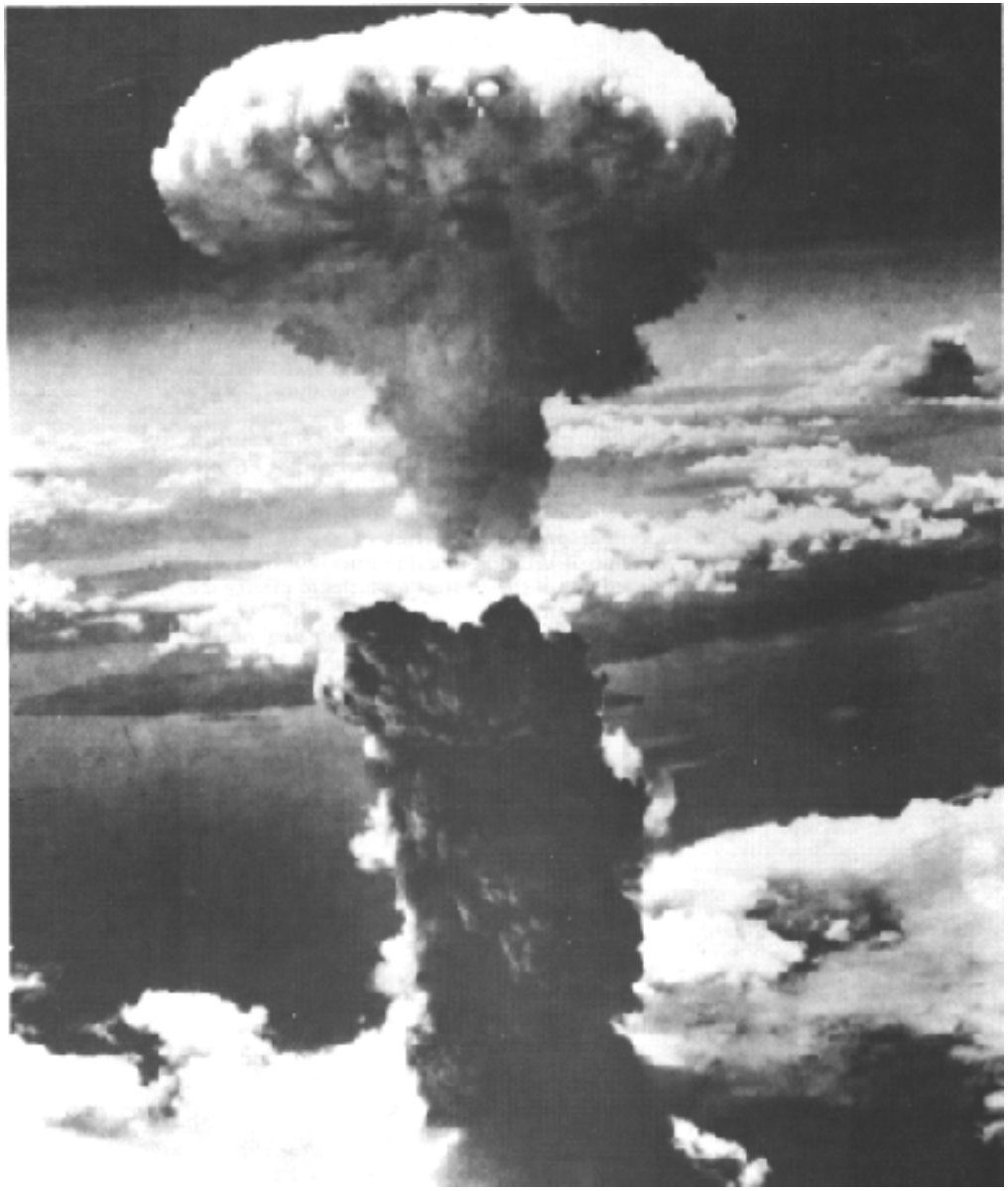
Living with nuclear weapons: 60 years going on 100 (if we are wise, vigorous, and lucky)

Richard L. Garwin
www.fas.org/RLG/

Hiroshima, October 1945

Tibbets' copy



Nagasaki mushroom cloud (20 kilotons)

Little Boy and Fat Man – Hiroshima and Nagasaki bombs
~13 and 20 kilotons

Atomic Energy for Military Purposes (The Smyth Report)

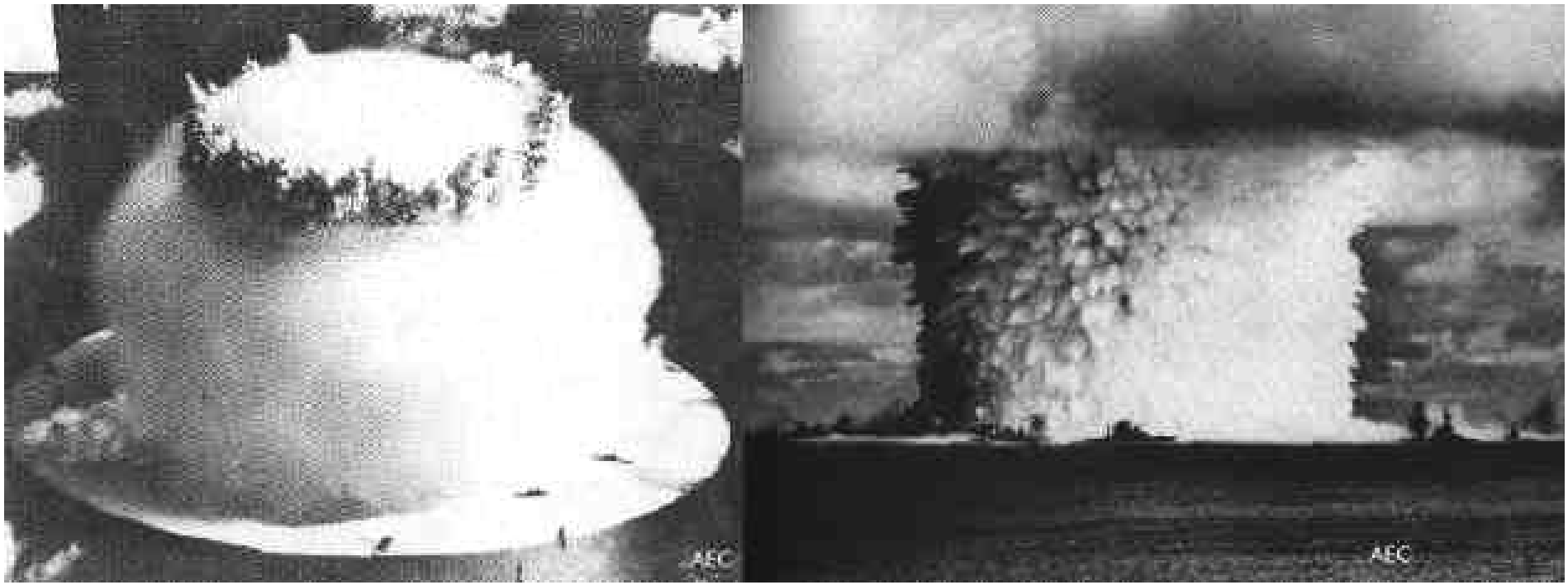
The Official Report on the Development of the Atomic Bomb Under the Auspices of the United States Government (1 July 1945)

By Henry De Wolf Smyth (Now at http://www.atomicarchive.com/Docs/SmythReport/)

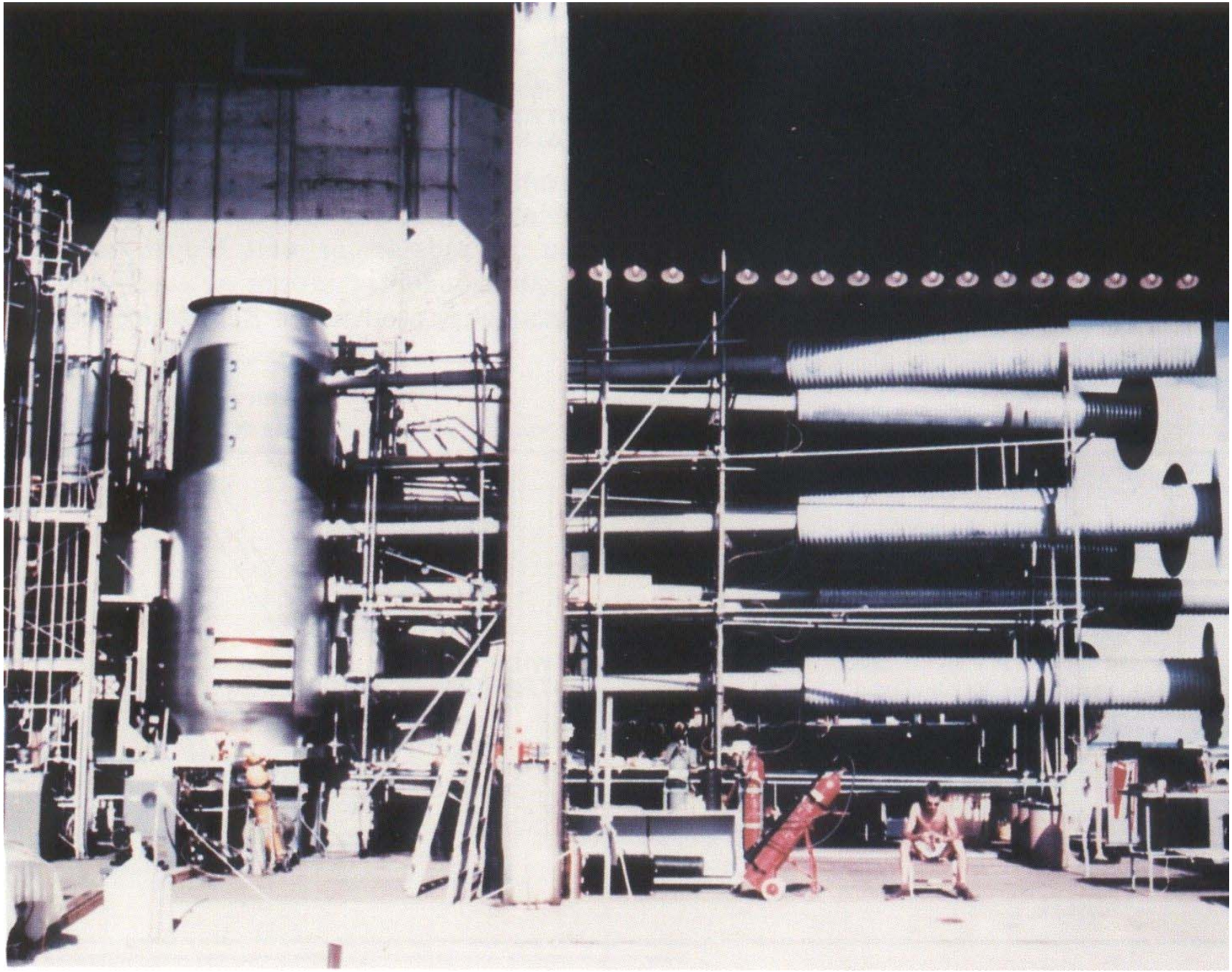
(August 1945)

Contents	

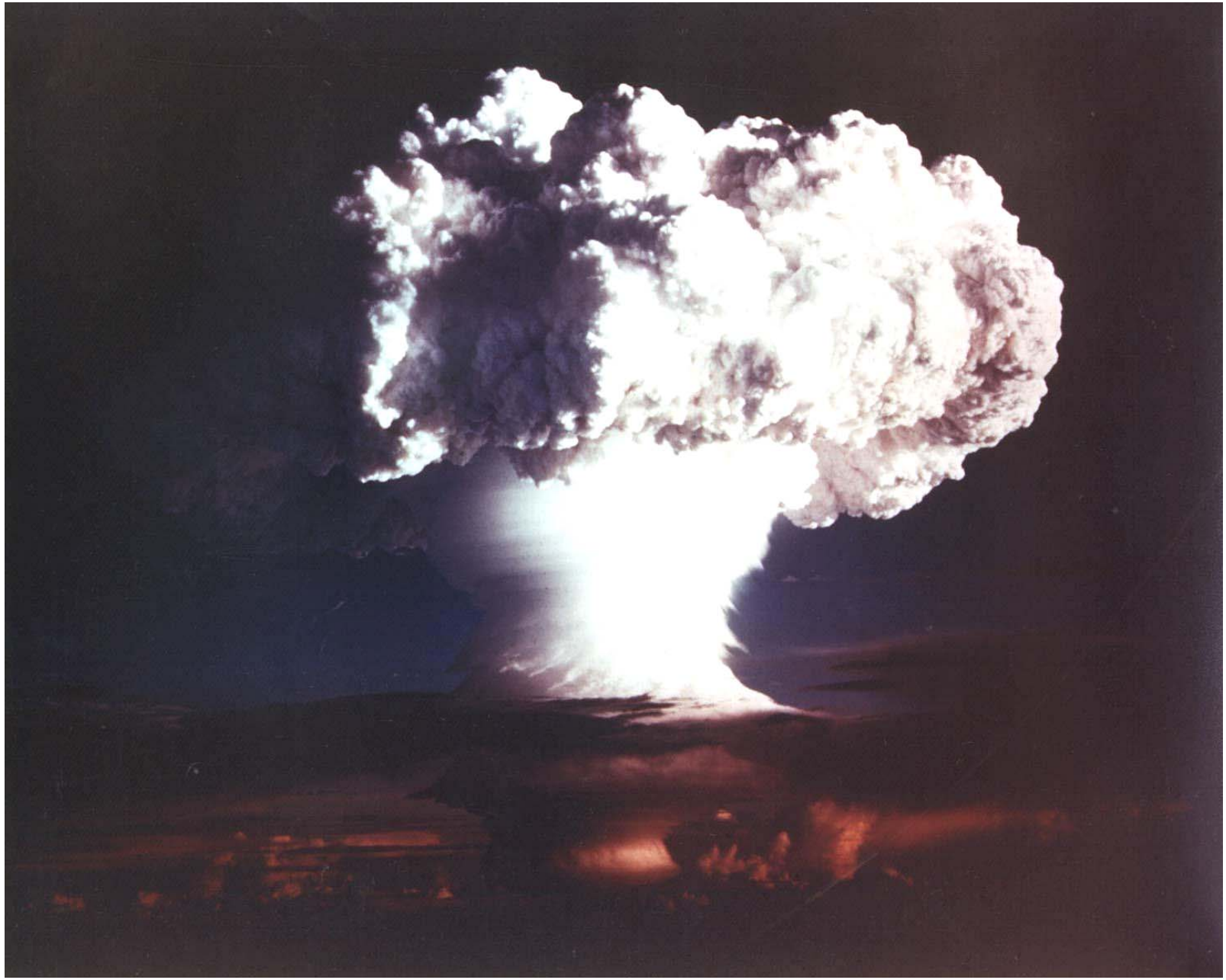
Contents



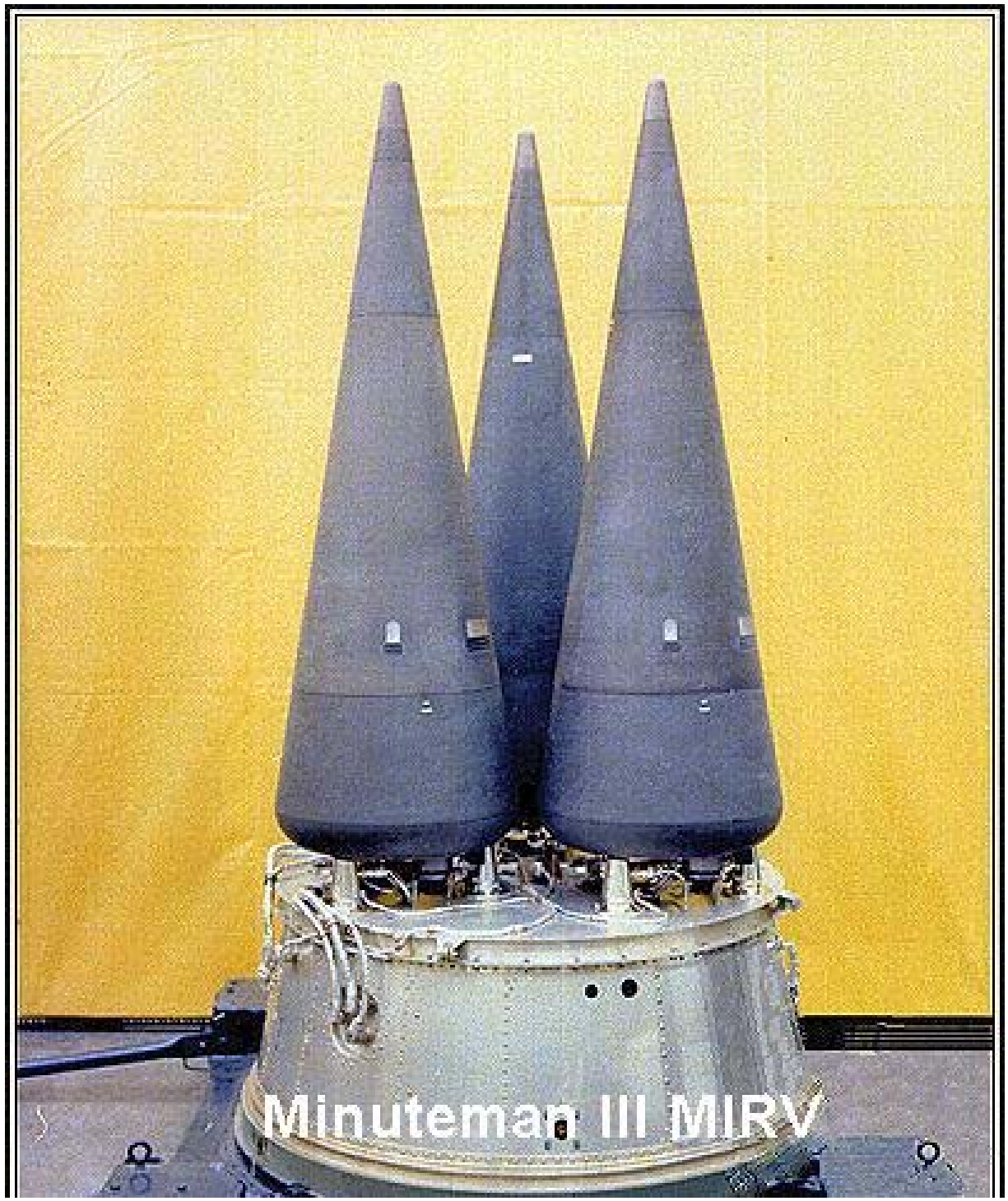
Bikini Baker, 1946 21 kilotons.
Note the ships in the stem of the mushroom cloud



Ivy Mike in preparation



Ivy Mike mushroom cloud, 11 megatons


Minuteman III MIRV

The Effects of Nuclear Weapons

Compiled and edited by
Samuel Glasstone *and* Philip J. Dolan

Third Edition

Prepared and published by the
UNITED STATES DEPARTMENT OF DEFENSE
and the
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

1977

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402

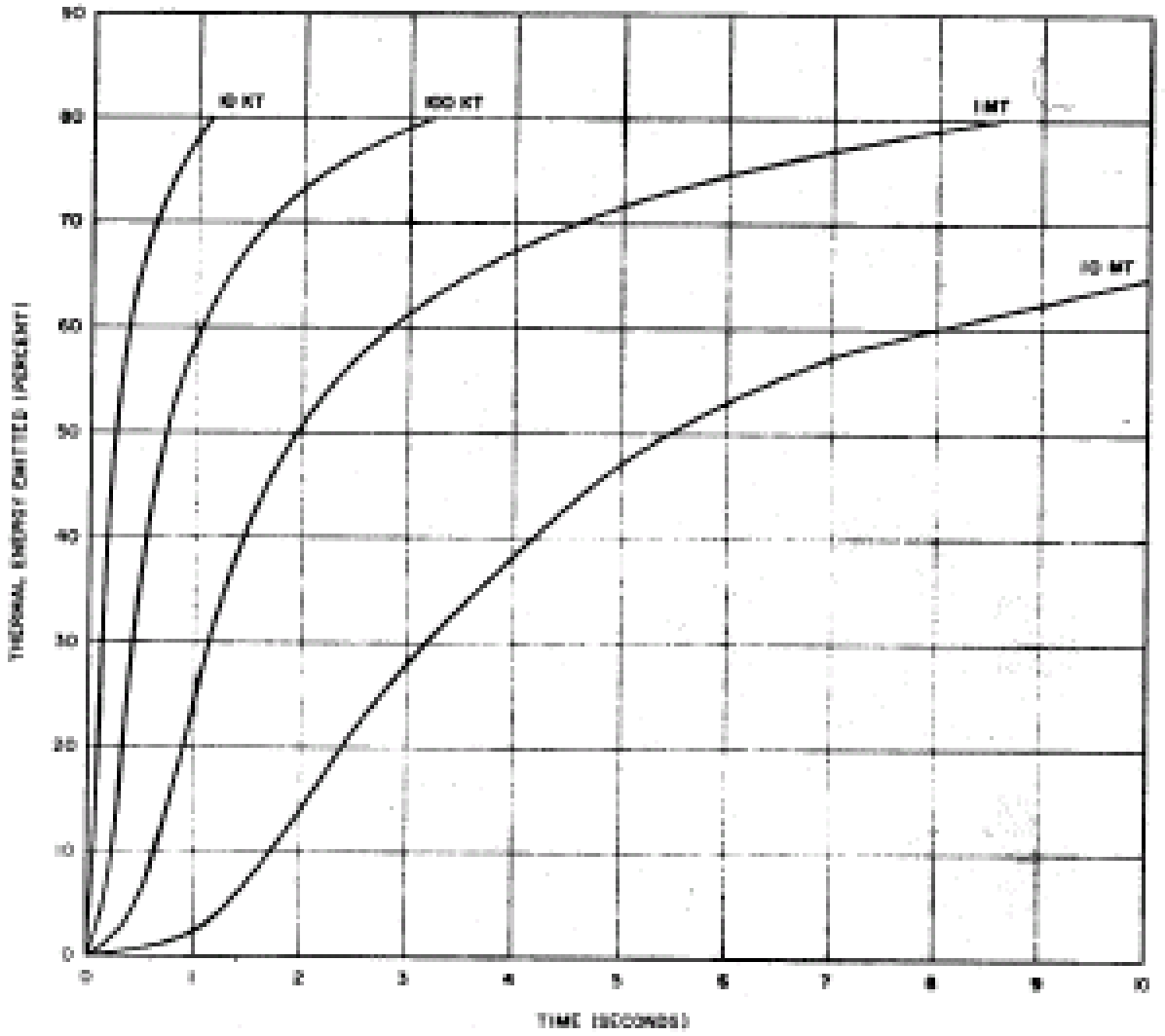
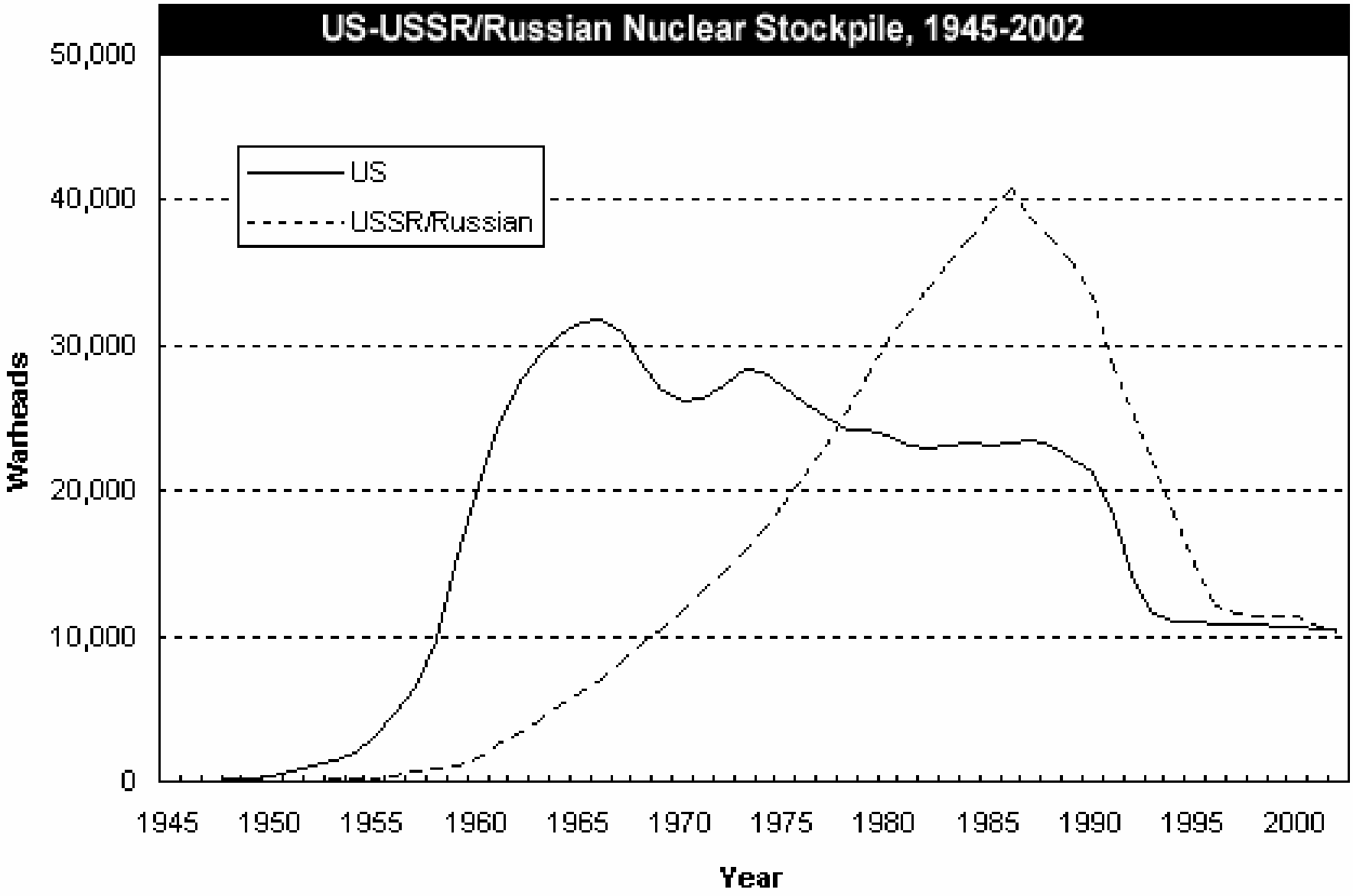


Figure 7.87. Percentage of thermal energy emitted as a function of time for air bursts of various yields.

Now on the web at http://www.princeton.edu/~globsec/publications/effects/effects.shtml


US-USSR/Russian Nuclear Stockpile, 1945-2002
US
USSR/Russian
Warheads
50,000
40,000
30,000
20,000
10,000
0
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
Year

NRDC graph

Nonproliferation Treaty (1970 entry into force)

Article I

Each nuclear-weapon State Party to the Treaty undertakes not to transfer to any recipient whatsoever nuclear weapons or other nuclear explosive devices or control over such weapons or explosive devices directly, or indirectly; and not in any way to assist, encourage, or induce any non-nuclear weapon State to manufacture or otherwise acquire nuclear weapons or other nuclear explosive devices, or control over such weapons or explosive devices.

Article II

Each non-nuclear-weapon State Party to the Treaty undertakes not to receive the transfer from any transferor whatsoever of nuclear weapons or other nuclear explosive devices or of control over such weapons or explosive devices directly, or indirectly; not to manufacture or otherwise acquire nuclear weapons

Article IV

1. Nothing in this Treaty shall be interpreted as affecting the inalienable right of all the Parties to the Treaty to develop research, production and use of nuclear energy for peaceful purposes without discrimination and in conformity with articles I and II of this Treaty.

2. All the Parties to the Treaty undertake to facilitate, and have the right to participate in, the fullest possible exchange of equipment, materials and scientific and technological information for the peaceful uses of nuclear energy. Parties to the Treaty in a position to do so shall also cooperate in contributing alone or together with other States or international organizations to the further development of the applications of nuclear energy for peaceful purposes, especially in the territories of non-nuclear-weapon States Party to the Treaty, with due consideration for the needs of the developing areas of the world.

Article VI

Each of the Parties to the Treaty undertakes to pursue negotiations in good faith on effective measures relating to cessation of the nuclear arms race at an early date and to nuclear disarmament, and on a Treaty on general and complete disarmament under strict and effective international control.

NUCLEAR AND BIOLOGICAL MEGATERRORISM

August 21, 2002

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The loss of 3000 Americans to Al Qaeda terrorism September 11, 2001 brought to many the sudden recognition that America was no longer leading a charmed life. Since then, a great deal of hand wringing and discussion has ensued, but the problem is a serious one and won't go away. Not that it was unrecognized and unpublicized. For instance, in 1999 the Commission chaired by former U.S. senators Gary Hart and Warren Rudman reported:

"There will...be a greater probability of (catastrophic terrorism) in the next millennium...Future terrorists will probably be even more hierarchically organized, and yet better networked than they are today. This diffuse nature will make them more anonymous, yet their ability to coordinate mass effects on a global basis will increase...Terrorism will appeal to many weak states as an attractive option to blunt the influence of major powers...(but) there will be a greater incidence of ad hoc cells and individuals, often moved by religious zeal, seemingly irrational cultist beliefs, or seething resentment...The growing resentment against Western culture and values...is breeding a backlash...Therefore, the United States should assume that it will be a target of terrorist attacks against its homeland using weapons of mass destruction. The United States will be vulnerable to such strikes."

--U.S. Commission on National Security/21st Century, *New World Coming: American Security in the 21st Century*, September 1999, p. 48

The concept of megaterrorism was well known; the warning was there; only the date, place, and nature of the deed were in question to those who had looked at the prospects.

How have we survived 60 years of potential annihilation?

- Nuclear monopoly. Defense? Deterrence by assured destruction.

- Enormous stocks of nuclear weapons in part irrational, but rationalized by needs of assured destruction in face of potential air defense, missile defense and destruction before launch

- Joint U.S. and USSR interest in survival and nonproliferation.

- Barriers to proliferation- political, intellectual, material.
  - Highly enriched uranium (gaseous diffusion, centrifuge, "electromagnetic separation"...) 25 kg "Significant Quantity"-- SQ
  - Plutonium from production reactors or power reactors.

How have we survived (2)

- Common interest in survival—NATO, "Atoms for Peace," limits on nuclear testing, Nonproliferation Treaty and IAEA, US-Soviet pacts such as 1972 ABM Treaty and Limited Offensive Agreement. SALT, START.

- Undeterrable states? Which? Why?

- Bar access to weapon-usable material—HEU and Pu. Problem of "civil plutonium" produced about 250 kg/yr by typical power reactor. 250/"8" = 30 bombs/yr each

- Terrorists, nihilists—the unsolved problem. According to General George C. Marshall, solving a problem depends on the shape of the table.

The key is to have all the participants on one side and the problem on the other.

- Problem in enormous stocks and flows of weapon-usable material—HEU and Pu
  - In Russia and U.S., but also in many other states and facilities

- Some tools and progress
  - Nunn-Lugar program—consolidate and secure.
  - Megatons-to-Megawatts 20-year purchase of 500 tons of Russian HEU (20,000 nuclear weapon equivalents), but at least 700 tons more exist.

- But problem is not the first 99%-- not the problem of securing gold.

Terrorist nuclear explosion

- Knowledge barrier eroded or vanished
- Political barrier assumed absent
- Only remaining barrier is acquisition and transport of material

- Stolen nuclear weapon, improvised nuclear device—IND.

Urgent remedies

- Nunn-Lugar program—spend money with the people who will do the work in Russia and other countries—consolidate and secure weapons and weapon-usable materials
  - Spend money for national security—not votes. This is truly a matter of life and death.

- Accelerated blend-down of HEU for future world reactor fuel. Instead of 95% U-235 to 4.4% LEU, 95% to 19.9%-- not immediately weapon usable. Five times the rate, less cost, needs load subsidy to be repaid on ultimate blend-down.

- Nuclear explosion simulator—free for world leaders; hoi polloi pay for thrills

- Universal accounting and security for HEU, Pu, reprocessing of reactor fuel, and enrichment capability.

Urgent remedies (2)

- Iran's nuclear power program. Safeguard Iran's commitment not to acquire nuclear weapons or weapon-usable material.

- North Korea certainly has several weapons-worth of Pu and probably at least two more compact Nagasaki-type nuclear weapons. Need direct negotiations.

- Muscular extension of NPT with universal enforcement of a new provision that states not later use for nuclear weapons facilities or materials acquired as non-nuclear- weapon-states under the NPT.

- Serious barriers to smuggling of NW, uranium, plutonium

Remedies

- Expansion of nuclear power from world's present 400+ reactors (15% of world's electricity) to 3000 or 9000 must feature nonproliferation and protection against accidents and terrorism.

  Role for government in learning cost of extraction of uranium from seawater—a store of 3 billion tons.

  Competitive, commercial mined geologic repositories for reactor waste, under IAEA supervision and international protection.

In summary:

Not "nothing to fear but fear itself," but for our country of 300 million to lose 300,000 must not be the end of our history. We must plan and invest to prevent and then to live with this loss.

Still, finite probability does not add to a certainty:

$$\text{e.g., } P + 0.9P + (0.9)^2P + (0.9)^3 \ldots$$

sums to 10P—10 years of exposure to current unknown hazard P. (This simple formula is valid only if the resulting probability is small.)