

Preface

In August, 1945, two United States Army Air Force B-29 bombers each dropped single bombs on the Japanese cities of Hiroshima and Nagasaki. These new “atomic” bombs, colloquially known as *Little Boy* and *Fat Man*, each exploded with energies equivalent to over 10,000 tons of conventional explosive, the normal payload of 1,000 such bombers deployed simultaneously. Hiroshima and Nagasaki were both devastated. A few days later, Japan surrendered, bringing an end to World War II. In a speech to his people on August 15, Emperor Hirohito specifically referred to “a new and most cruel bomb” as one of the reasons for accepting surrender terms that had been laid out by the Allied powers. A later analysis by the United States Strategic Bombing Survey estimated the total number of people killed in the bombings to be about 125,000, with a further 130,000–160,000 injured.

While historians continue to debate whether the bombs can be credited with directly ending the war or simply helped to hasten its end, it is irrefutable that the development and use of nuclear weapons was a watershed event of human history. In 1999, the *Newseum* organization of Washington, D.C., conducted a survey of journalists and the public regarding the top 100 news stories of the twentieth century. Number one on the list for both groups was the bombings of Hiroshima and Nagasaki and the end of World War II. Journalists ranked the July, 1945, test of an atomic bomb in the desert of southern New Mexico as number 48, and the Manhattan Project itself, the U.S. Army’s effort under which the bombs were developed, as number 64. The Manhattan Project was the most complex and costly national-level research and development project to its time, and its legacy is enormous: America’s postwar military and political power, the cold war and the nuclear arms race, the thousands of nuclear weapons still held in the arsenals of various countries, the possibility of their proliferation to other states, the threat of nuclear terrorism, and public apprehension with radiation and nuclear energy all originated with the Project. These legacies will remain with us for decades to come.

The development of nuclear weapons is the subject of literally thousands of books and articles, many of them carefully researched and well-written. Why, then, do I believe that the world needs one more volume on a topic that has been so exhaustively explored?

Source material on the Manhattan Project can be classed into four very broad categories. First, there are many synoptic semi-popular histories. This genre began with William Laurence's *Dawn over Zero* (1946) and Stephane Groueff's 1967 *Manhattan Project: The Untold Story of the Making of the Atomic Bomb*. The current outstanding example of this type of work is Richard Rhodes' *The Making of the Atomic Bomb* (1986); references to a number of others appear in the "Resource Letters" by myself cited in the Further Reading list at the end of this section. Second are works prepared as official government and military histories, primarily for academic scholars. The original source along this line was Henry DeWolf Smyth's *Atomic Energy for Military Purposes*, which was written under War Department auspices and released just after the bombings of Hiroshima and Nagasaki. More extensive later exemplars are Hewlett and Anderson's *A History of the United States Atomic Energy Commission*, and Vincent Jones' *United States Army in World War II: Special Studies—Manhattan: The Army and the Atomic Bomb*. Third are the numerous biographies on the leading personalities of the Project, particularly some of the scientists involved. Well over a dozen biographies have been published on Robert Oppenheimer alone. Finally, there are specialized technical publications which require readers to be armed with some upper-undergraduate or graduate-level physics and allied sciences to appreciate fully.

Synoptic volumes are accessible to a broad audience, but tend to be limited in the extent of their technical coverage. Interesting as they are, one can read the same stories only so many times; eventually a curious reader must yearn for deeper knowledge: Why can only uranium or plutonium be used to make a fission weapon? How does one compute a critical mass? How was plutonium, which does not occur naturally, created? Official histories are superbly well-documented, but also tend to be non-technical; they are not meant to serve as student texts or popularly-accessible treatments. Biographies are not usually written to address technical matters, but here a different issue can creep in. While many biographies are responsible treatments of the life and work of the individual concerned, others devolve into questionable psychological or sociological analyses of events and motivations now decades in the past, where, not inconveniently, the principals have no opportunity to respond. Some of the synoptic-level treatments fall prey to this affliction as well.

The bottom line is that after many years of teaching a college-level general-education course on the Manhattan Project, I came to the conclusion that a need exists for a broadly-comprehensible overview of the Project prepared by a physicist familiar with both its science and history. My goal has been to try to find a middle ground by preparing a volume that can serve as a text for a college-level science course at a basic-algebra level, while also being accessible to non-students and non-specialists who wish to learn about the Project. To this end, most chapters in this volume comprise a mixture of descriptive and technical material. For technically-oriented readers, exercises are included at the ends of some chapters. For readers who prefer to skip over mathematical treatments of technical details, the text clearly indicates where descriptive passages resume.

Another motivation for taking on this project is that, over time, access to sensitive information regarding historically important events inevitably becomes more open. At this writing, almost 70 years have elapsed since the Smyth report, 50 have passed since the publication of Hewlett and Anderson's *New World*, and over 25 since Rhodes' *Making of the Atomic Bomb*. In the meantime, a considerable number of technical and non-technical publications on the Project have appeared, and many more original documents are readily available than was the case when those authors were preparing their works. From both a personal professional perspective and an access-to-information viewpoint, the time seemed right to prepare this volume.

Writing about decades-old events is a double-edged sword. Because we know how the story played out, hindsight can be perfect. We know which theories and experiments worked, and which did not. The flip side of this is that it becomes far too easy to overlook false starts and blind alleys, and set out the story in a linear this-then-that sequence that gives it all a sense of predetermined inevitability. But this would not give a due sense of the challenges faced by the people involved with the Project, so many aspects of which were so chancy that the entire effort could just as well have played *no* role in ending the war. After the discovery of nuclear fission, it took some of the leading research personalities of the time well over a year to appreciate how the subtleties of nuclear reactions might be exploited to make a weapon or a reactor. Even after theoretical arguments and experimental data began to become clear, technological barriers to practical realization of nuclear energy looked so overwhelming as to make the idea of a nuclear weapon seem more appropriate to the realm of science-fiction than to real-world engineering. Physicist and Nobel Laureate Niels Bohr was of the opinion that "it can never be done unless you turn the United States into one huge factory." To some extent, that is exactly what was done. Again, my goal has been to seek a middle ground which gives readers some sense of the details and evolution of events, but without being overwhelming.

The scale of the Manhattan Project was so great that no single-volume history of it can ever hope to be fully comprehensive. After the Project came under Army auspices in mid-1942, it split into a number of parallel components which subsequently proceeded to the end of the war. This parallelism obviates a strict chronological telling of the story; each main component deserves its own chapter. Thousands of other publications on this topic exist precisely because many of those components are worthy of detailed analyses in their own right. Thus, the present volume should be thought of as a gateway to an intricate, compelling story, after which an interested reader can explore any number of fascinating sub-plots in more depth.

It is my sincere hope that you will enjoy, learn from, and seriously reflect upon the science and history that unfold on the following pages. I hope also that they whet your appetite for more. Sources of information on the Project are so extensive that a single individual can hope to look at but a few percent of it all; I have devoted well over a decade of my professional career to studying the Manhattan Project, and know that I still have much to learn. The future will need more

scientists and historians to serve as Manhattan Project scholars. To students reading these words, I invite you to consider making such work a part of your own career.

A Note on Sources

As much as possible, I have drawn the information in this book from primary documentary sources (see below), from works whose authors enjoyed access to classified information (Smyth, Hewlett and Anderson, Jones, and Hoddeson, et al.), from memoirs and scholarly biographies of individuals who were present at the events related, and from technical papers published in peer-reviewed scientific journals. A list of references appears at the end of each chapter under the heading Further Reading; a detailed list of citations can be found at www.manhattanphysics.com.

One will occasionally find that even very credible sources report the details of events slightly differently: dates may vary somewhat, numerical quantities and funding amounts differ, lists of individuals involved may be more or less consistent, and so forth. Written records of meetings were often deliberately left incomplete. The Manhattan Project's commander, General Leslie Groves, frequently preferred to issue only verbal orders, and some information still remains classified. As a result, full understanding of some aspects of the Project is simply not possible. To fill in the gaps, it is necessary to extrapolate from what is known to have happened, and to work from the potentially fallible recollections of individuals involved. In such cases, I have tried to work with the most authoritative sources available to me, but I do not doubt that some errors and inconsistencies have crept in. For these I apologize to my readers in advance.

The primary source of Manhattan Project documentary material is four sets of documents available on microfilm from the National Archives and Records Administration (NARA) of the United States. These comprise a total of 42 rolls of film, and readers who are motivated to explore them need to be aware that information on a given topic can be spread over multiple rolls within each of the four sets, and that documents on a given topic within a given roll by no means always appear in chronological order. Some documents that are still classified are deleted from the films. The four sets and their NARA catalog numbers are as follows:

A1218: Manhattan District History (14 rolls). This massive multi-volume document was prepared as an official history of the Project after the war by Gavin Hadden, an aide to General Groves. Known to historians and researchers as the MDH, these documents are a fundamental source of information on the Project.¹

¹ As this book was going to press, the Department of Energy began posting the MDH online at https://www.osti.gov/opennet/manhattan_district.jsp. In particular, previously redacted material on the K-25 plant (Sect. 5.4) is now being made available.

M1108: Harrison-Bundy Files Relating to the Development of the Atomic Bomb, 1942–1946 (Records of the Office of the Chief of Engineers; Record Group 77; 9 rolls).

M1109: Correspondence (“Top Secret”) of the Manhattan Engineer District, 1942–1946 (Records of the Office of the Chief of Engineers; Record Group 77; 5 rolls).

M1392: Bush-Conant File Relating to the Development of the Atomic Bomb, 1940–1945 (Records of the Office of Scientific Research and Development, Record Group 227; 14 rolls).

An index for each set can be viewed by searching its catalog number on the NARA ordering website (select “Microfilm” from the tabs at the top of the page): <https://eservices.archives.gov/orderonline/start.swe?SWECmd=Start&SWEHo=eservices.archives.gov>.

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In addition to the individuals listed above, the fingerprints of a lifetime’s worth of family members, teachers, classmates, professors, mentors, colleagues, students, collaborators, and friends are all over these pages; a work like this is never accomplished alone. I thank them all. Over the course of several years, Alma College has generously awarded me a number of Faculty Small Grants which have gone toward developing this work, as well as a sabbatical leave during which this book was completed.

Most of all I thank Laurie, who bore with it.

Further Reading

Books, Journal Articles, and Reports

- S. Groueff, Manhattan Project: *The Untold Story of the Making of the Atomic Bomb*. (Little, Brown and Company, New York, 1967). Reissued by Authors Guild Backprint.com (2000)
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- V.C. Jones, *United States Army in World War II: Special Studies—Manhattan: The Army and the Atomic Bomb* (Center of Military History, United States Army, Washington, 1985)
- W.L. Laurence, *Dawn over Zero: The Story of the Atomic Bomb*, Knopf, (New York 1946)
- B.C. Reed, *Resource Letter MP-1: The Manhattan Project and related nuclear research*. Am. J. Phys. **73**(9), 805–811 (2005)
- B.C. Reed, *Resource Letter MP-2: The Manhattan Project and related nuclear research*. Am. J. Phys. **79**(2), 151–163 (2011)
- R. Rhodes, *The Making of the Atomic Bomb*, (Simon and Schuster, New York, 1986)
- H.D. Smyth, *Atomic Energy for Military Purposes: The Official Report on the Development of the Atomic Bomb Under the Auspices of the United States Government, 1940–1945*. (Princeton University Press, Princeton 1945). Available electronically from a number of sources, for example, <<http://www.atomicarchive.com/Docs/SmythReport/index.shtml>>.

Websites and Web-based Documents

Newseum story on top 100 news stories of twentieth century:
 <<http://www.newseum.org/century/>>



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