The H-bomb secret

To know how is to ask why

Howard Morland

What you are about to learn is a secret — a secret that the United States and four other nations, the makers of hydrogen weapons, have gone to extraordinary lengths to protect.

The secret is in the coupling mechanism that enables an ordinary fission bomb — the kind that destroyed Hiroshima — to trigger the far deadlier energy of hydrogen fusion.

The physical pressure and heat generated by x- and gamma radiation, moving outward from the trigger at the speed of light, bounces against the weapon's inner wall and is reflected with enormous force into the sides of a carrot-shaped "pencil" which contains the fusion fuel.

That, within the limits of a single sentence, is the essence of a concept that initially eluded the physicists of the United States, the Soviet Union, Britain, France, and China; that they discovered independently and kept tenaciously to themselves, and that may not yet have occurred to the weapon makers of a dozen other nations bent on building the hydrogen bomb.

I discovered it simply by reading and asking questions, without the benefit of security clearance or access to classified materials. There may be some missing pieces here and there — some parts of the puzzle that eluded my search — but the general accuracy of my descriptions and diagrams has been confirmed by people in a position to know.

Why am I telling you?

It's not because I want to help you build an H-bomb. Have no fear; that would be far beyond your capability — unless you have the resources of at least a medium-sized government.

Nor is it because I want India, or Israel, or Pakistan, or South Africa to get the H-bomb sooner than they otherwise would, even though it is conceivable that the information will be helpful to them.

It isn't so much because the details themselves are helpful to an understanding of the grave public policy questions presented by hydrogen weaponry — though they may well be essential.

'A complete one-megaton bomb ...would fit under your bed'

I am telling the secret to make a basic point as forcefully as I can: Secrecy itself, especially the power of a few designated "experts" to declare some topics off limits, contributes to a political climate in which the nuclear establishment can conduct business as usual, protecting and perpetuating the production of these horror weapons.

The pernicious effects of hydrogen bomb secrecy are well illustrated by an incident that occurred in Washington five months ago.

On October 24, 1978, Representative Ronald V. Dellums, a member of the House Armed Services Committee, sent a letter asking the Department of Energy to explain publicly why it expects a shortage of plutonium in its nuclear weapons production program.

Would the neutron bomb, which was then going into production, require more plutonium than the standard tactical nuclear weapons it is designed to replace?

Had the shortage been induced by the plutonium requirements of a new generation of multiple-warhead ballistic missiles — the Navy's Trident (successor to Poseidon), and the Air Force's M-X (successor to Minuteman III)?

What were the weapons specifications that had led the Department of Energy to contemplate a massive industrial retooling: the rebuilding of its old plutonium production plant at Hanford, Washington, and the restarting of a standby reactor at Savannah River, South Carolina?

"Each of these options will involve both financial costs and environmental costs," the letter stated. "The American people need to know the reasons for the anticipated plutonium shortage in order to have informed opinions on the cost-benefit aspects of the plutonium shortage issue."

As chairman of the Subcommittee on Fiscal and Government Affairs, and as a Congressman whose California district includes one of the nation's two nuclear weapons laboratories, Dellums had more than a casual interest in such questions.

Three weeks later he received the Energy Department's reply:

"...It is not possible to respond to most of the questions in an unclassified manner. The enclosure to your referenced letter contains 'secret/restricted data' and should be so classified." The enclosure was the list of questions. *It* is now a secret.

Had Dellums invoked the security privileges available to Representatives and Senators with a "need to know," he could readily have obtained the answers. But he did not choose to do so. The response he received demonstrates the lengths to which the keepers of the secrets are prepared to go in dealing with the public: They do not simply withhold the answers; *they can also confiscate the questions.*

Such tactics have served since the dawn of the atomic age to shield nuclear weapons policies from public scrutiny and debate, giving an advantage to those who formulate the policies and have a stake in their perpetuation. And yet the advantage is one gained mostly by default. It results as much from the self-imposed restraint of those who are not members of the classification elite as from the weapon makers' own complicated security system. The importance of looking behind "secret/restricted" curtains, the relative ease of doing so, and the value to be gained from the exercise are lessons we have still to learn.

The self-serving purposes of official secrecy — not the least of which is its paralyzing effect on the spirit of public inquiry — can best be understood by examining the most momentous official secret of them all: the mechanism of a hydrogen bomb.

Of all the world's nuclear weapons secrets, none has eluded publication more successfully than the secret of the H-bomb. In the twenty-five years since its first successful field test in the South Pacific, no description of how it works has ever been made public.

The diagrams that accompany this article are a close approximation of that process. They show the progression of events that occur during the detonation of a hydrogen weapon. The energy of an exploding fission bomb, the circular object near the top of each drawing, is transferred by means of radiation pressure to the hydrogen part of the weapon. Radiation pressure — a term never mentioned in the open literature — is

Somebody talked

"Does anyone know the secret of the H-bomb?"

Howard Morland didn't really expect an answer when he threw the question out half-seriously one night a year ago in a dormitory at the University of Alabama at Tuscaloosa.

About thirty students had gathered to see his traveling slide show on atomic power and the arms race; in the discussion that followed he was explaining that his next project would be to find out more about nuclear weapons.

"Sure, I know," said a young man in the back of the room. "The secret is in the radiation reflectors."

The student went on to explain that he knew some of the people who worked at the big Union Carbide plant in Oak Ridge, Tennessee, where most of the components for hydrogen weapons are built, and that they had told him the reflection of x- and gamma rays was the key to how the weapons work.

The explanation made little impression on Morland at the time, and he didn't even bother to get the student's name. But later on it helped him crack what the weaponmakers consider to be one of their best-kept secrets.

Such chance remarks were part of the mosaic of information from which Morland, a thirty-six-year-old peace activist, constructed the report on these pages — a report confirmed by people who are knowledgeable about the hydrogen weapon program but are not at liberty to discuss it openly. He undertook the project on assignment from *The Progressive* to demonstrate that official secrecy in this area serves no useful public purpose.

A 1965 graduate of Emory University in Atlanta, Morland has had only a smattering of science education: two courses in physics, two in chemistry, and one in quantum mechanics. As a journalist, it was only this winter that he published his first article ("Tritium: the New Genie," in the February issue of *The Progressive*). What knowledge he has of military affairs comes largely from the two years he spent piloting Air Force cargo planes between California and Vietnam.

But Morland put his training and experience to use in an intensive six-month self-education project in which he read virtually every scrap of information available on the subject, visited every production plant to which he could gain access, and interviewed scores of scientists and engineers in and out of the weapons program.

Every technical fact was double-checked; none was printed unless it could be authenticated by at least two knowledgeable sources. His diagrams and descriptions received widespread review in the scientific community prior to publication. Copies also were submitted to the Department of Energy for verification as to technical accuracy. The Department declined to do this.

Morland's research was supported by donations to *The Progressive*'s arms race investigation fund. He also received research assistance from a colleague, Louise Franklin Ramirez.

the essence of what remains of the H-bomb secret.

This description and the details that follow are the result of six months' investigation of the nuclear weapon production complex in the United States. It is a mosaic of bits and pieces taken from employe recruitment brochures, environmental impact statements, books, articles, personal interviews, and my own private speculation. A number of reliable sources have confirmed that the information fragments are correctly assembled.

The simple facts are deducible from careful journalistic inquiry and from well-known physical principles. If weapons proliferation is to be controlled, the availability of this information must be recognized by policy makers, who presently prefer to believe the information is unique to the weapons states.

A discussion of nuclear weapons secrets might well begin with Albert Einstein's memorable comment: "There is no secret, and there is no defense." He offered as a corollary, "There is no possibility of control except through the aroused understanding and insistence of the peoples of the world."

Nuclear energy, Einstein concluded, "cannot be fitted into outmoded concepts of narrow nationalisms." But America had emerged from World War II as the sole possessor of nuclear weapons — and those who had capitalized on Einstein's mathematical genius had no use then for his political equations. Less than a year after the Hiroshima bombing, Congress passed the Atomic Energy Act, extending wartime information control into the indefinite future and creating the illusion that it was possible for one nation to keep nuclear secrets from another.

By that time, it was too late to keep the A-bomb secret from the world. The Army had already told where the factories were, what they did, who designed them, and who ran them. The disclosures came in a report by Princeton physicist H.D. Smyth, written before the weapon was ever tested, to protect the Army's bureaucratic flank in case the $2 billion Manhattan Project turned out to be a dud. It was published immediately after the war. Foreign scientists wishing to build fission bombs could learn from the Smyth Report about the materials required, the nature and the scale of operations needed to obtain the materials, the enrichment and production techniques that worked best, and the names of people to contact for further information. Atomic spies could read the Smyth Report like a manual telling them where to go and what to look for.

'...Workers...look like astronauts on a training exercise'

Smyth's exhaustive account, later regretted by the security-conscious Atomic Energy Commission, was the first of many flaps over secrecy.

On March 15, 1950, *Scientific American* went to press with an article by Cornell physicist Hans Bethe about thermonuclear fusion, the process that lights the sun and other stars. The AEC, sensitive about anything having to do with the H-bomb, ordered the presses stopped. Three thousand copies of the magazine were destroyed, and the presses were restarted with several sentences removed. At that time, the H-bomb had not yet been invented. The concept was still under study, and a feeble — and ultimately abortive — public debate was starting over the issue.

Publisher Gerard Piel charged the Commission with "suppressing information which the American people need in order to form intelligent judgments," but Bethe declined to complain about it. "These people can cause me all kinds of trouble," he said. To supplement his job teaching physics at Cornell, he had been doing consulting work for the AEC.

When the first prototype hydrogen weapon exploded in the South Pacific on November 1, 1952, the public had no idea how it worked, except that some of its energy came from hydrogen fusion. No one outside the U.S. and Soviet governments knew that five of its ten megatons of explosive energy had come from fission, not fusion, and that 5,000 square miles of ocean surface had, therefore, been contaminated with lethal levels of radioactive fission products. The evidence sank to the ocean floor.

Sixteen months later, when the second bomb went off, that part of the H-bomb secret was revealed. A hundred miles downwind, the entire population of Rongelap Island and the crew of a Japanese fishing boat called *The Lucky Dragon* were dusted with powdered coral containing enough radioactive fission products to blister their skin and make their hair fall out. One fisherman died. Japanese scientists analyzed the deadly ash on the fishing boat deck and concluded that the bomb was as much a uranium bomb as a hydrogen bomb. Half its energy had come from the fission of uranium-238, as had most of its deadly fallout.

The bomb designers had felt no obligation to warn the world that their new invention was anything more than a bomb with a super-powerful blast — that, in fact, its radioactive fallout could lethally poison a far greater area than its blast could destroy. Indeed, the hydrogen weapon had been publicized as a "clean bomb." Edward Teller and J. Robert Oppenheimer, weapon designers whom the press routinely called "brilliant," kept the faith with the nuclear weapon priesthood and kept their mouths shut. They would not divulge weapon design information merely to discuss such moral issues as fallout.

The dangers of fallout from nuclear testing soon became a national preoccupation, but when American and Soviet nuclear testing went underground in 1963, radioactive fallout ceased to be a public issue. Nuclear weapon production entered a golden age of public apathy. Multiple warhead missiles were designed and deployed without serious complaint, and arsenals grew enormously. By removing their products from sight, the weapon makers were able to continue to refine their weapons without protest.

Few people remember that nuclear weapon secrets were the underlying issue in the witchhunts and blacklists of the Joseph McCarthy era. In ways sometimes subtle, sometimes direct, the continuing challenges to civil liberties in America today are traceable, in part, to widespread belief in the need for *some* secrecy. People assume that even if nothing else is secret, surely hydrogen bomb designs must be protected from unauthorized eyes.

The puncturing of that notion is the purpose of this report.

The hydrogen bomb secret is now more than twenty-five years old. Five national governments have built industries to produce H-bombs, and there is little reason to think that any other nation that wanted to build them would have trouble finding out how to do it. Pieces of the secret have been declassified and published in what weapon makers call "the open literature," which is accessible to you and me. But enough of the secret has been kept from the general public to perpetuate the mystery and discourage inquiry. Weapon makers can still hide behind their solemn duty to secrecy when hard questions are asked about what they are doing.

Congressman Dellums's questions are a case in point.

They concern a predicted shortage of plutonium in the weapons program — a shortage that calls for hundreds of millions of dollars to be spent upgrading production reactors and fuel reprocessing facilities in Washington state and South Carolina. Why?

Is the nuclear warhead and bomb production rate scheduled to increase dramatically? Do the latest weapon designs call for more plutonium than older designs? (Enriched uranium, which is used together with plutonium, remains abundant.) Is the plutonium shortage really a tritium shortage in disguise, caused by the neutron bomb's high requirement for tritium? (Tritium and plutonium production operations compete for space in the same South Carolina reactors.) Is the Energy Department's proposal really a porkbarrel project for South Carolina, where nuclear weapons production is the state's largest industry? Or for Washington state, home of the powerful and military-minded Senator Henry M. (Scoop) Jackson?

The Department's assertion of secrecy protected it from having to provide public answers. The answers, as we shall see, would have raised profound questions of public policy.

Before considering technical details, it should be noted that for most people there will always be an H-bomb secret, just as there will always be, for most people, a radio secret and an automobile secret. Not everyone is interested in how things work. But millions of people in our highly technological society are amateur experts on gadgets as varied as the electric doorbell and the nuclear power reactor.

Anyone familiar with elementary principles of college physics — such as those underlying the technical problems of nuclear waste disposal and the biological effects of radiation — can also understand the technology of nuclear weapons, if provided with the necessary information. The growing scientific and technical expertise which has strengthened worldwide opposition to nuclear power is equally vital to a revival of effective public concern over nuclear weapons.

Knowledge of the basic principles of hydrogen weapon design is helpful in understanding the structure of the nuclear weapon production system. It provides insight into the purposes of continued nuclear testing, the nature of new developments in nuclear weaponry such as the neutron bomb, and the devastating effects of nuclear war.

Paying attention to the details is also a way of reminding ourselves that the weapons are real. The most difficult intellectual hurdle most people encounter in understanding nuclear weapons is to see them as physical devices rather than as abstract expressions of good or evil. The human mind

'Understanding the product is necessary to understanding the system'

'No defense'

The following is from a letter from Albert Einstein, signed January 22, 1947, appealing for support for the Emergency Committee of Atomic Scientists:

"Through the release of atomic energy, our generation has brought into the world the most revolutionary force since prehistoric man's discovery of fire. This basic power of the universe cannot be fitted into the outmoded concept of narrow nationalisms. For there is no secret and there is no defense; there is no possibility of control except through the aroused understanding and insistence of the peoples of the world.

"We scientists recognize our inescapable responsibility to carry to our fellow citizens an understanding of the simple facts of atomic energy and its implications for society. In this lies our only security and our only hope — we believe that an informed citizenry will act for life and not death."

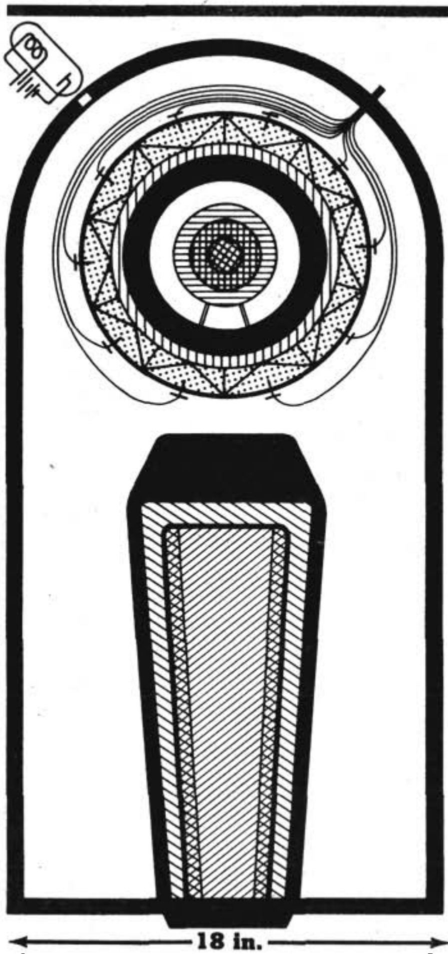


Figure 1. Schematic diagram of a 300-kiloton thermonuclear weapon before detonation. Concentric spheres near the top make up the primary system, or fission trigger. The rest is the secondary system.

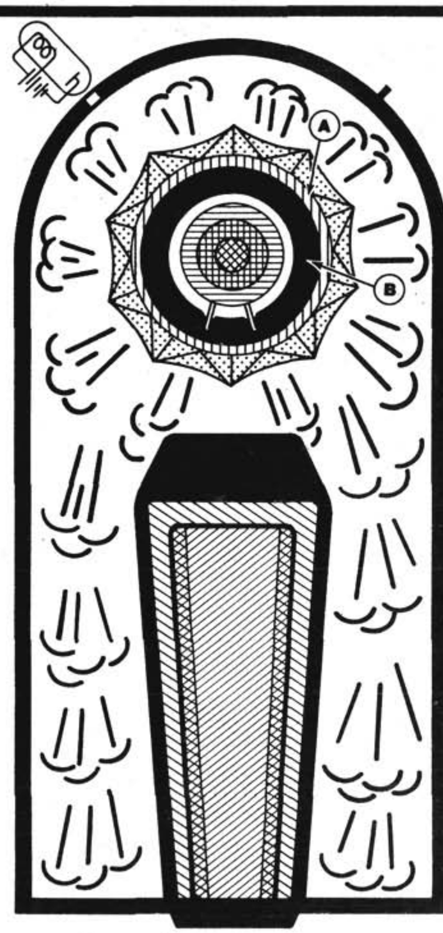


Figure 2. High explosives in the primary system begin to burn, driving beryllium neutron reflector (A) and heavy Uranium-238 tamper (B) inward toward the fissile core. The space between the tamper and the core allows the tamper to develop momentum before hitting the core.

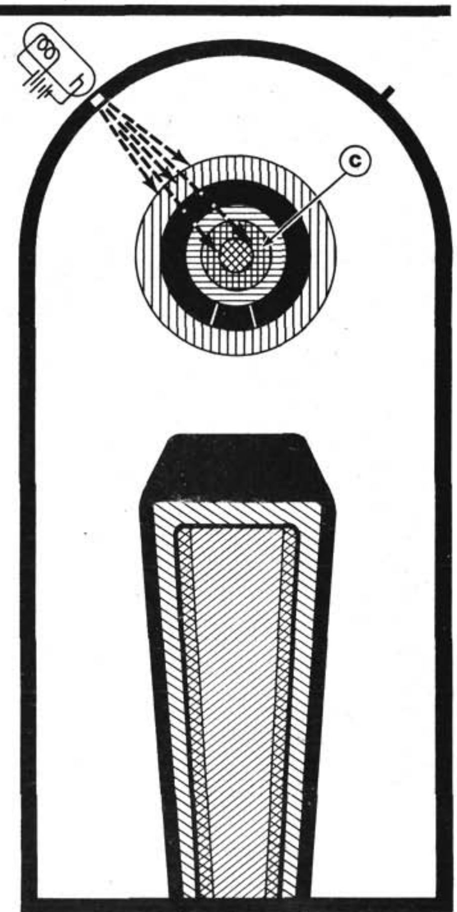
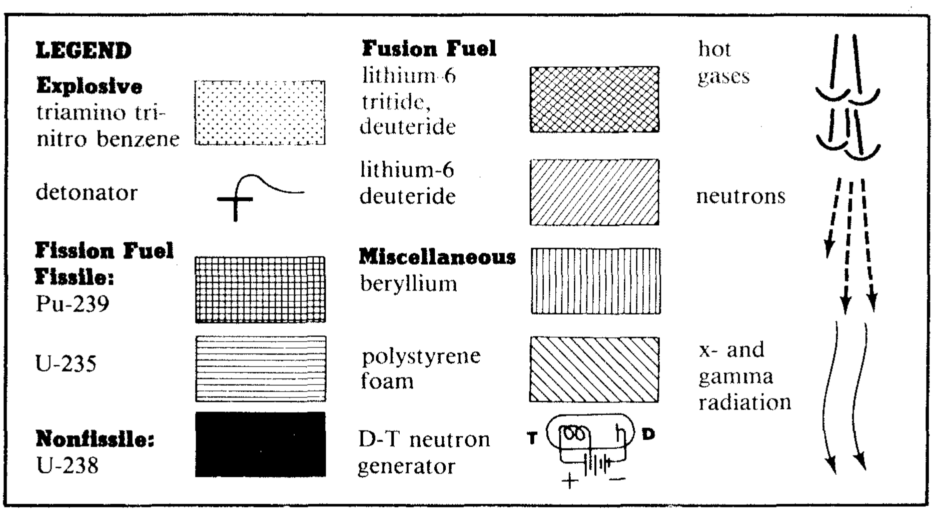


Figure 3. The fissile core is squeezed to more than double its normal density, going supercritical. Neutrons fired from a high-voltage vacuum tube start a chain reaction in the fissile material. The chain reaction concentrates first in the fast-fissioning Plutonium-239 (C).



boggles at gadgets the size of surfboards that can knock down every building for miles around. But these are devices made by ordinary people in ordinary towns. The weapons are harder to believe than to understand.

There are three stages to the detonation of a hydrogen weapon: fission, fusion, and more fission. Although one event must follow the other for the weapon to work, they happen so rapidly that a human observer would experience only a single event — an explosion of unearthly magnitude. Within the bomb, however, fission — the splitting of uranium and plutonium nuclei — comes first.

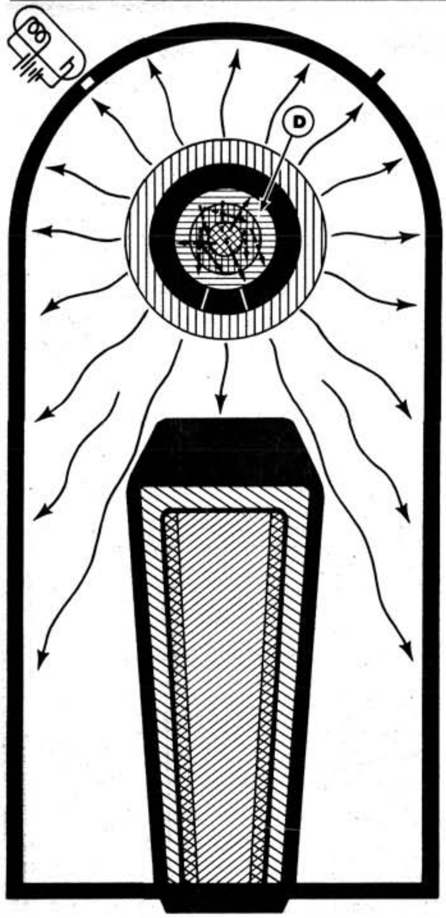


Figure 4. The chain reaction spreads to slow-fissioning Uranium-235 (D). Fusion fuel at the center of the core showers the core with neutrons, "boosting" fission efficiency. As the core expands to its original size, reaction stops, completing the first stage of the detonation. Energy release so far: forty kilotons. Prompt gamma rays and x-rays travel outward at the speed of light.

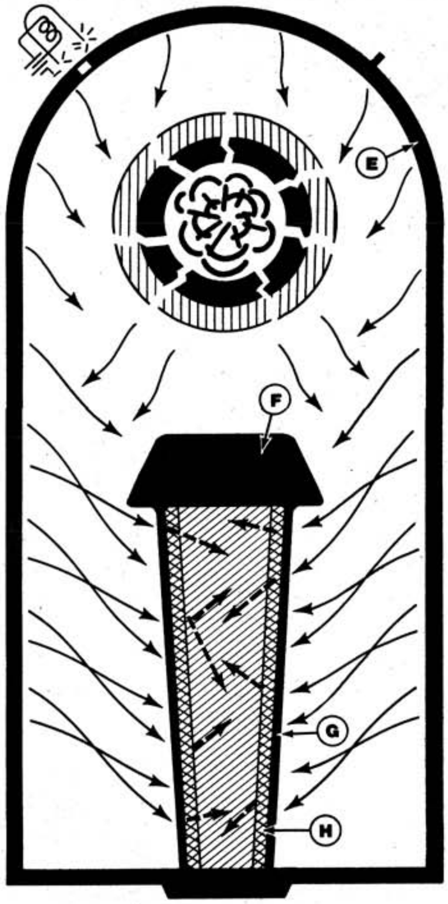


Figure 5. The weapon casing (E) reflects radiation pressure around the thick radiation shield (F) and onto the sides of the fusion tamper (G), collapsing the tamper inward. Heat and pressure of the impact start fusion in the tritiated portion (H) of the fusion fuel "pencil." The precise location of the tritium within the pencil depends on where the designer intends the fusion reaction to begin. Neutrons from this fusion activity breed tritium throughout the pencil.

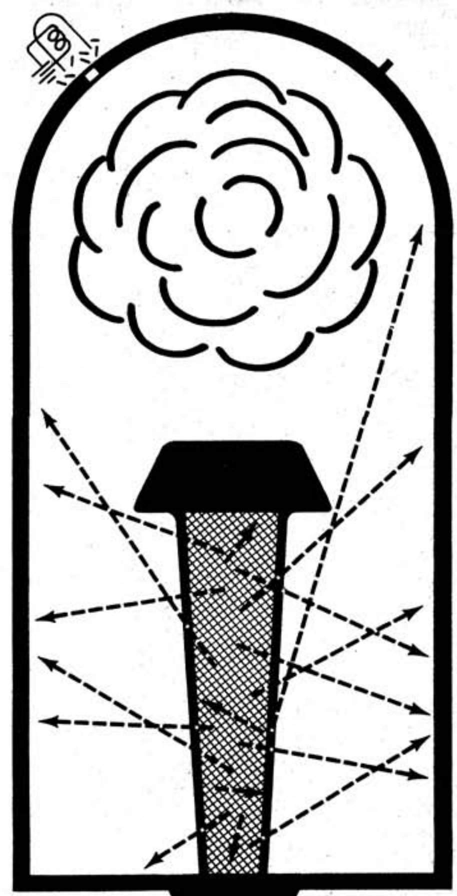


Figure 6. Fusion fuel reacts virtually simultaneously throughout the pencil, releasing 130 kilotons of energy to complete the second stage. High-energy neutrons from fusion are absorbed by Uranium-238, which has so far served as a fission tamper, radiation shield, radiation reflector, and fusion tamper. Now it serves as fission fuel.

The mechanism for the first fission stage is a miniaturized version of the Nagasaki bomb. It has roughly the same explosive power as the World War II weapon, but it measures less than twelve inches in diameter. This fission "trigger" vaguely resembles a soccer ball, with the same pattern of twenty hexagons and twelve pentagons forming a sphere. Detonator wires are attached to each pentagonal or hexagonal face. When its full explosive energy is realized, this oversized cantaloupe becomes the source of the radiation pressure which ignites the fusion stage.

Weapon designers call this miniature A-bomb the "primary system." The rest of the nuclear part of the weapon is called the "secondary system." In published accounts, the primary system is often referred to as the "trigger." By itself, it could level a small city, but in a hydrogen weapon it merely provides the energy necessary to ignite the second stage, which releases energy by fusing hydrogen to form helium. A fission bomb is the only force on Earth powerful enough to provide the compression and heat needed to detonate a fusion bomb.

The secondary system is the mechanism which captures the fission energy of the primary system and puts it to work in the fusion process. The design of the secondary system is the H-bomb secret.

The challenge in designing a hydrogen weapon is to make the secondary system finish its task of fusion before the expanding fireball of the primary systems engulfs and destroys it. About a millionth of a second is all the time available for doing the job. Pure radiant energy, in this case the energy of x- and gamma radiation, is the only thing fast enough and manageable enough to be harnessed for that purpose.

X- and gamma radiation travel at the speed of light, more than a hundred

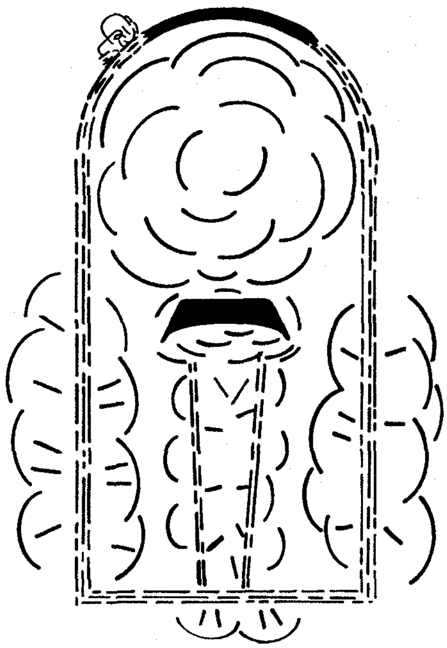


Figure 7. Uranium-238 fissions, adding another 130 kilotons of energy to the explosion and generating enough fission products to kill everyone within 150 square miles with fallout. This is the end of the third stage. A fireball begins to develop....

times faster than the expanding debris from an exploding A-bomb. If the primary system and the fusion fuel are located some distance apart, say twelve inches, the radiant energy of the primary system will have time to race ahead of the expanding nuclear debris and reach the fusion fuel first.

The cylindrical shape of most hydrogen weapons plays an important role in determining how this radiant energy will be distributed inside the casing. The primary system is located inside one end of a three- or four-foot-long hollow cylinder casing, and the fusion fuel is located inside the other end. The cylinder is normally eighteen inches in diameter, large enough to contain the soccer-ball sized primary system inside one end and leave a few inches to spare around the sides. A complete one-megaton bomb (having the explosive power of one million tons of TNT) would fit under your bed.

The cylindrical casing is more than just the package that holds the nuclear parts together. It is also a radiation reflector designed to capture radiation from the primary system and focus it on the fusion fuel. It is the largest and heaviest component of any hydrogen weapon, and one of the most important.

The reflector-casing is usually made of uranium-238, a heavy, shiny, metal called "depleted uranium." In the last stage of the weapon's detonation sequence, the depleted uranium explodes with the power of many Hiroshima bombs, producing most of the weapon's deadly fallout. However, the first function of uranium-238 in the secondary system is to serve not as an energy source but as a finely engineered energy reflector.

All the major components of the secondary system are made by Union Carbide, the chemical company, in the foothills of the Great Smoky Mountains of Tennessee. The 500-acre bomb factory where the work is done still bears the code name, Y-12, assigned it by the World War II designers of the atomic bomb. The Oak Ridge buildings where scientists enriched uranium for the Hiroshima weapon now house the world's most sophisticated H-bomb production line. When an American hydrogen weapon explodes, most of the explosive power comes from components made at Y-12. Half the equipment in the country's far-flung nuclear weapon production complex is concentrated there.

Few residents of Oak Ridge and nearby Knoxville are aware that such products come from their peaceful valley. A chemistry professor who occasionally lectures at Y-12 told me he didn't know what went on at the plant; he sometimes wondered, but he didn't think it was the production of bombs. A woman whose husband is an Oak Ridge radiologist expressed outright disbelief that Oak Ridge was still in the weapons business. And yet the weapons role of the plant is not secret; it just isn't mentioned in public.

Much of the H-bomb secret is in a form that can't be written down. It exists in the hand-and-eye coordination of the skilled workers who operate machine tools at the Y-12 plant, or in the quality of the machines themselves. One of the high-precision tasks is the squeezing of large blocks of uranium-238 metal into thin sheets and the machining of those sheets to make radiation reflectors.

The raw material for this process arrives by truck or rail from Fernald, Ohio, where gaseous uranium-238 hexafluoride has been chemically reduced to pure metal blocks. At Y-12, the blocks are fed like cordwood to a giant rolling press which flattens them into sheets five-and-a-half feet wide and one inch thick. The sheets are then fed through smaller presses which reduce their thickness to as little as five-thousandths of an inch. When a sheet has reached the proper thinness, the weapon part is cut from it the way cookies are cut from a sheet of dough. The rough-cut parts are then machined to final dimensions.

A graduate student at the University of Alabama, who knows people who work in Oak Ridge, told me the reflector-casing is composed of thousands of finely machined reflecting surfaces. Jack Case, Union Carbide's manager for the plant, says some parts made at Y-12 are so thin and delicate that special techniques for "fixturing," or attaching rough-cut parts to a lathe, had to be developed. Normal fixturing techniques would mar the parts or allow them to sag and be distorted by their own weight. Y-12 pioneered in the use of chemical adhesives and suction in fixturing. The reflector-casing may be composed of many thin pieces of uranium-238 sandwiched together into an exotic metal plywood.

Radiation reflectors for the H-bomb arsenal enter the Oak Ridge Y-12 plant as great blocks of uranium-238 metal and emerge as finely engineered canisters the size of household garbage cans. When war comes, the canisters will reflect and focus the radiation that sets off hydrogen fusion.

Fusion is called a thermonuclear process because heat makes it happen. Temperatures of several hundred million degrees Celsius are needed to start the process. However, the *rate* of fusion is determined by the *density* of the hydrogen fuel. In a weapon, the rate of fusion must be extremely rapid. For a useful amount of fusion fuel to fuse in the allotted millionth of a second, it must first be greatly compressed. Without tremendous compression, the fusion fuel would not fuse fast enough to add much energy to the explosion before it was scattered uselessly by the expanding fireball of the primary system. In a hydrogen weapon, radiation pressure is what compresses the fusion fuel sufficiently to make the device destroy a city's suburbs as well as its center.

Radiation pressure, the principle by which the secondary system works, is normally too weak to be detected by human senses. You cannot feel the physical push of a flashlight beam, for instance. There are no examples in the human environment of radiation intense enough to move solid objects with more than barely measurable force. But the primary system of a hydrogen weapon is a nuclear power plant that generates twenty million kilowatt-hours' worth of thermal energy in a few billionths of a second, all inside a lump of metal compressed to the size of a baseball. Its radiant energy can exert enormous force on an object located only inches away.

In fact, the radiation pressure inside the weapon casing can theoretically be as high as a million million times greater than atmospheric pressure — about eight billion tons per square inch. Physicists would describe the radiation as a "gas of photons," a dense cloud of highly energetic pulses of electromagnetic energy, pushing violently against anything it touches. For the briefest moment, the inside of the weapon becomes an x-ray oven, similar in principle to a microwave oven, but with unearthly temperatures and pressures.

As any science student can tell you, heat is the enemy of compression. The greatest densities are achieved when a substance is compressed cold: Heat tends to make it expand. Because fusion fuel in a weapon must therefore be compressed *before* it reaches ignition temperature, the fusion fuel of the secondary system is not exposed directly to radiation from the primary system. It is protected on the end nearest the primary system by a large radiation shield.

Around the sides of the fusion fuel is a tapered cylinder called the fusion tamper. Radiation from the exploding fission trigger is reflected around the large shield, or pusher, in the center of the weapon and onto the sides of the fusion tamper. The fusion tamper then collapses inward with enormous force, driven by the pressure of x- and gamma radiation from the primary system. The fusion tamper compresses the fusion fuel and simultaneously heats its perimeter to ignition temperatures.

An important part of nuclear weapon design is the judicious use of empty spaces inside the weapon. The empty space between a raised hammer and a nail allows the hammer to strike the nail with much greater force than could be mustered if the hammer were placed against the nailhead before pressure was applied. In a hydrogen weapon, the fusion tamper serves as a hammer that strikes the fusion fuel simultaneously from all sides, compressing the fuel; the empty space between the fusion tamper and the fuel is used to produce maximum compression. In addition, the delicate ceramic-like fusion fuel must be firmly cradled and supported from all sides during the weapon's possibly rough ride to the target.

A key ingredient in the design of this aspect of the secondary system is the polystyrene foam that keeps the fusion fuel centered inside the fusion tamper. By holding the fuel and the tamper apart, the foam allows the tamper to develop momentum before it strikes the fusion fuel. Polystyrene foam is thus both a packaging material and an empty space, protecting the hydrogen fuel during weapon delivery and collapsing into nothing during detonation.

'Continued...testing...is a paradox unless you know the secret'

The price of secrecy

Ten years ago the Pentagon appointed a nine-member "Task Force on Secrecy" to investigate the effectiveness of the nation's security system. This was one of its findings:

"With respect to technical information, it is understandable that our society would turn to secrecy in an attempt to optimize the advantage to national security that may be gained from new discoveries or innovations associated with science and engineering.

"However, it must be recognized, first, that certain kinds of technical information are easily discovered independently, or regenerated, once a reasonably sophisticated group decides it is worthwhile to do so.

"In spite of elaborate and very costly measures taken independently by the U.S. and the U.S.S.R. to preserve technical secrecy, neither the United Kingdom nor China was long delayed in developing hydrogen weapons.

"Also, classification of technical information impedes its flow within our own system, and may easily do far more harm than good by stifling critical discussion and review or by engendering frustration. There are many cases in which the declassification of technical information within our system probably had a beneficial effect and its classification has had a deleterious one."

One of the task force members was Dr. Edward Teller, father of the U.S. hydrogen bomb.

The foam is made in Kansas City, Missouri, by the Bendix Corporation, in a factory that manufactures most of the non-nuclear parts for nuclear warheads and bombs.

Only the heavier isotopes of hydrogen serve as fuel in a hydrogen weapon. Hydrogen-2 and hydrogen-3, known respectively as deuterium and tritium, are the fuel which explodes with the force of many trainloads of TNT. Tritium is expensive and highly radioactive. For practical reasons, most of the tritium is stored in the weapon as lithium-6, a less expensive, non-radioactive material which is converted instantly to tritium once the fusion process begins. Conveniently, lithium-6 bonds chemically with deuterium to make a gray powder, called lithium-6 deuteride, that is much easier to manage than either pure deuterium or tritium in gaseous form, although it must be kept dry.

The fusion fuel in a hydrogen weapon, except for a small amount containing tritium, is made at the Oak Ridge Y-12 plant. Metallic lithium-6 is chemically bonded with deuterium, obtained from the Department of Energy's Savannah River plant (operated by DuPont), and compacted into a chalk-like solid, resembling a large aspirin tablet in consistency. The pressed powder is then baked and machined to final dimensions. The result is a ceramic material so unstable chemically in the presence of moisture that it must be assembled in "dry rooms."

Dry-room workers in the Y-12 plant wear air-conditioned waterproof body suits with sealed fish-bowl helmets to keep their body moisture from causing the lithium-6 deuteride to decompose spontaneously. When viewed through the windows of their dry rooms, they look like astronauts on a training exercise.

When the charge of lithium-6 deuteride for a single weapon is assembled, it makes a column one or two feet high and several inches in diameter. It is tapered to fit inside the fusion tamper the way the core of a carrot fits inside the carrot.

When this charge of fusion fuel is struck simultaneously on all sides by the imploding fusion tamper, it is compressed and heated. Fusion begins in the perimeter where some tritium is present. The lithium-6 is converted to tritium throughout the charge, while the exploding perimeter further compresses the center and the bulk of the fusion fuel fuses and explodes.

'People who make the weapons enjoy talking shop'

The third and final stage in the explosion of the weapon is virtually an afterthought. In fact, it is optional, although in most hydrogen weapons it is a highly desired option — it provides roughly half the total energy release of the weapon and most of the fallout. In this third stage, the uranium-238 casing which was used to capture and focus the radiation undergoes fission as a result of bombardment by the high-energy neutrons released by the second-stage fusion process.

The result can be an explosion a thousand times more powerful than the blast that destroyed Hiroshima.

Do we need to possess this technical information? Yes. Without it, there is little hope of understanding the vast industrial complex that turns out three new nuclear weapons a day. The only book about modern nuclear weapon production, *The Great American Bomb Machine,* written eight years ago by Roger Rapoport, illustrates the point. Because of an inadequate understanding of thermonuclear weapon technology, Rapoport completely overlooked the Oak Ridge Y-12 plant, the most important factory in the system. The significance of the role of Union Carbide and the Energy Department's Oak Ridge Operations Office cannot be explained without knowledge of the importance of lithium-6 deuteride and uranium-238 to nuclear weapons manufacture. Understanding the system's product is necessary to understanding the system.

Another example:

Continued nuclear testing underground in Nevada is a paradox unless you know the secret. Underground nuclear explosions are never higher in yield than a few kilotons, despite unofficial acknowledgement that our latest strategic nuclear weapons are in the 100 to 500 kiloton range. The widespread belief that the weapon makers are testing only the primary systems, or triggers, is incorrect.

The primary system can be tested without an actual nuclear detonation. The fissile material, plutonium-239 and uranium-235, can be replaced with electronic sensing devices, and the high-explosive charges detonated. Instrument readings and high-speed photographs tell the designers most of what they need to know about the primary system. Such tests are conducted frequently, above ground, at the nuclear weapons laboratories in Los Alamos, New Mexico, and Livermore, California. The explosion is about as powerful as that of an ordinary mortar shell (but far more dangerous, because it scatters a cloud of uranium-238 and beryllium dust).

The secondary system, on the other hand, cannot be tested without the intense radiation that comes only from an exploding fission weapon. The primary system must actually be detonated with a nuclear yield in order for the secondary system to be tested. The fusion fuel in the secondary system can be replaced with electronic sensing devices. The second and third stages of the explosion need not occur, but the primary system must explode in all its fury if useful information is to be had about the rest of the weapon. Hence the weapon makers' compulsion for underground testing.

As refinements in radiation reflector

design have allowed more of the energy of the primary system to be captured and focused, smaller fission explosions have become adequate as triggering events. One result of fifteen years of underground tests is a reflector that will set off half a kiloton of secondary fusion explosion with as little as half a kiloton of fission energy. Enter the neutron bomb. The neutron bomb radiation reflector has to be made of high-density metal other than uranium-238, so there will be no dirty fission explosion following the fusion. The metal is probably tungsten alloyed with nickel, iron, and, perhaps, rhenium. Underground testing was part of its design procedure.

Unofficial sources say that a neutron weapon with a total energy yield of one kiloton, one-twentieth of the Nagasaki weapon, must contain more radioactive tritium than a full megaton weapon of more conventional design. The reason is that the deliberately weak neutron weapon is unable to generate much of its own tritium; more of it must be provided ready-made. Since the country's only supplier of tritium is also the sole present supplier of plutonium-239, an increase in orders for tritium is one plausible explanation for the plutonium shortage about which Congressman Dellums inquired.

How could I, a journalist with no formal training in nuclear physics, learn things the Government has kept out of public print for a quarter of a century? It was surprisingly easy. People who make these weapons enjoy their work. Like most of us, they enjoy talking shop. They also promote their activities in order to raise funds from Congress and to recruit employes. They learn to talk and write without using classified words, but they can't live in a vacuum.

In fact, any persistent investigator with the time, inclination, and determination to learn the underlying scientific and technological principles, to pierce the jargon and euphemisms of the industry, to examine the voluminous public record, to look and listen carefully, and to put two and two together, can discover the findings and inventions of others.

In the business of nuclear weaponry, as in science and technology itself, no secret, once discovered, can long endure, as Einstein observed. Attempts to limit knowledge may succeed temporarily, but ultimately they are no match for a determined investigator.

The more practical effect of secrecy is to discourage and inhibit public participation in the formulation of public policy — in this case not only nuclear weapons policy but also a broad spectrum of related policies (national security, energy, environmental protection, natural and human resource allocation) with which it is inextricably intertwined.

'The effect [of secrecy] is to stifle debate about...nuclear policy'

Since World War II, the process of secrecy — the readiness to invoke "national security" — has been a pillar of the nuclear establishment. As Representative Dellums's recent experience demonstrates, that establishment, acting on the false assumption that "secrets" can be hidden from the curious and knowledgeable, has successfully insisted that there are answers which cannot be given and even questions which cannot be asked.

The net effect is to stifle debate about the fundamentals of nuclear policy. Concerned citizens dare not ask certain questions, and many begin to feel that these are matters which only a few initiated experts are entitled to discuss. This self-imposed restraint only entrenches further those who are committed to the nuclear arms race.

The secret of how a hydrogen bomb is made protects a more fundamental "secret": the mechanism by which the resources of the most powerful nation on Earth have been marshaled for global catastrophe. Knowing *how* may be the key to asking *why*.

Is it dangerous to tell how a hydrogen bomb is made? No. For one thing, the information falls far short of providing a blueprint for nuclear weapon construction. The general features of nuclear fission bombs became available long ago in the Smyth Report. Subsequent Atomic Energy Commission declassifications and the accumulation of mountains of data and experience with the growth of the worldwide nuclear enterprise have eliminated the secret of fission bomb construction. Credible designs and instructions for these have been prepared by college-level physics students.

The building of a hydrogen bomb, which can be ignited only by a fission weapon, is a different matter. It would take millions of dollars worth of specialized equipment and hundreds of trained technicians to build a hydrogen bomb — a feat beyond the capability of all but the most industrially sophisticated nations.

Whatever insights these descriptions may provide to nations seeking to perfect their thermonuclear capability — Israel and South Africa, for example — they are at best a trifling addition to the information already available. No government intent upon joining the nuclear terror club need long be at a loss to know how to proceed. Nothing you or I could learn would long elude the nuclear physicists and engineers whose participation would be essential to such as enterprise.

The risks of proliferation of hydrogen weapons, such as they are, must be weighed against the public gain that may come from greater awareness of how and why they are already being produced.

Whether it be the details of a multimillion dollar plutonium production expansion program or the principles and procedures by which nature's most explosive force is being packaged in our midst, we have less to fear from knowing than from not knowing. What we do with the knowledge may be the key to our survival. ■