BOOK REVIEWS

Bombs After Hiroshima

Dark Sun. The Making of the Hydrogen Bomb. RICHARD RHODES. Simon and Schuster, New York, 1995. 731 pp. + plates. $32.50. Sloan Technology Series.

Not before the middle of this book do we read anything about the hydrogen bomb. But what we do read about is fascinating: the history of the Soviet atomic bomb from its beginning and of the American project after the end of World War II, the stories of the atomic spies, and much history of the Cold War. And then, of course, the story of the hydrogen bombs.

Russian nuclear scientists, like their colleagues in other countries, speculated about nuclear explosives from 1939 on. In fall 1941 the Soviet Union, through an agent close to the British government, got a report that Britain was taking the possibility of an atomic weapon very seriously. In May 1942 Stalin, alerted by a personal letter from the physicist Georgi Flerov, said "we should do it." But only after their victory at Stalingrad, in January 1943, did the Soviets seriously set up an atomic project.

Senior scientists selected 40-year-old Igor Kurchatov to head the project, a wise choice. Kurchatov was an excellent physicist and a superb organizer. Appointed officially on 11 February 1943, he assembled a core team of first-class theoretical and experimental physicists. Early in March 1943, he was shown the material collected by Soviet espionage, by then probably mostly originating from Klaus Fuchs. "This material is of immense value," Kurchatov declared; it showed the Soviet scientists how to proceed and fundamentally changed their ideas. Only Kurchatov was permitted to see the original intelligence reports. The group worked intensively, but support remained modest throughout the war.

The great stimulus came with Hiroshima. Stalin had been warned casually by Truman at Potsdam, but the bombing of Hiroshima truly stirred him: He must have the atomic bomb. He had the advantage that a first-rate group was already hard at work. He called Kurchatov to his office, told him to ask for anything he needed regardless of cost: "Provide the Bomb." Beria was appointed to head the whole project, replacing the rather ineffective Molotov. Boris Vannikov was put in charge of industrial development, a formidable task when most of European Russia lay in ruins.

Beria was suspicious of everybody; his own scientists, his spy organization, even the official American book on nuclear matters, the Smyth Report. He often threatened his scientists, but he gave them good working and living conditions. The first pile, F-1, built in Moscow to prove the principle, went critical earlier than expected. The production reactor, in Chelyabink province (built largely with the labor of gulag prisoners, whose treatment apparently was even worse than described by Solzhenitsyn), started producing in 1948.

Under constant threat from Beria, Kurchatov's group decided to copy the U.S. Nagasaki bomb, for which Fuchs had given them detailed description and dimensions. (This was against the advice of Peter Kapitza, probably the most famous Russian physicist; he wanted a Russian design.) But the most important need was clearly speed and certainty of success. Indeed, the test went off on 29 August 1949 at Semipalatinsk in central Siberia and was a full success. It finally earned the scientists respect from Beria and Stalin.

The Soviets had relied heavily on espionage. Rhodes gives us many details about the spies, and they all look reliable, in contrast to the account proffered by Sudoplatov *et al.* in a book that appeared last year. The chief spy was of course Klaus Fuchs. Born in 1912, Fuchs became a deeply committed communist in Germany in the early 1930s, leading a group of students in street battles. Fuchs's whole family was communist. One sister committed suicide before the Nazis could arrest her, another sister managed to flee to America. Fuchs's father, a Protestant minister, spent some time in a Nazi prison. After his release, he courageously helped anti-Nazis (not necessarily communists) and Jews escape from Germany. In 1933, Klaus had to flee to England, where he continued his studies in Bristol. After the fall of France in 1940, he was interned and sent to Canada (to a camp full of Nazis). After his return to England, he was known as a very good physicist; soon he became assistant to Rudolf Peierls, working chiefly on the theory of separation of the isotopes of uranium. The British method was adopted and implemented on a large scale by the United States; Peierls was asked to help. When this had been accomplished, Peierls was asked to come to Los Alamos. Both times, he brought Fuchs along.

The detonation of "Mike," the first U.S. hydrogen bomb, at Eniwetok, 1 November 1952. Mike yielded 10.4 megatons and produced a mushroom cloud 27 miles high. [From *Dark Sun*]

I knew Fuchs at Los Alamos. All of us worked terribly hard, but Fuchs managed to work twice as hard. He volunteered, in addition to his theoretical work, to keep in contact with the experimental work on explosive lenses; so he had "hands-on" experience on the two most critical phases of the project, isotope separation and implosion. Back in England, he had offered his services to the Soviet embassy. Now he gave his knowledge freely to his American espionage go-between, whom he knew as Raymond. His information included the approximate date of the bomb test at Alamogordo and the detailed design of the Nagasaki plutonium bomb, with all dimensions.

Raymond, alias David Gold, met with Fuchs in Santa Fe, and they transacted their business while driving around in Fuchs's dilapidated car. In contrast to the self-possessed Fuchs, Gold was not very successful in life. He was deeply disturbed by the anti-Semitism in America, thought that the Soviet Union was better, and therefore agreed to work as an espionage courier. In the chapter about these events the book reads like a spy novel. One time, Gold's control, the Russian Yatzkov, asked him to see a second person in New Mexico, David Greenglass, a soldier at the Los Alamos Laboratory, who worked as a machinist on the fabrication of explosive lenses. This breach by Yatzkov of the espionage rule "never let one courier contact two sources" helped greatly in the later unraveling of atomic espionage. Greenglass had been recruited for espionage by Julius and Ethel Rosenberg; he was Ethel's brother.

This entire spy system unraveled only in 1949. An energetic FBI agent, Robert Lamphere, noticed that a big batch of coded messages from the Soviet Embassy to Moscow was available and that the United States had been able to crack the code, used just in 1944–45. Lamphere and his code expert soon uncoded a very scientific message about uranium isotope separation. It was traced to the British mission, then explicitly to Fuchs. British intelligence was alerted, and in January 1950 Fuchs confessed. He was tried by the Lord Chief Justice in a widely advertised trial; he was convicted and sentenced to 14 years in prison. In Britain espionage for an ally, as the Soviet Union was in 1943–45, was not categorized as treason and therefore not punishable by death.

In prison, Fuchs recognized Gold's picture as Raymond, his go-between. Gold confessed and implicated Greenglass, he in turn the Rosenbergs. Tried in the United States, Gold got 30 years in prison, Greenglass 15, both Rosenbergs death.

Now Rhodes leads us through a brief history of the Cold War.

Relations between the Soviets and the Western powers deteriorated. The Soviets made Poland into a strictly communist state, and in 1948 they marched into Czechoslovakia and toppled its democratic government. In a 1947 conversation with Stalin, U.S. Secretary of State George Marshall noticed that Stalin obviously enjoyed the economic and political turmoil in Western Europe. Stalin's attitude provided the impetus for the Marshall Plan, which worked immediately in England and France but was frustrated in Germany by the Soviet's issuance of unlimited amounts of German money. The Western powers decided to create their own money for the Western zones, with limited circulation. The Soviets answered with the Berlin blockade.

The answer to the Berlin blockade was brilliant: the airlift. The Soviets did not interfere with it; they did not want war, and they thought the airlift could not work. But under General Tunner, who had commanded the flights "over the hump" from Burma to China, it functioned like clockwork, a plane every three minutes, night and day, in all weather, summer and winter. The Soviets gave up in 1949.

In 1950 came Korea. The West completely misinterpreted it; they were afraid that it might be a prelude to a Soviet invasion of Western Europe. In fact, it was the private idea of Kim Il Sung, the North Korean dictator, reluctantly endorsed by Stalin. As we know, the fortunes of this war went back and forth. Planes of the Strategic Air Command (SAC) capable of carrying nuclear weapons were deployed to Guam, but President Truman decided against the actual use of the atomic bomb.

Vignette: Changing Times

In a 1991 article in the *Physical Review*, the cosmologist George Blumenthal [compared] one model of the universe, which contains several fudge factors whose values are not yet constrained by observational results, to Alice's Restaurant, where "you can get anything you want." For the older generation, the poignancy of this episode is that Blumenthal, who wrote his article with a much younger colleague, had to explain to his coauthor what Alice's Restaurant was all about.

—*Donald Goldsmith, in Einstein's Greatest Blunder? The Cosmological Constant and Other Fudge Factors in the Physics of the Universe* (Harvard University Press)

Under General Curtis LeMay the SAC had been molded into a fighting force of unequaled efficiency and precision. LeMay believed that he could knock out the war-making capability of the Soviet Union in one big strike with atomic bombs.

In 1945, at the end of World War II, the atomic weapons laboratory at Los Alamos had been greatly reduced. The military technicians and scientists were demobilized, the leading civilian scientists returned to their universities to do peace-time research and teaching, the younger scientists to complete their studies. Norris Bradbury, the successor to Robert Oppenheimer as director, was able to keep about half the laboratory together.

Edward Teller, convinced of the need to continue vigorously the development of nuclear weapons, spent about half his time at Los Alamos. His pet project was the creation of a hydrogen bomb. In spring 1946, he arranged a conference to assemble all that was known pertinent to H-bombs from the wartime work, both theoretical and experimental. Fuchs attended that conference, then went back to England. Later in 1946, Teller invented a new design for an H-bomb, called by him the Alarm Clock, in Russia the Layer Cake: alternate layers of natural uranium and a compound of deuterium such as LiD, lithium deuteride. A core of plutonium or uranium-235 would be assembled by implosion, its explosion would compress and heat the LiD, which would give off high-energy neutrons, which in turn would cause fission in the natural uranium, and so on.

The Los Alamos Laboratory devoted itself to improvement of fission bombs. The active material, instead of being a solid sphere to begin with, as in the Nagasaki bomb, would be fabricated as a shell, with a "levitated" sphere in its center. Part of the expensive plutonium was replaced with less expensive uranium-235. Levitation increased the energy yield and made it possible to reduce the size and weight of the explosive. Similar improvements were achieved, without espionage, by the Soviet laboratories.

In Washington, Senator Brian McMahon sponsored a law transferring nuclear weapons from the custody of the Army to a civilian agency, the Atomic Energy Commission (AEC). A General Advisory Committee (GAC) would provide mainly technical advice. There would be a Joint (Senate and House) Congressional Committee on Atomic Energy (JCAE) and a Military Liaison Committee. David Lilienthal, until then director of the Tennessee Valley Authority, was appointed chairman of the AEC. The GAC, once it was formed, elected Oppenheimer its chairman.

The AEC took office on New Year's day 1947. One of its first actions was to inspect the arsenal of nuclear weapons. None were found, only many parts of weapons. So the AEC and its GAC had to agree that the prime function of the AEC, for the foreseeable future, had to be weapons development and production.

Lewis Strauss, one of the AEC commissioners, initiated an Air Force capability to detect tests of nuclear weapons that might be conducted by other countries; under the auspices of an agency designated AFOAT-1, Air Force planes would fly routinely with "sniffers" to collect dust in the atmosphere, which would then undergo chemical analysis. The technique was developed by monitoring U.S. weapons tests.

The successful weapon test of the Soviet Union in 1949 came as a shock to the Americans involved. It was detected by AFOAT-1 in the Pacific, east of the Soviet Union. Most scientists had expected a Soviet test five years after our own, but most administrators (including General Groves and President Truman) had expected that the United States would keep its monopoly much longer. Many people felt that there should be an answer to the Soviet test. Most agreed that the nuclear production capability of the AEC should be increased. But some felt that more was needed.

Ernest Lawrence, the inventor of the cyclotron, and Luis Alvarez, who was doing ingenious experiments using it, decided the time had come to make a major effort to develop Teller's thermonuclear weapon, the Super. They went to Washington and found enthusiastic support from the JCAE. The AEC was divided and asked the GAC for advice. At a meeting of the GAC at the end of October 1949, Oppenheimer asked all members to express their opinion before he gave his own. There was unanimous opposition to a crash program to develop the Super.

The military usefulness of the Super was questioned. Assuming that both sides would get the Super, the security of the United States would be further diminished if the yield of the bomb were increased by another factor 1000. The members of the GAC also felt it was morally wrong to introduce this additional step into the arms race.

The GAC did not prevail. After heated debate in Washington, President Truman decided in January 1950 to go full steam ahead with the thermonuclear development.

The trouble was that there was no design available. Teller's "classical Super" turned out, in many calculations by Ulam and others, to be far more difficult and costly than expected. There was the alternative of the Alarm Clock, but its yield was strictly limited. The lure of unlimited yield of the classical Super was irresistible.

So it went for a year, until early in 1951, when Ulam had the idea of compressing a thermonuclear secondary with the hydrodynamic shock produced by a primary fission bomb. Teller accepted the idea, improving it by using the pressure of the radiation from the primary, rather than hydrodynamic shock. The idea was immediately persuasive to everybody, including Oppenheimer, the GAC, and the AEC. Los Alamos, in 17 months, produced the first thermonuclear device, proved in the Mike test in the Pacific and yielding over 10 megatons.

This and many other developments are described in fascinating detail in *Dark Sun.* I can only admire the thorough research that is the basis of this book. Most of the story of the spies was new to me, and even some of the difficult engineering leading to the successful test of Mike. There were many conflicts of personality, in Washington and in Los Alamos. The book is full of suspense. Its only fault is that it kept me from doing other work.

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The *Enola Gay* Script

Judgement at the Smithsonian. PHILIP NOBILE, Ed. Marlowe, New York, 1995. xviii, 270 pp., illus. Paper, $12.95.

The controversy that led to the cancellation of the Smithsonian Institution's Air and Space Museum exhibit centered on the *Enola Gay*, the airplane that dropped the atomic bomb on Hiroshima, has attracted much attention both here and in Japan as the 50th anniversary of the event has loomed on the horizon. Those who have pondered at second hand the expressions of outrage the planned exhibit evoked from veteran's groups and others and the generally quieter voices charging distortions in the critics' representations of the content of the exhibit will in this book find an opportunity to make some assessment of the matter for themselves. The book reprints, verbatim according to the editor, the original script for the exhibit, entitled "The Crossroads: The End of World War II, The Atomic Bomb, and the Origins of the Cold War." Beginning with a recommendation that "parental discretion is advised" and concluding that the "dilemma" posed by nuclear weapons "is not about to disappear," the 127-page script is divided into five main "units" with numerous subunits, typically about 200 words in length. The photographs and captions that were to be included in the exhibit are not included, but the script contains a small amount of other illustrative material. Only about a third of the book is given over to the script itself, which is placed between two essays by commentators obviously sympathetic to the original conception of the exhibit. In a 90-page introduction Nobile recounts and comments on the controversy in a punchy style, for instance characterizing Air Force historian Richard Hallion, whose 1993 memo characterizing the text as "a great script . . . obviously based on a great deal of sound research" is quoted on the cover of the book, as "prematurely honest. Faster than you can say Pearl Harbor, he got with the Pentagon program and morphed into an ardent enemy of the Smithsonian." A still lengthier afterword by Stanford University historian Barton Bernstein, who was a member of the exhibit's Advisory Board, summarizes the various views concerning the decision to drop the atomic bomb that were expressed by political and military leaders of the time or have been developed by scholars since the event and gives his own commentary on the Smithsonian events, expressing the hope that though in the short run the opponents of the exhibit defeated the Air and Space Museum's attempt at "distilling the existing scholarship on the A-bomb for public consumption" the controversy itself will bring heightened attention to the issues. Both Nobile and Bernstein (the latter with over 200 notes) cite a variety of source material bearing on the controversy, and the book includes an index to the exhibit script. A note from the publisher states that the work was prepared without any participation from Smithsonian staff.

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Books Received

Affine Lie Algebras and Quantum Groups. An Introduction, with Applications in Conformal Field Theory. Jürgen Fuchs. Cambridge University Press, New York, 1995. xiv, 433 pp., illus. $100; paper, $39.95. Cambridge Monographs on Mathematical Physics. Reprint, 1992 ed.

Biogeochemical Monitoring in Small Catchments. Jiří Černý *et al.*, Eds. Kluwer, Norwell, MA, 1995. x, 432 pp., illus. $259 or £166 or Dfl. 395. From a symposium, Prague, Sept. 1993. Reprinted from *Water, Air and Soil Pollution*, vol. 79, nos. 1-4 (1995).

Current Topics in Primate Vocal Communication. Elke Zimmermann, John D. Newman, and Uwe Jürgens, Eds. Plenum, New York, 1995. x, 286 pp., illus. $89.50. From a congress, Kuta-Bali, Indonesia, Aug. 1992.

Diazo Chemistry. Vol. 1, Aromatic and Heteroaromatic Compounds. Heinrich Zollinger. VCH, New York, 1994. xiv, 453 pp., illus. $115.

Experiments in Plant Tissue Culture. John H. Dodds and Lorin W. Roberts. 3rd ed. Cambridge University Press, New York, 1995. xiv, 256 pp., illus. $59.95; paper, $24.95.

Feminism and Nursing. An Historical Perspective on Power, Status, and Political Activism in the Nursing Profession. Joan I. Roberts and Thetis M. Group. Praeger, Westport, CT, 1995. xxiv, 371 pp. $65.

Guidance and Control 1995. Robert D. Culp and James D. Medbery, Eds. American Astronautical Society, San Diego, 1995 (distributor, Univelt, San Diego). xx, 580 pp., illus. $120; paper, $90. Advances in the Astronautical Sciences, vol. 88. From a conference, Keystone, CO, Feb. 1995.

The History of Accelerator Radiological Protection. Personal and Professional Memoirs. H. Wade Patterson and Ralph H. Thomas, Eds. Nuclear Technology, Ashford, UK, 1994. xiv, 445 pp., illus. $60 or £33.

Introduction to the Modern Theory of Dynamical Systems. Anatole Katok and Boris Hallelblatt. Cambridge University Press, New York, 1995. xviii, 802 pp., illus. $79.95. Encyclopedia of Mathematics and its Applications, vol. 54.

The Last Panda. George B. Schaller. University of Chicago Press, Chicago, 1994. xx, 299 pp., illus., + plates. Paper, $13.95. Reprint, 1993 ed.

Publishers' Addresses

Below is information about how to direct orders for books reviewed in this issue. A fuller list of addresses of publishers represented in *Science* appears in the issue of 26 May 1995, page 1220.

Marlowe and Company, c/o Publishers Group West, P.O. Box 8843, Emeryville, CA 94662. Phone: 800-788-3123; 510-658-3453. Fax: 510-658-1834; 510-658-1934.

Simon and Schuster, 200 Old Tappan Rd., Old Tappan, NJ 07675. Phone: 800-223-2336; 201-767-5000. Fax: 800-445-6991.