominent theme in its intelligence assessments: "the rapid Russian progress in developing atomic energy was undoubtedly made possible by Russian success in espionage."[125]

121. Arnold (ref. 86), 93-94, 25-26.
122. Personal communications, 24 and 26 June 2002.
123. "Statement of Michael Wilcox Perrin," 31 Jan 1950, PRO KV 2/1250.
124. Guy Hartcup and T. E. Allibone, *Cockcroft and the Atom* (Bristol, 1984), 157.
125. "Report on Russian Research and Development," JIC(52)16, 27 Feb 1952, PRO CAB 158/14.

Despite American estimates that the first Soviet bomb, used Joe-1, plutonium, British radiochemical analyses of the samples were equivocal.[126] In light of Fuchs' confession that he had provided almost complete knowledge of the plutonium bomb, it was easy to suppose that Joe-1 was of the type used on Nagasaki.[127] Intelligence officials accordingly assumed that the Soviets would stockpile plutonium bombs even though intelligence also indicated that the Soviet Union had been interested in the production of Uranium-235 since 1947.[128]

Knowledge that Fuchs had passed information on the hydrogen bomb to the Russians did not play any part in intelligence estimates of the Soviet hydrogen bomb program. Indeed as late as 1953 the JIC had little intelligence at all: "we have very little concrete information about Soviet hopes and intentions in the atomic energy field…there is no evidence to date whether or not the USSR is experimenting with or making thermo-nuclear weapons."[129]

Surveillance and analysis of the debris of the 1953 series of Soviet tests produced evidence of "a thermonuclear component," which was interpreted as evidence of "a program directed towards producing thermo-nuclear weapons." But no use could be made of it. The JIC: "we have not been put in possession of enough detail of the Russian success, and of what may have led to it, to enable us to give serious consideration to its implications, still less to draw any conclusions. We therefore merely report the event without further discussion."[130] Apparently the JIC did not know, or take into account, the bearing of the thermonuclear weapons material passed by Fuchs on Soviet development. By the time the British had figured out how to construct the hydrogen bomb, when they would have known how important Fuchs' material was, the Soviet Union had detonated one the previous year.

American

The Americans were aware of Perrin's findings, but also conducted extensive investigations themselves. According to Clegg and Lamphere, Fuchs believed that he had saved the Soviet program one year by allowing scientists to work on the bomb itself while the plutonium was being produced.[131] Like the British, the Americans were quick to associate the unexpectedly early appearance of Joe-1 with the espionage: "the evidence available to date of Soviet atomic energy espio-

126. Michael S. Goodman, "British intelligence and the Soviet atomic bomb, 1945-1950," *Journal of strategic studies, 26:2* (June 2003), 120-151.
127. "Appreciation of Russian Atomic Energy Program – Jan 1951, JIC/491/51, 3 Mar 1951, PRO CAB 176/30.
128. Ref 125. British intelligence was in error; the Soviet tests in 1951 employed U-235.
129. "Soviet and Satellite War Potential," JIC(53)14(FINAL), 10 Apr 1953, PRO CAB 158/15.
130. "Russian Research and Development," JIC(54)36, 6 Apr 1954, PRO CAB 158/17.
131. "Report of Hugh H. Clegg and Robert J. Lamphere Covering Interviews with Klaus Fuchs in London, England, Foocase File 65-58805, Serial 1412, 29.

nage activities warrants at least the inference that Soviet plant design, construction and operation have been carried out with reasonably full knowledge of all other atomic energy programs."[132] The Fuchs case exposed the weakness of the American intelligence system arising from its decentralization. As the Chairman of the Joint Atomic Energy Intelligence Committee commented,[133]

> [I]t is the opinion of the JAEIC that considerable counter-espionage information is and has been available in the files of the FBI and elsewhere which would have and probably still is of considerable value to the JAEIC in making its estimates of the status of the USSR atomic energy program…this possibly large area of information is being denied us. Furthermore, in view of the paucity of information from other sources, the elimination of this deficiency is urgently necessary if the JAEIC is to perform its duties adequately.

Fuchs told the FBI, in contrast to what he had told Perrin, that he had not given the Soviets any information discussed during the Super conference in 1946. The Americans recognized his duplicity, since MI5 had sent them copies of Perrin's reports.[134] Possibly as a result of this discrepancy, various organizations within the U.S. government tried to determine what information regarding the hydrogen bomb Fuchs had access to. The AEC's evaluation—written by some of the leading LASL scientists—of this information was rapidly completed and passed to the FBI in May 1950. The report made no conclusions but aimed to evaluate Fuchs' participation in thermonuclear work at Los Alamos. While it had been confidently stated that the "Classical Super" was the only design known to the British, the evaluation mentioned that in February 1947 Ernest Titterton of the British Mission had been present at a meeting where the "Alarm Clock" design had been discussed.[135]

Another study of the significance of Fuchs' treachery was authorized by Robert LeBaron, Chairman of the Military Liaison Committee by Major-General Kenneth Nichols and Brigadier-General Herbert Loper.[136] The result concluded that "if [the Russians] had accepted everything [Fuchs has provided] and taken action they could very well be ahead of us in the development of the hydrogen bomb."[137]

132. "Status of the Soviet Atomic Energy Program," CIA/JAEIC Report, 4 Jul 1950, DDRS. 1979-20A, p. 1.
133. W.K. Benson to Chairman, Scientific Intelligence Committee, 9 Feb 1950, in Robert L. Benson and Michael Warner, eds., *VENONA: Soviet espionage and the American response, 1939-1957* (California, 1996), 145.
134. (Ref. 131), 27-28.
135. Fuchs' participation in the thermonuclear weapon program at Los Alamos, in Foocase, File 65-58805, Serial 1246.
136. Shelton (ref. 93), 3-37.
137. Interview with Gen. K.Nichols, LHCMA Nuclear Age: 11/83; Richard G. Hewlett and Francis Duncan, *Atomic shield: 1947-1952. Volume II of a history of the United States Atomic Energy Commission* (London, 1969), 415.

A far more important study was conducted in 1952, with a different question in mind: not "what information did Fuchs have access to," but "how much had the Russians actually learned about the American H-Bomb from Fuchs?" One of those involved, John Walker, commented that "our entire H-Bomb program rests, vis-à-vis the Russians, on a gigantic assumption – that we have a short cut and that they are blindly following the 1946 information given them by Fuchs….[T]he only point missing is radiation implosion." A subsequent "damage assessment" conducted by the AEC concluded that Fuchs transmitted the idea of radiation implosion as well as elements of the Mike shot.[138]

Estimates made in late 1950 assumed that the Soviets were pursuing a thermonuclear bomb and experiencing the same difficulties that confronted the Americans. "There is considerable uncertainty as to whether or not it is physically possible to construct a thermonuclear weapon that will function satisfactorily." But every effort had to be made, since the same problems no doubt were being "intensively investigated" on the basis of the details Fuchs had furnished in 1946.[139] American intelligence continued to hold this view during 1951 also; but by January 1953 it had concluded that "although research which may be relevant has been noted, there is no evidence of thermonuclear development activities [in the Soviet Union] at the present time."[140] The emphasis changed significantly six months later. A report of June 1953 warned that, although no indication of Soviet development of hydrogen bombs had been found, "Soviet research, development and even field testing of thermonuclear reactions based on the disclosures of Fuchs may take place by mid-1953." U.S. intelligence thus recognized for the first time that Fuchs' material held invaluable information for the Soviet thermonuclear weapons program.[141]

Following his spell in prison Fuchs took a position in a nuclear research laboratory in East Germany. There he collaborated with German physicist Heinz Barwich, who had worked on the Soviet nuclear program, but who soon afterward defected to the west.[142] Klaus Fuchs was a complicated individual. He provided precious information, contributed invaluable calculations, and conducted priceless research for the nuclear weapons programs of Britain, the United States, and the Soviet Union. He appears to have assisted the Soviet Union in much the same way as he assisted Britain—to prevent an American atomic monopoly. Recent evidence indicates that he provided positive assistance in the development of fission weapons in all three countries. His contributions to the thermonuclear weapons programs, which Bethe demeaned, now also appear to have been significant.

138. Herken (ref. 57), 397, note 61. Mike (1952) was the first test of a thermonuclear weapon.
139. "Status of the Soviet Atomic Energy Program," 27 Dec 1950, DDRS 1983-89.
140. "Status of the Soviet Atomic Energy Program," 8 Jan 1953, DDRS 1987-1.
141. "NIE-65: Soviet Bloc Capabilities Through 1957," June 1953, PRO DEFE 41/155.
142. Heinz Barwich and Ellie Barwich, *Das Rote Atom* (Munich, 1967), 188.

The Fuchs case highlighted the detrimental effect of the McMahon Act on the British. Despite strong atomic intelligence relations, the cessation of technical exchange had a visible effect on the British ability to formulate intelligence analyses. Consequently they were unable to fully appreciate what Fuchs' disclosures meant for estimates of the Soviet hydrogen bomb—a factor evident in the changing nature of American predictions.

By continuing to aid the British in much the same way as he had earlier helped the Russians, Fuchs insured that the U.S. did not enjoy a monopoly of nuclear weapons technology. He thereby induced the British to hide from the Americans the information they had obtained; it undermined the McMahon Act, which they were desperate to overhaul. Recalling Fuchs willing service at Los Alamos and Harwell as a baby-sitter, jokesters around Whitehall liked to say: "The children called him Uncle Klaus. The Russians called him Santa Klaus!" So, with good reason, could the British.

MICHAEL S. GOODMAN

The grandfather of the hydrogen bomb?: Anglo-American intelligence and Klaus Fuchs

ABSTRACT:

It has been assumed that Klaus Fuchs could not have provided significant information to the Soviet Union regarding the hydrogen bomb because the calculations he took with him from Los Alamos were flawed. Recent evidence from British, American and former Soviet sources suggest that Fuchs played an invaluable role in the early development of thermonuclear weapons in all three countries. This article considers this new evidence and places Fuchs' role in the development of the H-bomb in the context of intelligence estimates that arose following his arrest.
