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NATIONAL SECURITY AND THE NUCLEAR TEST BAN

(Below are reprinted the major portions of an article which appeared in the Scientific American of October 1964, by Drs. Jerome B. Wiesner and Herbert F. York. The authors have long been government consultants on science and military policy: Dr. Wiesner was most recently science adviser to President Kennedy; Dr. York, first director of the Livermore Laboratory, was later director of defense research and engineering in the Pentagon.)

The partial nuclear-test ban—the international treaty that prohibits nuclear explosions in the atmosphere, in the oceans and in outer space—has been in effect for a little more than a year. From July, 1945, when the first atomic bomb was set off in New Mexico, until August, 1963, when the U.S. completed its last series of atmospheric bomb tests in the Pacific, the accumulated tonnage of nuclear explosions had been doubling every three years. Contamination of the atmosphere by fission products and by the secondary products of irradiation (notably the long-lived carbon 14) was approaching a level (nearly 10 percent of the natural background radiation) that alarmed many biologists. A chart plotting the accumulation of radioactive products can also be read as a chart of the acceleration in the arms race.

Now, for a year, the curve has flattened out. From the objective record it can be said that the improvement of both the physical and the political atmosphere of the world has fulfilled at least the short-range expectations of those who advocated and worked for the test ban. In and of itself the treaty does no more than moderate the continuing arms race. It is nonetheless, as President Kennedy said, "an important first step—a step toward peace, a step toward reason, a step away from war."

The passage of a year also makes it possible to place in perspective and evaluate certain misgivings that have been expressed about the effect on U.S. national security of the suspension of the testing of nuclear weapons in the atmosphere. These misgivings principally involve the technology of nuclear armament. National security, of course, involves moral questions and human values—political, social, economic and psychological questions as well as technological ones. Since no one is an expert in all the disciplines of knowledge concerned, it is necessary to consider one class of such questions at a time, always with the caution that such consideration is incomplete. As scientists who have been engaged for most of our professional lifetimes in consultation on this country's military policy and in the active development of the weapons themselves, we shall devote the present discussion primarily to the technological questions. . . .

TECHNICAL CASE STUDY: 100 MEGATON BOMB

The point is well illustrated by the 100-megaton nuclear bomb. Whether or not it is necessary, in the interests of national security, to test and deploy a bomb with a yield in the range of 100 megatons was much discussed during the test-ban debates. The bomb was frequently referred to as the

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FAS STATEMENT ON CHINESE TEST

(The FAS Executive Committee issued the following statement on October 20.)

China's entry into the "nuclear family" emphasizes the fact that nuclear secrets do not keep. The only way to prevent the spread of nuclear arms is by means of enforced international agreements.

To be sure, China's action poses no immediate threat to our security; there is no need to resume atmospheric testing in response. It will take many years for China to develop a significant arsenal of weapons and the means to deliver them.

From the long range point of view, however, as each additional nation develops its own nuclear arms, the security of every nation is decreased. The wider the spread of nuclear weapons, the greater the chance of their being used and, consequently, the greater the chance of starting a war that could quickly escalate to involve and destroy a large part of civilization.

The Federation of American Scientists urges our Government and all nations to work with a renewed sense of urgency for enforced agreements to control the nuclear arms race. The Test Ban Treaty—which was ratified one year ago—is a step in the right direction. But it is only a first step. Unless followed by much more comprehensive arrangements, the present trend towards expanding the "nuclear family" will continue. If humanity is to survive, the trend must be reversed while there is still time.

CHINESE BOMB TEST

Announcement of Communist China's first nuclear explosion on October 16 increased to five the number of the "nuclear club," and to two (with France) the active violators of the effort to ban atmospheric tests.

Although the Chinese bomb test has long been predicted by U.S. officials (most recently by Secretary Rusk, at the end of September), the advanced techniques used in this test were a great surprise. Observers had expected that the first test would use plutonium and a relatively simple "gun-barrel" trigger such as was used in the Hiroshima bomb (and in the first French test). However, the AEC announced that analysis of the radioactive debris showed that the Chinese bomb was fired by the more difficult implosion technique and, even more unexpectedly, that it used uranium-235. Separation of U-235 by the gaseous diffusion requires far more advanced technology (in the design of diffusion barriers as well as pumps and valves for handling the corrosive uranium hexafluoride) than does production of plutonium in a nuclear reactor. A diffusion plant also requires much more capital and construction outlays, and huge amounts of electricity to operate. (The United States' three gas diffusion plants used about 10 percent of the country's electric power when they were running at full production.) While there had been newspaper stories of a gas diffusion plant under construction near Lanchow, there were no reports that such a plant was actually producing U-235. Observers had thought

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THIRD ATOMS-FOR-PEACE CONFERENCE: MATURITY IN THE NUCLEAR POWER INDUSTRY?

The Third International Atoms-for-Peace Conference, held early in September at Geneva, may have seemed "bigger and better than ever," but at least one reviewer of the scene there has raised several questions as to the value of this activity. Thus, an article in the September issue of "Nuclear Industry," the monthly magazine of the Atomic Industrial Forum, has stated that "the general impression seemed to be that while [the Geneva Conference] had doubtless been a success, it was hard to say just what it had accomplished or to be entirely sure that it had been worth the effort." One reason for this conclusion, according to the article, is that a strong future for nuclear power has already been taken for granted and there was little need for confirmation of this fact by the conference. Thus, while programs may be in various stages of development in different countries and may be suffering growing pains of one sort or another, no one seems to doubt that nuclear power will emerge a strong economic factor. Furthermore, the "Nuclear Industry" article continued, "the complexities, problems and limitations of nuclear electric generation are equally well understood—particularly the problems that stem from specific local situations—and they too are accepted as a fact of life." All of this is by way of saying that there is now a degree of maturity in the nuclear industry.

There seems to have been an air of commercialism at the conference. This was the result of a certain amount of infighting over the merits of various products and reactor methods. This was probably inevitable as individual manufacturers and even national programs have become more and more committed to certain courses of action having varying degrees of success.

As an example, three Russian engineers presented a conference report which showed that the Soviet nuclear power program is strikingly parallel in direction and emphasis to U.S. efforts, except for cost figures of the plants. These showed the estimated construction cost of a plant in the U.S.S.R. was about 40 percent higher than that of a comparable U.S. plant and that the delivery cost of electricity was about 15 percent higher. However, one of the Russian authors told a news conference that costs of the two plants are really comparable. In effect, he challenged the accuracy of cost estimates of the American plant, which was the new power plant at Oyster Creek, N. J. The figures had also been questioned privately by British experts at the meeting. However, U.S. officials there defended the estimates as being "very good ones." (W. Post, 9/1.)

Despite this kind of claim and counterclaim, challenge and rebuttal, there still were, according to the "Nuclear Industry" article, intangible benefits to be derived from the conference in the opportunities it afforded these thousands of specialists and administrators to meet and talk.

Further the conference served as a forum for important policy statements. For example, at an informal information meeting sponsored by the Atomic Industrial Forum, AEC Chairman Seaborg and other AEC officials answered questions on the new private ownership law and its implications for reactor operators abroad (see Newsletter, 9/64.)

Finally, there was a certain amount of new information to come out of the conference, not only in the individual papers dealing with specific points but also in the broader studies and discussions. "Nuclear Industry" concludes that, taking all these factors into account, it seems likely that U.N. officials and advisers may decide against putting time, effort and money into a fourth meeting. While the thousands of delegates might agree with this opinion, they might also feel that in an undefinable way they profited from this Third International Atoms-for-Peace Conference.

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"big" bomb, as if the bombs now in the U.S. arsenal were somehow not big. The absurdity of this notion is almost enough by itself to settle the argument. A one-megaton bomb is already about 50 times bigger than the bomb that produced 100,000 casualties at Hiroshima, and 10 megatons is of the same order of magnitude as the grand total of all high explosives used in all wars to date. Other technical considerations that surround this question are nonetheless illuminating and worth exploring.

There is, first of all, the "tactics" of the missile race. The purpose of a missile system is to be able to destroy or, perhaps more accurately, able to threaten to destroy enemy targets. No matter what the statesmen, military men and moralists on each side may think of the national characteristics, capabilities and morality of the other side, no matter what arguments may be made about who is aggressive and who is not or who is rational and who is not, the military planners on each side must reckon with the possibility that the other side will attack first. This means that above all else the planner must assure the survival of a sufficient proportion of his own force, following the heaviest surprise attack the other side might mount, to launch a retaliatory attack. Moreover, if the force is to be effective as a deterrent to a first strike, its capacity to survive and wreak revenge and even win, whatever that may mean, must be apparent to the other side.

Several approaches, in fact, can be taken to assure the survival of a sufficient missile force after a first attack on it. The most practical of these are: (1) "hardening," that is, direct protection against physical damage; (2) concealment, including subterfuge and, as in the case of the Polaris submarine missiles, mobility, and (3) numbers, that is, presenting more targets than the attacker can possibly cope with. The most straightforward and certain of these is the last: numbers. For the wealthier adversary it is also the easiest, because he can attain absolute superiority in numbers. A large number of weapons is also a good tactic for the poorer adversary, because numbers even in the absence of absolute superiority can hopelessly frustrate efforts to locate all targets.

There is an unavoidable trade-off, however, between the number and the size of weapons. The cost of a missile depends on many factors, one of the most important being gross size or weight. Unless one stretches "the state of the art" too far in the direction of sophistication and miniaturization, the cost of a missile turns out to be roughly proportional to its weight, if otherwise identical design criteria are used. The protective structures needed for hardening or the capacity of submarines needed to carry the missile also have a cost roughly proportional to the volume of the missile. Some of the ancillary equipment has a cost proportional to the size of the missile and some does not; some operational expenditures vary directly with size or weight and some do not. The cost of the warhead generally does not, although the more powerful warhead requires the larger missile. It is not possible to put all these factors together in precise bookkeeping form, but it is correct to say that the cost of a missile, complete and ready for firing, increases somewhat more slowly than linearly with its size.

U.S. EMPHASIS ON SMALLER MISSILES

On the other hand—considering "hard" targets only—the effectiveness of a missile increases more slowly than cost as the size of the missile goes up. The reason is that the radius of blast damage, which is the primary effect employed against a hard target, increases only as the cube root of the yield and because yield has a more or less direct relation to weight. Against "soft" targets, meaning population centers and con-

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ventional military bases, even "small" bombs are completely effective, and nothing is gained by increasing yield. Given finite resources, even in the wealthiest economy, it would seem prudent to accept smaller size in order to get larger numbers. On any scale of investment, in fact, the combination of larger numbers and smaller size results in greater effectiveness for the missile system as a whole, as contrasted to the effectiveness of a single missile.

This line of reasoning has, for some years, formed the basis of U.S. missile policy. The administration of President Eisenhower, when faced with the choice of bigger missiles (the liquid-fueled Atlas and Titan rockets) as against smaller missiles (the solid-fueled Minuteman and Polaris rockets), decided to produce many more of the smaller missiles. The administration of President Kennedy independently confirmed this decision and increased the ratio of smaller to larger missiles in the nation's armament. During the test-ban hearings it was revealed that the U.S. nuclear armament included bombs of 23-megaton yield and higher, carried by bombers. Recently Cyrus R. Vance, Under Secretary of Defense, indicated that the Air Force has been retiring these large bombs in favor of smaller ones. There are presumably no targets that call for the use of such enormous explosions.

DETERMINANTS OF MISSILE EFFECTIVENESS

The argument that says it is now critical for U.S. national security to build very big bombs and missiles fails completely when it is examined in terms of the strictly technical factors that determine the effectiveness of a missile attack. In addition to explosive yield the principal factors are the number of missiles, the overall reliability of each missile and the accuracy with which it can be delivered to its target. The effectiveness of the attack—the likelihood that a given target will be destroyed—can be described by a number called the "kill probability" (Pk). This number depends on the number of missiles (N) launched at the target, the reliability (r) of each missile and the ratio of the radius of damage (Rk) effected by each missile to the accuracy with which the missiles are delivered to the target (CEP). The term "CEP," which stands for "circular error probable," implies that the distribution of a large number of hits around a given target will follow a standard error curve; actually, for a variety of reasons (which include the presence of systematic errors, coupling between certain causes of error and the sporadic nature of the larger error factors) the distribution does not really follow a standard error curve. The term "CEP" is still useful, however, and can be defined simply as the circle within which half of a large number of identical missiles would fall.

Now, in the case of a soft target, Rk is very large for the present range of warhead yields in the U.S. arsenal. The reason is that soft targets are so highly vulnerable to all the "prompt" effects (particularly the incendiary effect) of thermonuclear weapons. The range of these effects, modified by various attenuation factors, increases approximately as the square root or the cube root of the yield at large distances. Under these circumstances, given the accuracy of existing fire-control systems, the ratio Rk/CEP is large and the likelihood that the target will be destroyed becomes practically independent of this ratio. Instead Pk depends primarily on r, the reliability of the missile. If r is near unity, then a single missile ($N=1$) will do the job; if r is not near unity, then success in the attack calls for an offsetting increase in the number of missiles [$Pk = 1 - (1 - r)\ N$]. In either case changes in Rk make little difference. That is to say, a "big" bomb cannot destroy a soft target any more surely than a "small" one can.

When it comes to hard targets, the ratio Rk/CEP becomes much smaller even for bombs of high yield. The blast effects —including the ground rupture, deformation and shock surrounding the crater of a surface burst—have comparatively small radii at intensities sufficient to overcome hardening. Moreover, as mentioned above, the radii of these effects increase only as the cube root of the yield. This rule of thumb is modified somewhat in both directions by the duration of the blast pulse, local variations in geology and other factors, but it is sustained by a voluminous record from weapons tests. Since the radius of blast damage is of the same order of size as the circular error probable, or smaller, the ratio Rk/CEP must be reckoned with in an attack on a hard target. Yet even in this situation the cube root of a given increase in yield would contribute much less to success than a comparable investment in numbers, reliability or accuracy.

Yield is of course a product of the yield-to-weight ratio of the nuclear explosive employed in the warhead multiplied by the weight of the warhead. In order to gain significant increases in the first of these two quantities further nuclear tests would be necessary. Increase in the weight of the warhead, on the other hand, calls for bigger and more efficient missiles. In the present state of the art, efforts to improve CEP and reliability as well as weight-carrying capacity hold out more promise than efforts to improve the yield-to-weight ratio. The reason is that missile design and control involve less mature and less fully exploited technologies than the technology of nuclear warheads. Finally, an increase in the number of missiles, although not necessarily cheap, promises more straightforward and assured results than a fractional increase in yield-to-weight ratio. Of all the various possible technical approaches to improving the military effectiveness of an offensive missile force, therefore, the only one that calls for testing (whether underground or in the atmosphere) is the one that offers the smallest prospect of return.

Suppose, however, a new analysis, based on information not previously considered, should show that it is in fact necessary to incorporate the 100-megaton bomb in the U.S. arsenal. Can this be done without further weapons tests? the answer is yes.

WEAPONS EFFECTS ALREADY KNOWN

The extensive series of weapons tests carried out by the U.S.—involving the detonation of several hundred nuclear bombs and devices—have yielded two important bodies of information. They have shown how to bring the country's nuclear striking force to its present state of high effectiveness. And they have demonstrated the effects of nuclear weapons over a wide range of yields.

Although renewed atmospheric testing would contribute some refinement to the data on weapons effects, the information would be, at best, of marginal value. Such refinements continue to be sought in the underground tests that are countenanced under the partial test ban. From this work may also come some reductions in the cost of weapons, modest improvements in yield-to-weight ratios, devices to fill in the spectrum of tactical nuclear weapons and so on. There is little else to justify the effort and expenditure. The program is said by some to be necessary, for example, to the development of a pure fusion bomb, sometimes referred to as the "neutron bomb." It is fortunate that this theoretically possible (stars are pure fusion systems) device has turned out to be so highly difficult to create; if it were relatively simple, its development might open the way to thermonuclear armament for the smallest and poorest powers in the world. The U.S., with its heavy investment in fission-to-fusion technology, would be the last nation to welcome this development and ought to be the last to encourage it. Underground testing is also justified for its contribution to the potential peaceful uses of nuclear explosives. Promising as these may be, the world could forego them for a time in exchange for cessation of the arms race. Perhaps the best rationale for the underground-test program is that it helps to keep the scientific laboratories of the military establishment intact and in readiness—in readiness, however, for a full-scale resumption of the arms race.

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ANTIMISSILE DEFENSE UNLIKELY

Paradoxically one of the potential destabilizing elements in the present nuclear standoff is the possibility that one of the rival powers might develop a successful antimissile defense. Such a system, truly airtight and in the exclusive possession of one of the powers, would effectively nullify the deterrent force of the other, exposing the latter to a first attack against which it could not retaliate. The possibilities in this quarter have often been cited in rationalization of the need for resuming nuclear tests in the atmosphere. Here two questions must be examined. One must first ask if it is possible to develop a successful antimissile defense system. It then becomes appropriate to consider whether or not nuclear weapons tests can make a significant contribution to such a development.

Any nation that commits itself to large-scale defense of its civilian population in the thermonuclear age must necessarily reckon with passive modes of defense (shelters) as well as active ones (antimissile missiles). It is in the active mode, however, that the hazard of technological surprise most often lurks. The hazard invites consideration if only for the deeper insight it provides into the contemporary revolution in the technology of war.

The primary strategic result of that revolution has been to overbalance the scales in favor of the attacker rather than the defender. During World War II interception of no more than 10 percent of the attacking force gave victory to the defending force in the Battle of Britain. Attrition of this magnitude was enough to halt the German attack because it meant that a given weapons-delivery system (bomber and crew) could deliver on the average only 10 payloads of high explosive; such a delivery rate was not sufficient to produce backbreaking damage. In warfare by thermonuclear missiles the situation is quantitatively and qualitatively different. It is easily possible for the offense to have in its possession and ready to launch a number of missiles that exceeds the number of important industrial targets to be attacked by, let us say, a factor of 10. Yet the successful delivery of only one warhead against each such target would result in what most people would consider an effective attack. Thus where an attrition rate of only 10 percent formerly crowned the defense with success, a penetration rate of only 10 percent (corresponding to an attrition rate of 90 percent) would give complete success to the offense. The ratio of these two ratios is 100 to one; in this sense the task of defense can be said to have become two orders of magnitude more difficult.

Beyond this summary statement of the situation there are many general reasons for believing that defense against thermonuclear attack is impossible. On the eve of attack the offense can take time to get ready and to "point up" its forces; the defense, meanwhile, must stay on the alert over periods of years, perpetually ready and able to fire within the very few minutes available after the first early warning. The attacker can pick its targets and can choose to concentrate its forces on some and ignore others; the defense must be prepared to defend all possible important targets. The offense may attack the defense itself; then, as soon as one weapon gets through, the rest have a free ride.

The hopelessness of the task of defense is apparent even now in the stalemate of the arms race. A considerable inertia drags against the movement of modern, large-scale, unitary weapons systems from the stage of research and development to operational deployment. The duration and magnitude of these enterprises, whether defensive or offensive, practically assure that no system can reach full deployment under the mantle of secrecy. The designer of the defensive system, however, cannot begin until he has learned something about the properties and capabilities of the offensive system. Inevitably the defense must start the race a lap behind. In recent years, it seems, the offense has even gained somewhat in the speed with which it can put into operation stratagems and devices that nullify the most extraordinary achievements in the technology of defense. These general observations are expensively illustrated in the development and obsolescence of two major U.S. defense systems.

TWO OBSOLETE DEFENSE SYSTEMS

Early in the 1950's the U.S. set out to erect an impenetrable defense against a thermonuclear attack by bombers. The North American continent was to be ringed with a system of detectors that would flash information back through the communications network to a number of computers. The computers were to figure out from this data what was going on and what ought to be done about it and then flash a series of commands to the various interceptor systems. In addition to piloted aircraft, these included the Bomarc (a guided airborne missile) and the Nike-Hercules (a ballastic rocket). By the early 1960's this "Sage" system was to be ready to detect, intercept and destroy the heaviest attack that could be launched against it.

The early 1960's have come and yet nothing like the capability planned in the 1950's has been attained. Why not? Time scales stretched out, subsystems failed to attain their planned capabilities and costs increased. Most important, the offense against which the system was designed is not the offense that actually exists in the early 1960's. Today the offensive system on both sides is a mixture of missiles and bombers. The Sage system has a relatively small number of soft but vital organs completely vulnerable to missiles—a successful missile attack on them would give a free ride to the bombers. As early as 1958 the Department of Defense came to realize that this would be the situation, and the original grand plan was steadily cut back. In other words, the Sage system that could have been available, say, in 1963 and that should have remained useful at least through the 1960's would in principle have worked quite well against the offense that existed in the 1950's.

To answer the intercontinental ballistic missile, the Deparment of Defense launched the development of the Nike-Zeus system. Nike-Zeus was intended to provide not a defense of the continent at its perimeter but a point defense of specific targets. To be sure, the "points" were fairly large—the regions of population concentration around 50 to 70 of the country's biggest cities. The system was to detect incoming warheads, feeding the radar returns directly into its computers, and launch and guide an interceptor missile carrying a nuclear warhead into intersection with the trajectory of each of the incoming warheads.

Nike-Zeus was not designed to defend the 1,000 or so smaller centers outside the metropolitan areas simply because there are too many of these to be covered by the resources available for a system so huge and complicated. Nor was the system designed to defend the retaliatory missiles, the security of these forces being trusted to the more reliable protection of dispersal, concealment, mobility and number. In principle, the defense of a hardened missile silo would have presented by far the simplest case for proof of the effectiveness of Nike-Zeus as advanced by those who contend that such a system can be made to "work." There would be no ambiguity about the location of the target of the incoming warhead. By the same token Nike-Zeus might have been considered for the defense of a few special defense posts, such as the headquarters of the Air Defense Command of the Strategic Air Command. These special cases are so few in number, however, that it had to be concluded that the attacker would either blast his way through to them by a concentration of firepower or ignore them altogether.

At the time of the conception of the Nike-Zeus system its designers were confronted with a comparatively simple

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problem, namely that of shooting down the warheads one by one as they presented themselves to the detectors. Even this simple problem had to be regarded as essentially unsolvable, in view of the fact that a 90-percent success in interception constitutes failure in the inverted terms of thermonuclear warfare. At first, therefore, the designers of the offensive system did not take the prospect of an antimissile system seriously. Then the possibility that the problem of missile interception might be solved in principle gave them pause. Thereupon the designers of the offense began to invent a family of "penetration aids," that is, decoys and confusion techniques. The details of these and the plans for their use are classified, but the underlying principles are obvious. They include light decoys that can be provided in large numbers but that soon betray their character as "atmospheric sorting" separates them from the heavier decoys (and actual warheads) that can be provided in smaller numbers to confuse the defending detectors down to the last minute. Single rockets can also eject multiple warheads. Both the decoys and the warheads can be made to present ambiguous cross sections to the radar systems. These devices and stratagems overwhelmed the designed capability of the Nike-Zeus system and compelled its recent abandonment.

If the installation of the system had proceeded according to plan, the first Nike-Zeus units would have been operational within the next year or two. This could have been celebrated as a technical milestone. As a means of defense of a substantial percentage of the population, however, the system would not have reached full operational deployment until the end of the decade. In view of its huge cost the system should then have looked forward to a decade of useful life until, say, the late 1970's. Thus, in inexorable accordance with the phase-lag of the defense, the U.S. population was to be defended a decade too late by a system that might have been effective in principle (although most probably not in practice) against the missiles of the early 1960's.

TODAY'S OBSOLESCING PROGRAM

The race of the tortoise and the hare has now entered the next lap with the development of the Nike-X system as successor to Nike-Zeus. The Advanced Research Projects Agency of the Department of Defense has been spending something on the order of $200 million a year on its so-called Defender Program, exploring on the broadest front the principles and techniques that might prove useful in the attempt to solve the antimissile problem. Although nothing on the horizon suggests that there is a solution, this kind of work must go forward. It not only serves the forlorn hope of developing an active antimissile defense but also promotes the continued development of offensive weapons. The practical fact is that work on defensive systems turns out to be the best way to promote invention of the penetration aids that nullify them.

As the foregoing discussion makes clear, the problems of antimissile development are problems in radar, computer technology, missile propulsion, guidance and control. The nuclear warheads for the antimissile missile have been ready for a long time for delivery to the right place at the right time. Although it is argued that certain refinements in the existing data about weapons effects are needed, the other uncertainties all loom much larger than the marginal uncertainties in these physical effects. The antimissile defense problem, then, is one in which nuclear testing can play no really significant part.

THE USELESS SHELTER

The pursuit of an active defense system demands parallel effort on the passive defense, or shelter, front because the nature of the defense system strongly conditions the tactics of the offense that is likely to be mounted against it. To take a perhaps farfetched example, a Nike-Zeus system that provided protection for the major population centers might invite the attacker to concentrate the weight of his assault in ground bursts on remote military installations and unprotected areas adjacent to cities, relying on massive fallout to imperil the population centers. This example serves also to suggest how heavily the effectiveness of any program for sheltering the civilian population depends on the tactics of the attacker. Fallout shelters by themselves are of no avail if the attacker chooses to assault the population centers directly.

In any speculation about the kind of attack to which this country might be exposed it is useful to note where the military targets are located. Most of the missile bases are, in fact, far from the largest cities. Other key military installations, however, are not so located. Boston, New York, Philadelphia, Seattle, San Francisco, Los Angeles (Long Beach) and San Diego all have important naval bases. Essential command and control centers are located in and near Denver, Omaha and Washington, D. C. The roll call could be extended to include other major cities containing military installations that would almost certainly have to be attacked in any major assault on this country. The list does not stop with these; it is only prudent to suppose still other cities would come under attack, because there is no way to know in advance what the strategy may be.

The only kind of shelter that is being seriously considered these days, for other than certain key military installations, is the fallout shelter. By definition fallout shelters offer protection against nothing but fallout and provide virtually no protection against blast, fire storms and other direct effects. Some people have tried to calculate the percentage of the population that would be saved by fallout shelters in the event of massive attack. Such calculations always involve predictions about the form of the attack, but since the form is unknowable the calculations are nonsensical. Even for the people protected by fallout shelters the big problem is not a problem in the physical theory of gamma-ray attenuation, which can be neatly computed, but rather the sociological problem of the sudden initiation of general chaos, which is not subject to numerical analysis.

Suppose, in spite of all this, the country were to take fallout shelters seriously and build them in every city and town. The people living in metropolitan areas that qualify as targets because they contain essential military installations and the people living in metropolitan areas that might be targeted as a matter of deliberate policy would soon recognize that fallout shelters are inadequate. That conclusion would be reinforced by the inevitable reaction from the other side, whose military planners would be compelled to consider a massive civilian-shelter program as portending a first strike against them. Certainly the military planners of the U.S. would be remiss if they did not take similar note of a civilian-shelter program in the U.S.S.R. As a step in the escalation of the arms race toward the ultimate outbreak of war, the fallout shelter would lead inevitably to the blast shelter. Even with large numbers of blast shelters built and evenly distributed throughout the metropolitan community, people would soon realize that shelters alone are not enough. Accidental alarms, even in tautly disciplined military installations, have shown that people do not always take early warnings seriously. Even if they did, a 15-minute "early" warning provides less than enough time to seal the population into shelters. Accordingly, the logical next step is the live-in and work-in blast shelter leading to still further disruption and distortion of civilization. There is no logical termination of the line of reasoning that starts with belief in the usefulness of fallout shelters; the logic of this attempt to solve the problem of national security leads to a diverging series of ever more grotesque measures. This is to say, in so many words, that if the arms race continues and resumes its former accelerating tempo, 1984 is more than just a date on the calendar 20 years hence.

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Ever since shortly after World War II the military power of the U.S. has been steadily increasing. Throughout this same period the national security of the U.S. has been rapidly and inexorably diminishing. In the early 1950's the U.S.S.R., on the basis of its own unilateral decision and determination to accept the inevitable retaliation, could have launched an attack against the U.S. with bombers carrying fission bombs. Some of these bombers would have penetrated our defenses and the American casualties would have numbered in the millions. In the later 1950's again on its own sole decision and determination to accept the inevitable massive retaliation, the U.S.S.R. could have launched an attack against the U.S. using more and better bombers, this time carrying thermonuclear bombs. Some of these bombers would have penetrated our defenses and the American casualties could have numbered in the tens of millions.

Today the U.S.S.R., again on the basis of its own decision and determination to accept the inevitable retaliation, could launch an attack on the U.S. using intercontinental missiles and bombers carrying thermonuclear weapons. This time the number of American casualties could very well be on the order of 100 million.

The steady decrease in national security did not result from any inaction on the part of responsible U.S. military and civilian authorities. It resulted from the systematic exploitation of the products of modern science and technology by the U.S.S.R. The air defenses deployed by the U.S. during the 1950's would have reduced the number of casualties the country might have otherwise sustained, but their existence did not substantially modify this picture. Nor could it have been altered by any other defense measures that might have been taken but that for one reason or another were not taken.

From the Soviet point of view the picture is similar but much worse. The military power of the U.S.S.R. has been steadily increasing since it became an atomic power in 1949. Soviet national security, however, has been steadily decreasing. Hypothetically the U.S. could unilaterally decide to destroy the U.S.S.R. and the U.S.S.R. would be absolutely powerless to prevent it. That country could only, at best, seek to wreak revenge through whatever retaliatory capability it might then have left.

Both sides in the arms race are thus confronted by the dilemma of steadily increasing military power and steadily decreasing national security. *It is our considered professional judgment that this dilemma has no technical solution.* If the great powers continue to look for solutions in the area of science and technology only, the result will be to worsen the situation. The clearly predictable course of the arms race is a steady open spiral downward into oblivion.

We are optimistic, on the other hand, that there is a solution to this dilemma. The partial nuclear-test ban, we hope and believe, is truly an important first step toward finding a solution in an area where a solution may exist. A next logical step would be the conclusion of a comprehensive test ban such as that on which the great powers came close to agreement more than once during 10 long years of negotiation in Geneva. The policing and inspection procedures so nearly agreed on in those parleys would set significant precedents and lay the foundations of mutual confidence for proceeding thereafter to actual disarmament.

CHINESE BOMB TEST

(Continued from Page 1)

that all such projects were greatly delayed by the Soviet cutoff of aid to China in 1960.

On the international scene, the test is likely to give the Communist Chinese regime a bigger role in world councils. While the U.S. stands determined that China should not blast its way into the United Nations, the prospects are for greater demands for her participation both in the UN and in disarmament negotiations. In the longer run, China's program may tilt the scales for other countries which have not yet decided to build nuclear weapons: India is reportedly now considering a weapons program. (N.Y. Times, 10/17, 10/22; Wash. Post, 10/25.)

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