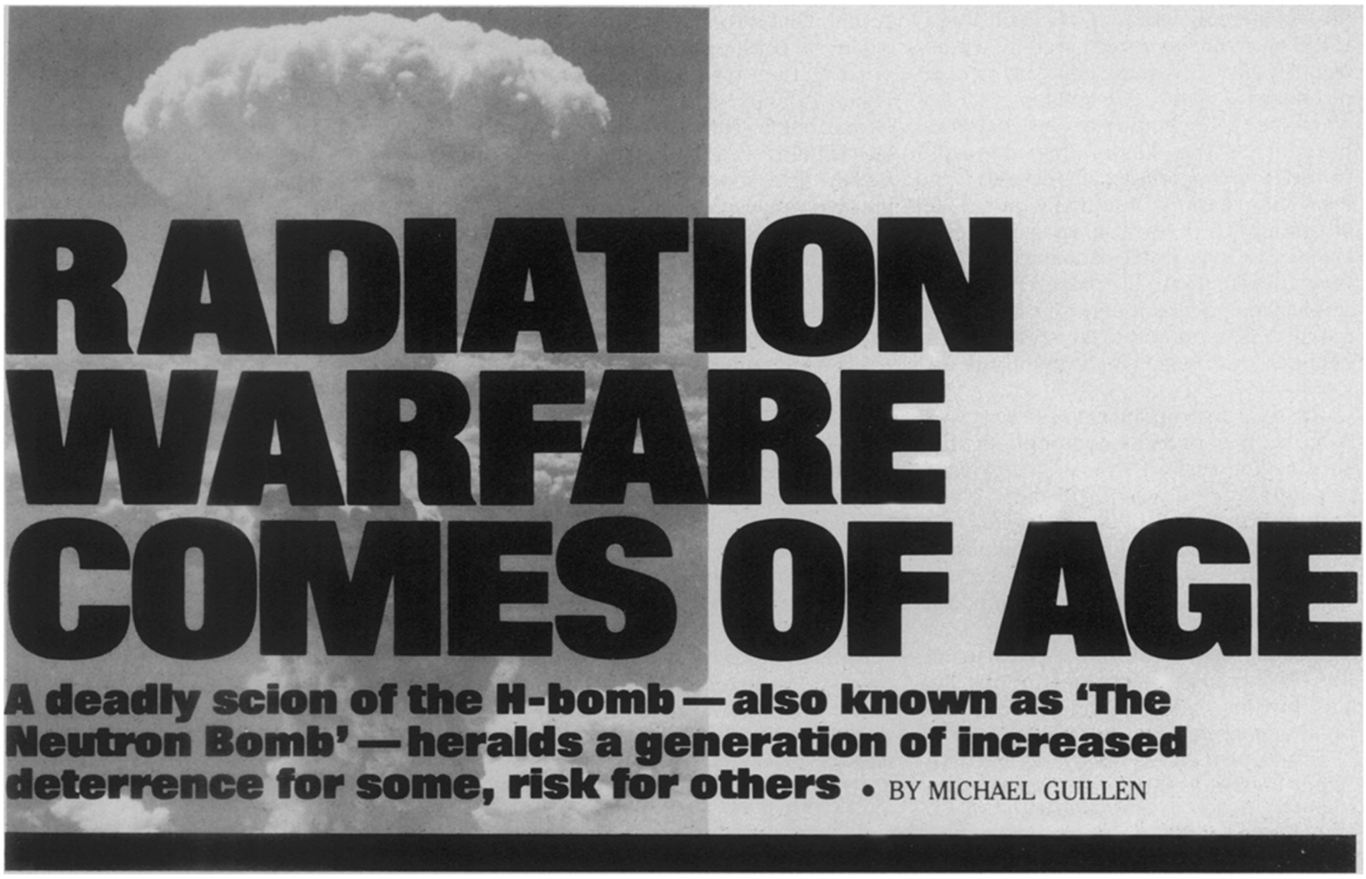


U.S. Air Force

RADIATION WARFARE COMES OF AGE

A deadly scion of the H-bomb—also known as 'The Neutron Bomb'—heralds a generation of increased deterrence for some, risk for others • BY MICHAEL GUILLEN

The Enhanced Radiation Weapon [ERW] *is a nuclear weapon designed to produce significantly more and/or higher energy outputs of neutrons, or X-rays, or gamma rays, or a combination thereof, than a normal weapon of the same total yield...*

From a joint statement issued by the Departments of Defense and Energy

As a result of President Ronald Reagan's decision last month, an unspecified large number—probably thousands—of ERW's are now being assembled by the Department of Energy (DOE), provoking renewed debate as to the weapon's true capabilities, its intended purpose and its political implications.

Although there has been a great deal of public information written and broadcast over the past two decades about the ERW—often referred to simply as the "neutron bomb" — some of the more important technical issues have been either omitted altogether or oversimplified. Therefore, any description of the ERW today must begin with some mention of what the weapon is not.

For instance, the ERW does not kill *only* people, while leaving proximate buildings intact. Nor is the ERW a radically new kind of beast. As we shall see, the ERW is essentially a modified fusion bomb—designed to enhance the radiation component of the explosion at the expense of its thermal and physical blast components. But though the ERW explosion suppresses the thermal and blast damage normally caused by a similar-sized conventional nuclear weapon, as Pentagon spokesman Lt. Col. Mark R. Foutch told Science News: "In the immediate area of the blast, a building would be flattened, just as usual."

Above: A-bomb attack on Nagasaki, Japan, August 9, 1945.

Strictly speaking, the ERW is not a bomb, which is to say it isn't delivered aboard a bomber and then dropped over a target. It is, rather, a warhead, or several warheads; for now, two kinds of them are being assembled for use in the American Lance missiles and eight-inch howitzer cannons. According to available information, each warhead can carry a destructive force roughly in the one-kiloton neighborhood. This is compared to the 20-kiloton yield of the nuclear bomb dropped on Hiroshima toward the end of World War II.

But one musn't be misled: Size here is not the story. The ERW commands our attention precisely because it was conceived *not* as a weapon capable of indiscriminate destruction on a monumental scale but as a scaled-down nuclear weapon modified to be useful in conventional warfare.

The very idea of a tactical nuclear weapon useful for warfare in small and moderate-sized theatres is an object of spirited debate; on the one hand, there are those who see the ERW as an unusually intimidating weapon whose ultimate purpose is to discourage the Soviets from relying on their tanks to intrude aggressively on Allied territory; on the other, there are those who see the ERW as an unprecedented stepping stone between conventional and full-scale nuclear warfare, making it an all-too-tempting military option that would facilitate the eventuality of World War III.

Although the dispute is essentially political, critical elements of it are scientific, centering on how the ERW supposedly works and the nature of its assets and liabilities as a tactical weapon. (The terms "tactical" and "strategic" are familiar ones in military parlance, but their meanings are often unintentionally misrepresented; according to Foutch a *tactical* weapon is used in a localized theatre-level conflict, whereas a *strategic* weapon is used on a more global scale in "striking at an enemy's war-making capabilities." This distinction, of course, becomes vague when speaking of the geographically close-packed countries of Europe. Many of the debate's aspects are fueled by differences of opinion. Other more technical ones are aggravated by uncertainties caused in part by the ERW being a classified project.

One thing, however, is quite certain: The principle of the ERW's operation is based on that of the hydrogen bomb. (Not only is the ERW based on a three-decades-old idea, it is itself a mature concept; one of the earliest public reports about it appeared in the Washington Post on July 19, 1959.) And since the operation (not the principle) of a conventional H-bomb depends on an atomic bomb, it follows that a proper understanding of the ERW begins with a brief review of how an A-bomb works.

The explosive source of energy in an atomic bomb is the nuclear fission of, most commonly, uranium-235. Each time a U-235 atom breaks apart naturally, a neutron is emitted with an attendant release of energy — about two million electron volts (MeV). The bomb's trigger coalesces parcels of the fissionable material (hitherto kept apart), which together form a critical mass — minimally, about 22 kilograms. The critical mass generates a sufficiently large traffic of neutrons so that their collisions with the uranium induce a self-sustaining flux of neutrons — a chain reaction. The rapidity with which all this happens is evidenced in the bomb's explosion.

The total destruction caused by such an A-bomb has several components, basically four. First, there is the damage wrought by the actual physical blast, which for a 20-kiloton bomb extends to a radius of more than one-half kilometer around ground zero, the point directly below the usually airborne explosion (see figure).

Second, some of the energy released in the explosion goes into heating the air, soil, buildings and anything else in the bomb's environs.

Third, immediately following and as a direct consequence of the fission chain reaction, there is released a burst of so-called "prompt radiation," which commonly includes X-rays, gamma rays and neutrons. We shall see that this radius of damage is, generally speaking, greater than the blast radius, although the criteria for assessing radiation-related damage are more subtle, and controversial, than for identifying structural damage due strictly to the blast.

Fourth, among the shards sent flying in all directions by the explosion are radioactive fragments of uranium nuclei; some of these irradiate the surrounding soil. Kicked up into the air and impelled by the bomb-induced winds, this fallout ultimately rains down on persons and structures situated many kilometers away and lingers. Its protracted presence is determined by the lifetimes of the various radioactive nuclei, which can be tens, hundreds, and even thousands of years long.

One speaks of these four categories of damage in connection with an H-bomb, even though its source of energy is fundamentally different than an A-bomb's. The energy in this case derives from the fusion of two nuclei, such as deuterium and tritium (ordinary hydrogen embellished with one and two extra neutrons, respectively). Accompanying each such reaction is a neutron with an energy about an order of magnitude greater than the energy of fission neutrons. Furthermore, kiloton for kiloton, an H-bomb explosion creates numerically more neutrons than does an A-bomb explosion — about ten times more.

Although in principle the H- and A-bombs are based on antithetical mechanisms, in practice they are brought together. That is to say, a real H-bomb is not a pure fusion device as described, but a combination fusion/fission bomb (see Figure 1). Enclosed in a single casing is a fission bomb, which when detonated releases the energy needed to invigorate the fusion nuclei so that they will begin colliding and coalescing with one another. A "booster," possibly in the form of an envelope of additional fissionable material, is incorporated into the design of a conventional H-bomb in order to enhance the explosion's blast effect.

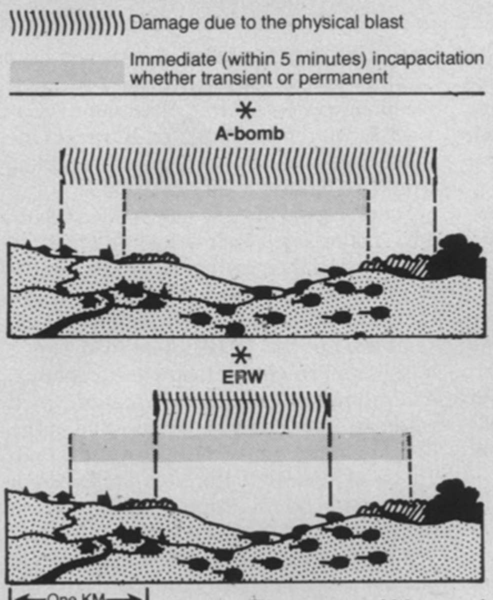
The ERW concept is essentially the result of scientists realizing some time ago that a side-effect of the booster is to significantly slow down the neutrons — more precisely, the prompt radiation — released by the bomb. The slower the neutron, the less energy it delivers and the shorter its range: Thus the conventional H-bomb generates an explosion that preferentially apportions energy into blast effects, at the expense of prompt radiation effects.

An ERW in its most fundamental form, therefore, is an ordinary H-bomb denuded of the booster. The result is a weapon, a greater proportion of whose explosive energy is channeled into prompt radiation; since any bomb has a fixed energy budget, it follows that proportionately less of the ERW's explosive energy is channeled into blast, thermal and fallout effects. For the ERW warheads currently being assembled, the energy budget is divided up something like this (in percentages): 35, 25, 35 and 5 corresponding to blast, thermal, prompt radiation and fallout. Unlike any other kind of bomb — nuclear or conventional — the ERW is designed to harm persons primarily by irradiating them with a fatal or debilitating dose of highly penetrating prompt radiation.

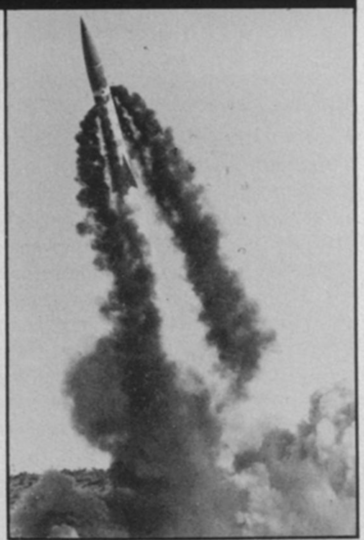
Using these figures, one would expect that compared to the Hiroshima 20-kiloton A-bomb, a one-kiloton ERW would have a comparable prompt radiation effect — in extent and severity — but with one-tenth the area damaged by the attendant blast. "For the same killing power," Foutch told SCIENCE NEWS, "you can use a weapon about only one-tenth the yield of a standard nuclear weapon."

It is this extraordinary efficiency to kill

COMPARING ERW AND A-BOMB EXPLOSIONS



Above: The extent of blast and radiation damage expected from an ERW detonated 500 meters above ground.



The 56-mile-range Lance missles stationed in Europe for the defense of NATO countries could be fitted with ERW's, stockpiled in the U.S., within an hour of a decision by the President to do so.

Artist's drawing depicts a recent-generation Soviet tank, model T-72; formidable as its armor is, it would be readily penetrated by the neutron radiation from an ERW.

people without extensive incidental (or "collateral," in military jargon) damage that makes the ERW highly spoken of in terms of its possible usefulness in Europe. As President Reagan said at his last news conference: "This weapon was particularly designed to offset the great superiority that the Soviet Union has on the Western front against the NATO nations—a tank advantage of better than four to one. . . ." Not only is tank armor largely transparent to the ERW's prompt radiation, the radiation accomplishes its purpose with minimum damage done to Europe.

This usefulness was foreseen in abstraction by S. T. Cohen and W. R. Van Cleave, who in the June 1976 issue of the JOURNAL OF THE ROYAL UNITED SERVICES INSTITUTE FOR DEFENSE STUDIES wrote: ". . . serious levels of urban structural damage can be avoided by raising the burst height of ER weapons to levels where destructive blast pressures cannot reach the surface, but militarily-significant radiation intensities can. In this manner, with but a relatively small decrease in the military radius of effects, destructive blast effects can be largely eliminated."

U.S. ARMY'S NEW RADIATION CASUALTY CRITERIA

IP Immediate Permanent Incapacitation

17,000 to 19,000 rads, with a mean of 18,000 rads.*
Personnel will become incapacitated within five minutes, and remain so until death occurs within one day.

7,000 to 9,000 rads, with a mean of 8,000 rads.
Personnel become incapacitated within five minutes, and are unable to perform tasks that are physically demanding until death occurs in one to two days.

IT Immediate Transient Incapacitation

2,500 to 3,500 rads, with a mean of 3,000 rads.
Personnel will become incapacitated within five minutes of exposure, and will remain so for 30 to 45 minutes, when they will recover, but remain functionally impaired until death, which will occur within four to six days.

LL Latent Lethality

650-rad band (500 to 800 rads).
Personnel will become functionally impaired within two hours of exposure. They may respond to medical treatment, and survive this dose; the majority, however, will remain functionally impaired until they die in several weeks.

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The corresponding radii of damage, R_D, from a 1 kiloton low airburst are:

CRITERION	DOSE (RADS)	R_D (METERS)
Immediate Permanent Incapacitation		
A. physically undemanding	18,000	400
B. physically demanding	8,000	500
Immediate Transient Incapacitation	3,000	640
Latent Lethality	650	760

*The rad is the basic unit of absorbed dose of ionizing radiation. It equals 100 ergs of energy per gram of matter.

When the discussion turns to evaluating specifically how many tank crews could be expected to succumb to an ERW explosion and in how long a time, the debate spoken of earlier becomes particularly vocal. And it happens to be an especially crucial disagreement. Depending on whom you listen to, the ERW is portrayed as more or less than advertised.

The issue focuses on the U.S. Army's radiation casualty criteria (see sidebar). It should be said that these criteria have been defined for several decades, but were revised in various and significant ways by the Army about five years ago. According to the current criteria, a person exposed to 8,000 rads of, say, neutron radiation will suffer "immediate permanent incapacitation." (A rad means that 100 ergs of energy is deposited into every gram of irradiated matter.)

In terms of that hypothetical Soviet tank driver, it means that he will be unable to handle the controls within five minutes of being irradiated. (It is important to keep in mind that the dosage actually required to produce this effect is higher because of some attenuation inevitably caused by a tank's armor.) A person exposed to 3,000 rads will also be physically incapacitated within five minutes, but will recover after about a half-hour, until he dies some five days later. And finally, anyone exposed to 650 rads will become "functionally impaired" within a few hours and eventually die.

A one-kiloton ERW, roughly the size of the present-day Lance and 8-inch warheads, will spew 8,000 rads of prompt radiation out to a radius of somewhere between one-half to one kilometer, depending on the altitude at which the warhead is detonated. Beyond that, the radiation dosages would fall off, down to levels of a few hundred rads at about one-and-a-half kilometers. (Freeman Dyson of the Institute for Advanced Study in Princeton once calculated the ERW's destructive capacity and found that: "one gram of hydrogen [used for fusion in the ERW] could in principle give five times the lethal dose [or about 3,000 rads] of radiation to anybody within one kilometer radius. . . .")

At issue are what the Army's new criteria say about the probable outcome of using the ERW warheads against, say, Soviet tanks in Central Europe. Fred M. Kaplan, formerly at MIT's Center for International Studies, argues that: "When Russian tanks are beginning an offensive, they usually move in two echelons; spaced anywhere from 75 to 100 meters apart." As a consequence of their wide spacing and large numbers — estimated at about 20,000 — "the action would call for a barrage, hundreds and perhaps thousands of ERW's," Kaplan told SCIENCE NEWS. But in that case, he says, the accumulated destruction of so many ERW's will have nullified its purpose as a weapon with pinpoint accuracy and causing minimal collateral destructiveness.

In response, proponents of the ERW tend to emphasize the weapon's singular importance in discouraging the Warsaw Pact nations from invading the NATO alliance. "We hope to deter conflict," Foutch says. If you allow the Soviets to think that the United States' "only nuclear weapons are so large and clumsy and the side effects are so horrible," he told SCIENCE NEWS, "[then] they're likely to feel that you'll never use them." Since the ERW is very portable (weighing about 200 pounds), and "more believable as a useful weapon in a battlefield . . . we think it will prevent war."

Critics like Kaplan argue that the ERW could easily have the opposite effect, provoking the Russians into a full-scale nuclear war by leaving them no other realistic response in the face of an ERW onslaught against their tanks. "I think the assumption that the Soviets would surrender upon our use of the neutron bomb," he told SCIENCE NEWS, "is naive as hell."

Critics also object to the ERW simply because it introduces an unprecedented opportunity to engage more realistically in nuclear warfare. They can be heard to argue that descriptions of the ERW as a "moderate" and "effective" weapon — terms used by President Reagan during his last news conference — seem to suggest that its actual usage is only a matter of time.

Others like Senator Sam Nunn (D-Ga.) have in the past expressed their advocacy of the ERW. In an interview appearing in the July 25, 1977 U.S. NEWS AND WORLD REPORT, Nunn said: "If your adversary perceives that you are willing to use your weapon if they initiate hostilities, . . . the chances of conflict decrease and I believe the nuclear threshold is raised."

The debate whether the ERW would deter us from or tempt us into a full-scale nuclear war aside, Kaplan told SCIENCE NEWS, he is not convinced that the weapon can even do what it advertises. "Except for the tankmen who were fairly close to the actual detonation, many of the irradiated enemy would remain alive for hours" — long enough to keep operating their tanks. Furthermore, he says, "armor-penetrating neutrons would not make a tank so radioactive as to exclude the possibility of other tank crews replacing those adversely exposed. . . ." As a result, he says, "The tanks could drive on."

And so, it seems, could the debate over ERW deployment "drive on" for many years to come. □