TEST BAN DEBATE, ROUND THREE: WARHEAD SAFETY

By FRANK VON HIPPEL

The first excuse was "verification"; the second, "reliability." Now the laboratories say testing must continue to make nuclear warheads "optimally safe."

During 1990, with the end of the Cold War, nuclear warhead safety became the U.S. nuclear weapon design laboratories' leading argument against a comprehensive test ban (CTB). This shift marks the third stage in the test ban debate.

From about 1961 to 1978, ban opponents argued that it was theoretically possible for the Soviet Union to "decouple" low-yield nuclear explosions in huge underground caverns, reducing the tests' seismic signals to a level where they would be difficult to distinguish from background events.[1] Enough uncertainty was created about the verifiability of underground tests that they were not included in the 1963 Partial Test Ban Treaty.

Determined to overcome the verification problem, in 1978 the Carter administration resumed negotiations on a CTB with an apparently cooperative Soviet Union. Opponents then argued that warhead reliability could not be maintained without testing.[2] A number of former weapons designers wrote rebuttals—the most detailed of which was a 1987 report by Lawrence Livermore weapons physicist Ray Kidder that had been requested by the chairmen of the House Armed Services and Foreign Affairs committees and other members of Congress.[3] However, progress toward a ban was held up.

In the spring of 1990, the warhead safety issue surfaced in public as a result of recommendations from the U.S. nuclear weapons laboratories that the SRAM-A short-range attack missile not be loaded onto bombers on runway alert and that urgent safety-related modifications be made in nuclear artillery shells deployed in Europe.[4] In response, the House Armed Services Committee asked Sidney D. Drell of Stanford University, a long-time high-level government adviser on technical and national security, to chair an expert advisory panel which also included John S. Foster, Jr., a former Livermore director, and Charles H. Townes of the University of California, Berkeley, another long-time high-level government adviser on strategic weapon policy. (An excerpt from their report, published in December 1990, is printed on pages 35–40.)

At about the same time Drell's group

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was commissioned, the House Foreign Affairs Committee chairman and other pro-CTB members of Congress asked Kidder for advice on the need for nuclear testing to improve weapon safety. On September 10, 1990, Kidder responded with a preliminary assessment (pages 32–34). In response to another congressional request, Kidder is now engaged in a more detailed study.

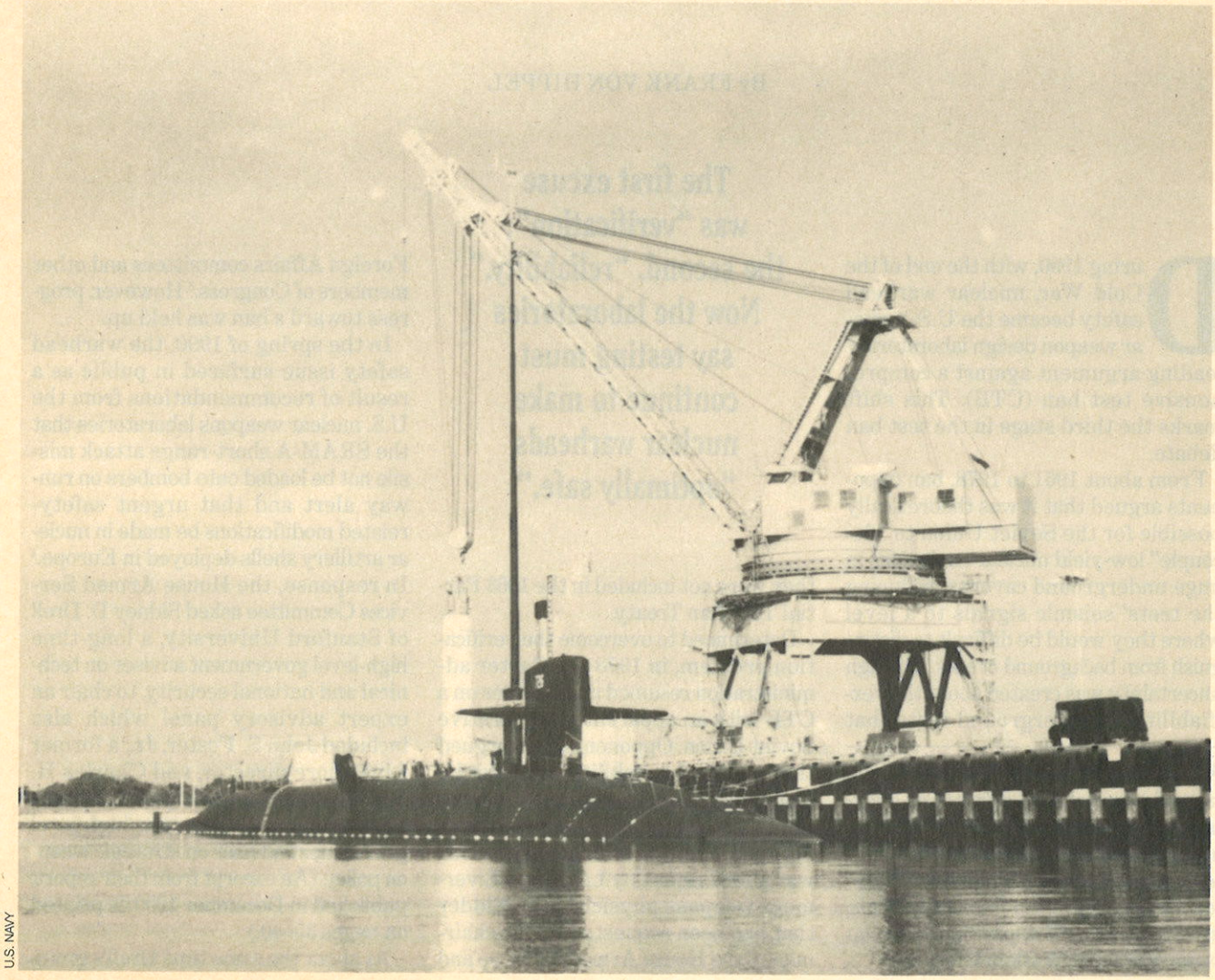
The Drell and Kidder reports differ in part because their authors were asked to address different issues: the Drell panel was asked to advise on warhead safety; Kidder was asked to advise about safety-related testing requirements. Kidder concluded that "only a modest number of nuclear tests [of] weapons currently under development" are needed for safety reasons. The Drell report's implications for testing must be inferred.

To those who advocate a CTB by 1995,[5] the Drell report's most troubling implication is its recommendation that completely new "safety-optimized designs should be studied aggressively." One example of such a design would require the plutonium core of the warhead trigger to be kept in a hardened container separated from its high-explosive chemical implosion system until just before the warhead reached its target. The Kidder report warns that developing such a warhead "would be a major and protracted undertaking requiring a very large number of tests" and concludes that "the cost-benefit aspect of such an undertaking is questionable in view of both the performance penalties that would be paid and its strong adverse implications for nuclear arms control."

The Drell report does not discuss the arms control implications of its recommendations. It appears to have been driven by another concern: the "political consequences" of a nuclear warhead accident that results in plutonium contamination. The panel apparently feared that a plutonium-contamination accident could trigger a public rejection of nuclear deterrence similar to the rejection of nuclear power that occurred during the 1970s and 1980s. In judging "how safe is safe enough," both reports were therefore affected to a considerable extent by political as well as technical issues.

Aside from the disagreement over the value of "safety-optimized designs," the Drell panel and Kidder agree about the existing stockpile's safety problems and the shorter-term improvements that could be made to mitigate them.

What are the dangers of a nuclear warhead accident? In order of declining importance, they are: a nuclear



U.S. NAVY

explosion with a significant yield, the widespread dispersion of inhalable particles of plutonium that could occur if the weapon's chemical explosives detonated,[6] or the contamination of a relatively small area with plutonium-containing ash if the weapon burned but did not explode.

An accident that triggered a warhead's electrical arming, fuzing, and firing systems could cause an explosion with a nuclear yield. Both reports agree that the electrical systems of older U.S. warheads should be brought up to modern standards to protect against this possibility. Kidder adds that this process would not require nuclear testing.

Since 1968, U.S. weapons have been explicitly designed to avoid an explosion of a significant yield as a result of impact or fire at a single point. The unclassified version of the Drell report hints, however, that recent supercomputer calculations have shown that not all U.S. nuclear warheads meet this "one point" safety requirement. Kidder indicates that this problem relates to nuclear artillery shells. Because of their small diameter and other constraints, it is difficult to design nuclear artillery shells that achieve an effective implosion, and the uncompressed core is therefore closer to a supercritical state.

Kidder notes that these warheads could be rendered safe by "mechanical safing." One example of mechanical safing might be a neutron-absorbing wire introduced into the hollow interior of the plutonium core that could be mechanically withdrawn shortly before the warhead reached its target. Kidder also points out that, with the reunification of Germany and the demise of the Warsaw Pact, these nuclear artillery shells will probably soon be in storage.

The risk of plutonium dispersal caused by the detonation of a warhead's chemical explosive has been reduced in most modern nuclear warheads by using "insensitive high explosive" (IHE) in the implosion mechanism. The Drell report notes, however, that at the beginning of 1990, only 25 percent of the stockpile was equipped with IHE. Kidder points out that, although Minuteman ICBM and submarine-launched ballistic missile warheads use conventional rather than insensitive high explosives, all other U.S. warheads that do not contain IHE are expected to be retired. He also points out that it would be possible to substitute existing warhead designs that contain IHE for the ballistic-missile warheads that do not. It would also probably be possible, if the military insisted, to design and test somewhat higher-yield replacement warheads containing IHE before 1995.

Both reports express concern about possible accidents during transportation and loading of nuclear weapons. Here a Trident missile is loaded onto the USS *Ohio*.

A decision to develop new "safety-optimized" weapon designs would invite the laboratories to start again with a blank sheet of paper.

Both reports agree that an airplane crash or fire presents the greatest danger of a plutonium-dispersal accident. The only two U.S. warhead accidents that caused widespread plutonium contamination were crashes of nuclear-armed B-52s which occurred in 1966 and 1968. Since then, the air force has kept nuclear-armed aircraft on the ground. However, the Drell panel points out that the Defense Department—unlike the Energy Department—continues to routinely transport non-IHE nuclear weapons by air. Kidder urges that the peacetime transport of nuclear weapons by air be halted and that nuclear-armed alert aircraft not be stationed near operating runways.

The least serious type of warhead accident, one in which a warhead burned but did not explode, would cause local plutonium contamination. As the Drell report points out, in contrast to an explosive plutonium dispersal accident which could create a plutonium inhalation hazard over an area of hundreds of square kilometers, a fire would contaminate an area on the order of one square kilometer, and most of the plutonium-containing particles would be too large to be inhaled.

The Drell panel reports that some modern warheads contain "fire-resistant pits" that are designed to contain molten plutonium for the duration of a several-hour-long jet-fuel fire, and the panel recommends that all warheads loaded on aircraft be so equipped. Kidder's report does not take a position on this point. The new SRAM-II (short-range attack missile) warhead has a fire-resistant pit, but it is not publicly known whether other aircraft-carried weapons are so equipped. If a decision were made soon to develop and test such designs, the necessary nuclear tests could presumably be done before the 1995 Nuclear Non-Proliferation Treaty extension conference.

Whether the warhead-safety issue delays a comprehensive test ban beyond 1995 depends on whether it is necessary to go beyond well understood technical fixes—improved electrical systems, insensitive high explosive, and fire-resistant pits—to "safety-optimized designs," where, in effect, the weapons laboratories would be invited to start again with a blank sheet of paper. Kidder does not think that this is necessary. The Drell panel is not so sure. The source of the difference seems to be that Kidder thinks that a test ban is an important arms control objective and the Drell panel does not. Ultimately, however, this is a political decision that the Congress should face up to without undue delay. ■

1. A.L. Latter et al., "A Method of Concealing Underground Nuclear Explosions," *Journal of Geophysical Research*, vol. 66 (1961), pp. 943–46.

2. *Effects of a Comprehensive Test Ban Treaty on U.S. National Security Interests*, Hearing before the Subcommittee on Intelligence and Military Applications of Nuclear Energy of the U.S. House Committee on Armed Services (Washington, D.C.: U.S. Government Printing Office, 1978).

3. Ray E. Kidder, *Maintaining the U.S. Stockpile of Nuclear Weapons During a Low-Threshold or Comprehensive Test Ban*, Lawrence Livermore National Laboratory Report, UCRL-53820, unclassified version, 1987.

4. *Department of Defense Authorization for Appropriations for Fiscal Year 1991*, Hearings before the Senate Armed Services Committee, May 23, 1990, pp. 219–79.

5. See, for example, *Toward a Comprehensive Nuclear Warhead Test Ban* (Washington, D.C.: International Foundation, 1991).

6. See, for example, Steve Fetter and Frank von Hippel, "The Hazard from Plutonium Dispersal by Nuclear-Warhead Accidents," *Science & Global Security*, vol. 2 (1990), pp. 21–42.

SAFETY NO BARRIER TO TEST BAN

By RAY E. KIDDER

Older, less safe weapons are being retired or retrofitted—and nearly all of the most important weapon safety improvements can be made without nuclear testing.

This brief report was prepared in response to a letter of July 17, 1990, by the Honorable Dante B. Fascell, chairman of the House Committee on Foreign Affairs, requesting an assessment of the safety of U.S. nuclear warheads with particular attention to the extent to which additional nuclear explosive tests might be needed to further improve their safety. Chairman Fascell's letter contained five questions concerning this issue that I have attempted to answer as follows:

Are our nuclear weapons safe?

The safety record of our nuclear weapons has been remarkably good. The nuclear safety record of our nuclear weapons has been perfect. In the 45-year history of nuclear weapons there has never been an accident which produced any nuclear yield. There have been only two accidents in which the [conventional] high explosive (HE) contained in the nuclear warhead detonated: the 1966 accident in Palomares, Spain, and the 1968 accident in Thule, Greenland, both involving B-52 aircraft. These detonations would probably not have occurred if the warheads had contained insensitive high explosive (IHE) instead of conventional HE, and could not have occurred had it been the practice not to allow nuclear weapons to be airborne in peacetime.

As you know, questions have recently been raised concerning the safety of three of our artillery-fired atomic projectiles (AFAPs): the W48, W79, and W82. These projectiles do not entirely satisfy existing requirements for nuclear safety. They can be rendered safe by means of a retrofit that does not necessitate further nuclear tests. In the meanwhile, it is my understanding that they have been rendered safe by other effective means. In the longer term, given the reunification of Germany and the demise of the Warsaw Pact, it seems likely that our overseas AFAPs can be returned to the United States and placed in storage.

Questions have also been raised concerning the safety of the SRAM-A [short-range attack missile], with the result that it has been removed from alert aircraft pending a safety review. It is intended that the SRAM-A warhead (W69) be replaced with the SRAM-II warhead (W89) currently under development, a modern warhead that employs IHE and enjoys special fire-resistant features. I believe that the perceived safety problem with the W69 could, if deemed necessary, be fixed by retrofit without requiring a nuclear test. An alternative to retrofit would be to keep the SRAM-A off of Strategic Air Command alert aircraft and out of harm's way until it can be replaced and retired.

There has been some criticism of the fact that the W88 warhead for the Trident II D5 missile does not employ IHE. It is clear that the safety of the D5 missile would be improved if the W88 warheads were replaced with warheads employing IHE. Safety tests that have been conducted to date suggest that while such improvement is not without merit, it is not necessary to meet current safety requirements.

More than half of the nuclear weapons currently in the stockpile were designed 20 years ago or more, and do not have some of the important electrical, nuclear, and plutonium-dispersal safety features of modern weapons. This is not to say that they are unsafe, but clearly their safety is not up to modern standards. The majority of these old-timers are due for retirement without replacement. Of those that will be replaced, the majority will be replaced by modern warheads already in stockpile. Those remaining will be replaced with weapons currently under development, these latter requiring only a modest number of nuclear tests before being ready for production.

The safety of the existing stockpile needs improvement. But with an appropriate schedule of retirement, retrofit, and replacement of older weapons with the more modern weapons currently in stockpile or under development, the safety of the U.S. stockpile will be well assured; particularly so if the transport of nuclear weapons by air in peacetime is prohibited.

Do we need to increase the number of nuclear tests we conduct to ensure the safety of our nuclear arsenal? Or, do we need to increase the number of nuclear tests we conduct only for the relevant programs in question?

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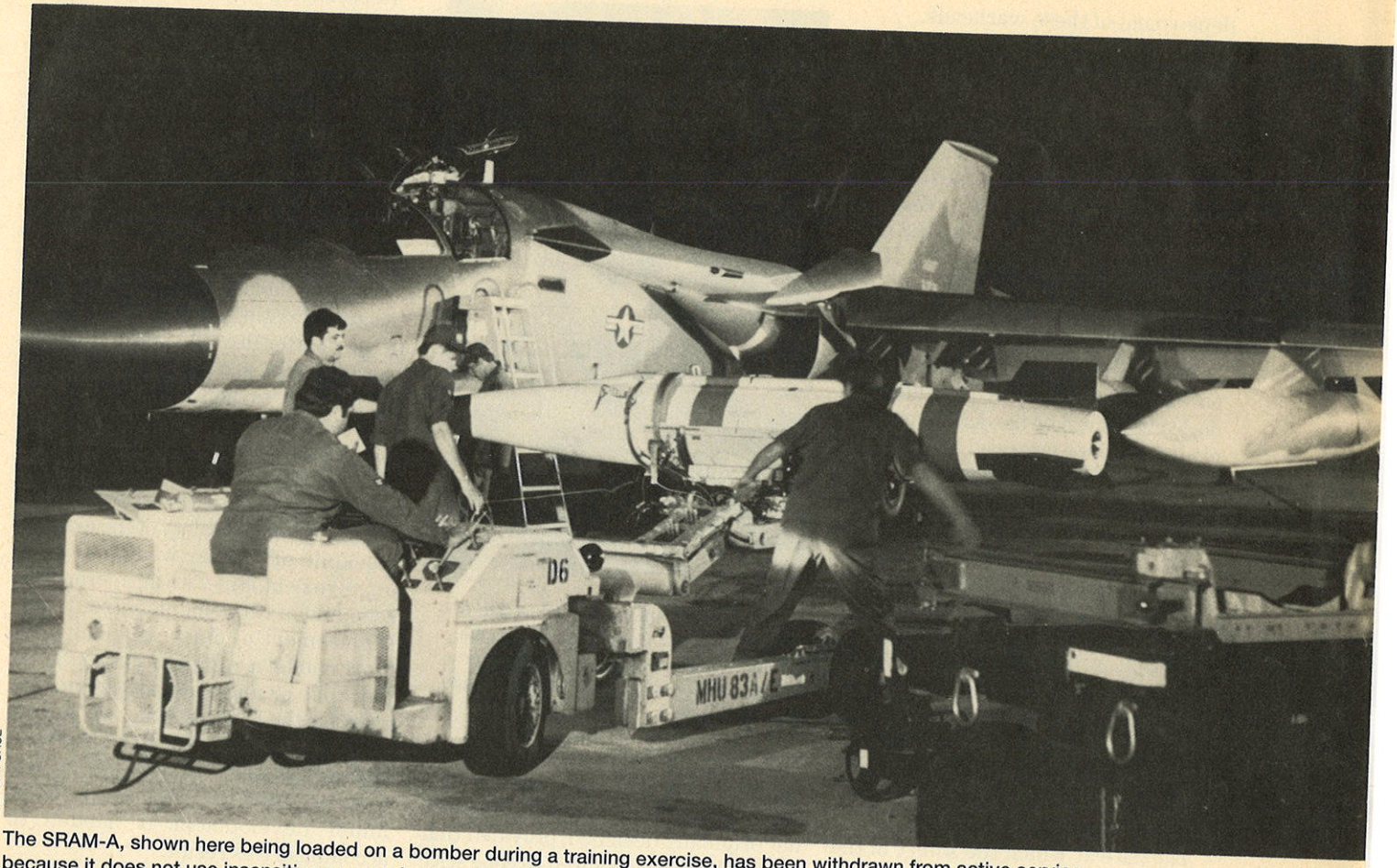


U.S. AIR FORCE

The SRAM-A, shown here being loaded on a bomber during a training exercise, has been withdrawn from active service because it does not use insensitive non-nuclear explosives.

No significant increase, beyond the modest number of nuclear tests required by weapons currently under development, is needed to ensure the safety of our nuclear arsenal.

With respect to those nuclear weapon systems whose safety has been recently called into question, effective corrective measures can be or have been taken that do not require any significant increase in nuclear tests. The AFAPs are now one-point safe. (The condition known as "nuclear one-point safety" is satisfied if, given that detonation of the warhead's HE has taken place at any one point, there is less than one chance in a million of obtaining a nuclear yield exceeding that equivalent to four pounds of HE.) SRAM-A will presumably be replaced by SRAM II. Should a decision be made to replace the W88 warheads in the D5 missile, which does not seem likely at this time, a replacement could be made that would require no more than one or two additional nuclear tests. A further decision to replace the third-stage propellant in the D5 missile with a less hazardous, non-detonatable variety would require missile tests, but no nuclear tests.

Are there ways to deal with the warhead safety question other than through nuclear testing?

There are a number of ways. Improvements can be made in the conditions and operating procedures associated with the storage, transport, and deployment of the weapons. For example, the transportation of nuclear weapons by air could be prohibited in peacetime, as well as their deployment aboard alert aircraft that are in close proximity to operating runways. Aircraft carrying nuclear weapons present the greatest risk of a serious nuclear accident because an airplane crash will subject the nuclear warheads to both violent impact and intense heat of burning missile propellant and jet fuel. Should U.S. land-based nuclear weapons be withdrawn from all overseas bases not directly accessible by sea, air transport of these weapons would not be needed.

Should we add insensitive high explosives to all our nuclear weapons? If so, why?

It has been modern practice to employ IHE in all nuclear bombs and missiles that are deployed aboard aircraft because of the possibility of severe impact and fire stated above. It has not been the practice to employ IHE in the warheads of submarine-launched ballistic missiles (SLBMs), one reason being the less hazardous, more benign environment they enjoy. These practices are supported by the accident record. There have been several aircraft accidents in which fire and impact have led to some dispersal of plutonium, an extremely hazardous radioactive material. There have been no accidents with SLBMs that have resulted in plutonium dispersal of which I am aware. The current exemption of SLBM warheads from the requirement to use IHE carries with it, however, an obligation to observe correspondingly more stringent precautions in the handling, loading, and

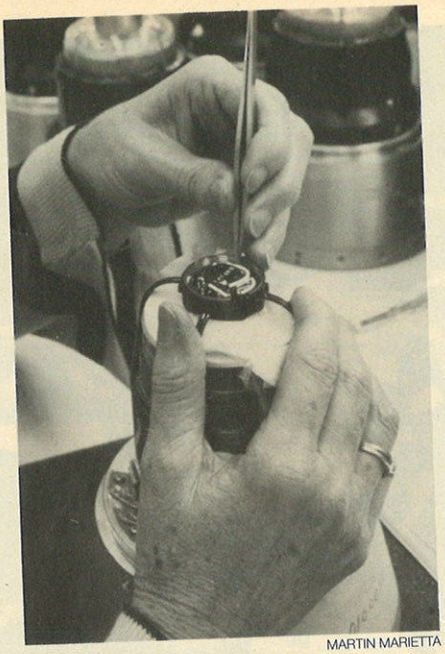
deployment of these warheads.

None of the many types of nuclear weapons that entered the stockpile prior to 1979 are equipped with IHE. However, with the exception of three ICBM types (Minuteman II and two types of Minuteman IIIs) and one SLBM type (Trident I C4), all of these older weapons will be either retired, or replaced with modern weapons equipped with IHE. This program of retirement and replacement will accomplish the result of adding IHE to all our nuclear weapons (with three exceptions noted) in the normal course of events. No additional nuclear tests will be needed beyond the modest number required by weapons currently under development.

A means of improving nuclear weapon safety that does not involve the use of IHE and does not require nuclear tests is to upgrade the arming, fuzing, and firing components of our older nuclear warheads to meet modern requirements of electrical safety. These components are sufficiently external to the nuclear package that changes in them can be made without influencing the nuclear performance of the warhead, so that nuclear explosive tests are not needed.

The pace at which the safety of the stockpile is brought up to modern standards could be increased by accelerating the retirement of those weapons that are not planned to be replaced, and by increasing the electrical and nuclear safety of those weapons scheduled for replacement by means of retrofits that would require few if any nuclear tests. During the interval of time before replacement or retirement, an effective means of assuring the nuclear safety of these older weapons would be to equip them with mechanical safing. Such means can assure safety with respect to detonation at a single point (one-point safety) or at any number of points (multi-point safety), and have been in successful use for more than 20 years.

What advantages are there to reconfiguring our nuclear testing program so that instead of matching specific warheads to specific delivery vehicles, we make our warheads more interchangeable with our delivery vehicles? How costly is this? Would the need to conduct nuclear tests be reduced if we reconfigured our nuclear testing program in this way?



MARTIN MARIETTA

Atomic artillery shells, about the size of this conventional Copperhead projectile, may be unsafe. But they will surely be withdrawn from Europe where they have been deployed.

Existing nuclear warheads can be repackaged and incorporated into new delivery vehicles for which they were not originally designed, provided that they will not be required to cope with unacceptably more-stressing conditions in their stockpile-to-target sequence. In this sense, they are already interchangeable. The W84 and W85 warheads that have been salvaged from the ground-launched cruise missiles and Pershing II, eliminated by the recent treaty banning intermediate-range nuclear missiles, are examples of warheads with modern safety features that could be repackaged for use in other weapon systems. The same would be true of many other types of weapons in the current stockpile.

In addition to repackaging existing warheads for use in new delivery vehicles, it is possible to retrofit existing warheads, or to modify warheads in development, for use in existing delivery vehicles other than those for which the warheads were originally designed. An example of the latter possibility would be to modify the SRAM II W89 warheads so that they could replace the W88 warheads now deployed in the Trident II D5 missile. The D5 would then enjoy the advanced safety features of the W89 warhead without requiring significant alteration itself.

Repackaging or retrofitting an existing warhead for a new application eliminates the costs associated with designing, engineering, developing, and testing a new warhead. Depending on the circumstances, production costs may also be reduced. Repackaging or retrofitting therefore can reduce both the cost and the number of nuclear tests that are needed to field a new weapon system capability.

The constraints imposed by restriction to an existing warhead, as opposed to the greater flexibility afforded by a new warhead, are the price one must pay for these savings in cost and reductions in nuclear tests. The cost-benefit comparison will of course be strongly influenced by the difficult-to-quantify benefits of a reduction in nuclear testing.

To conclude, the safety of the existing stockpile of nuclear weapons needs improvement. But with an appropriate schedule of retirement, retrofit, and replacement of older weapons with more modern weapons currently in stockpile or under development, the safety of the U.S. stockpile will be well assured. No significant increase beyond the modest number of nuclear tests required by weapons currently under development is needed to accomplish this result.

The safety of nuclear warheads could be still further improved by utilizing the concept of "separable components" in which the warhead's plutonium and HE are physically separated from each other until the warhead is to be armed. Such a design would virtually eliminate the possibility of plutonium dispersal and would also ensure nuclear safety. Implementation of these safety benefits, however, would be a major and protracted undertaking requiring a very large number of nuclear tests. The cost-benefit aspect of such an undertaking is questionable in view of both the performance penalties that would be paid and its strongly adverse implications for nuclear arms control.

A recurrent theme of this assessment has been the improvement in the safety of our nuclear weapons that would result if their transport by air or their deployment aboard aircraft in close proximity to operating runways were prohibited in peacetime. Given the relaxation in tensions between the United States and the Soviet Union, I believe that such safety measures deserve serious consideration. ■