The Collected Works of Eugene Paul Wigner

The Collected Works of Eugene Paul Wigner

Part B · Volume VIII

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Eugene Paul Wigner

The Collected Works of Eugene Paul Wigner

Part A

The Scientific Papers

Editor: Arthur Wightman

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Arthur Wightman

Part B

Historical, Philosophical, and Socio-Political Papers

Editor: Jagdish Mehra

Annotated by
Conrad Chester Gérard Emch Jagdish Mehra

The Collected Works of Eugene Paul Wigner

Part A

The Scientific Papers

Volume I
Part I: Eugene Paul Wigner – A Biographical Sketch
Part II: Applied Group Theory 1926–1935
Part III: The Mathematical Papers

Volume II
Nuclear Physics

Volume III
Part I: Particles and Fields
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Part B

Historical, Philosophical, and Socio-Political Papers

Volume VI
Philosophical Reflections and Syntheses

Volume VII
Historical and Biographical Reflections and Syntheses

Volume VIII
Socio-Political Reflections and Civil Defense

The Collected Works of

Eugene Paul Wigner

Part B

Historical, Philosophical, and Socio-Political Papers

Volume VIII

Socio-Political Reflections and Civil Defense

Annotated by Conrad Chester†
Edited by Jagdish Mehra

Springer

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Editors' Preface

The papers have been divided, necessarily somewhat arbitrarily, into two parts

Part A: The Scientific Papers
Part B: Historical, Philosophical, and Socio-Political Papers

Within each part, the papers have been divided by subject, and within each subject printed chronologically. With some exceptions, every scientific paper is reprinted in its original form. One class of exceptions consists of papers that are simply translations into Hungarian from German or English; they are omitted, but listed in the bibliographies. Scientific papers originally in Hungarian have been translated into English. Some of the papers of Volume V/Part III, Articles, Reports, and Memoranda on Nuclear Energy, have been reset and the figures redrawn. The originals were declassified reports, some in nearly illegible shape. Some reports and patents in Volume V/Part III and Part IV are listed by title only. In contrast to the scientific papers where the coverage is essentially complete, in Part B, a selection has been made. We believe it is representative of Wigner's far ranging concerns. The five books in which Wigner was involved as author, co-author, or lecturer are not reprinted in The Collected Works, but are noted in the annotations and bibliographies.

After the publication of Volume I, V, and VI of The Collected Works, Eugene Wigner died (1 January 1995). The heirs of his estate have donated his scientific papers and correspondence to Princeton University where they are available to researchers at

The Eugene P. Wigner Papers
Manuscripts Division
Department of Rare Books and Special Collections
Princeton University Libraries

Springer-Verlag and the co-editors of The Collected Works intend to give to Princeton University for inclusion in this collection, whatever scientific papers are left over after the publication of The Collected Works is complete.

Jagdish Mehra
Arthur S. Wightman

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Wigner on Civil Defense

Annotation by Conrad Chester †*

I. Influences and Background

Wigner's interest in civil defense was influenced in part by his experiences growing up in Central Europe at the time he did. He was a teenager during most of World War I. He was a new Ph.D. working in Germany at the time of the economic crash in Germany in 1929 and saw first-hand the Nazi Party become a major political force in the Reichstag in the German elections of 1930 [1]. In 1929 Wigner was offered a position at Princeton University in the Mathematics and Physics Departments. From 1930 until 1933, he split his time between Princeton and Berlin. In 1933 Adolf Hitler became Reichschancellor and ordered the dismissal of all faculty members of Jewish extraction at all German Universities. From 1933 on, although no longer immersed in the events in Europe, he maintained a lively interest in them through the newspapers and through communications with relatives, friends and colleagues. Wigner had several colleagues among those in the subsequent exodus of scientists from Germany.

Germany's takeover of Austria in March 1938 and Czechoslovakia in October 1938 convinced Wigner that pacifism and appeasement of dictators is (1) futile, and (2) leads to low-cost victories for the dictators.

In his subsequent work he often referred to these events as examples of what happens to nations which do not take adequate care of their defenses or practice unilateral disarmament in the face of an aggressive, power-hungry, or land-hungry neighbor.

In December 1938, Otto Hahn and Lise Meitner were trying to explain the apparent presence of radioactive barium in uranium that had been bombarded by neutrons, the first manifestation of nuclear fission. The influence this development had on Wigner's thinking is well told elsewhere [2].

Wigner was one of the leaders in the development of the atomic bomb. He played an important part in the design of the water-cooled graphite moderated

* Dr. Chester died in 1996 while the text of this volume was in the final stages of preparation. A few small changes have been made in his manuscript; for these the Editors accept responsibility.

reactor, several of which produced the plutonium for the bomb which destroyed Nagasaki.

Wigner was one of the scientists in the Manhattan Project who circulated a petition among their colleagues asking that the first atomic bomb be demonstrated to the Japanese over an uninhabited area rather than on one of their cities. He later came to believe that the decision to bomb Hiroshima and Nagasaki made by President Truman was the right one. An invasion of the Japanese home islands was avoided and with it the deaths of 1.5 million Japanese and 180,000 to 200,000 Americans [3].

At the end of World War II, the Soviet Union pushed the Germans out of Eastern Europe and occupied most of it. Subsequently, communist dictatorships were installed in every Soviet-occupied country with varying amounts of bloodshed from the assassination of potential political opponents.

Discovery of the Nazi death camps at the end of World War II (and subsequent revelation of the Soviet extermination of the Kulaks and the existence of the Gulag Archipelego) provided Wigner with further examples of the undesirability of being subjected to a dictatorship, even if the alternative is nuclear combat. Further disclosure of the massacre of the Polish Officer Corps in the Katyn Forest by Stalin's secret police and of the educated one-quarter of the population of Cambodia by the forces of Pol Pot convinced Wigner of the existence of a uniquely communist penchant for exterminating whole social classes for marginal political advantage. "Better red than dead" may not be a real political option for the elite of a nation facing communist takeover. Unilateral disarmament and preemptive surrender may merely exchange death by blast and radiation sickness in an unprepared nation for death by starvation and mass execution.

After World War II, the U.S. military carried out an evaluation of the effectiveness of strategic bombing. The results generally indicated that the bombing was less effective than believed at the time, sometimes startlingly so. For example, the great firestorm produced in Hamburg in August 1943, killed only 15 % (45,000 of 280,000) of the population inside the storm perimeter. No one was killed in the German "sonnenbunkers", the massive thick-roofed bomb shelters built for civilians in many German cities.

The results of these studies and the experiments then being conducted by the Civil Effects Branch of the Division of Biology and Medicine of the United States Atomic Energy Commission (USAEC) and the Office of Civil Defense were available to Wigner in his capacity as a member of the General Advisory Committee of the AEC.

These experiments, carried out in conjunction with the U.S. nuclear weapon testing program on protective construction and biological effects, convinced Wigner that it is technically feasible to protect civilians from all the prompt effects of nuclear explosions. This can be done at reasonable cost at distances from the point of explosion greater than that at which a blast over-pressure of six atmospheres (100 psi) or less is experienced, a little less than a mile

from a megaton. (Blast over-pressure decreases as the cube of distance from an explosion.) [4]

The predominant event of the early 1960's affecting civil defense was the Berlin Crisis. Khrushchev threatened effectively to turn over the overland routes from West Germany to Berlin to the East German Government, which would have abrogated U.S. access to the city and probably precipitated World War III. It was this crisis over the summer of 1961 that brought interest in civil defense in the U.S. to a peak and led to legislation in 1963 establishing for a few years a strong civil defense research and development program. Following the Berlin Crisis was the Cuban Missile Crisis in the fall of 1962. In early 1963, Wigner was awarded the Nobel Prize for Physics for his contributions to nuclear physics and reactor theory.

In the summer of 1963 an interdisciplinary group of senior scientists was assembled by the National Academy of Sciences at Woods Hole in Massachusetts to reexamine the problem and technical feasibility of civil defense. This meeting was held at the request of Stewart Pitman, then the Assistant Secretary of Defense for Civil Defense under the Kennedy Administration, and the official to whom the Office of Civil Defense reported. Eugene Wigner was chairman of the study called "Project Harbor". The conclusion of this study was that civil defense was practical and affordable and would be very effective in life saving. It was from this point that Wigner's effort in civil defense really began. In 1964, he established the Oak Ridge Civil Defense Research Project at the Oak Ridge National Laboratory which continued with a handful of people supported by the AEC and the Office of Civil Defense and their successors to research civil defense for the next 25 years.

In the fall of 1963, the U.S. and USSR signed the atmospheric test ban treaty, the first step in a process that led to detente and then *Glasnost.*

II. Themes

At least a dozen themes can be identified in Wigner's writing and speaking on civil defense, to which he returns repeatedly.

These include:

1. The potential and demonstrated effectiveness of civil defense.
2. The acceptability of costs of a blast shelter system.
3. The non-threatening nature of blast shelter systems.
4. Soviet Civil Defense System and its effectiveness.
5. Immorality of Mutual Assured Destruction (MAD).
6. Nuclear blackmail.
7. Arguments and inferred motivation of opposition (principally from intellectuals) to civil defense.
8. Use of education to strengthen and build support for civil defense.
9. Ballistic missile defense.
10. Societal destruction without nuclear weapons.

11. The price of dictatorship: Living in an Ant Society.
12. The goal of an open and peaceful world.

1. Effectiveness of Civil Defense

There is little argument that civil defense measures can save lives. This was observed experimentally in World War II in conventional bombing of cities [5]. Shelters that will protect their occupants against overpressures as high as six atmospheres (100 psi) are relatively inexpensive to design and build. "If blast shelters of 100 psi pressure resistance are provided to the inhabitants of the cities, then it begins not to be worthwhile anymore to attack the cities even if one's purpose is to destroy the people because shelters render the attack ineffective. At least as far as the population is concerned" [6]. "... if the city people are provided with blast shelters and others with fallout shelters the total population loss would be below 20 %." To provide such shelter would cost around $20 billion (in 1964 dollars). Fallout protection can be provided for the population, which is not in target areas, at the cost of identifying and surveying it in existing masonry buildings [7]. At this time Wigner advocated the so called "tunnel-grid systems", which was an inter-connected grid of eight-foot-diameter tunnels to be built underneath target cities. They would permit movement out of the high population density areas to the outskirts of the city. It obviates the problem of entrances and air intakes of being blocked by rubble, and the problems of air intakes in a fire storm area by simply moving the occupants out of those areas. The Chinese have constructed systems like this under several of their larger cities. After about 1966, the efficacy of shelters in saving lives was no longer debated [8, 9].

A civil defense measure that is even more effective than blast shelters in saving lives is evacuation [10]. It is provocative if only one side has evacuation capability because once in that posture the evacuated side is much less vulnerable and can threaten to attack the other side more credibly. It is for this reason that in early work in civil defense, evacuation as a strategy was opposed by even civil defense advocates [5].

If the Soviet Union evacuated before an attack directed at their evacuated population, their casualties would be only five to ten million people, less than half the loss in World War II. In a more realistic situation in which the evacuated population would not be targeted, casualties would be very small.

Evacuation has another advantage: it is vastly cheaper than blast shelter construction. It is for this reason that Wigner recommends the development of evacuation plans for the U.S., which he prefers to call a counter evacuation capability [11, 12]. Blast shelter costs are competitive at the margin with the estimated incremental costs of the Soviet SS9 ICBM for target populations of density higher than 25,000 people per square mile [13]. One set of assumptions and calculations lead to a result that the survival of U.S. population can be increased from 35 % to 90 % with the expenditure of $15 billion in shelter construction. Wigner's view of the situation was well expressed in his 1976

testimony before the Joint Committee on Defense Production U.S. Congress: "This writer became convinced of the possible effectiveness of civil defense measures when he served as a member of the General Advisory Committee to the Atomic Energy Commission. The committee met four of five times a year and was briefed at almost every meeting on the progress of nuclear weapons development and on the effectiveness of these weapons. These briefings convinced me of the fact so aptly stated by V. Chuykov: 'although the discussed means of destruction (nuclear weapons) are called mass means, with knowledge and skillful use of modern protective measures they will not destroy masses of people, but only those who neglect the study, mastery, and use of these measures.' Indeed an easy calculation shows that if the USSR carries out its city evacuation plans the total number of casualties that all the nuclear weapons in our missiles could cause would be a good deal less than one-half the losses they suffered in World War II. A reasonable estimate based on the Oak Ridge test of a blast resistant 'expedient shelter', described in the USSR civil defense handbooks, gives for the loss which our missile carried nuclear weapons could cause about 3 % of the USSR population."

"What is our own situation? According to the published part of the Ponast II study, the missiles of the USSR could inflict in the present situation a population loss of 45 %. An evacuation plan similar to that of the USSR would reduce that loss to about 11 %. Its cost is estimated by Ponast II as $1.2 billion ..., still according to the Ponast II study a blast resistant shelter system similar to that of China would reduce the number of people exposed to mortal danger to about five and one-half percent – would cost around $35 billion" [14, 15, 16, 3, 17].

2. Shelter Affordability

Shelter cost is a very important variable in the design of shelter systems and civil defense programs. Because so many people have to be sheltered, the cost of a shelter system rivals that of major weapon systems and is used by opponents of civil defense as one of the arguments against building shelter systems. Based on the work done by the Harbor Study in 1963, Wigner estimated that a blast shelter program complementing a low-cost fallout shelter program would cost about $22 billion at that time. It was several percent of the GNP at the time. Wigner makes the point that we could afford to spend that kind of money spread out over several years without difficulty. We have done it for other programs. The effect of such a shelter system would be to reduce fatalities in an anti-population attack from a very high level down to about 20 %. Fallout shelter, which is needed by everyone outside of the urban industrial areas, can be had for essentially no money: either obtaining space in existing masonry buildings or it can be incorporated in new construction at little to no cost by proper selection of building materials and design [6, 7, 8].

One of the objections to civil defense shelter systems is that the enemy can destroy them more cheaply than it costs to build them. Wigner and his

colleagues at The Little Harbor study compared the cost of a blast shelter with the cost of a weapon to overcome its protection [13]. "This report presents the conclusions of a committee of the National Academy of Sciences which was convened to study the effectiveness of various civil defense measures. It estimates the cost of a blast shelter with 100 psi blast resistance as $300 per shelter space. It also estimates how much our government spends for missiles with various explosive powers. Since it has been variously claimed that the Soviets can produce their most powerful missile, the SS9, at a lower price than the U.S. spends for its missiles, we should use for the cost of the USSR missile less than half of what our own cost would indicate. We assume an SS9 exploded over our country costs $35 to $40 million to the USSR (we pay about $50 million for a weapon with half the power). This will render our conclusions most conservative."

"An SS9, if airburst, may cover an area of seven to nine square miles with 100 psi over-pressure. In case of a ground burst (to produce fallout also) the area becomes five to six and one-half square miles. For $35 to $40 million one can build 100 psi shelters for 115 to 135 thousand people. If the five to nine square miles in question contains more than about 125,000 people the defense is more expensive than the offensive power necessary to overcome it otherwise it is cheaper. Only about 15 million of our people live in areas with a population density exceeding this. Thus, even if one uses our adverse cost estimates one must conclude that only for a small part of our urban population (of about 75 million) (figures for 1970) does the cost of protection equal the cost of overcoming the protection [18, 13, 19]."

In hearings before the Joint Committee on Defense Production 1976, the estimated cost of a interconnected tunnel shelter system similar to that built by the Chinese was estimated at around $35 billion. It was pointed out that Swiss civil defense has been investing in such a shelter system and is spending 15 times more money per capita than we are and has been keeping it up for many years. The point is made that if China can afford an underground tunnel system, then a nation as rich as the U.S. should be able to afford one also [16].

3. The Non-provocative Nature of Civil Defense by Blast Shelter

The basic tenet of the U.S. strategic policy of mutual assured destruction, and the 1972 ABM treaty, is that each side's civilian population would not be protected. The corollary of this is that construction of a civil defense capability would indicate preparations for going to war and would, therefore, be considered provocative by the side without civil defense capability. Wigner disagrees with this viewpoint as he disagrees with the concept of keeping the population undefended.

His first point is that no civil defense is 100 % effective. Reducing the potential fatalities in the U.S. from several tens of millions to "only" a few million is not going to produce any detectable increase in the willingness of U.S. leadership to go to war. Wigner believed that the U.S. leadership is not reckless [20].

U.S. leaders are also constrained democratically by an electorate that usually has too much good sense to go lightly to war.

Wigner argues that civil defense reduces the magnitude of the threat of nuclear war. It reduces the sensitivity of a disarmament agreement to cheating and should make it easier to achieve a disarmament agreement. Both of these should lead to a more relaxed international environment.

In 1969, the Soviet Union's plan for evacuating their cities in nuclear confrontation was publicly disclosed [21]. Wigner recognized that this evacuation severely upset the strategic balance if one side had the time to carry out an evacuation. It was stoutly maintained by the Soviet Union including the premier at the time, Alexi Kosygn, that their evacuation plan threatened no one; it was purely defensive and, therefore, should not be provocative. Wigner applauded the implementation of a good civil defense program by the Soviet Union as an example for the U.S. to follow. He believed that this would lead to a more relaxed international climate if the degree of damage each side was capable of inflicting on the other was reduced [22].

To the argument that constructing a civil defense program, particularly blast shelters, would cause the other side to increase their number of strategic missiles to neutralize the blast shelter program, he quotes the cost ratio calculation done in the Little Harbor Study which showed for most of the population the cost exchange ratio favored the defense. More importantly, when the Soviets deployed their civil defense program we actually reduced our ability to kill population by putting multiple warheads on our missiles and freezing their number. When we did not deploy a civil defense program the Soviets went ahead and increased their missile strength dramatically anyway [3].

4. Soviet Civil Defense

The Soviet Union has had a large and vigorous civil defense program since World War II when they experienced direct bombing and shelling of civilian residential areas in cities. During the war they improvised reinforced basements and after the war continued to construct new buildings with very heavy floor slabs over the basements. Their subway tunnels were designed with blast doors and buried very deeply beneath the surface to be resistant to conventional high explosive bombs and artillery shells. When the United States had its monopoly on nuclear weapons, the official Soviet policy was that they could protect their population against nuclear weapons with shelters [23]. The subject of Soviet civil defense was well aired in Project Harbor in 1963 [24]. Wigner was well aware of this development [8].

In the Soviet Civil Defense Manual published in 1969, the Soviet Union publicly described their new city evacuation plan [21]. In this plan all non-essential personnel would be evacuated from cities at the outset of a crisis and the workers would commute back into the city for 12-hour shifts to maintain essential services and essential production, especially military. The workers and duty in the target area would be provided with high-quality blast shelter.

The boldness and probable effectiveness of the Soviet plan got the attention of Eugene Wigner and other students of the Soviet Union in this country. Wigner discusses the Soviet's civil defense program in more than half of the papers that he has written on civil defense. In 1970, he wrote his most quoted paper, "The Myth of Assured Destruction". In this paper Wigner did a very unrealistic but outrageously conservative, or pessimistic from the Soviet standpoint, calculation of the casualties that could be inflicted by the U.S. strategic forces against a population which had been moved out of a city and dispersed to a distance of 50 kilometers. A very conservative calculation indicates that the U.S. forces might inflict five million casualties on the Soviets [11].

Wigner then proposed that the U.S. adopt a counter evacuation strategy [12]. Soviet losses are estimated with varying assumptions in several papers [25, 26, 16, 3, 27]. Wigner frequently recites Marshal Chuykov's famous comment in his book, "Our Common Task" (quoted above) that weapons of mass destruction are effective only against the ignorant and unprepared. Wigner keeps coming back to the danger of blackmail from the Soviet evacuation plan and the motives behind the plan. However, in one paper [28] he acknowledges that the motivation in going to an evacuation plan may have been simply that it is so much cheaper than trying to build blast shelters for the entire population. Other descriptions of the plan are in [29, 28, 30].

5. The Immorality of MAD

Mutual Assured Destruction is the name given to the U.S. strategy adopted in the late 1960s. By this time the U.S. and the Soviet Union each possessed overwhelming capability for destroying each other's societies. The U.S. possessed little or no capability to protect its industry and population. This strategy, aptly given the acronym MAD made hostages of the citizens of each country for the good behavior of that country's government. Given the technology available, there was little else the U.S. could do once it had signed the 1963 ballistic missile defense treaty, and had failed to make the necessary investment in civil defense.

It puts the whole weight of peace keeping on deterrence and requires that each side countenance the loss of tens of millions of its citizens should deterrence fail.

As early as 1967 Wigner noted "the image of the U.S. abroad will suffer badly if it relies solely on 'retaliation'". As compared with defense, retaliation is a cruel and unjust policy, punishing innocent people rather than the guilty government. The callousness' of the attitude is sure to be exposed by opponents' propaganda" [8]. In an address before the CDC in 1973 Wigner said, "the ... reason for my devotion to civil defense is, I believe shared by most people. It is the abhorrence of the doctrine of Assured Mutual Destruction (sic). A world in which nations can destroy each other and are deterred from such destruction only by the fear of their own destruction is not a world of peace" [9].

Wigner also questioned the workability of Mutual Assured Destruction. "... I believe that the so called Mutual Assured Destruction is nonsense, because

suppose even if the attacked nation could retaliate, if the other nation pretends that it does not believe it and makes a demand, is there any point in resisting? What good does it do if it can destroy hundreds of thousands of the aggressors' lives if its own nation is exterminated" [31]?

Another aspect of mutual assured destruction is that it requires an adversary that (1) is rational, (2) wants to live. This might not be the case for religious fundamentalists led by an unbalanced leader.

6. Nuclear Blackmail

Wigner's experience observing the fall of Czechoslovakia and Austria to the Nazis prior to World War II and most of Central Europe to the communists after World War II made him very sensitive to political or military blackmail; that is, using the threat of force to coerce a weaker party into some action inimical to its own interests. Wigner foresaw the proliferation of nuclear weapons and saw the reduction of U.S. vulnerability by civil defense as contributing to world stability [24]. Wigner was frightened of the Russian evacuation plan when it was first announced. He believed that it could only be deployed by someone who was planning an aggression, but it did put its user in a very superior bargaining position against a side that had no such capability. The calculation that Wigner did in his paper "The Myth of Assured Destruction" [11] indicated the advantage the Soviets would have in a confrontation with the U.S. when we did not have an evacuation plan. Soviet casualties could be as low as five and one-half million, about a quarter of what they lost in World War II [11]. Wigner often makes the point that it is immoral to dangle such a tempting attraction as the possibility of nuclear blackmail in front of a dictator. Wigner says, "Can a president of the United States bargain with this deterrent (five and one-half million Russians killed) against the threat of a first strike which can kill 80 million Americans?"

This scenario, confrontation with the Soviet citizens evacuated and the U.S. not evacuated is a recurring concern for Wigner [12, 25, 9, 28, 16, 27]. Wigner feared that such a scenario would be followed by a demand that would severely injure the country, such as "dismantle the Air Force".

The present U.S. posture is to depend on a spontaneous evacuation of target areas by the population in their own automobiles. It would not be as complete or well controlled, or be able to last as long, as a planned counter-evacuation; but it still would have the possibility of saving many lives.

Perhaps the most important function a civil defense program can perform in maintaining the peace is removing the temptation of any foreign aggressor to attempt to blackmail the U.S. by threatening a nuclear attack [12]. The possession of an effective civil defense capability by the U.S. could very substantially reduce the credibility of the threat and the temptation to make it in the first place. In a crisis, if the U.S. had a blast shelter system, political pressure on the president for fast action would be greatly reduced and might substantially assist the resolution of the crisis [17].

7. Opposition to Civil Defense

Wigner always found perplexing and distressing the emotional opposition on the part of otherwise intelligent liberal intellectuals to civil defense programs. He refers to this problem in over half of his papers on civil defense. He will summarize their argument and then refute it. For example, he mentions the argument that economic recovery is impossible from a nuclear war and then cites the example of East Germany and Hungary that recovered from World War II, even though their housing and industry were almost completely destroyed and they were occupied by a plundering conqueror [20]. Wigner is critical in several cases of opponents of civil defense because they do not consider the alternative to rejecting civil defense, they simply find it unacceptable. Wigner believes the reason for the opposition may be a fear on the part of the intellectuals that widespread involvement of the general population in defense which might co-opt it into approving foreign policy adventures, i.e. wars [3]. It is also possible that the perception of nuclear weapons has convinced the world's general public and leadership that nuclear war is so destructive that it is completely impossible. Civil defense may trigger such an emotional response because it tends to contradict the perception of an all-destroying nuclear war. This leads to the contradiction that, (1) civil defense is ineffective, and (2) it will make national leaders reckless in contemplating a more daring foreign policy.

Wigner believed that nuclear war is survivable and that based on the experience of Japan and Germany, recovery (at least in the U.S.), would surely follow cessation of the fighting. He also believed that total destruction is not a unique experience to the twentieth century as shown by his frequent citing of the 30 Years' War in Europe, which though it decimated the population, ultimately, was settled and recovery followed. A nuclear war is not needed to destroy an economy. Forty years of communism can do it. So can the economic policies of some third world nations.

Curiously, many of the most violent opponents of civil defense are highly in favor of mutual assured destruction. There is no evidence in any of Wigner's writings that he has put the question to these same opponents of civil defense on how they would deal with a nuclear-armed leader who is also a fundamentalist religious fanatic. In 1996, that seemed a much more likely problem than facing an overwhelming strategic force like that of the Soviet Union.

8. Use of Grade School Education

Wigner long advocated educating the American people in weapons effects and protective measures. In recent years he has put more emphasis on teaching children in grade school similar to that done by the Soviet Union [31].

Wigner proposed teaching a cadre of approximately 150 "trainers of trainers" that would go around and teach two or three instructors at each high shool [27].

Wigner believed that students would be more open minded about instruction on nuclear war than some of their instructors might be. He did not confront

the difficulty of dealing with 50 separate state boards of education in order to get his program implemented into the curriculum.

9. Active Defense (ABM)

Active defense here means the deployment or use of anti-ballistic missiles against an attackers' offensive warheads. Wigner has very little to say about this subject other than it would be nice to have, but it is the subject of his most sophisticated paper on the whole subject of defense [33]. This paper, with C.M. Haaland, demonstrated that it is possible to calculate optimum assignments of attacking warheads and interceptors to cities for both the offense and the defense. This calculation assumed limits on the number of interceptors available that were comparable to the total number of warheads attacking. This would be the case if the interceptor missiles had to have nuclear warheads. Modern technology developed by the Strategic Defense Initiative offers the possibility of interceptor missiles that are not nuclear and can be made in much larger numbers than attacking nuclear warheads. This eliminates the attacker's option of penetrating by exhaustion, the basis of Wigner's ABM paper.

Wigner always regarded the ABM as subject to a "technological chess game". Given a choice between active and passive defense, Wigner always said that he would prefer passive defense. Cost-effectiveness analyses always showed that the first investment in defense should be in passive or civil defense.

10. Destruction of Civilization without Nuclear Weapons

Wigner points out in several of his papers [34, 7, 31, 35] that the destruction of societies, civilizations, and whole peoples has occurred repeatedly in history long before the advent of nuclear weapons. The example that Wigner refers to in several of his papers is the 30 Year's War in what is now Germany. Over the time period of 1618 to 1648 the population of this area was reduced by one-half to two-thirds. Repeated plundering of the indigenous farming society by armies marching back and forth over the area made the survival of the farmers very difficult. It is probable that the proximate cause of most of the casualties was not the primitive weapons of the time but combinations of starvation, hypothermia and sickness.

By attempting to put nuclear population losses in perspective Wigner was taking a risk that opponents of civil defense would use his model of the 30 Years War in Germany as an example of the conditions that could follow a war.

11. The Price of Dictatorship: Living in an Ant Society

Wigner speculated on the consequences of surrender following a failure to maintain adequate defenses. He did not say so, but his models were China under Mao-Tse Dung, and the Soviet Union under Brezhnev, "... it is sure that if a single dictator acquired power over the whole globe, the world would develop

into an ant heap in which everybody would be told what he has to undertake perhaps even whom he should marry" [31].

Wigner did not believe that life under dictatorship would necessarily be worse than enduring a nuclear war. His repeated position was that we would have to endure neither if we maintain adequate defenses.

"However, surely, if the dictatorship ruled the world it would be disastrous from the point of view of human values which are dear to us. An ant society would result, a degradation of human life and initiative, much worse than any now existing, even under dictatorships. We are, and should be, willing to pay a very high price to avoid this" [9].

12. The Goal of Peaceful Open World

Wigner wrote of the goal of a pluralistic democratic world on several occasions starting with his earliest papers including the one on arms control [34]. "The true objective is a world in which everyone can breathe freely, in which no nation is worried lest it be confronted with a surprise attack tomorrow and in which human dignity is respected." A little later he says, "A world in which one can travel freely, in which there are no secrets, (and) in which one can communicate with one's fellow men everywhere, such a world is a better world toward which we can strive with true enthusiasm." This is reasonable approximation of *Glasnost*.

Part of this vision is that rulers not be tempted to try and increase their domains and enhance the extent of their power [16]. On more than one occasion Wigner suggested that governments should compete with each other on the basis of the well-being of their people rather than on the basis of power [27].

III. Achievements and Consequences of Wigner's Effort

An outside observer could conclude that Wigner's lifetime effort in civil defense was a failure. There are no large federal programs in civil defense (the budget remains a few hundredths of a percent of the Department of Defense budget), and no blast shelter program in the United States. The most important accomplishment by the Oak Ridge Civil Defense Research Project that can be cited is the publication of "Nuclear War Survival Skills", by Cresson Kearny in 1979 [36]. This result of experimental work demonstrated that in a crisis, effective blast and fallout protection for civilians could be improvised in a few days by their own efforts in the absence of a permanent blast shelter program. This publication consists of the instructions.

The discovery, translation, and publication by the Oak Ridge Project of the Soviet Civil Defense Manuals [21] showed that the Soviet Union was adopting an evacuation program to protect their civilians. This led to the adoption of an evacuation program for U.S. Civil Defense, initially called "Crisis Relocation Planning". Wigner preferred to refer to the U.S. program as a "counter-evacuation" program that would only be implemented in the face of a Soviet

evacuation. It was recognized after the Three Mile Island nuclear accident that a very substantial number (of the order of 50%) of the civilian population would evacuate spontaneously without government direction in a severe crisis. The present civil defense program has been modified to take advantage of this.

Some could argue that the most that could be claimed for Wigner's accomplishments in civil defense was that the helped keep a low-level civil defense program (run now by the Federal Emergency Management Agency) alive in the U.S. for 25 years. This would understate the case. The real accomplishment is that Wigner kept before the public the civil defense alternative to the unilateral disarmament and preemptive surrender advocated by many in the academic and media communities: "better red than dead." It could also be argued that, by maintaining an effective resistance to expansionism of the Soviet Union, the U.S. (principally strategic forces) helped to end the Cold War on terms which are quite similar to Wigner's vision of a world of democratic governments whose principal concerns are the well-being of their citizens.

However, history has not "come to an end". The world has an ample supply of ruthless and ambitious demagogues and would-be dictators who could become the Hitler or Stalin of tomorrow, or the next Khomeni, Kaddaffi, or Pol Pot in the third world. The technology of ballistic missiles, nuclear explosives, and chemical and biological weapons continues to develop and diffuse. Extortion or nuclear blackmail attempts by a certifiably unbalanced leader could be quite possible in the future. One technological option for dealing with this threat is to reduce the vulnerability of our population to the threat by one or two orders of magnitude by the passive defense techniques advocated by Wigner.

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PART I

Exploring the Technology 1960–1964

In this period, Wigner was still learning about the technology and economics of civil defense. His experience as the chairman of Project Harbor and Director of the Oak Ridge Civil Defense Research Project put him in a position to speak and write authoritatively on the subject.

Fallout: Criticism of a Criticism

E. P. Wigner

Bulletin of the Atomic Scientits *16*, No. 3, 107–108 (1960)

Problems Presented by Radioactive Fallout, *a statement by the General Advisory Committee to the U.S. Atomic Energy Commission, was published in the June 1959 issue of the* Bulletin. *Ralph Lapp's criticism of the GAC report was published in the September 1959 issue. Eugene P. Wigner, who replies below to Dr. Lapp, is professor of mathematical physics at Palmer Physical Laboratory, Princeton University, and consultant to the GAC.*

SINCE I collaborated with the General Advisory Committee (GAC) to the U.S. Atomic Energy Commission on their statement concerning the dangers of radioactive fallout, which is the subject of Dr. Lapp's criticism, I wish to answer this criticism. Clearly, the responsibility for the following statement rests on me alone.

The report of the GAC contains about 1,000 words, but Dr. Lapp's criticism is confined to two sections of the report (Sections 5 and 6). In addition, he complains that the report is not documented. Apparently, this has caused a great deal of extra work for him. I am sorry that this was the case. However, the report was made not to the scientific community, but to the public. It was phrased in language which we believed anyone can follow without devoting a great deal of study to the problem. Documented, technical details would have confused most readers more than they would have enlightened them. If Dr. Lapp wanted to check some of the original papers and reviews on which our report was based, the GAC (or I) would have been pleased to provide him with the references which he needed. This may be a good opportunity to draw attention to the Report of the United Nations Scientific Committee on the Effects of Atomic Radiation (Thirteenth Session, Supplement 17), which contains a review of the problem written in clear and, as far as possible, nontechnical language. The information contained in this document, though far from complete, should enable the reader to judge the problem of fallout independently.

As mentioned before, Dr. Lapp criticizes only two passages of the report, and the following lines will deal only with these two sections. The first of these sections deals with external radiation, which is held responsible for most of the genetic damage, the second one with the internal radioactivity, due mainly to strontium-90, which is held responsible for shortening the life-span of the present generation by causing bone cancer and leukemia. However, Dr. Lapp's statement that these two sections constitute "the heart of the GAC report" should not remain unchallenged. Section 4, the one preceding the section quoted by Dr. Lapp, and without which this latter section is difficult to understand, reads:

> (4) The present state of knowledge does not permit a full evaluation of the biological effects of fallout. However, in order to place the hazard of fallout in proper perspective, it should be pointed out that the amount of total body external radiation resulting from fallout to date, together with future fallout in any part of the world from previous weapon tests, is:

(*a*) less than 5 per cent as much as the average exposure to cosmic rays and other background radiation.

(*b*) less than 5 per cent of the estimated average radiation exposure of the American public to X-rays for medical purposes.

As far as genetic damage is concerned, this means that any deterioration of the human race, caused by cosmic radiation and other not-man-made radiation, is somewhat accelerated by fallout. The degeneration which, as a result of these natural causes, would take 100 years, now takes place in 95 years. Since the degeneration of the race has been going on since man was created, an increase of the tempo of this degeneration by 5 per cent may not be so alarming. Actually, it is clear that the fallout increases the degeneration rate in the U.S. (if any), much less than do the medical X-rays. Is it fair to say that these facts are not as close to the heart of the matter as those quoted by Dr. Lapp?

Section 5, which Dr. Lapp criticizes, is still concerned with external radiation. It points out that "human beings have lived for many generations in parts of the world which have five times or more the background radiation normal to the United States, or more than one hundred times the average amount of radiation from fallout in the United States." Dr. Lapp quotes the testimony of Dr. Shields Warren in Congress, which shows that the GAC statement is conservative: the numbers should be "between 5 and 20" rather than 5 or more, leading to a natural radiation level which is up to 400 times higher than the radiation level due to fallout. This means that the aforementioned genetic damage, if it exists, takes place at these localities in a period of 5 to 20 years (100/20 to 100/5). Dr. Lapp admits that, so far, no adverse effect of the increased radiation at these places has been observed. Most of us would think that if an increase of 1,900 per cent, or even only of 400 per cent as quoted by the GAC, of the radiation level does not lead to obvious damage, an increase of 5 per cent should be tolerable. Dr. Lapp seems to feel that the preceding facts should not be mentioned because so far "no studies of the biological effect of this abnormally high background radiation have been made." Since no study is absolutely convincing or closes all loopholes, it is not clear at what point Dr. Lapp wishes to consent to the data in question being discussed.

The second part of the GAC report which Dr. Lapp criticizes, section 6, deals with the effects of internal radiation:

(6) In regard to internal effects of strontium-90 due to ingestion, the amount of strontium-90 which has been found in food and water is less of a hazard than the amount of radium normally present in public drinking water supply in certain places in the United States, and in public use for many decades.

Dr. Lapp questions the calculation which underlies this statement and presents his own calculation. This contains, however, two significant errors. Since it is neither necessary nor worth while to quibble about minor factors, I will accept his comparison of the radiation doses. These he gives as 2.5 rads from the radium at the aforementioned places in the U.S., and as 2 rads from the fallout strontium. Thus the radiation dose due to radium is higher than the dose due to fallout strontium. Furthermore, these radiation doses should be multiplied by their radiobiological effectiveness, which has been variously estimated as being between 2 to 100 times greater for radium than for strontium.[1] ("The present state of knowledge does not

[1] Hindmarsh, Owen, Vaughan, Lamerton, and Spiers, *British Journal of Radiology*, 31, (1958), 518. "It would seem more reasonable to take a value of between 50 and 100, rather than the value of 10 used up till now."

permit a full evaluation of the biological effects of fallout.") The value given by the aforementioned report of the United Nations Scientific Committee is 10. If this figure is adopted, the danger due to radium in the aforementioned localities is $2.5 \times 10/2 = 12.5$ times greater than the danger due to strontium fallout. Even the smallest ratio (2) of radiobiological effectiveness *gives a comfortable margin for the correctness of the General Advisory Committee statement*. Dr. Lapp disregards the difference in the radiobiological effectiveness of the two radiations and introduces another factor in the opposite direction. However, as a result of this factor, his comparison applies to the "maximum probable radiation level" from fallout on the one hand, and the average radiation level from radium, on the other. I submit that such a comparison is not what our statement referred to. We compared the *average hazard* (not radiation dose) from radium, to a person in the localities mentioned, with the average hazard from fallout strontium to a person in the U.S. Actually, it suffices to eliminate one of the errors in order to see the validity of the GAC statement.

It may be of some interest to quote from Dr. Dunham's report:[2]

> Bearing these dose estimates in mind one can on the basis of one current theory[3] estimate a maximum number of additional cases of bone cancer per year in this country during the next 70 years of from 50 to 100, and for leukemia it might be as much as double that figure. Of course, there may be no additional cases at all, as the U.N. Scientific Committee was so careful to point out. Genetic effects during the next thirty years would average not more than 20 persons born each year with tangible genetic defects, and several times that number with lesser genetic effects, stillbirths and the like. In this country there would occur then not more than 500 greater or lesser tragedies of this nature including bone cancer and leukemia.

It goes without saying that every hazard to the life of man which can be removed without creating a greater hazard should be removed, and the section of the GAC statement which I consider the heart of it deals with just this question. Nevertheless, if one compares the preceding figures with the number of deaths from homicide in the U.S., which is about 8,500 per year (*not to mention a great number of other preventable causes*), one is indeed wondering why attention became so sharply focussed on the danger from radioactive fallout.[4]

One of the unfortunate consequences of the propaganda is that the question of the fallout danger has largely been removed from the area of dispassionate scientific study. This statement is not directed against Dr. Lapp, whose articles show an effort on his part to be objective. This writer is well aware that, as a result of the present justification of the GAC statement, he will be branded as a person who "wishes to continue testing." Actually, this is incorrect: it happens to be the opinion of this writer that it would be in the best interests of this country to discontinue testing if proper international safeguards can be established. However, this opinion is not based on the dangers from fallout.

[2] C. L. Dunham, *Radioactive Fallout—a Two-Year Summary Report*, TID-5550 issued by the Technical Information Service of the U.S. Atomic Energy Commission, page 9.

[3] The most pessimistic theory which became, as a result of the experiments of the Drs. Russell and their collaborators, quite unlikely. For somatic effects, see Robin H. Mole's article, *British Medical Bulletin*, 14, 174 (1958). I am indebted to Drs. A. Upton and W. S. Snyder of Oak Ridge National Laboratories for this quotation.

[4] This means that a 10 per cent reduction of the homicide rate would certainly save about twice more lives than are *perhaps* lost due to the effects of weapons testing. Other preventable causes of death cause even larger losses of life.

Recall the Ends – While Pondering Means

E. P. Wigner

Bulletin of the Atomic Scientists *17*, No. 3, 82–85 (March 1961)

AS A RESULT of a variety of studies, conducted mainly in the United States, there is a substantial body of literature on arms control. The general impression one receives from a study of the available literature can be summarized in a short sentence: the problem is very difficult. This applies particularly to the physical methods of inspection, and one cannot escape the impression that a good deal of wishful thinking has entered the articles on this subject. The nonphysical inspection techniques discussed by Jay Orear (see page 107) appear more promising, but even these show, on closer inspection, very serious gaps. In order to obtain a fair estimate of the difficulties of physical inspection, one has only to read the papers of the proponents of nonphysical inspection; the difficulties of the latter method are aptly analyzed in the papers on physical inspection. Also, present efforts are directed solely toward the elimination of weapons which are now known—they will not prevent the discovery of new, possibly even more dangerous weapons. Every such discovery will necessitate a new effort—probably just as difficult as the present one—toward new measures of control.

The ways in which an unsympathetic but self-reliant population can thwart inspection are too many to recount. But the very idea of a nonphysical inspection presupposes some rapport between control organs and at least some of the population. It is most questionable that such rapport could be established by as superficial means as monetary rewards. As to "guaranteed sanctuaries," there were too many violations of such promises; no circumspect person would take them at face value. These points are too self-evident to have escaped anyone who has made a detailed study of the question of arms control *without mutual confidence*. More subtle are two other points, because they contain hidden assumptions. The first of these assumptions is that there is no real temptation to conceal armaments; because of the nuclear stalemate, armaments are useless and their use would entail such severe losses that even the victor would suffer more than his gains are worth. This last statement is true only in the present state, when both parties are heavily armed. The same measures of disarmament which would increase the safety of every nation, also would tempt each to evade the measures of disarmament. In a disarmed world, armaments are of very great value. As a result, it is most doubtful that an agreement on disarmament can be devised which it would be in the interest of both parties to observe.[1]

The second hidden assumption is that a reasonable

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[1] It is often claimed that the U.S. has no "interest" in attaining military ascendancy over Russia and conversely, the USSR has no "interest" in a military ascendancy over the U.S. This argument, if taken seriously, makes it necessary to analyze the concept of "interest." What we call our interest is the fulfilment of our ambitions. The argument therefore amounts to the assertion that the government of the USSR, for instance, has no desire to assume military superiority over the U.S. It would be irresponsible to base the future of the independence of one's country on as delicate a psychological judgment as the assertion implies. Furthermore, no matter how much we trust the present rulers of the Soviet Union, in particular Premier Khrushchev, the motives and desires of his successors are surely unpredictable. This point has been emphasized by Dr. Leo Szilard.

It is of some interest to note that the proponents of unilateral disarmament do not share the belief that the USSR has no "interest" in subjugating the U.S. "We know perfectly well that the consequences of such radical action—unilateral disarmament—include invasion, conquest and tyranny." This opinion is not quoted to oppose unilateral disarmament, but to show that at least some who consider themselves to be highly moral have a different evaluation of the "interests" of nations than those who subscribe to the thesis that the rulers of the different nations have no desire to extend their realm.

probability of detection would deter nations from violations of the disarmament agreements. In the present state of the world, there is no reason to believe this. The only "penalty" envisaged in the case of a violation is that the other side of the disarmament agreement would abrogate the treaty. This is no serious penalty since it would, at worst, restore the pre-treaty situation. It would do even less, because the abrogating nation would have to act on the basis of suspicions only—thus incurring the disapproval of the rest of the world—and because the violator may have gained military ascendancy by the time the abrogation took effect. It follows that the temptation to violate the disarmament agreement would remain great.

In no disarmament control system which has been proposed to date can the violation be proved absolutely: it must be inferred from a number of minor indications. In Dr. Orear's system, these indications include the microscopic shift of the flap of an envelope; the fact that someone happened to turn up around the corner when the control organ's agent mailed his letter. Even the fact of these indications can be flatly denied by the violator, and even those who will accept the reality of the shift in the flap of the envelope (or the spying on the control agent) may not consider that these circumstances constitute adequate reasons for abrogating a treaty on disarmament. The abrogator will become unpopular throughout the world. A democracy will find it difficult to convince a sufficient majority even of its own public opinion that abrogation was necessary. Abrogation undertaken on the basis of suspicion would divide the country. At any rate, from the point of view of the violating nation, the abrogation would not be a serious calamity. It would merely restore the pre-treaty condition with some added propaganda advantage. Even this may be a too pessimistic appraisal from the point of view of the violator. By the time of the abrogation of the treaty, and by the time the rearmament of the opponent becomes appreciable, the violator may have secured his military ascendancy.

Past Disarmaments

Past history indicates the difficulties implicit in disarmament attempts. The attempt to limit the armaments of Germany, as provided in the Versailles treaty, indicates some of these difficulties. Germany eluded the disarmament clauses of the Versailles treaty, originally by the formation of the "schwarze Reichswehr" and otherwise.[2] This was done in the early days of the Weimar Republic, that is, under a government which surely had peaceful intentions. It was possible for a defeated nation to create a secret army. And although the signatories of the Versailles Treaty surely suspected the existence of this paramilitary organization, they could not formulate and prove their suspicions clearly enough to intercede.

[2] I am much indebted to Prof. H. J. Gordon of the State University of Massachusetts for a review of the literature on the "schwarze Reichswehr."

Return to Fundamentals

It may be argued that the paramilitary organizations in Germany did not constitute a truly significant military power. Still, an organization of a similar size, equipped with modern weapons, would constitute a decisive force *in a disarmed world*. Thus, all that we suspected as likely to happen under an uncareful program of disarmament, did happen, furthermore, in a defeated country which was, militarily, at the mercy of its opponents.

If arms control in an atmosphere of tension is so difficult as a first step, it behooves us to investigate its relation to our ultimate objectives. Our true objective is a peaceful world, as much as possible free of tensions, in which all mankind can prosper and progress. Clearly, disarmament may be at best a first step toward this objective; it is not the objective itself. It is not even clear whether it is the most effective step: if the tension remains and hostilities break out, it will be a meager comfort that atomic weapons will be used only after a few months, rather than at once. The art of the preparation of atomic weapons will stay with us and the temporary absence of these weapons may soothe our fears but is not a solution of our problems. Even the permanent abolition of atomic weapons would be no solution. As Premier Khrushchev reminded us, new and and more terrible weapons can be discovered in the future. The Thirty Years' War, for instance, bears witness that untold misery can be generated also with relatively primitive weapons.

All this indicates that we have perhaps formulated our objective in too narrow a fashion. The true objective is a world in which everyone can breathe freely, in which no nation is worried lest it be confronted with

a surprise attack tomorrow, and in which human dignity is respected. Armaments are more nearly a consequence of the tensions which follow from our not having achieved these aims than their cause. They do aggravate the tensions in their turn, but if the tensions are not present to begin with, their effect remains small also. The fact that U.S. armaments arouse no fear in Italy, or USSR armaments in China, illustrates this. Nevertheless, as a means to reduce tensions, it is clearly imperative to reduce the almost hysterically excessive amount of present armaments. But this is not itself our ultimate objective. As one of our means it may be realizable—as the only means, it is not.

More than Disarmament

It is clear that the reduction of tensions, the establishment of confidence, are at least as important as is disarmament, and the rest of the present paper will be concerned with measures in this direction. Such measures should not endanger the safety of the nations which adopt them.

The first and most obvious measure is to desist from inciting hatred toward any other nation. This point has been mentioned before but it remains ineffective because it requires fine judgment to distinguish between moderate, justifiable criticism of another government and the fanning of hatred toward it. A measure for dealing with hatreds based on ignorance was proposed at the time of the incipient conflict with the Nazi government. It had no prospect of adoption then because the Nazi government was opposed to the soothing of passions. The situation is probably different now. The proposal is that each government allot to the potentially hostile government a certain amount of space in every one of its journals and a certain period of time on its radio. There is no danger that the guest writer or guest speaker would abuse this privilege by insulting the host government or by propagating gross distortions. Such a procedure would be self-defeating, because most of the journal or radio time would be available for rebuttal before an intrinsically sympathetic audience. On the contrary, the guest statements would have a chance for sympathetic hearing only if they were strictly objective and honest. They might educate not only the audience but also the speaker.

There are two great advantages to this plan. First, it can be introduced as gradually as anyone might wish. Second, the measure is almost self-monitoring and violations would be resented not only by the host government but also by the host population as an insult to its power of discrimination. It would also force every government to articulate its aspirations and objectives and to prove to a skeptic audience that they are in the interest of all. This might lead to a critical reappraisal of the objectives and elimination or modification of some of them in a most salutary direction.

Together with this measure might go the freedom of circulation of all foreign papers in every country. The circulation of these would probably remain limited; nevertheless, the possibility of reading other papers remains very reassuring.

The second measure is an extension and modification of the summit conferences. A friend of mine proposed that a direct telephone line be established between the White House and the Kremlin. Perhaps one should go even a few steps further and arrange for a scheduled meeting between the heads of government every month, between some on the next-to-highest level every week. At present, the heads of government see only people with whom they share the intention to maintain the power of their own country. This would be at least diluted if heads of government would meet regularly. To the loyalty to their own organizations would be added loyalty to all of mankind. When undertaking a decision as heads of government, at the backs of their minds would be the thought that their actions might come up at the next multi-nation discussion. Surely, the heads of government have no more important purpose than to secure peace and understanding; they must have the time to attend the meetings which serve these objectives.

The third measure is to strive more vigorously toward the open world which Professor Niels Bohr advocated eloquently in his letter to the United Nations.[2] Surely, nothing has contributed to mutual suspicion as much as the ubiquitous presence of secrets and prohibitions. The knowledge that there are no secret installations or secret intentions will contribute conversely to mutual confidence. It is unreasonable and probably hopeless to demand of another nation that it disarm because "I am disarming myself, but surely you must not know what happens in my country; you are excluded from vast territories in it." A world in which one can travel freely, in which there are no secrets, in which one can communicate with one's fellow men everywhere, such a world is a better world toward which we can strive with true enthusiasm. A world merely disarmed, with controllers nosing about everywhere and being thwarted at every step, is not. As Niels Bohr said in his open letter to the United Nations: "The efforts of all supporters of international cooperation, individuals as well as nations, will be needed to create in all countries an opinion, to voice with ever increasing clarity and strength the demand for an open world."

As far as I know, the desirability of the preceding propositions is generally admitted. One often hears, however, the argument that the propositions are not sound because, in the early stages of the program, Russia would have to make greater concessions than would the United States. This surely does not apply to the first

[2] Niels Bohr, "For an Open World," *Bulletin*, July, 1950, page 213.

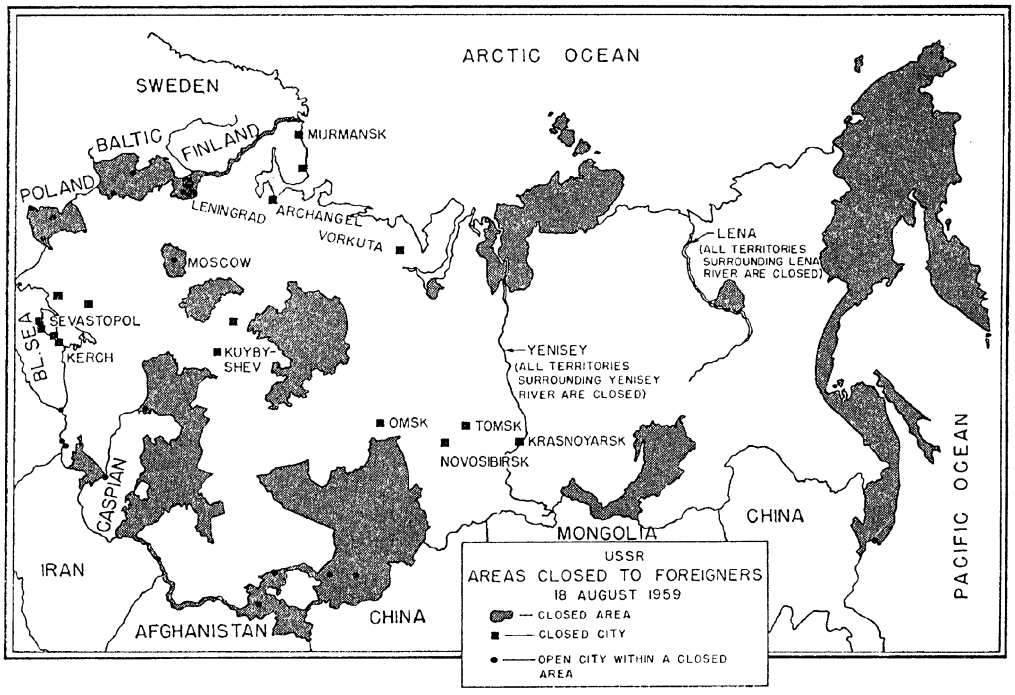
two proposals and the opposite applies to many propositions which we discuss seriously and which may even be adopted. However, this is not the crux of the matter. We are not seeking reciprocity but a better world. As long as the process of the establishment of the better world does not endanger the safety of any nation, reciprocity is not a relevant consideration.

It is questionable whether giving up excessive secrecy is a real sacrifice for any government. But, at any rate, the approach, on the part of the Soviet government, to the lower level of secrecy of the U.S. cannot endanger the USSR because this lower level of secretiveness does not endanger the U.S. either. Surely from all the public statements, one would believe that Russia is better armed than the U.S. Let us admit that secrecy may be a potent weapon and that a gradual recision would decrease military power. Such a decrease remains harmless, however, if the military power remains high enough to assure the safety of the nation. Since the lower level of U.S. armaments with less secrecy assures the safety of the U.S., the more potent armaments of the USSR will surely assure the safety of that country without more secretiveness than practiced by the U.S.

We want to establish a better and more stable world; this, and not reciprocity, is our purpose. We want to make the transition safe for everyone but we should not impose further and unnecessary conditions on the transition. In particular, the principle of equal sacrifice in military power is a fetish of the obsolete policies of power politics which we had better forget.

Soviet Territories Closed to Foreigners

Territories of similar size, although not identical with those shown in this map, have been closed since 1941. In retaliation, in 1955 the United States government made similar territories in the U.S. inaccessible to citizens of the USSR. However, the United States government has repeatedly offered to abolish all travel restrictions to Soviet citizens on a mutual basis. The last note in this matter was presented August 19, 1958, but has been unanswered to date.



Why Civil Defense

A consideration of its effects if war comes, if not, and on the likelihood of nuclear war

E. P. Wigner

The Technology Review *66*, No. 8, 21–23, 60 (June 1964),
Massachusetts Institute of Technology, Cambridge, Massachusetts

PROPOSALS for civil defense raise questions regarding both what can be accomplished and the concomitant effects. The present discussion will be concerned only with the concomitant effects. As to the question of feasibility, it must suffice for the present to note that all who have seriously studied this question agree that civil defense preparations could drastically reduce the civilian casualties of a nuclear war.

Most of the contents of the present article have been stated before, though possibly not in as systematic a way.* We shall consider, first, the effects of civil defense preparations in case of a nuclear conflict; then, the effects of such preparations during a period of peace which may or may not be terminated by a conflict; and finally, the effects of civil defense preparations on the likelihood of a conflict.

To Save Lives

The self-evident effect of civil defense preparations in case of a nuclear conflict would be to save lives. This country spends very large sums each year to keep a secure striking force in instant readiness should an aggressive power attack the U.S. or one of its allies. But this defense system is aimed primarily at deterring aggression, that is, at making an attack so costly that the would-be aggressor would hesitate and in fact renounce force as a method for obtaining world hegemony. This system provides relatively little armor for the direct protection of the American people, their institutions, and their government in case a nuclear conflict should break out in spite of the measures taken to "deter" it. The reason is that, in this nuclear missile age, with offensive weapons so much more powerful than the defensive ones, there is a temptation to rely solely on the former.

Few will deny that a civil defense program could save many lives. These would be lives that could not be saved in any other way. Even if we build enough offensive weapons, Polaris submarines and Minutemen, to make our retaliatory power so great that it would be madness to attack us, it is conceivable that an accident or an erroneous belief that we could be knocked out could lead to an attack on the United States. A conviction that once the damage was done, the United States would not dare, or would not want, to retaliate, might also prompt an attack. In either case, no amount of additional striking power in the American arsenal would count for much. The enemy would be striking us in the teeth of our deterrent.

For protection the people of the United States can rely only on antiballistic weapons and on a civil defense system. From the information now available, it appears that an ABM system which would provide substantial protection for our nation without a civil defense system cannot be developed in the next 20 years. We conclude that in the aforementioned contingencies civil defense would have immense lifesaving value which cannot be replaced by any other defense.

At present a nuclear war seems unlikely. Hence, expensive precautions against such a war may seem extravagant. We suggest, however, that civil defense is very much like insurance. Almost everyone in this country is in some way insured. No one feels cheated if, after paying for fire insurance for 20 years, his house still stands uncharred. For civil defense, too, we must pay a premium to improve our chances of survival in case of an unlikely, but extremely destructive event—large-scale nuclear war. It is true that civil defense cannot protect us against many of the effects of a nuclear

THE AUTHOR is one of America's most honored physicists. Last year he not only shared a Nobel prize for his study of nuclear structure but also directed a study of civil defense that the National Academy of Sciences undertook for Assistant Secretary of Defense Steuart Pittman. Scores of authorities participated in that "Project Harbor" study at Woods Hole last summer. Professors Robert J. Hansen, '48, and Ithiel de Sola Pool, and many Alumni represented M.I.T. among them. Professor Wigner was greatly stimulated by members of the Harbor study and is particularly grateful to E. P. Blizard of the Oak Ridge National Laboratory for help in preparing this article.

*The many highly emotional articles written on the subject sometimes have submerged more closely reasoned ones. Among the latter, Nicholas Rosa's article of 1961 in *The Reporter*, Moldauer's article in the May, 1962, *Bulletin of the Atomic Scientists*, and Milton MacKaye's observations in the October, 1963, issue of *Nuclear News* come to mind.

war. Similarly, however, disease remains a scourge even if one's medical expenses are paid.

The obvious function of civil defense preparations to save lives is often forgotten and one focuses on the more subtle military, political, economic, and moral problems. These are important issues but they should not be permitted to obscure the central, self-evident function of civil defense, which is that in the rather unlikely event of a nuclear attack, civil defense will be crucially important to every citizen of our country.

To Expedite Recovery

People have argued that the lifesaving potential of civil defense is of little value, because, they say, the survivors of an attack will perish anyway as a result of the economic dislocations and "the living will envy the dead." Events in Eastern Germany and in Hungary refute this view; people have not lost the ability or desire to live in spite of a complete economic collapse, and in spite of the subsequent exploitation of the collapsed economy by a foreign power. It is true, however, that civil defense can do less toward safeguarding the economy than toward safeguarding lives.

No matter how a war originated, it would be lost if the United States failed to emerge from it as a viable nation, able to recover most of its economic power and societal structure within the lifetimes of most of its citizens. It is clear, nevertheless, that the recovery of a nation whose population had been largely preserved, and which had stockpiled enough necessities of life to last for several months following the catastrophe, would be faster, and would be accompanied by less suffering, than the recovery of a decimated nation, which had neglected to make the most elementary provisions.

Such statements as "the living will envy the dead" are not really arguments against civil defense, but forecasts of how bad the situation might be even if civil defense preparations are undertaken. They give no clues as to how these situations could be avoided, and civil defense measures certainly would alleviate rather than worsen postwar conditions.

Effects in Times of Peace

If we were sure that our freedom would never be challenged, we would not maintain a military establishment and there would be no need for civil defense. Both military preparations and those for civil defense imply a sacrifice in peacetime in order to minimize the consequences should war occur.

Opponents of civil defense, however, have charged that it would, in a sense, corrupt the ideals of the nation. This argument has assumed several forms. Some people contend that it is better to die standing up than to survive in a hole underground. Others are dismayed by the problems of admitting neighbors to a private shelter. Civil defense also has been accused of promoting a garrison state, of leading to a neurotic nation, and of being unconstructive and contributing nothing to the quest of peace. We shall consider all these points. The contradictions between some of them indicate, however, that they are more nearly expressions of a subconscious impulse than the results of reasoned argument, and we shall try to bring the nature of that impulse into the open.

Let us begin with the notion that it is somehow cowardly and unworthy of a man to crawl into a shelter and survive a nuclear attack. Would it be more becoming of him to stand in the open and die? Man has always sought shelter and protection from his enemies. As recently as World War II the symbol of the American soldier was a man in a foxhole. No one, least of all the soldier, thought it ill-fitting or cowardly to seek protection in a hole in the ground rather than to meet enemy shells fatally in the open. Hiding in a shelter, facing the reality of a situation, is far more courageous than hiding one's head in the sand and saying, "If only we are nice to one another, there won't be a nuclear war."

The problem of the man who is asked to share his already crowded shelter with the family of his neighbor is the same as that of the man who is asked, in the middle of winter, to share his last loaf of bread with his neighbor. He faces a serious moral problem for which we believe a solution should be looked for in the direction of providing everyone with a loaf of bread rather than depriving the first man of his loaf. Even if an ambitious civil defense program is instituted, terribly difficult decisions will have to be made, but the situation will be better the more complete the program.

It is true that the organization of a cadre of Civil Defenders would add another category to our many groups of federal employees, but we now have an army of more than two million men and this has not made us a garrison state. The Civilian Reserve Corps which we wish to see created in addition to the cadre of Civil Defenders would be largely a voluntary organization, well below the size of the armed forces.

For many of us, it is difficult to comment on the contention that civil defense preparations would make our people neurotic by reminding them of the possibility of a nuclear war. We see hospitals and cemeteries every day and they remind us of the possibility of dreadful diseases and that our lives will eventually end. But hospitals also assure us that we will be taken care of should sickness strike, and cemeteries assure us that our bodies shall have a resting place. We feel that we would be much more neurotic if we tried to forget the existence of disease and death. Further, we have seen many children whose nightmares ceased when their parents built shelters.

The last argument, that civil defense is not constructive and does not prepare us emotionally or politically for peace and co-operation, is, we believe, entirely correct. One can hardly expect however, that all of our activities do this. We do actively help new nations, and we will be able to do this only as long as we remain whole and unconquered. Civil defense in a real sense serves to armor a wellspring of democracy. Our influence in the world will be felt all the more if our population is safer.

The heterogeneity and incongruousness of the arguments concerning the alleged effects of civil defense on our lives raises the suspicion that they have an unadmitted, and perhaps subconscious, origin. We believe that this is so. Many of us are willing to pay our taxes to support the defense effort of the country but wish to hear nothing further about it. We wish to live in a refined atmosphere into which the brutal activities that the defense of our country imply do not penetrate. This

is a natural desire, particularly on the part of highly educated, sophisticated people. These are particularly afraid that they will not be able to disregard the existence of civil defense as they are able to disregard the grim functions for which the armed forces are prepared. Hence, they oppose civil defense and wish to leave the defense of the country to a force which they are willing to pay but not to respect. Unfortunately, no country has survived whose citizens considered its defense beneath their dignity.

Effects on Likelihood of War

We now come to the question which we believe is uppermost in the minds of most Americans: Will civil defense preparations make a war more or less likely? It is impossible to foresee all of the effects of civil defense preparations, or of the absence of such preparations, on future relations between nations. The two principal effects of civil defense which we can foresee are, however, in the direction of peace.

The present precarious balance of international relations is caused, to a considerable extent, by the preponderance of offensive weapons over defensive ones. This preponderance gives the party striking first a great advantage. Hence, for those to whom a conflict appears in the long run unavoidable, there is a strong temptation to strike first. The situation would be even more "unstable" if there were only two contending parties, or if the one which temporarily has the upper hand (the U. S.) really yearned to destroy the other, rather than merely to remain undefeated.

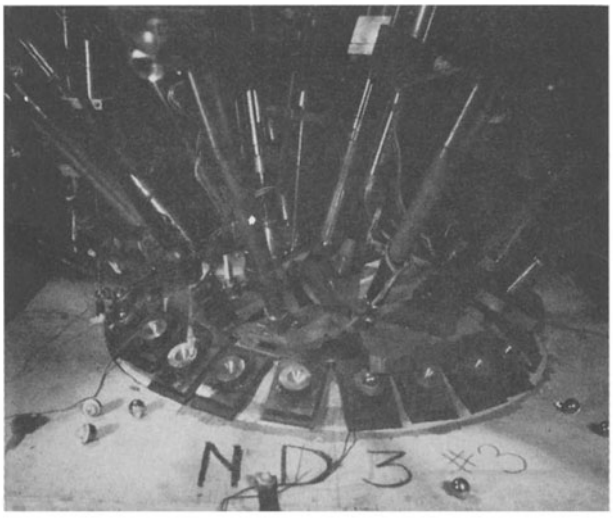
Either strengthening the defensive capabilities or weakening the offensive power might reduce this instability. The most effective measure in the first direction would be a buildup of civil defense. Disarmament is a step in the second direction. Civil defense does not presuppose mutual confidence between the antagonists and does not raise the question of inspection. Effective civil defense, in fact, may be a necessary precursor of disarmament. Let us assume, for example, that the United States and the Soviet Union reach some accord on gradual disarmament, and that many weapons and missiles are destroyed. Some inspection system will be required, but none can guarantee that all weapons have been destroyed. Nor can any agreement erase from men's minds knowledge of how to produce weapons. After disarmament was ostensibly complete, the Soviet Union still could threaten us with a few weapons, which would be superior to no weapons at all. With our population protected, we could resist such threats for a few months, and gain the time required to assemble our own weapons again. Without civil defense, we would be at the mercy of the aggressor.

The few-weapon situation also could arise under other conditions. If some small country, ruled by a dictator, built or otherwise acquired a few megaton-size weapons, its ruler might be tempted to threaten the U.S. with a few bombs with primitive delivery systems, such as mined merchant ships or concealed bombs in cities, to gain a free hand in his part of the world. Such nuclear cloak-and-dagger methods seem far-fetched to us now, but they could appear inviting some day to the possessor of a few bombs seeking personal aggrandizement.

The Effects on Leaders

It often has been said that the protection of our population might make our leaders more aggressive, and cause them to skirt the dangers of war with less trepidation. Civil defense, in other words, could increase the chances for war, but we shall give reasons for not believing this. The *absence* of civil defense also could generate aggressiveness in leaders aware of the advantages of striking the first blow.

Although many crises may arise, we do not believe that our elected leaders will risk war any more than



Knowledge of requirements for civil defense shelters is being increased by studies in the M.I.T. Models Laboratory. The photo is of hydraulic jack loading on a model of a reenforced concrete dome.

absolutely necessary, whether or not the population is protected. Civil defense can never be absolute; it cannot save all of the people. War also would cause a tremendous loss in our productive facilities and transform our economy, virtually, into that of an underdeveloped nation. Hence, we do not believe that an American President ever would act more aggressively than necessary; reduction of possible casualties from perhaps 80 million to perhaps 20 million certainly would not make a President reckless. Times may come when national survival entails risks, and civil defense would minimize but not obviate them. Nuclear war will never be an attractive policy to a sane, responsible, informed leader.

The situation is by no means symmetric between the U.S. and its possible opponents. Human lives are more expendable in other cultures than in ours. It was not a U.S. President who declared that one-third of the present population of his country would still be ample. Also as far as the national wealth is concerned, the U.S. stands to lose more than any of its potential opponents. The danger that the U.S. would become reckless because it could protect its people is negligible compared with the danger that the government of one of its opponents might become reckless because the U.S. could *not* protect its people.

But let us, for the sake of the argument, assume that the American leadership might be a little more reckless if it felt that the people were well protected. There would then be a balancing force from the people themselves if they had an effective, extensive civil defense system. In the Cuban crisis of 1962, many voices, and some very influential ones, were heard advocating a firmer policy, and disdain for the dangers of war, because of a feeling that it would come eventually anyway. A civil defense program should produce, as a side effect, a population which is better informed about nuclear war, and less liable to want to "get it over with" at the cost of human lives. This would outweigh any increased aggressiveness that civil defense preparedness might engender.

It is difficult to write about the objectives and motivation of civil defense without thinking more generally about the problems of defense and future efforts to maintain peace. The question which is hard to avoid is whether the future will bring increasingly strong weapons and the devotion of an increasing fraction of our attention to questions of war and peace. The writer of these lines, at least, hopes that this will not be the case.

If leaders of all nations realize that the United States is determined to guard its independence and the way of life of its citizens, it is to be hoped that their objectives will change and that they will forsake aggressive tendencies. The Soviet Union, however, quite possibly may find itself under heavy pressure in the future to adopt a more belligerent attitude—and being able to point out that belligerency would not be very effective might then help its leaders resist such pressure.

A Fable

Once upon a time there was a rich and powerful Caliph who ruled his domain in peace and justice. His country was happy, and he himself extremely wealthy. Hearing of this felicitous land, Mongol tribes soon began to knock at the gates of his country, to threaten it, to invade it. Now the Caliph had one fault: he was very loath to part with his wealth, least of all to squander it on armies and fortifications. The inevitable came to pass. The Mongols conquered the Caliph's country, and he himself was finally captured in his strong room, amidst all his wealth. The Mongol Khan, who was a brutal man, ordered the Caliph's execution by a special method: pouring molten gold down his throat. "You see," said the Khan, "that gold which you have hoarded so assiduously will finally kill you."

The United States is not an eastern Caliphate. But the United States is an extremely wealthy country. It can well afford to protect itself. Does it seem prudent to save the taxpayer's money at the risk of losing the taxpayer?

Letter on Article by Wiesner and York

E. P. Wigner

Scientific American *211*, No. 6, 8,10,12 (Dec. 1964)

Sirs:

Although we scientists often pride ourselves that our familiarity with the "scientific method" enables us to form more rational political views and to raise the level of political discussions, most of our writings on the problems that confront our nation today resemble the monologues that men in politics use. We state our views and desires but do not point out the areas of disagreement with our opponents, or the extent, or the reasons therefor. No fruitful scientific discussion could proceed on such a basis, and in the following paragraphs, in which I comment on the article "National Security and the Nuclear-Test Ban," by Jerome B. Wiesner and Herbert F. York [SCIENTIFIC AMERICAN, October], I hope to come closer to a dialogue. Thus I shall attempt to specify both the areas in which I agree with the authors and those in which I disagree, and to give my reasons for disagreeing.

In the early stages of writing this letter it appeared that only the views expressed by Wiesner and York on policies, attitudes and technical questions would have to be discussed. It soon became apparent, however, that there is a third subject that could not be disregarded: the inferences the daily press drew from the article and the extrapolations it attached thereto.

Turning first to *questions of broad policy expressed in the article itself,* there is much with which it would seem a vast majority of our colleagues can agree. The principal area of agreement concerns the success of the test-ban treaty. One would have to be blind not to see that the tensions between the U.S.S.R. and our country have much relaxed since this treaty has been in effect. It would be stretching a point to say that the cessation of testing is only the consequence, and not at the very least partially a *cause,* of the relaxation of tensions. As to the delay that peaceful uses of atomic explosives suffer as a result of the test cessation, the article says, "Promising as peaceful uses of nuclear explosives may be, the world could forgo them for a time" in exchange for a quieter international atmosphere, and I can only concur.

On the other hand, it would be a mistake to overlook the fact that the test-ban treaty is the result of extensive negotiations in which *both* parties made significant concessions. There is no evidence that generous acts of the U.S. through which it unilaterally weakens itself have any but adverse effects on the policy of the U.S.S.R. Nor does the insistence on *mutual* concessions have to create an unfriendly atmosphere. On the contrary, the constant pressure on our government, by means of public statements, to give in, raises false hopes in the negotiators of the U.S.S.R. The thwarting of these hopes, and the irritation of our own negotiators because of these pressures, do create an unhappy atmosphere. It is to be hoped that the

article by Wiesner and York, with its insistence on a comprehensive test-ban treaty but without equal insistence on policing and inspection, will not have such an effect. It certainly counsels moderation not only to our government but also to that of the U.S.S.R. (An apt description of the adverse circumstances under which our negotiators often labor was given by R. Gilpin in his *American Scientists and Nuclear Weapons Policy*.)

Another statement of the article with which few will quarrel is that "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." It is unfortunate that the subtitle of the article abbreviates this to "there can be no technical solution to the problem of national security." This subtitle, whether written by the authors or by a somewhat careless editor, printed as it is in large italics, could give the impression, and has given the impression to some of the daily press, that technical problems will play no further role in the future. This is, of course, not the meaning of the statement quoted. In fact, the sentence "Today as never before national security involves technical questions" stands just three inches below the subtitle.

Actually the great powers have never confined themselves to looking for solutions in the area of science and technology only but have initiated extensive negotiations toward easing tensions. As we have seen, some of these were successful.

If one is asked whether one agrees or disagrees with the policies recommended by the article, one soon discovers that the article does not recommend any policies. It leaves its reader with a sense of frustrated disorientation coupled with the impression that the past policies of this country were fundamentally wrong and something fundamentally new has to be tried. Some passages even carry the implication that our defense preparations have aggravated the danger to our freedom, independence and survival. "Ever since shortly after World War II the military power of the U.S. has been steadily increasing. Throughout the same period the national security of the U.S. has been rapidly and inexorably diminishing." Does this suggest that the decrease of our security is a *result* of the increase of our military power? To some who wish to think so it apparently does; to the people of countries whose military power did not grow adequately—to the people of Czechoslovakia, Hungary and Tibet—it would not. When I maintained in a discussion with one of the top scientific negotiators of the U.S.S.R. that the U.S. used its early atomic monopoly with great restraint, he answered, "I don't know. We wanted to do many things that [as a result of your atomic strength] we [the U.S.S.R.] could not." I am afraid that the borders of Stalinist Russia would have moved *much* farther to the West in Europe had the military power of the U.S. not been "steadily increasing."

Furthermore, is it really true that the national security of the U.S. has been "rapidly and inexorably diminishing"? If one thinks only in terms of physical possibilities, in terms of a fanatical enemy who takes seriously Lenin's dictum "Better only one-third of the world's population surviving if those are then good communists," the security has decreased. But is that a valid picture? Have we not spoken of the relaxation of tensions before? True, we still hear the threats of burying us, alone or in collaboration with the Chinese brothers, the praise of the "irreconcilable class hatred that exposes and strikes the enemies of our social system," and the glorification of the sparks flying from the sabers of cavalrymen (both in Khrushchev's speech on culture of March 8, 1963). But one also hears, with an increasing volume,

the realization of the need for coexistence and of peaceful competition. One does not have to shut one's ears to the threats in order to hear also the voice of reason and adjustment. Furthermore, is it not clear that the realization of the need for coexistence is in large measure the result of the understanding that the sparks flying from the sabers of cavalrymen can ignite other fires? A U.S. that is not only strong but *evidently* strong is in the interests of all: it is reassuring to the West and should turn the interest of the rulers of the East away from domination and toward the true welfare of their people. Are there no signs that it is at least beginning to do so?

To put the preceding point more pragmatically: Although the worst conceivable alternative may have become worse with the progress of time, the probability of such an alternative has decreased sharply. As a result, from the point of view of the most likely turn of events, the security of the U.S. has probably greatly increased, particularly in the course of the past few years.

Let us now turn to the *technical points of the article.* I am sorry to say that I find it more difficult to agree with them than with the general statements discussed before. The first remark that comes to mind is that the alleged need for developing the 100-megaton bomb was not the only, in fact not the principal, argument against the test-ban treaty. Personally I feel that this treaty was worth what we paid for it, and that it benefits both the U.S. and the U.S.S.R. It would be only fair toward those who opposed the treaty, however, to state that they were chiefly concerned with the testing of certain defense measures against antiballistic missiles, not with the development of the 100-megaton bomb.

Nevertheless, we must recall in connection with this bomb that the U.S.S.R. found it worthwhile to break the test moratorium in order to test it. In addition, the statement of the article that "on any scale of investment, the combination of larger numbers and smaller size results in greater effectiveness of the missile system" cannot be maintained. The cost of a missile is approximately proportional to the square root of its explosive yield. The illustration in the article that shows a linear relation is incorrect (and is contradicted in the text). Hence the yield is proportional to the square of the cost. The range of destruction is proportional to the cube root of the yield and hence to the 2/3 power of the cost. Finally, the area of destruction is proportional to the *square* of the range of destruction and hence to the 4/3 power of the cost. It follows that if one disregards soft targets that can be destroyed by a single smaller bomb, the cost effectiveness of weapons actually *increases* somewhat with their yield. Even this is not the complete picture. A hardened defense installation can be destroyed with a smaller explosion only if this takes place closer by and at lower altitudes. It is easier to prevent such an explosion by antimissile measures, or otherwise, than an explosion at the larger distances and high altitudes at which a very large bomb can still destroy the installation.

Drs. Wiesner and York state that we do not need tests in order to design a 100-megaton bomb. This is true but disregards the time element. The time schedules for the production of a bomb with the characteristics that exploit the inherent advantages of size are extremely long in the absence of tests. If the bomb should be needed, it would be meager comfort to know that, given only a few more years, we could have had it.

The cases for and against the big bomb remain unproved and I personally cannot become enthusiastic about it. I

do feel strongly, however, that the rejection of defense measures, in particular the rejection of civil defense, is unjustified. Drs. Wiesner and York recognize that the instability that has to be overcome is due to the "overbalance [of] the scales in favor of the attacker rather than defender." If this is so, a wholehearted effort should be made to redress the overbalance. It does not seem, however, that they have explored the possibilities of civil defense even halfheartedly. Most readers will be struck by the contradiction between the postulates that, on the one hand, the retaliatory installations are invulnerable and, on the other hand, that shelters are useless. In fact, when discussing civil defense, the authors say: "The only kind of shelter that is being seriously considered these days, for other than certain key military installations, is the fallout shelter." They then proceed to show that fallout shelters by themselves do not suffice to render the position of the defender strong enough. Although they do not state this explicitly, they give the impression that they would not be opposed to abandoning altogether the fallout shelter program as insufficient. The opposite alternative, to strengthen the civil defense program by the installation of blast shelters at important locations, is dismissed all too easily with arguments that are in no way convincing. Thus the writers mention the danger of a short warning time in a surprise attack but do not mention that a complete surprise is difficult to achieve, and in fact the two world wars did not break out without warning. In addition, the shelters could well be located in such a way that they could be reached by most people in the 15-minute warning time the writers concede. Similarly, the writers mention the possibility of chaos and disorientation in shelters but fail to mention that these dangers are much greater if no shelters exist. They do not mention either that the history of past disasters does not bear out their fears of antisocial behavior as long as proper leadership is provided. During the siege of Budapest people stayed in shelters for many weeks but continued to cooperate and help each other. The authors emphasize throughout the article that, in contrast to an attack of World War II, a nuclear attack that is 10 percent effective would be considered successful. This would hardly be the case if the population were well sheltered. Hence a combination of antiballistic missiles and shelters seems to hold more promise of reducing the "overbalance" of offense over defense than any other measure known to me.

Finally, and perhaps most importantly, the authors do not mention that no nation will dare to disarm if its population remains exposed to the awesome dangers the authors so well depict. Hence civil defense is also a prerequisite to disarmament.

Let us come finally to the "extrapolations" contained in the *reports of the daily press*. Many of these were crude exaggerations that may have served a useful purpose, however, by attracting attention to the article. They were encouraged by the mode of communication of the article, which made most of its points by implication. However, the result often approached the bizarre. Even *The New York Times* headline reads "Disarmament Is Called the Answer to 'Stalemate,'" as if it were desirable to have a checkmate ending to the game. The words "stalemate" and "disarmament" occur once each in the article, the former toward the middle and the latter as the last word.

A more nearly justified "extrapolation" made from the article is that no further methods of offense or defense need be explored, that is, that military science is a complete and closed book. Even this is only implied by the article.

To evaluate it, it may be useful to recall similar statements about other areas, in particular about physics. These were made around the turn of the century, before the advent of atomic theory, before virtually any knowledge of the nucleus, before quantum and relativity theories, before any inkling of the results of almost all areas that are at present at the center of interest of research in physics. Statements of this sort mean partly that those who make them have, at the time of making the statements, no promising ideas in the field about which they speak. Others may have such ideas, and those making the statements may themselves conceive such ideas at a later time. The statements in question also appear to herald the impending initiation of new lines of endeavor. In the case of physics this was the turn toward microscopic phenomena; in the area of "weaponry" it may well be the exploration of a more effective defense.

Having stated the areas of disagreement, it would be well to reemphasize the agreement with what appears to be the main thesis of Wiesner and York: the importance of not relying on physical power alone. It is a truism that the purpose of power is only the achievement of certain goals, called national objectives. However, military power, like police power, works best when it works through its presence rather than by active involvement, and when it is supporting persuasion to follow rules of conduct that are just and reasonable. Certainly included is the rule to leave our country free to follow its own path of independence and individual freedom.

EUGENE P. WIGNER

Princeton University
Princeton, N.J.

Civil Defense

Address to the Mercer County, New Jersey Civil Defense and Disaster Control Organization, May 26, 1964

E. P. Wigner

Journal of the N. J. Chiropodists Society *1*, No. 1, 6 (1964)
(Reset by Springer-Verlag for this volume)

I have often spoken about Civil Defense and on many occasions I addressed a hostile audience. It is a very great pleasure tonight to speak to friends who need no convincing that Civil Defense is important and that it should be one of the most essential endeavors in this country. Perhaps I also ought to tell you that we are now engaged in a joint enterprise because I shall spend the coming year, at least, working full-time on Civil Defense with a group at the Oak Ridge National Laboratory.

As I said, I have often spoken about Civil Defense and the discussion always is concerned with the same two questions: is Civil Defense desirable and is Civil Defense possible. Outside this group, both questions are, as you know, controversial, and there are many who would answer one or both questions in the negative. Some one said that man was given the faculty of speech so that he can conceal his thoughts, desires, and emotions, and I often think of this when people talk about Civil Defense. Many who fear that it is not possible to provide effective protection against atomic weapons, realizing the difficulties all too well, hide these fears under a pretension of not wanting Civil Defense. They say it has too many side effects, it causes nervous tension, it incites to war. In contrast, there are those whose opinion is the opposite and who oppose Civil Defense for emotional and political reasons, yet what they say is that Civil Defense is impossible, that in case of an atomic war the lives of people cannot be protected and that, at any rate, so much will be destroyed that the few survivors will not find life worth living.

Actually I believe that the questions with which we started are poorly phrased. The real question is: to what *degree* is Civil Defense protection possible and what is the cost of the different degrees of protection. I shall discuss this question from a point of view different from the one which you encounter in your daily activities. Your work is affected by the political climate of the country as a whole and by the attitudes of many individuals of whom some participate reluctantly and others offer strong opposition. I would like to discuss Civil Defense from a different point of view: what should and could be accomplished with whole-hearted and complete cooperation. What would be the cost of such a project in money and manpower and other sacrifices? In other words, what would we have to pay for it, and in what manner? What I said already indicates

that I realize that when we speak about the cost of Civil Defense, we should not think only in terms of the cost in money.

A study organized by the National Academy in Woods Hole investigated the questions about which I am going to talk to you: namely, what are the technical possibilities and what is the monetary and the non-monetary cost of Civil Defense. We found that very significant protection is possible for relatively little money. It may be useful to give a few figures. We felt that very significant protection would require not only fallout shelters which are at present at the center of interest and which are a pre-requisite for all further efforts. They are, let me repeat this, a pre-requisite for all further efforts. But if we want to provide a protection which is more adequate than other types of shelters – blast shelters – are also necessary.

We considered, of course, the question what the purpose of our potential enemies might be. We came to the conclusion that they would not want to destroy the greater part of the population. The purpose of the aggressor is not the destruction of the country which it attacks but the subjugation of its people. His principal target would not be the lives of the people but their defense organization and their retaliatory power. If this is so, the defense of the lives of the people would be somewhat easier. However, it may be dangerous to count on this and the plans should be formulated, if at all possible, by assuming the worst possible results of an enemy attack.

There are about 75 million people in the country who live in cities with a population in excess of 250,000 people. If an anti-population attack takes place, the inhabitants of the largest cities would be attacked in the first place. Hence, they would have to be protected by blast shelters. If blast shelters of a hundred PSI pressure resistance are provided for the inhabitants of the cities, then it begins not to be worthwhile any more to attack these cities even if one's purpose is to destroy the people because the shelters render the attack ineffective, ineffective at least as far as damage to the population is concerned. The enemy would then shift the attack to other areas. However, whatever he does, if the city people are provided with blast shelters, and the others with fallout shelters, the total population loss would be below twenty percent. Twenty percent sounds like a low figure but actually it is not a low figure. If we calculate how much twenty percent of the United States' population is, we realize that it is a terribly high figure. To contemplate what it would mean to lose twenty percent of the people is bitter and gruesome. However, the difference between losing twenty percent and losing a very much larger fraction is even more gruesome to contemplate, particularly so if we realize that it is unnecessary.

Let me tell you how much we found that it would cost in money to give the protection about which I spoke. I can give it in dollars; and in dollars, putting everything together, it would cost about 22 billion. Now 22 billion dollars does not mean terribly much because we usually do not deal in terms of such amounts of money. It is more meaningful to say that it would mean spending, for several years, a sum equal to one percent of the gross national

product. The gross national product of this country is 600 billion dollars. We could compensate for spending one percent of the gross national product on Civil Defense if everyone worked, during every month, two hours longer than he now does. Well, I do not know whether that would be so terrible. Alternately, it could mean that we reduce the unemployment.

Of course, it is true that the work would not be uniformly distributed. As far as shelters are concerned, it would be done principally by the construction industry and it is true that the construction industry would have to expand ten percent, which means that every man in the industry would have to work, on the average, two hours longer per week. (I have a bit rounded the figures, but did it cautiously.) But even that is not too bad. The construction industry is not fully occupied now. It is not what bothers people. The material cost is high if one expresses it in dollars, it is high if one expresses it in a number of other ways, but this is not decisive. This country could easily afford it. We spend as much on the lunar program, that is to get a man to the moon, as we would have to spend on Civil Defense. If I think of myself – I am a scientist and would like to see people arrive on the moon and see what the moon is like – but if I have to choose between having a person on the moon in eight years or, instead, an effective Civil Defense in this country in six years, I do not need to tell you which one I would choose. To summarize this point: I feel sure it is not the cost in money that bothers people.

Perhaps I have not yet given a full picture. I have spoken so far about the construction of the shelters. That is not all that is needed and this point was brought out very strongly by the Woods Hole study. The shelters must be stocked but this is included in the cost estimates which I mentioned. In addition, however, it is necessary to establish a tactical Civil Defense organization. It is necessary to make it possible for people to get to the shelters, to enter the shelters, to fight fires outside, to provide food also for the period when they can leave the shelters. This would be about two weeks after the cessation of the hostilities. If the food is all in the mid-west, there would be famines in the east and in the west. The economic damage would be terrible and in order to mitigate its effects, one would have to stockpile certain items and make other preparations. All this together would cost perhaps as much as the shelters although this additional money would not be spent through the construction industry but through other industries. Gasoline should be stored, fire fighting equipment should be installed, and so on. In other words, we must see to it that people not only survive but when they have survived, they must also be taken care of, although perhaps only austerely and poorly. They must be given a purpose for life, put to work to re-establish the economy and get the country going and vigorous again. The preparations for this would cost about as much as the shelters would cost. However, as I said, my opinion is that these are not the real costs – not the costs which are difficult to carry. The costs which many people find difficult to accept are not monetary costs but emotional ones.

There is, in the appreciation of the emotional costs, a division of the country between intellectuals and other citizens. The average citizen doesn't have a very

emotional attitude. Again I am speaking on the basis of the study at Woods Hole, where we had psychologists' and opinion researchers' work. However, you probably know these things from your own experience. The average person does not have anything like the aversion, the strong emotional distrust and distaste for Civil Defense shown by many intellectuals. However, he does not believe that he is going to be bombed and I think and hope that he is right. Under these conditions, the average citizen does not want to assume one more burden, one more problem to think about. And this is understandable. We know how difficult it is to persuade people to assume burdens which are not traditional, and even those which may be traditional. People like to go after their daily occupations and do not like to worry. Our life could not be as pleasant and light-hearted if we had to think and directly take care of the emergencies which may have to be faced – old age, sickness, disasters. Instead, we have institutions to take these worries off our minds: we have banks which store assets for us which we can exchange for food and clothing when we become too old to provide for ourselves; we have hospitals to take care of us should we fall victims of disease; and we have insurance companies to get a new house for us should ours burn down. Instead of thinking of old age, disease, disaster, we have institutions which take over these worries. I feel convinced that if there were no banks and other investment opportunities, many people would neglect to store up what they are bound to need when old.

Similarly, the Harbor Study recommends that we establish an institution to take the problem of protection in case of a nuclear war off our minds. We shall establish a Civil Defense cadre which would be in charge of the construction and provisioning of the shelters, which would tell us how to use the shelters in a national emergency, which would instruct us in the shelters what to do after we emerge from them. We should have community shelters rather than private shelters so that individual attention and vigilance is not necessary. By making Civil Defense an institutional matter, most citizens can almost forget it. I believe that the Study had the right attitude even though I am not totally happy with it.

One of our collaborators in the Harbor Study saw me a short time ago and we discussed this question. He said, "Yes, we came to this conclusion over your dead body." And this is almost true. In my opinion it is wrong that we don't want to worry about these problems, that we want to push them off onto other people. But I must concur with the Study; we are not here to reform mankind and to make it more foresighted. We are here to take care of them in case of need. We are something like an insurance company which wants to sell the insurance.

You know that if you buy insurance, you actually don't buy only the insurance which you need most. You buy other insurance also which you do not need so much but which is also useful. A similar proposal has been made with respect to Civil Defense. I am referring to the so-called dual use of shelters. Dual use of shelters implies that the community shelters should be usable not only in case of a nuclear disaster but also in case of other emergencies. Further

than that, they should have a daily use as recreation centers, storage places, or garages.

I was in Sweden a short time ago and was shown their Civil Defense preparations. The Swedish Civil Defense is probably the best one in the world at present. They showed me what they call deep rock shelters; there are several such shelters in the capital, Stockholm. We drove into one of these with an automobile. What did we see there? Mostly automobiles. The shelter was a big garage which people use every day. Of course, in case of a disaster, there are provisions to get rid of the cars. The shelter has thick heavy doors which could be closed in that case. But they can be used not only as shelters, not only in case of a disaster. This has other advantages as well. People get familiar with them, know where they are, and they become part of their lives.

I now return to the attitude of some of our intellectuals who are violently opposed to Civil Defense. Let me say first that one can easiliy overestimate the fraction of people, even of intellectuals and university people, who are opposed to Civil Defense. One can overestimate it because it is easier to oppose something than to be in favor of it so that more people do it with gusto. I can easily give five reasons why mathematics should not be taught, and why it corrupts people, and makes life miserable for many young men in high school, and furthermore it is not necessary to know it. In fact, it is dangerous. It is easy to voice destructive criticism and many people like to do it. This is one reason we hear so much against Civil Defense. The second reason is that it is easier to cater to laziness and indolence than to purposeful action. The third reason is that people who are against Civil Defense often have some element of frustration in their make-up. A few days ago I read a little article which wonderfully describes this. It is by Robert Waelder, *Protest and Revolution Against Western Society.* According to him, in many cases these people are not so devoted to their work and family as others, and they find more easily time for, and outlet in, their opposition.

Much more literature – I think 80% – is against than for Civil Defense and much of it is completely irresponsible. A few weeks ago I read an article in the *Bulletin of Atomic Scientists* in which the author said that a complete fallout shelter program would cost 50 billion dollars. Now 50 billion dollars is more than would be spent on the complete blast shelter program which I mentioned. But it doesn't cost anything to say that it will cost 50 billion dollars and it's so easy to say it – so why not? Who will contradict it? People who favor Civil Defense are more responsible and speak less. It is my impression – and this is supported by opinion research – that even among the egg-heads, those who are opposed to Civil Defense form a minority. Let me mention but one supporting evidence. A violent anti-Civil Defense statement was circulated at the University where I am teaching and a great number of my colleagues signed it. However, a few friends and myself got together and we wrote out another statement endorsing Civil Defense and circulated it. It was endorsed by many more signatures than the other statement. However, most people who are interested in Civil Defense are terribly busy and few can take time to write and circulate statements.

This brings me to the last question which I would like to talk to you about – what we can do to change this, what we can do to bring our fellow citizens, our colleagues, our friends to a more reasonable, more realistic attitude toward our effort. Of course anything one does takes time and all of us are busy. Nevertheless, we should try to devote a couple of hours every week to this problem. When I say this, I am doing just what I said was so difficult to do – namely, to try to persuade people to accept a little more work and worry.

There are three things that we could do. The first is to learn more about history and politics than we do. We read and hear entirely irresponsible statements but not having the facts at our fingertips, it is difficult for most of us to contradict them. There is a great deal of literature on how terrible a nuclear explosion would be, and there is no doubt in your or my or in anybody else's mind that it would be terrible. However, few people tell the equally terrible stories about what happened to a nation which was subjugated by its enemy. These stories – some of them occurred in the not distant past – are equally terrible. We must avoid war *and* we must avoid the danger of surrender.

The second suggestion is that we do not permit the aims and possibilities of Civil Defense to be maligned. Again, we should have the facts about it at our fingertips. I refer to facts similar to those I mentioned – how much does a shelter cost – what is the total national product – what is the total expenditure of the construction industry – how much more construction would have to go on – how much warning time would we have. I am afraid that it is partly our fault that more people are not more familiar with these facts – more the fault of people like myself than your fault because these facts have not been written down clearly and in understandable language. It would cost one percent of the gross national product for roughly six years to have a really satisfactory Civil Defense posture. One percent means we work two hours more every month.

You may feel that it is not fair for me to counsel you to speak up on Civil Defense. For me, Civil Defense has been, so far, an avocation. You may fear that people will tell you if you speak up, "Oh, you say this because you are working for Civil Defense." The opposite is true. Unless a person speaks up for his own convictions and for his own work and emphasizes the significance of it, people will feel, "Oh, even he doesn't believe in it." The newspapers also invariably give space even to the most ridiculous statements by someone who is deeply interested in a question, no matter for what reason. They feel that all want to hear what the person who is really involved has to say. And this is the correct attitude. Of course, I am against all misleading statements – they are self-defeating anyway. But I do think that the world wants to know the truth and wants you to set right unintentional as well as intentional errors about the possibilities and objectives of Civil Defense.

The third suggestion which I would like to make is that you speak up in favor of Civil Defense, as I do now, seizing every opportunity. Let us imitate our opponents in this regard; they do speak up constantly without provocation. In this regard, they give us a good example.

I realize that what I am suggesting is additional work and I realize also that you probably have your hands full with work as it is. I believe, however, that we owe an effort in the direction which I indicated – we owe it to our children, we owe it to our neighbors, we owe it to our country but above all, I think, we owe it to ourselves and our convictions.

Thank you very much.

Civil Defense – Project Harbor Summary Report (Foreword)

E. P. Wigner

National Academy of Sciences, Publication 1237, Washington, D.C., 1964;
"Civil Defense" (L-H Rpt.) USAEC, TID-24090, P.O. Box 62,
Oak Ridge, Tennessee

It is difficult to report on a group effort such as the Harbor Study because the change in attitudes and intuitive convictions acquired by the members in the course of the study are at least as important a result as the technical conclusions. For many participants, the most striking experience was the ease with which contacts between members with different backgrounds and interests were established and how the appreciation of relevant problems – physical, technical, economic, societal and even emotional – grew in members of the group. This experience is good augury for the success of a concerted effort undertaken jointly by specialists in many fields.

On the other side of the picture is the fact that Harbor has introduced few entirely new ideas and uncovered no panaceas. The promise of coupling anti-ballistic missile systems with passive defense was increasingly realized. This coupling would make the task of the former easier and the measures of the latter more effective as far as the preservation of lives is concerned. Perhaps less striking but probably more important were the general conclusions, some of which follow.

The most significant change in the threat of the foreseeable future is expected to come from more numerous, more efficient, and more powerful nuclear weapons rather than from weapons of essentially new types. Thus, a civil defense system could be instituted now which would not be rendered ineffective by changes in the nature of offensive weapons of the foreseeable future.

Nuclear war would result in great loss of life, great devastation, and great misery. But appropriate protective measures which are well within the economic means of the nation could drastically reduce the number of casualties. Even without such protective

measures, situations in which all life on earth would be destroyed can in the foreseeable future occur only in fiction.

The preservation of the economic wealth of the nation is a more difficult task, and perhaps also more costly, than the preservation of lives. It would take many years after a nuclear war to make all the commodities that we now take for granted generally available. On the other hand, if some elementary and relatively inexpensive measures are taken ahead of time, no famine need result and there would be no crippling shortage in the other immediate necessities of life.

The management and operation of a civil defense program of reasonable size and effectiveness might require a federal cadre of about 30,000 professional people, cooperating closely with local authorities and using local capabilities. It was one of the conclusions of the project that a civil defense program along the lines described in the project reports and this summary would not seriously interfere with the normal functioning of our institutions nor of our democratic society. It would create no serious problems of acceptance or impact, at home or abroad. In the opinion of many, it would reduce tension and would further constructive thinking.

I wish to express thanks to all who participated in the Harbor Study, and to the government agencies that provided information and administrative assistance. Although representatives of these agencies participated directly in the study, the conclusions and recommendations of the Project Harbor reports do not necessarily reflect the official position of these agencies.

EUGENE P. WIGNER
Director

PART II

The Age of MADness 1964–1969

After the death of J. F. Kennedy the Department of Defense and U.S. Defense policy came to be dominated by Secretary R. S. MacNamara and his systems analysts. They decided on a national strategy of Mutual Assured Destruction, or MAD. In this strategy both sides do nothing to protect their population and industry, but maintain secure strategic nuclear offensive forces. The immorality of this strategy appalled Wigner, and became a dominant theme in his writing of this period.

Civil Defense: Wigner on Project Harbor

E. P. Wigner

Bulletin of the Atomic Scientists *22*, No. 2, 21–22 (Feb. 1966)

Dr. Wigner, who served as chairman of the National Academy of Sciences 1964 summer study on civil defense—Project Harbor—is professor of physics at Princeton University and was awarded a Nobel Prize in 1964. The article by Howard Margolis on which he comments here begins on page 19 of this issue, and is prefaced by a note on how the complete Summary Report to which reference is made may be obtained.

I greatly appreciate the opportunity to comment on Howard Margolis' article.

It seems to me that Mr. Margolis' article deals with two subjects. The first part is devoted to the relation of the Harbor Summary Report to the full report, the second part to my views on the necessity and promise of civil defense measures.

In the first part of the article, Mr. Margolis first states that the Harbor Summary Report was written by me. Except for the foreword and a few paragraphs here and there this is simply an error, the origin of which is not clear to me. The executive committee of the project was responsible for the preparation of the summary and the procedure followed is described in the statement of Richard Park, secretary of the executive committee, which appears below [page 23]. No critical comments were received concerning the last published draft, which was circulated among the project members before publication. In fact, this is, in my opinion, a somewhat pedestrian condensation of much stronger statements of Harbor participants. It is natural that, in a group of sixty-odd individual thinkers, there was some division of opinion concerning the rate at which a program, more effective than the present one, should be implemented. There was no decision, however, that such a program should be implemented and, as far as I know, no participant felt that the summary is partial to some point of view. It is of some interest to note that Mr. Margolis made the same error when commenting on the full report of the strategy and tactics panel that he made when commenting on the summary. He felt that the report of this panel was dominated by Herman Kahn. I can assure him that Dr. Kahn accommodated the views of all members of this panel, and the panel reached a complete consensus concerning its report. Actually, Dr. Kahn's personal views run quite closely parallel to mine.

In the same part of his review, Mr. Margolis states that the "only view that comes out strongly from the summary" is the "desirability of an immediate and moderately vigorous commitment to a full blast shelter program." The passage of the summary which describes blast shelters follows. (This passage was actually written by E. P. Blizard and myself.)

"Various shelter postures are possible, beginning with the present, fallout-shelter-only posture. The marking, provisioning, and other preparation of these shelters could be accomplished at the present rather modest level of

expenditure. Far toward the opposite end of the spectrum of possible postures would be a system which could accommodate the inhabitants of all cities with a population in excess of 250,000. All together, 75 million people live in such cities, and the cost of providing Class I (100 psi, 10,000 protection factor fireproof) shelters for them may be $20 billion. Recent studies indicate that such shelters together with fallout shelters for the remaining population could protect the lives of 80 per cent of the U.S. population against an anti-population attack of 3,000 megatons provided that the warning is received in time for the population to reach the shelters."

It will be noted that this passage describes blast shelters as an "opposite end of a spectrum" and, in keeping with the objective of Project Harbor, which was to study, not to recommend, it does not recommend anything. I can only conclude that Mr. Margolis feels that the facts relating to the effectiveness of blast shelters are so strong that they constitute also a recommendation of such shelters. I am inclined to agree with this view.

Mr. Margolis is to be complimented for having read the full Harbor report and also the summary so carefully. It is not surprising, perhaps, that he particularly noted, among the slightly divergent views of the full report, those with which he agrees.

Let me now come to the second part of Mr. Margolis' article where he criticizes my views on civil defense. Even though these views are not expressed in the Harbor summary, it is essentially true that I am convinced of "the desirability of an immediate and moderately vigorous commitment to a full blast shelter program," and I have expressed such views in other places. I would not have used the term "immediate" at the time of the Harbor study; now, after two more years of research, I might be inclined to agree to it.

Mr. Margolis gives three reasons for my views:

1. An expanded program of defense rather than an increase in offensive strength would diminish the present disparity between the two capabilities. It would decrease the advantage of the aggressor and hence reduce the tenseness of the international atmosphere.

2. The Soviet Union may not (in my opinion, it would not and possibly even could not) offset our defense preparations by increasing its offensive power but react by building up its own defenses. Hence, an effective civil defense program would increase our national security vis-a-vis the USSR.

3. At any rate, our defense preparations would be effective against countries with fewer or smaller nuclear arms, such as China. This is important since it is at present China which seems most determined to defeat us.

Since the preceding represent my reasons for favoring an expanded civil defense program, I took the liberty of rephrasing Mr. Margolis' rendering of my reasons. To the above three, I would add:

4. Disarmament becomes more nearly a possible policy if the concealment of a few nuclear weapons does not provide the concealer with a decisive advantage and if there is at least some protection against lesser powers which may not adhere to a disarmament agreement.

5. Our present defenselessness tempts other governments to threats and coercion. What would we do if an enemy demanded, under threat of nuclear attack on the U.S., that we withdraw our protection of say, South Korea? Retaliation would not bring back to life those who might be killed in a nuclear attack on us, and the potential enemy knows this. Furthermore, is it

not better to protect our people than to kill, in retaliation, *many* thousands of innocent people who were totally unable to prevent aggression by their government?

6. Last but not least, if all else should fail, shelters would save untold millions of lives.

Mr. Margolis questions reason (2) for civil defense. I am convinced that he is mistaken and that the argument, as stated, is valid. However, it is not necessary for me to argue this now: any single one of the preceding reasons would suffice for my favoring civil defense measures. In my opinion, the cost is not a decisive factor: the blast shelter program could be easily financed at one-tenth of our defense budget, or around the cost of the manned lunar program. Reasonable preparations to facilitate recovery after a possible nuclear disaster might cost more, but would still not strain our resources.

Let me add that it is difficult for me to understand those who appear frightened by the possibility that the U.S. may become less vulnerable. Is it really necessary for peace on this planet that an increasing number of governments have the power to destroy the lives of millions of Americans on short notice? Do the opponents of civil defense not see that such power also provides a temptation to use it, at least for blackmail? Mr. Margolis points repeatedly and emphatically to the public apathy with regard to civil defense. If we are to trust public opinion polls, a large majority of the public is in favor of civil defense. But, in any case, if history is any guide, public apathy toward a measure would in no way prove the undesirability thereof.

In his concluding sentence, Mr. Margolis reiterates his claim that the "Harbor Summary Report somehow ended up in some ways more like a brochure for Wigner's views than a summary of the reports coming out of the National Academy of Science's summer study." The paragraph of the Harbor summary which was quoted before and the paragraph immediately following it are the only passages of the Harbor summary dealing with blast shelters in any detail. They give only facts and describe physical capabilities and limitations; they do not give views or make recommendations. Mr. Margolis does not question the physical facts, nor does he suggest that relevant ones have been omitted. Does he feel that these facts and capabilities should not have been mentioned because the American public may adopt the same views and arrive at the same recommendations to which they led me?

The procedure for preparing the Project Harbor Summary Report is described below by the technical director of the NAS Advisory Committee on Civil Defense.

The Project Harbor Summary Report condenses into less than thirty pages the six panel reports—totalling over 600 pages—that constitute the official, full-length Project Harbor Report. This summary report consists of summaries of these six reports, following an introduction and a foreword. The responsibility for the summary rested with the executive committee of Project Harbor. As stated in its introduction, such points of disagreement that existed among the panel conclusions were resolved in the summary to as great a degree as possible by the executive committee.

In preparing the summary report, the following procedure was followed: where a panel had already prepared and approved a summary during the

course of the study, it was used as a first draft. When this was not the case, summaries of the full panel reports were drafted by the staff of the NAS Advisory Committee on Civil Defense, in collaboration with the chairmen of the panel concerned; were circulated to panel members for review and comment; and were revised to reflect such comments. The resulting summaries were then edited for clarity, by the NAS advisory committee staff, the director of the Project Harbor study, and the NAS staff editor.

During this process, between January and May 1964, four successive drafts of this summary were circulated to all Project Harbor participants for their review, comments, and suggestions. The cover letters that circulated these drafts stated that such comments had to be received promptly to be useful and sometimes gave a deadline for reply. In instances when participants did not respond, it was assumed that the drafts were approved. Each succeeding draft reflected the comments received.

The Executive Committee met to consider the summary report on March 24, 1964, and approved it, subject to final, mechanical editing.

RICHARD PARK
Technical Director
Advisory Committee
on Civil Defense

The Possible Effectiveness of Civil Defense

E. P. Wigner

In: Civil Defense (H. Eyring, ed.), Publication No. 82 of the American Association for the Advancement of Science, Washington, D.C., 1966, pp. 33–51.
Ibid: E. P. Wigner's Panel Discussion, pp. 121–124

The Two Purposes of Civil Defense

I think that, after having listened to a few discussions on civil defense, you will all agree that it is a controversial subject. And there is good reason for this. It is a very complex subject to which the natural as well as the social sciences can contribute. Similar to earlier speakers, I will not quite resist the temptation to speak on several facets of the problem. However, in the main, my remarks will be based on the laws of physics and specific engineering studies. Let me, however, first put them into some broader perspective.

As in all technological problems, the first question that arises concerns the purpose of the installation for which we wish to provide technological capability. As I see it, the purpose of civil defense is, in the first place, to preserve our peace; that is, to render a war less likely without abandoning the way of life which we usually take for granted—and here I should quote the Preamble to the Constitution or the Declaration of Independence. The second purpose is to preserve as many lives and as much means of livelihood as possible in case neither civil defense nor the other efforts to preserve peace should prove successful.

In the past there have been some innovations, such as radio and television, which were considered by nearly everyone to be desirable. Other innovations, such as railroads, fertilizers, selective service, and so on through a rather long list, were passionately opposed by a large number of people and, apparently, civil defense now shares their fate. I do not believe that the desirability of the second objective—the preservation of lives—is really controversial, nor that it is really questionable that civil defense measures would save many lives in the event of war. Rather, the

question that remains to be resolved in this regard is one of degree, the degree of effectiveness.

The first, and I believe principal, objective of civil defense—the preservation of peace and of our way of life—is more often questioned. All shades of opinion seem to agree that the preponderance of offensive over defensive weapons is a principal contributor to the present tenseness of the international atmosphere. A better balance between the two could be established by disarmament. The same could be achieved by strengthening the defense, and civil defense is the key element here. It is true that disarmament would create a more stable situation at a lower level of both offensive and defensive strengths and, instinctively, we all would prefer that. However, disarmament seems to be difficult and, actually, the absolute magnitude of the available weapons, offensive and defensive, matters little. The most bloody and terrible wars were fought with weapons which seem primitive to us: the Thirty Years' War reduced the population of Germany to one-third of its prewar level. In short, it is clear that it matters little whether we reduce the gunpowder in our opponent's rifle, or harden our skin so that it will repel the bullet propelled by the full charge.

No matter how the balance between offense and defense is established, the international situation will be calmer and more relaxed. The advantage of the party striking first will be reduced, and hence also the temptation to strike first. Even disarmament will become more possible. At present, the concealment of a few large nuclear weapons would assure a great advantage to the aggressor. If the country is better protected, it can take a more relaxed view concerning a few weapons in enemy hands. It can disarm, at least to some extent, even if several of the less powerful potential enemies do not adhere to the disarmament agreement and do not permit any inspection. Disarmament might simply become one of the fruits of the more relaxed atmosphere.

Even though there is much more that could, and perhaps also should, be said about the objectives and the usefulness of civil defense preparations, let us now turn to the main subject of this discourse: the preparations themselves.

Technical Problems of Civil Defense

Before embarking on a description of civil defense preparations, let me admit that the description will not be complete. If railroads did not exist

and I should try to describe them, hundreds of questions would have to remain untouched. What will happen to the hot steam that escapes from the cylinders? What will keep the railroad cars together and be flexible enough to round the corners? How will the passengers escape suffocation from the carbon monoxide produced by the burning coal? How will the engineer know whether any person, or animal, or other train is on the tracks beyond the curve? Will the tracks not be stolen or rust? If trains get stuck between stations and people are left stranded there, communication will become actually *more primitive* than it would be without trains. Evidently, all these questions can be answered—have been answered long since—but not by people who were emotionally opposed to the very idea of railroads and fast communication. The situation is similar with respect to civil defense: It is almost as complicated a job of engineering as is railroading, and involves, in addition, questions of organization, economics, and sociology. All I can hope to do is to acquaint you with the basic ideas.

Three kinds of civil defense preparations can be envisaged. The first kind—shelters—would protect the lives of people from the immediate effects of nuclear—and other—weapons. These can be described most completely. The second type is economic preparation in order to mitigate the effect of the devastation of any war on the economic structure and thus render life after the cessation of hostilities easier and the recovery from war damage faster. Although there is considerable literature on this subject, it has not been explored at all completely. The third type of preparation is organizational; its purpose is to maintain the structure of the government, the unity of the country, and its social organization. Less thought has been given to this question than to the other two—much less than it deserves. The reason may be that social scientists can visualize a nuclear war even less than we natural scientists can. Perhaps they trust improvisation more than we do.

Immediate Survival

Let us start with the defense against direct effects of nuclear weapons, that is, blast, heat, and fallout. Of the three, the radioactivity of fallout can cover the widest areas, and protection against this radioactivity is easiest. It is natural, therefore, that the first objective of the Office of Civil Defense was to provide protection against fallout radiation for all.

In spite of very meager appropriations, it has made remarkable progress. The United States has a population of about 190 million, but more than 190 million shelter spaces, perhaps 240 million, would be needed to assure that shelter would be available to people at work and at home. So far, 140 million fallout shelter spaces have been located, with a minimum protection factor of 40 against fallout radiation. This means that people in these shelters would receive less than a fortieth of the radiation they would receive outside. Information is being gathered on the need for water, food, and sanitation in the shelters and every effort is being made to provide these necessities. So far, stocks have been placed in shelters for more than 60 million people for an average period of 8 days.

A survey of small buildings with basements is also under way and this is expected to add many more spaces to the present supply, albeit some with a protection factor of only 20 to 40. The average protection factor of present fallout shelters is about 150. It is important to realize, however, that even a very moderate protection can be decisive. The effects of a radiation dose of 50 roentgens would not be noticed directly by the receiver; an eight times larger dose, or 400 roentgens, would result in death for half of all those who received it. It is, therefore, unquestionable that, in spite of its treatment as a stepchild, the fallout shelter program has made great strides. In case of nuclear war, it would save an untold number of lives and would do so at an almost unbelievably low cost.

The Tunnel-Grid System

Whether the fallout shelter program can also fulfill the other function of civil defense—to prevent a war by discouraging aggression—is more questionable. Hence, a more ambitious program of community-wide blast shelters for regions in the neighborhood of target areas and for cities has been explored at the Oak Ridge National Laboratory. The requirement, set rather early for this work and which has turned out to be decisive, was that the evacuation of the sheltered people become possible and that lines of communication be provided between the various shelters. It then soon became clear that the tunnels connecting the various shelters would have enough space for all so that they could serve as shelters themselves. This led to the conception of a community-wide shelter system. A similar conclusion had been reached earlier by Professor H. P. Harrenstien at the University of Arizona (*1*).

Figure 1 (left) shows a plan of the tunnels in a hypothetical city. Parallel tunnels are about a mile from each other and, evidently, one can proceed from any point in the tunnel by various routes to any other point. The total area of the city is about 140 square miles and, as we shall see, the tunnels can accommodate about 10,000 people per square mile, altogether nearly 1½ million. Figure 1 (right) shows the arrangement of the tunnels if the density of the people at the center of the city is large during daytime so that more space is temporarily needed in the business area.

In case of an emergency, people could enter the tunnels at the nearest entrance, and they could then reach any other desired point and, at any rate, distribute themselves uniformly over the area of the city. Figure 2 shows a cross section of the tunnel with the beds folded down. When the people are not yet in place and are using the tunnels to go to their destinations, the beds would be folded up. The tunnels in this conception consist of reinforced, commercially available, concrete pipes and are located below the utilities. They have a diameter of 8 or 10 feet and a wall thickness of about 8 inches. This gives a blast resistance of about 450 pounds per square inch (psi); however, several conditions limit the useful blast resistance to 100 psi, or perhaps 200. The air intake valves are not designed for a higher pressure, and the movement of the ground also becomes serious above these pressures. Figure 3 is a photograph of the inside of a mock-up which was installed at the Oak Ridge National Laboratory. When all people have arrived at their places, there is just about one person per foot-length of tunnel, giving a density of about 10,000 people per square mile.

Figure 4 shows an entranceway. It is patterned on the air locks that are used at nuclear installations. There are three intermediate rooms, and the door of at least one is always open. It closes when another similar door is opened, whereupon the door separating the intermediate room from the shelter proper opens and people enter the shelter proper. In this way, access to newcomers is never denied, even though there always remains a closed, blastproof door between outside and inside.

Figure 5 shows the effectiveness of the shelter. In the open, a 10-psi pressure wave may cause very serious injury, and inside buildings the situation may be aggravated by flying objects. As indicated by the graph, the pressure wave from a 20-megaton explosion, at the proper height, covers an area of almost 180 square miles with a pressure of 10 psi. How-

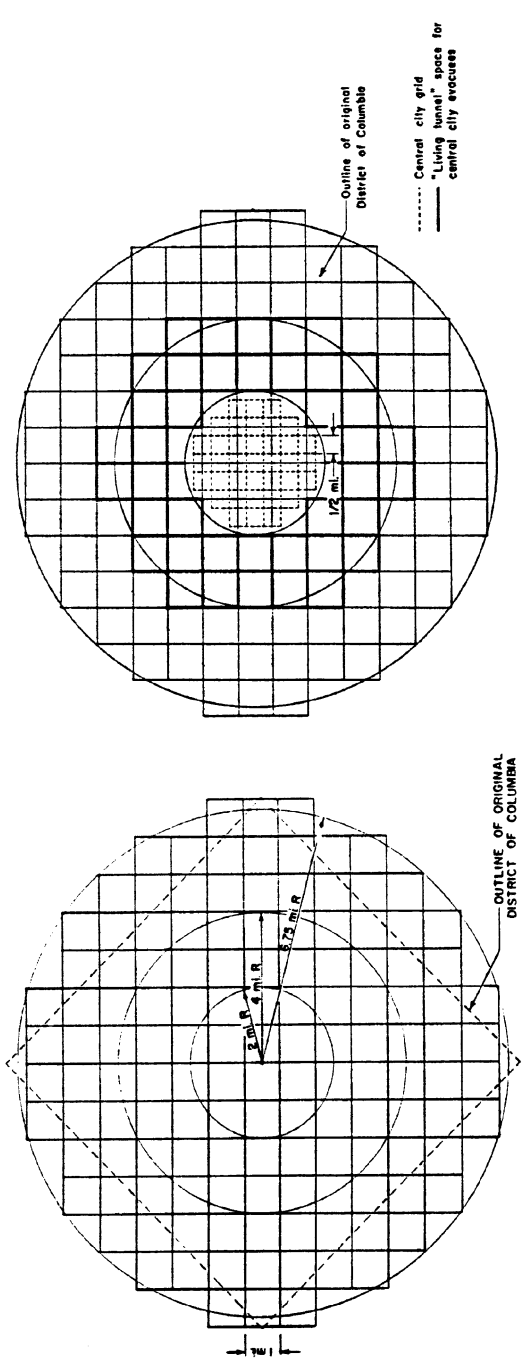


Fig. 1. (Left) Arrangement of the shelter tunnels under a hypothetical city with an area of about 140 square miles and a population of about 1½ million in which the people are always uniformly distributed. (Right) Arrangement of the shelter tunnels under a city of similar size and population as that of Fig. 1 (left) in which, however, the number of people is very large at the center during the daytime. [Oak Ridge National Laboratory]

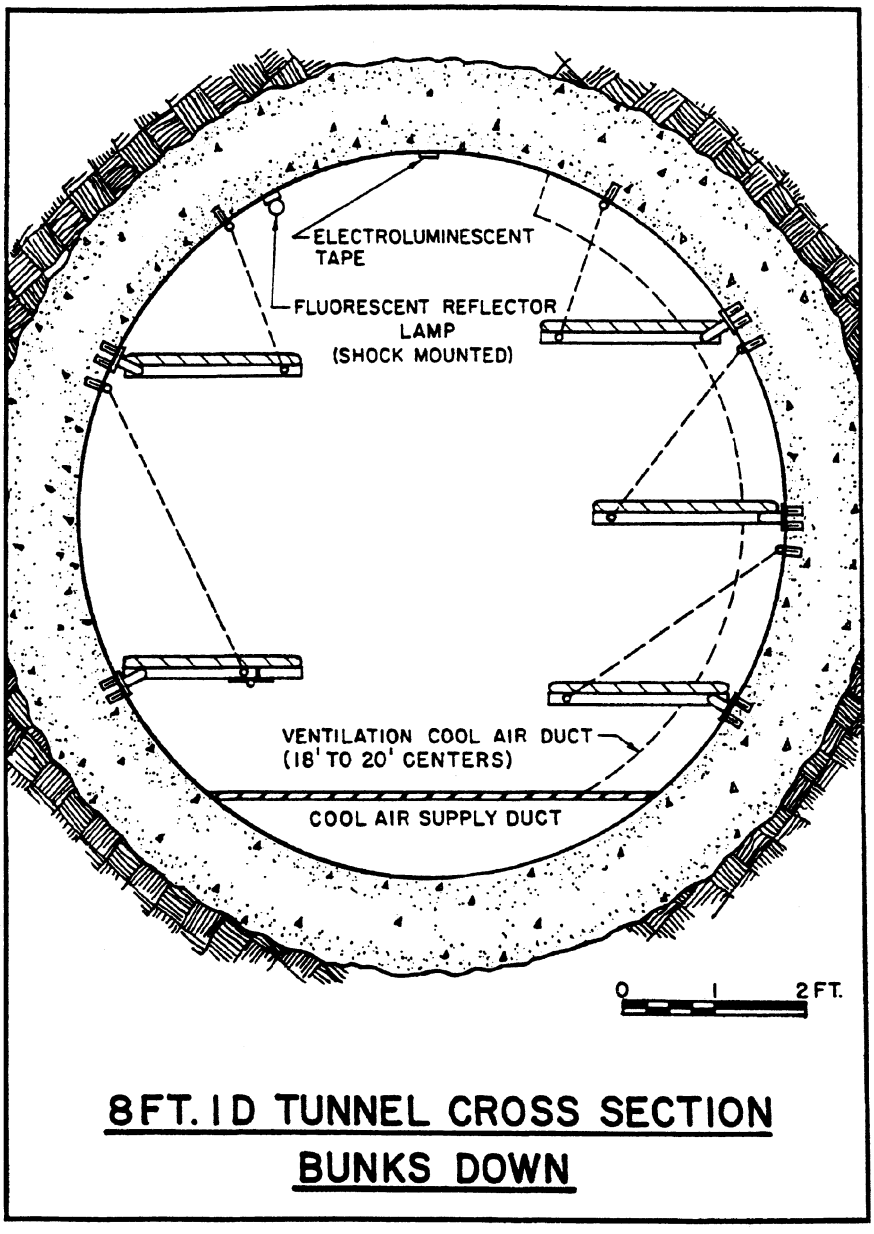


Fig. 2. Typical cross section of a shelter tunnel with the sleeping bunks folded down. [Oak Ridge National Laboratory]

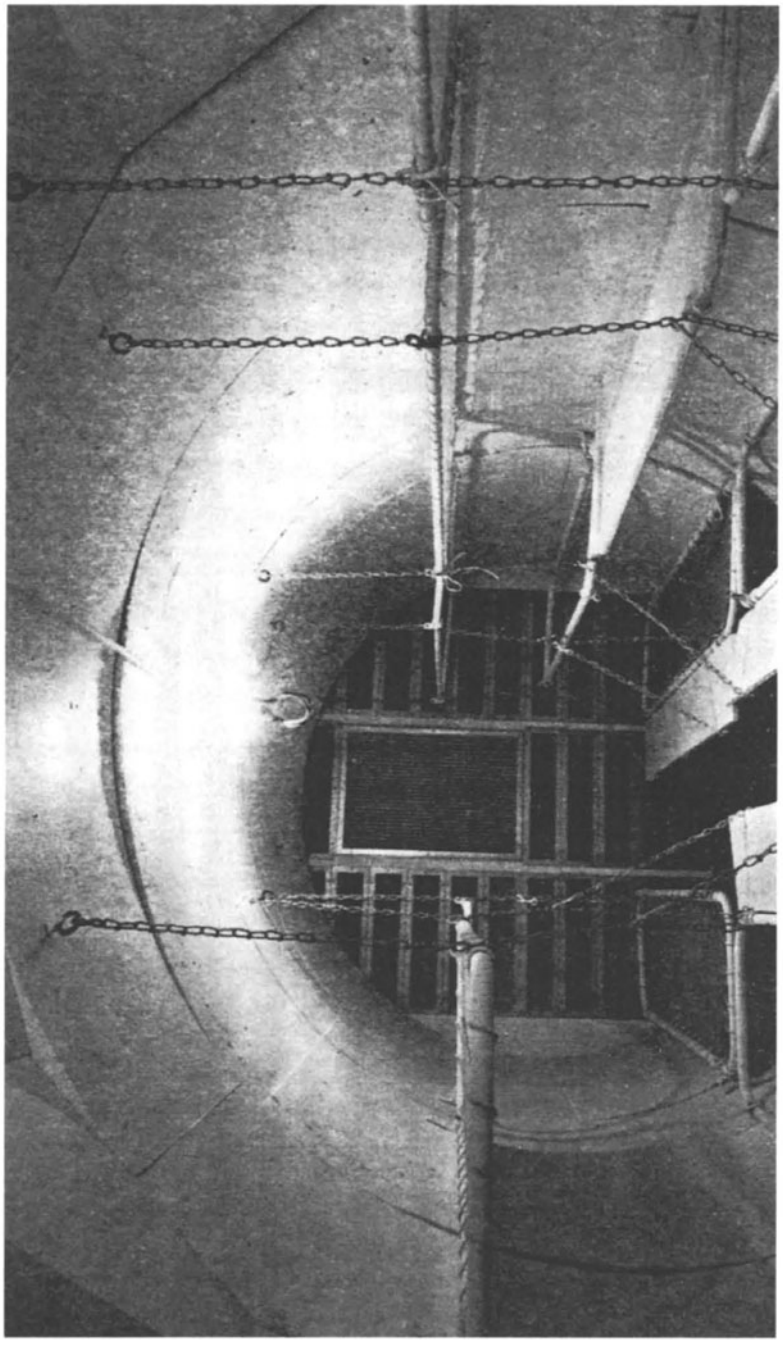


Fig. 3. Mock-up of the shelter tunnel during construction at Oak Ridge National Laboratory. [Oak Ridge National Laboratory]

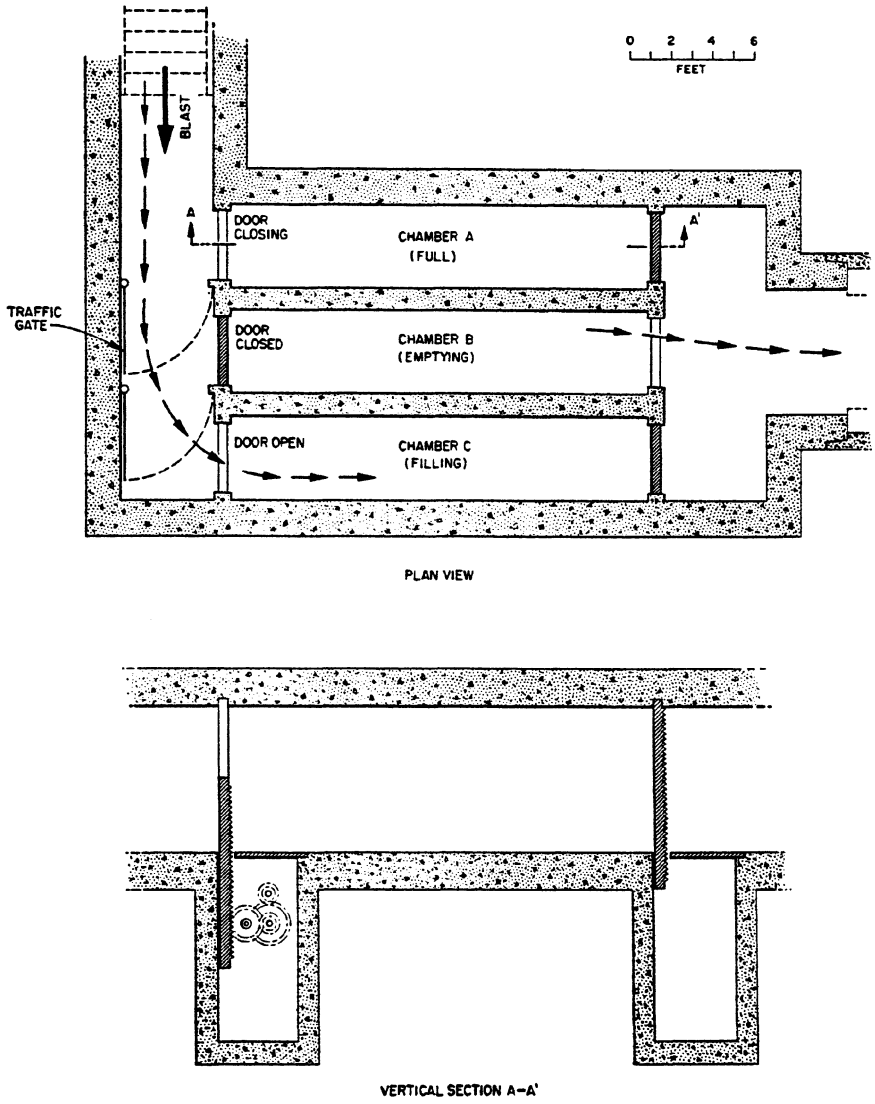


Fig. 4. Plan view and elevation of entrances. The plan view shows how the "locks" function. [Oak Ridge National Laboratory]

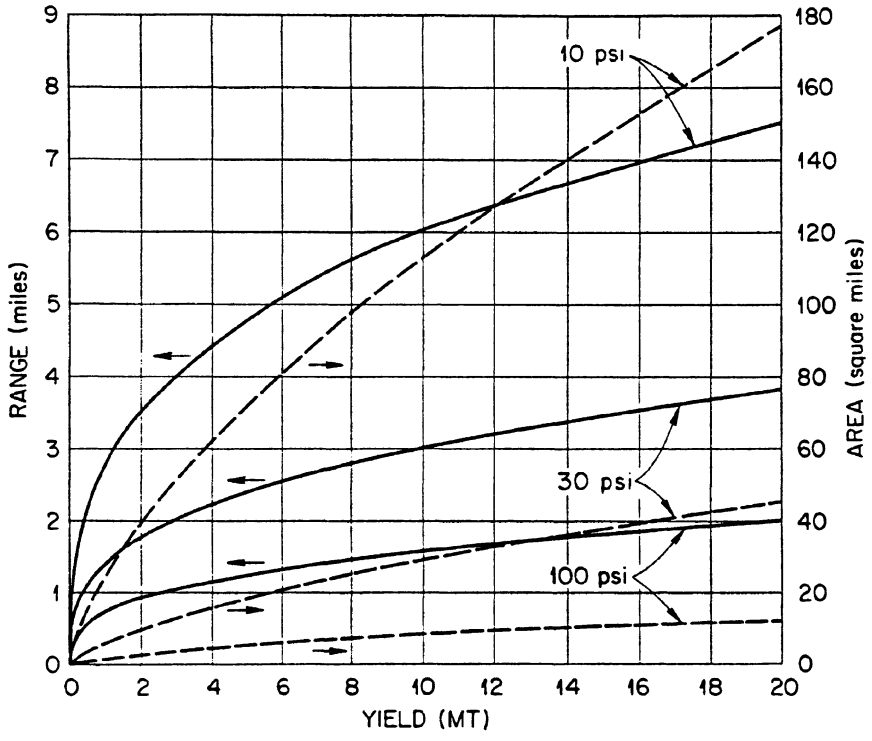


Fig. 5. The solid lines indicate the range at which a certain overpressure can be created, as a function of the magnitude of the explosion. The broken lines indicate the area which such an overpressure covers. One sees, for instance, that in the case of a 20-megaton explosion the area within which the pressure of the blast wave exceeds 10 psi is 177 square miles, the area within which it exceeds 100 psi is 12 square miles. [Oak Ridge National Laboratory]

ever, the area covered by 100 psi, which would damage the tunnels, is only about 10 square miles.

A dramatic illustration of the efficiency of such a shelter system was provided, unintentionally, by the St. Louis Committee for Nuclear Information. This committee postulated an explosion of 10-megaton magnitude above the intersection of Kingshighway and Lindell Boulevards in St. Louis. It then pointed out that fallout shelters, or shelters with a blast resistance of 5 psi, would save only a small fraction of the people. It concluded, or implied, that shelters are useless. We calculated the effect of the same explosion against a shelter system as described here and found

that the number of people endangered would be reduced to less than 7½ percent. Incidentally, even to achieve this number, the enemy would have to lower the height of the explosion to 7300 feet; an explosion at the height originally stipulated by the St. Louis Committee—21,000 feet —would not breach the tunnels anywhere.

Two Objections to the Program of Extended Protection

The most popular argument against civil defense starts with a vivid description of the horrors of a nuclear war; at times this constitutes the whole argument. It is unlikely that any American is not already conscious of these horrors—some may be almost obsessed by fear of them. A logical and open-minded listener would expect that the sequel to this introduction would be a description of all possible means of preventing, first, war itself, and second, of diminishing the impact of a possible nuclear attack. These means include, among others, an effective United Nations, anti-missile missiles, and civil defense. Instead, the argument often continues with an accusation of guilt by association which links civil defense with the horrors of war. Unfortunately, many who argue in this way are scientists who, in their emotional involvement, do not seem to be aware of their scientific obligation toward logical thought.

Let us consider, instead, two more rational objections to blast shelters. The first of these is that they protect only against fallout radiation and blast, not against the heat from fires which may be started aboveground by the heat flash of the explosion. "But these considerations do not take into account the enormous heat generated by urban firestorms, which is so intense that it would kill the inhabitants of closed shelters, unless they were specially constructed deep underground" is the statement of the St. Louis Committee for Nuclear Information (*2*). It is difficult to understand how this fear could have originated. Earth is a very poor conductor of heat and, at the depth at which the shelter system must be located in order to avoid interference with utilities, the heat influx from the surface is insignificant. Fires on the surface cause problems for the air supply of isolated shelters, but even these are about as serious as the problems which I mentioned in connection with the railroads.

The second objection to blast shelters is not absurd. It claims that it is the established policy of our opponents to increase their nuclear arsenal and delivery capability to such an extent as to neutralize any defense

measure which we might undertake. Hence, it is claimed, such defense measures are purposeless.

The questions then arise as to whether our opponents wish, and whether they can, increase their capabilities to the required extent. The first question is usually disregarded and its answer is assumed to be affirmative. The answer that is usually given to the second question is that, yes, they are able to expand their offensive power sufficiently and are able to do so at a fraction of the cost of the shelters which may prompt this expansion of effort.

This last argument surely does not apply to opponents less advanced economically, such as China. Because of the bellicosity of China, this seems to be a very important point and it may, in the future, apply to other nations as well. Hence, if one claims that we should not provide shelters, one really says that we should not protect our people even where we can and that it is necessary for peace on this planet that an increasing number of governments have the power to kill millions of Americans on short notice.

In the case of the U.S.S.R., the argument is difficult to refute categorically because (i) we cannot be sure of the intentions of the U.S.S.R. and (ii) we do not know how high its expenditures are per unit missile. We can say, however, that we reduced the production of nuclear materials at a time when the U.S.S.R. increased its defenses, both civil and active (*3*). If the U.S.S.R. is our mirror image, there is little reason to fear that our civil defense will induce it to any but similar defense measures. These would also bring disarmament closer. As to the cost of increased missile power to neutralize our increased defenses, it appears from the examples just given that the offensive power would have to be increased by a factor between 10 and 20 in order to neutralize the tunnel-grid system. It is difficult to believe that this could be done at a lower cost than that of the shelters. Let me admit, though, that the argument would not convince me even if the cost exchange ratio of shelters versus increased offensive power were not in favor of the shelters. The United States could afford to protect its people even if the exchange ratio were adverse.

Cost and Peacetime Uses of the Tunnel-Grid System

The cost of the Oak Ridge National Laboratory tunnel-grid system, for use as a shelter only, was estimated by a construction company,

Holmes and Narver, Inc. (*1*). This company was responsible for many of the sites for testing nuclear weapons and has, therefore, experience in the field. It arrived at a cost of around $500 per person—a figure about five times lower than some of the earlier estimates. This would put the total cost of protecting cities with a population of more than 250,000 at about $38 billion—not quite twice the cost of the lunar program (*4*, p. 324). No one who has given some detailed thought to ways of implementing a novel idea inexpensively, and compared the cost arrived at with an unplanned, haphazard implementation, will be much surprised by this reduction of cost. Actually, the estimate of Holmes and Narver is based on present construction methods and, presumably, can be reduced *a good deal further* (*5*). The discrepancy between the present and earlier estimates of the cost of blast shelters may be responsible, at least partially, for the difference of opinion concerning the "exchange ratio" between shelters and increased offensive power.

Let me enumerate some of the favorable characteristics of the tunnel-grid system:

1) The cylindrical structure is very resistant to blast damage.
2) The entire urban shelter system is interconnected.
   a) Members of a family, in various parts of the city, enter the same shelter and can be reunited.
   b) Critical personnel and facilities (for example, medical) are accessible to the entire population.
   c) Localized overcrowding can be reduced.
3) Some of the supporting facilities can be easily shared.
   a) Auxiliary power.
   b) Source of external air supply can be shifted, depending on the fire and rubble problem.
4) Protected city evacuation facilitated by multiple exits, each accessible to all.
5) Potential "dual" use, that is, use in peacetime.

As against these advantages, the most obvious drawback of the tunnel-grid system is that it may be subject to clandestine bacteriological warfare (infected objects smuggled in by secret agents). The objection was also raised that explosions, if they should penetrate the tunnels, might spread there with very little attenuation. However, we believe that this danger can be quite effectively countered.

A possible dual use of the tunnels might be as underground passage-

ways, either for pedestrians or for vehicular traffic. In the latter case, of course, tunnels would be larger than if designed only to be used as shelters. It may be useful to mention that plans for underground passageways are now being formulated, quite independently of civil defense, in 17 of our cities. Even if originally contemplated only for vehicular traffic, these passageways could be reinforced at not too great an additional cost and could then serve as shelters in an emergency. We attach such significance to the dual-use concept since it eliminates many of the apprehensions of a political nature which are often voiced against civil defense. Even if these fears are farfetched, it would be useful to eliminate them *ab initio*.

Economic Recovery: The Immediate Necessities of Life

The problems of immediate survival have been dealt with so extensively because any competence that I may have is in that area and also because the work at Oak Ridge National Laboratory, in which I participated, was directed toward problems of immediate survival. Nevertheless, there are many questions which were not touched, but I have confidence that we have a reasonable, though far from perfect, understanding of all problems in this area. A particular, and particularly important, subject which has not been discussed is the cooperation between civil and active defenses—the latter being antiaircraft and antiballistic missiles. I shall just say that, in my opinion, the two types of defenses could complement each other and produce a more effective defense than the sum of the two.

As far as economic recovery is concerned, most of my knowledge derives from the Project Harbor study—a summer study about 2 years old (*6*). This was organized by the National Academy of Sciences, had 62 participants, 16 of whom worked on the panel on Postattack Recovery. The study lasted 6 weeks.

It seems to me that the problem of recovery can be divided into two parts. The first is to assure that the immediate necessities of life remain available until the second phase, the restoration of production, can be accomplished. The solution of the first part of the problem appears easier than that of the second part and will be considered first.

The immediate necessities of life are food, lodging, and medicines. At the time of the Harbor study, the food surplus in our granaries was sufficient for 2 years and, I am told, there was a 6-month supply in processed, immediately usable form. Unfortunately, the situation is less favorable today. As a result of crop failures in other countries, in particular in the

U.S.S.R., our food surplus has decreased and we now have only a 1-year requirement on hand. Since 1961 we have given away more than $1½ billion in food each year. This constitutes a significant part of the production of the types of food that are in our stockpiles. Thus, in 1964 the amount of wheat that we gave away equalled 44 percent of the wheat produced in that year.

No matter how large the food supply is, it could not fulfill its function in an emergency unless it were distributed over the country in rough proportion to the population and stored in such a way that it remained protected from enemy attack. Neither is the case now, but both could be accomplished at a rather moderate expenditure.

A nuclear attack would unquestionably wreak havoc on aboveground structures and would cause a very severe housing shortage. People would have to do with improvised lodging for years—some would probably continue to use the shelters long after outside radioactivity had died down to tolerable levels. This may be, in fact, an important function of the shelters in the postattack period. The percentage loss of regular housing could well exceed that of Germany during World War II. It is true, on the other hand, that the present living space per person is much greater, so that crowding may not be more severe than it was in Germany after the war. It would, however, strike a population accustomed to more commodious quarters.

The storing of medical supplies is a less exacting problem than the storage of food. However, unanticipated medical problems may develop as a result of dislocations and the changed mode of life. The Harbor Postattack Recovery Panel recommended that these problems be studied so that better preparations could be instituted. As far as I know, no such study has been undertaken.

Economic Recovery: Restoration of Production

Stockpiling the immediate necessities of life may help over the early critical period in that economic effort can be concentrated on restoring production and the means of production. It can perform a function similar to that of the Marshall Plan for Europe and, in particular, for Germany.

Unfortunately, there are no detailed plans for the restoration of production and the problem appears to be difficult. The fact is that our economists have not tried to visualize in any real detail the state of our pro-

duction facilities after a war, and we do not know how and in what order production can and should be resumed. Agriculture, which will be reviewed by Dr. Rust, is perhaps a fortunate exception.

Some perspective on the problem can be gained by comparing the national wealth (around $1700 billion in 1958) (*4*, p. 351) with the yearly gross national product ($460 billion in 1958) (*4*, p. 326). Naturally, some of the wealth would be preserved under all conditions; some is, indeed, indestructible. On the other hand, since means of transportation would be destroyed in a war, replenishment of the national wealth would start slowly. After the establishment of a sound monetary system, it took Germany more than 2 years to repair the facilities destroyed during World War II to an extent where production assumed its prewar level.

Another perspective is given in the Harbor Summary, from which I wish to quote three paragraphs (*6*, p. 22):

> A factor favoring recovery capability is the great size of our resources, in particular of our food stock and production facilities. Unfavorable factors are the current vulnerability of these facilities, their concentration in or near large cities, and their dependence on each other so that destruction of one facility may paralyze many others. Also unfavorable are the inadequacies of plans for postattack recovery. The postattack situation, when compared with the problems of an underdeveloped nation, would have the decisive advantage of having already on hand the skills needed to rebuild and operate an advanced economy. These skills may be worth more than our material wealth. The postattack situation would be more difficult than that of an underdeveloped country because of the radiation that would hamper many postattack activities, and the fact that our people are now poorly adjusted to the low level of living that would be unavoidable under postwar conditions. Help from outside the United States, or from less heavily affected areas within it, could, however, be more effectively used here than in underdeveloped countries.
>
> A major vulnerability of the U.S. economic system, in addition to the interdependence of its elements, is its dependence on electric power, petroleum, communications, and transport. Because of interdependence and the importance of timing, the postattack measures for restoring production must follow a sequential order. For example, first priority might be restoration of power; next that of communications, water and sewage, fuel, and transportation.
>
> Among the various sectors of the economy, petroleum may be the Achilles heel, in that refineries, ports, and stocks are very vulnerable targets. The situation regarding medical supplies would be desperately bad if an attack came now, but could be improved relatively easily.

Social Recovery

With regard to the question of the restoration of production after a war, only a perspective can be presented, and a hope that a purposefully organized research effort would provide direction and better understanding. The situation is similar, but I believe even more nebulous, with respect to problems of the restoration of government and of our social system. On the debit side is the fact that few modern governments have survived a lost war and that, in a sense, every nuclear war would be lost by all parties. On the other side is the strong loyalty of the American people to our form of government, the role which local leadership plays therein, and the often heroic self-sacrifice of which people are capable in an emergency. I fear that we, highly educated people, often forget that learning affects only our intellect and that the hearts of people with less knowledge beat as strongly as ours. I have led a rather sheltered life among educated people, but have seen many selfless deeds, most of which were performed by less educated men.

The Harbor study proposed the creation of two organizations, partly for managing affairs during the shelter period, partly to facilitate restoration of the governmental and social structure. (It also proposed an organization to assist with economic decisions.) The first of these would be professional; its size, around 35,000, might approximate that of the Public Health Service. The other organization proposed, the Civil Defense Corps, would be much larger, perhaps 1½ million, but purely voluntary. It would provide most shelter managers, instruction in shelters concerning conditions to be expected outside, and so forth. It is hoped that members of these two organizations would become the natural leaders of those whose care is entrusted to them and would develop enough leadership to help them through the hardships of the postwar world.

Again: The Objectives of Civil Defense

How would civil defense preparations affect our society and our outlook on life? Some fear adverse effects, that civil defense would make people militaristic and even bellicose. This fear is responsible for much of the opposition to civil defense and is very widespread among intellectuals. It seems to me that it stems largely from the underestimate of the

common man about which I have already spoken. It is true that one cannot hide civil defense preparations behind high fences. But, as people generally became aware of these preparations and participate in them, they would also become more aware of their responsibility for international peace and the defense of their country. Undoubtedly, some will view this as an added burden. However, if one believes in the right and in the duty of all our people to share in shaping our destinies, increased public consciousness of international and defense problems *forms more a reason for than against civil defense.*

All but the first brief section of this review was concerned with the functioning of civil defense during and after an emergency. It is easy to forget, therefore, that if civil defense should function at all, it would have already failed in its principal objective, as our whole national policy would also have failed: they would have failed to prevent a war. However, civil defense would remain useful even then since it would alleviate suffering and prevent much loss of life. It cannot and need not be perfect for this purpose: even an imperfect civil defense could mean an almost infinite decrease of suffering and an enormous reduction in loss of life.

As to the larger issue, both Dr. T. B. Taylor and I stated at the Gatlinburg Conference (*7*) that civil defense is a short-range measure. Its objective is to discourage aggression, to dissuade governments from trying to increase their power by force and, what is probably even more tempting and equally pernicious, by the threat of force. Once this is accomplished we will be closer to President Johnson's presently distant ideal (*8*) of "a society in which man can live in peace, enjoy the freedom and personal security to shape his destiny according to his individual beliefs, and have the leisure to contribute to the culture of his civilization."

References

1. H. P. Harrenstien *et. al., Local Civil Defense Systems,* Final Report, Contract OCD-OS-62-232 (Engineering Research Laboratory, University of Arizona, Tucson, 1964). Even this report had several precursors. The following description of the tunnel-grid system is based on work at the Oak Ridge National Laboratory and the engineering study of Holmes and Narver, Inc. See, for instance, ORNL Report TM-1223, *Engineering Study for Tunnel Grid Blast Shelter Concept for a Portion of City of Detroit, Michigan,* by Donald T. Robbins and David L. Narver, Jr.
2. *Scientist and Citizen* (Greater St. Louis Committee for Nuclear Information, St. Louis, 1965) **7,** Nos. 6 and 7, p. 26.

3. According to the November 26, 1965 press release of the U.S. Atomic Energy Commission, "The cutbacks in U.S. plutonium production announced by President Johnson in early 1964 were completed in June of this year; four large U.S. plutonium production reactors now have been shut down. The U-235 cutbacks also announced in 1964 and 1965 have been initiated with the full reduction to be achieved by 1969. 1300 MW of electric power for the operation of gaseous diffusion plants have been dropped since June, 1964." This was done in the face of declarations such as "Civil Defense units have been set up at all enterprises, in industrial centers, in cities and rural areas" (Marshal Vasily I. Chuikov, interview to *Pravda*, March 1965). Such declarations prove, *at least*, that the U.S.S.R., on its part, does not fear that its civil defense will induce us to increase our offensive power so as to neutralize it.
4. *Statistical Abstract of the United States,* 1965, 86th annual edition (Government Printing Office, Washington, D.C., 1965). It may be of some interest to note, for comparison, that the total worth of the products of the construction industry is about $67 billion per year. Hence, if the construction of the tunnel-grid system were spread out over 7 years, it would require about 8 percent of the present effort of this industry.
5. We have already found two items of the original estimate in which the cost can be reduced substantially.
6. *Civil Defense: Project Harbor Summary Report,* Publication 1237 (National Academy of Sciences–National Research Council, Washington, D.C., 1964).
7. "Panel discussion on civil defense, American Nuclear Society annual meeting, Wednesday evening, June 23, 1965, Gatlinburg, Tennessee," ORNL Report 3865 (September 1965). A. M. Weinberg, moderator; D. F. Cavers, T. T. Stonier, T. B. Taylor, and E. P. Wigner, participants.
8. Letter to Glenn T. Seaborg, dated April 18, 1965.

Eugene P. Wigner

I appreciate the opportunity to comment on the addresses of the other speakers at our symposium.

Let me begin by complimenting our moderator, Dr. Rapoport. Even though an admitted opponent of a vigorous civil defense program, he remained fair and objective. He also emphasized the role of value orientations in the attitudes toward civil defense; his own attitude is motivated, I presume, by his pacifism. Now, evidently, we all desire peace fervently and the differences of opinion concern only the *ways* in which we wish to preserve peace.

Dr. Rapoport said, in a note to the *Bulletin of the Atomic Scientists* (*1*), that it is possible that surrender to Hitler would have led to fewer deaths and to less suffering than our chosen path of resistance. My view is opposite in this case: I believe that if the West had shown clear resolve and determination from the start, World War II could have been averted. Similarly, I do not believe that the United States could sink to the type of independence suggested by Dr. Rapoport, "shorn of discernible influence in international affairs" to the status of Finland or Iceland, *and not sink deeper*. "The mere existence of capitalistic countries is a menace to peace" are the words of the Secretary of Defense of one of the least rabid dictatorships (*2*). For rulers in dictatorships, the desire to extend their power is one of those primitive desires, the existence of which Dr. Rapoport so clearly recognizes.

Similarly, I am opposed to the policy of surrender which Dr. Rapoport's book (*3*) wants us to consider seriously, as is also the vast majority of our people. One of my reasons is practical: We would buy not even a miserable life for it. If we surrendered to dictatorship A today, our country would become the staging area for a war against dictatorship B tomorrow. My second reason is emotional. I believe, as does the vast majority of the United States, that our freedom and our way of life are worth defending, that we would deny this by surrendering meekly to a new dictatorship every 20 or 30 years. The people of the world would come to despise our way of life if we were unwilling to make sacrifices to defend it. We ourselves would be demoralized.

Since I was so much impressed by the sincerity of Dr. Rapoport's address, let me correct one straight error therein. The advocates of a strong civil defense program are not influenced by the technical challenges that

it offers. They are not influenced by these challenges because the civil defense measures do not offer such challenges; their basic principles are relatively straightforward. Certainly, the ingenuity needed for planning military equipment, or almost any other kind of machinery, is so much greater that I was told, about a year ago, that the absence of challenging problems in civil defense planning will undoubtedly interfere with this program.

Let me come to the addresses of the other speakers. I will not comment on those of Drs. Payne and Rust because I fully agree with them—I could only reaffirm what they said. Dr. Commoner's remarks were largely answered by Dr. Rust. Perhaps I should add that the objective of Harbor Study's Acceptance and Impact Panel did not concern persuasion. Rather, the objective was "to explore the basis for attitudes on civil defense, and to consider the reasons for objections and *whether and how* they could be met" (*4*). In other words, the objective was to determine the impact that various civil defense programs would have and which, if any, of the programs was free from the objections that have been voiced against civil defense in general. This effectively disposes of the criticism that the Harbor Project "put the cart before the horse."

I was much impressed, however, by Dr. Panofsky's address. He pointed out that the various parts of our economy are becoming increasingly interdependent and that this renders the planning for recovery from the effects of nuclear attack increasingly difficult. I am afraid he may be right. This does not lead me, however, to his conclusion that only a modest civil defense program is justified—one that would decrease the loss of life only moderately and remain ineffective as a means of preserving peace by discouraging "blackmail." I hope I am interpreting Dr. Panofsky correctly. In my opinion, the point made by Dr. Panofsky may render preparations for recovery more difficult; it does not render them less desirable. Furthermore, there are compensating factors: as the interdependence of different sectors of our economy grows as a result of technical progress, so does our ability to plan, and the miraculously fast recovery of Western Germany after World War II shows that human ingenuity and adaptability can do wonders if the morale of the people is restored. On this, let me quote Professor Janis of Yale (*5*): "To a very large extent, the morale of the survivors of an atomic bomb attack will be determined by the effectiveness of civil defense measures."

In contrast to these, I had great difficulty in following the addresses of Drs. Chamberlain and Sidel. The National Academy of Sciences does

not need my defense. Let me state, nevertheless, that I find it surprising that Dr. Chamberlain suggests that it should have suppressed the Project Harbor Summary. This was the product of a project sponsored by the Academy. I feel sure that Dr. Chamberlain would have very vocally resented the suppression of a similar report by the Academy if the report had presented his own conclusions. Does he wish the Free Speech principle to apply only to those views which he favors?

The other point made by Dr. Chamberlain questions the feasibility of one of the objectives of civil defense: the decreased vulnerability toward an attack by the U.S.S.R. He does not discuss the other objectives, such as defense against an attack by a less powerful country, decreased temptation to nuclear blackmail, relaxation of the international atmosphere, and some others. I am convinced that a very significant protection could be also provided against an attack by the U.S.S.R., and *even very authoritative statements would not convince me otherwise.* As a matter of fact, Dr. Chamberlain admits that his cost estimates apply only up to a certain magnitude of protection, and that the situation is *reversed* beyond that limit. He gives no numerical estimate of that limit. Even if this limit were not reached by the protection considered by us, his disregard of the other objectives of civil defense renders his analysis, to use his own words, "quite biased. . . . In no case should [it] be used as a basis for deciding that a large civil defense program should be undertaken in this country."

Even less could I follow Dr. Sidel's conclusions. It seems to me that the picture he projects of a nuclear war visited on an unsheltered population is the best argument *for* shelters. The number of burns, in particular, would be many, many times smaller if the shelter system which I described were in effect. He says that shelters would have no value because the doctors would be inside the shelters and have no access to the injured. This is not true for the connected shelter system which I described. His remarks on shelters, therefore, strongly argue *for the particular shelter system which I described.* However, even if one does not go into details, it is difficult to comprehend how a reduction of the total number of injuries and an increase in the number of those who can care for them would aggravate the situation. Similarly, I cannot see how the mental desolation he described would be increased by the knowledge that all possible measures had been taken to mitigate the effects of the disaster which occurred. Let me quote Irving Janis again (*5*): ". . . the morale of the survivors . . . will be determined by the effectiveness of the civil defense measures."

References

1. A. Rapoport, *Bull. Atomic Scientists* **21**, No. 10 (1955), p. 31.
2. Speech of Secretary of Defense Czinege of Hungary on April 4, 1964.
3. A. Rapoport, *Strategy and Conscience* (Harper and Row, New York, 1964). Compare, for example the preface.
4. *Civil Defense, Project Harbor Summary Report,* Publication 1237 (National Academy of Sciences–National Research Council, Washington, D.C., 1964), p. 4. Assignment of the Acceptance and Impact Panel. Italics added.
5. Irving L. Janis, *Bull. Atomic Scientists* **6** (1950) pp. 256, 259, and several other places.

Civil Defense and Disarmament

E. P. Wigner

Industrial Research *9*, No. 1, 80 (January 1967)

The 1963 Nobel Prize in physics was awarded to Dr. Eugene P. Wigner for formulating the laws governing the mechanics of nuclear particles and for his work on the principles of symmetry which underly the interaction of nuclear particles in accordance with their spinning motion. In addition to the Nobel Prize, Fermi Award, and Franklin Institute Medal, Wigner shared the Ford Foundation Atoms-for-Peace Award in 1960, and in 1961, he was presented with the Max Planck Medal of the German Physical Society.

TECHNICAL PROBLEMS of civil defense are relatively simple when compared to the problems of active defense. They require only a knowledge of the effects of nuclear weapons, not of the structure of the weapons themselves. The latter is necessary only if one attempts to destroy the weapons rather than to protect against the effects of their explosion.

Civil defense creates shelters or barriers between the explosion and the people to be protected — rather than sophisticated means to discover incoming weapons carrying missiles, to distinguish them from decoys and chaff, and to destroy them by means of the explosion of an antimissile bomb.

As compared to the problems faced by the antimissile, or even the anti-aircraft weaponeer, the technical problems of civil defense appear to be very simple.

What then are the facts on the possible effectiveness of shelters? To answer this question, the Oak Ridge National Laboratory undertook a study which led to the design of a shelter model.

The model consists of an underground network of tunnels under the city to be protected, with entrances within 10 minutes walking distance from any point on the street. The tunnels have concrete pipes 2½ meters (8 or 9 ft) in diameter.

The tunnels not only serve as shelters, but also as passageways through which every other part of the shelter system can be reached. This would permit separated families to be reunited, medical help to be furnished, and communication in the city to be maintained.

The blast resistance of the concrete pipe commonly available is about 30 kg/sq cm² (450 psi). However, according to the Oak Ridge study, the true resistance of the shelter system is only against a shock of about 7 kg/cm² (100 psi). At points of higher pressure, the ground motion, and hence the motion of the concrete pipes, becomes so large that it endangers the lives of those inside.

There are other problems also with the air intakes and entrances. Whether, and to what extent, these problems can be overcome needs further clarification. Even though problems of civil defense and of shelter construction are less subtle than those of military defense, imagination and technical vision can play a major role in making them more effective.

Even if the effectiveness of shelters is limited to 7 kg/cm² (100 psi), it still would reduce the area of life destruction of a 1-megaton bomb from about 40 km² (24 sq miles) to about 4 km² (1.7 sq miles), and of a 20-megaton explosion from 450 km² (175 sq miles) to 30 km² (12.5 sq miles).

The last figures could be reduced even further if the blast resistance could be increased above 7 kg/cm² (100 psi).

Blast resistance of the shelter is its single most important characteristic. It is, however, by no means the only characteristic.

There also are factors of different types, such as dissipating the body heat of the sheltered people during periods when outside air cannot be used for ventilation because of a conflagration above ground. (The much-advertised direct effect of fires to increase shelter temperature is, on the other hand, one of those effects which seem to have been invented only to discourage the consideration of shelters: a few feet of earth provides adequate thermal insulation.)

What can we expect from truly effective civil defense measures?

First, I believe, is a relaxation of the international atmosphere because the now very great advantage of the aggressor—the one who shoots first—will be diminished. The international atmosphere will be more relaxed also because the tactic which I fear most—the weapon which Hitler used most effectively—will become less effective.

This tactic is to extract a series of small concessions from the adversary who is both physically and morally unprepared, until both his physical power and his will to resist are broken. The less destruction an attack might cause, the less potent are the threats to achieve this.

How is civil defense related to disarmament?

Some fear that a civil defense program may result in increased fear, suspicion, hatred, and unrest. To me, the opposite seems more likely. Surely, the fact that my government is concerned about my well-being will have a reassuring effect on me. The opponent who is not able to destroy the life of a large fraction of my fellow citizens will be *less* hated.

There would be, however, an additional consequence of effective civil defense preparations on the desirability of which all will agree. At present, disarmament is too dangerous because a few nuclear weapons in the possession of a small nation outside the disarmament pact, or perhaps concealed by a strong nation in violation of the compact, constitute an intolerable menace.

All this would change if the effectiveness of nuclear weapons could be radically diminished by an effective passive defense. ■

Address on Civil Defense at Executive Offices Building on April 21, 1967

E. P. Wigner

Unpublished manuscript

Introductory Remarks

The two perennial questions of civil defense are: (a) is it possible and (b) is it desirable. The consensus on the first question has improved in the course of the last two or three years considerably and the possibility of effective protective measures against present armaments has not been questioned recently. It has not been questioned by the committee to which I spoke. In fact, it was implied by some that it is unnecessary to belabor the points which I made in this regard. This is a considerable change from a few years ago. However, it has not brought more similarity of views to the civil defense debate. It may have even sharpened the differences because these could not be blamed any longer on different assessments of the effectiveness of possible civil defense preparations.

The question whether civil defense is desirable, i.e., whether the country should install a highly effective civil defense system, is much more difficult to decide. The arguments cannot be based any longer on information that could be called solid; emotions, expectations and attitudes play a decisive role. I myself am convinced that the installation of an effective civil defense system by the United States is imperative and will benefit, eventually, all people. I am also convinced that the arguments which have been presented against this view are not clearly thought through and are often self-contradictory. I realize, on the other hand, that this does not prove that the negative attitude toward civil defense is not right. On the contrary, it may be based on subconscious aversion and intuition which, though it cannot be articulated clearly, may have greater significance than rational thought. Our intuition is stronger than our logic.

It is in accordance with the subconscious basis of the opposition to civil defense that, in spite of many efforts, I have been able to engage in sincere, meaningful discussion with opponents of civil defense only rarely. Most of these discussions ended with such extreme statements of the opponents that it would be embarrassing to repeat them. This shows that the moderate opponents of civil defense are particularly reluctant to probe into their reasons. However, no one can accept the intuition or subconscious aversion of another person unless he shares them, and I remain convinced that it is imperative for the U.S. to have, in addition to its offensive capability, also a true defense.

Let me admit, finally, that there is no entirely sharp division between the two questions: is civil defense possible? Is it desirable? The last part of the

following discussion of the possibility will have elements affecting the question of desirability.

The Possible Effectiveness of Civil Defense Measures

Only one number will be quoted to indicate the degree of protection which shelters and other civil defense preparations could provide. This number is based on a shelter concept which does not require further basic studies and could be, so to say, installed now. The number to be quoted is based on calculations which have been somewhat refined since those of the Harbor Study. They envisage a 100 psi shelter system, such as considered by the Oak Ridge National Laboratory's study group. They assume a 3000 Mt attack directed solely against the population and only passive (no active) defense. In many regards, these assumptions are oversimplified. Nevertheless, the number obtained, a casualty rate of 15 per cent of the total population, should be indicative of the extent of the protection that is possible.

It is well known that the offensive capability of the USSR is growing beyond the 3000 Mt magnitude. On the other hand, in an actual conflict, much of this capability would be used, presumably, against miltary targets. The casualty rate could also be decreased by active defense and by improvements of the shelters envisaged. In particular, the blast pressure resistance could well be improved above 100 psi. Its present limitation is due to the entrance ways and blast valves. Nevertheless, obviously, the casualty rate in the civilian population would remain very high in a nuclear war with any strong adversary. Even more certainly, any nuclear war would cause enormous economic losses.

The cost of the shelters considered has been estimated at $20 billion. Naturally, depending on the speed of the construction and the administrative set-up, this sum could be exceeded. However, assuming efficiency and a reasonable period of construction, it is an estimate with a sound basis. This number ($20 billion) is also as good an estimate of the cost of economic preparations, to assure a reasonably fast recovery, as I am able to arrive at.

The Opponents Will Nullify. The most usual, and most nearly valid, argument against the preceding evaluation of the effectiveness of vigorous civil defense preparations is that the opponents can "nullify" them by further building up their offensive capabilities. The cost ratio of the two efforts was estimated, several years ago, to be extremely favorable to the offense. The ratio, as now estimated, is not far from 1. Under certain conditions, it is below 1.

This argument is, of course, entirely correct. However, one can argue in the same way that it would be useless to build up the offense against the defense because such buildup can be "nullified" by further buildup of the defense, either in the form of antiballistic missiles, or further improved protective installations. The cost ratio is decisive if the offensive is expected to come from the USSR – a contingency considered to be unlikely at present. The cost ratio is less significant, and hence other considerations become more relevant, if a lesser power is expected to be the opponent.

There are strong indications, however, that the response of the USSR would be different. Defense of the people is not considered to be an aggressive move by the USSR. This was the instant reaction of the Pugwash Conference participants from the USSR and President Kosygin said (on February 9): "It seems to me that the system that wards off an attack is not a factor in the arms race." I feel convinced that he believed this.

A further and more factual evidence for the lack of direct connection between our defense measures and the buildup of the offensive capabilities of the USSR is the fact that these capabilities are being vigorously strengthened now, when the U.S. is not building up its defenses. It hardly could do more if we did build up our defenses. These would under all conditions reduce the casualties from an attack.

Finally, there is evidence that the USSR has no fear of an aggressive U.S. As Krushchev said, "You (the U.S.) cannot escape my embrace when I offer it." Stalin established the Berlin blockade, occupied Czechoslovakia, broke the Hungarian peace treaty at a time when the U.S. had a monopoly of nuclear weapons. Hence, *as far as aggression by the U.S. is concerned*, the USSR will not be alarmed by an increased ability of the U.S. to protect the lives of its people.

Let me repeat that if the "nullify" argument is correct at all, which does not seem to me to be the case, it is correct only with respect to a conflict with the USSR.

The Need for Defense

At present, the official policy of the U.S. is to rely on its "retaliatory power" to discourage aggression. There are reasons to believe, however, that such reliance will be more and more precarious and that a force better balanced between offense and defense will be needed in the future. Let me try to name three such reasons.

1. If we have no effective defense, technological progress will render it less and less expensive to acquire the capability to inflict enormous damage on the U.S. There will be an increasing temptation to acquire such capability and several nations will acquire it. In this way, lack of defense will promote proliferation of nuclear weapons.

2. It is difficult to foresee how the USSR may use its capability to kill many tens of millions of our people on short notice and how it may use its capability to threaten to kill people. The situation when several nations will have such capability is hard even to imagine. A rich man at the mercy of several hungry and determined people, not greatly restrained morally, is unpleasant even to contemplate. If we are at odds with two or three other nations, and an attack on us occurs, it may be difficult to convince the rest of the world that we know where the attack comes from. We may not know it ourselves. "Retaliation" would be very difficult under these conditions and all governments will know this.

3. The image of the U.S. abroad will suffer badly if it relies solely on "retaliation". As compared with defense, "retaliation" is a cruel and unjust policy – punishing the innocent people rather than the guilty government. The callousness of the attitude is sure to be exploited by the opponents' propaganda.

To these, let me add two of the old reasons in favor of the buildup of U.S. defenses.

4. Disarmament will be easier if the possession of a few concealed weapons is not decisive.

5. The situation in which opponents can murder each other is not a very desirable situation and is conducive to an increasing deterioration of international standards.

Civil Defense and/or Active Defense?

It is not my intention here to enter the argument concerning the relative merits of the two types of defense. It is clear that active defense can protect both people and economy whereas passive defense can protect only the people. On the other hand, civil defense has a much slower rate of obsolescence than active defense. There is a certain similarity of the relation between active and passive defense to the relation between earning one's living by playing chess and by growing potatoes. If one is clever enough, one can earn a much better living as a chessplayer. I myself would prefer to grow potatoes if I had to make a choice between the two. I remain also convinced that a combination of both defenses would be most effective.

Side Effects

It has been claimed, occasionally, that the institution of civil defense measures would destroy our values by arousing feelings of hostility in our people and by focussing their attention on war as a result of the drills which may become necessary.

This argument perturbs me a great deal. Most of the readers of this memo work on war and defense and spend at least ten times more time on this than the common man would have to spend (if any) on drills. There is no increase in our bellicosity as a result of our work. Do we seriously believe that common people are morally inferior to us? That the occasional reminder (if such should be necessary) that we live in a dangerous world would upset their mental balance? My own knowledge of non-scientists and non-leaders does not support such an evaluation of the common man.

On the other hand, if the calamity should strike us and no effective shelters would be available where needed, or even if we were to be seriously threatened, the morale of the people would drop precipitously. They would believe that our government did not care for their lives (an accusation actually leveled against our "monopolists" by General O. Tolstikov in Nuclear Age and War).

I have already heard the comment "Women and children last" in regard to our protective measures.

What Is to be Done Now

It is more difficult to propose a concrete program for the near future than to state general principles. I shall try, nevertheless, to make three proposals which could be implemented almost immediately.

1. Support research more vigorously and do not restrict it to fallout shelters. Subjects to be studied are

a. blast shelters

b. problems of social and emotional consequences of preparations, nuclear threats, and war

c. interaction between civil and active defense

d. problems of economic recovery in some detail

e. recovery of the nation as such.

It was my impression that this proposal had the approval of your committee. This does not seem to apply, however, to the following two proposals.

2. Install a prototype single-purpose blast shelter system in a relatively small community.

It is not quite easy to support this proposal in detail even though most who have experience in engineering will probably understand it. It is true that a small-scale effort will lack many of the characteristics which a nation-wide effort would have. It also is true that the physical characteristics of the shelter, such as blast resistance, cannot be tested. I will try to name a few questions to which it would give at least a partial answer.

a. Problems of procurement

b. Interference of the construction with normal activities

c. Attitude of people toward fact of construction

d. Increase of hostility in community toward potential enemies of the U.S.

e. Changed evaluation of the government's intentions.

None of these points will be completely answered but some help toward answering them will be provided. This would be very important. In particular, as far as the last three questions are concerned, these could be debated endlessly without any real progress toward agreement. The debate would be helped greatly by the experiment. However, it is my opinion that the real usefulness of the proposal will become evident only if it is carried out.

3. Install a dual-purpose shelter in one of the larger communities.

The reasons for this proposal are identical with those for the preceding one. The present proposal may be more expensive than the preceding one because of the greater size of the community. However, it might be also more useful because, probably, more dual purpose than single purpose shelters will be built eventually.

Defense from Nuclear Attack

Remarks on Stuart Chase's Statement

E. P. Wigner

Letter to The New York Times, February 27, 1967, p. 28

To the Editor:

Stuart Chase, in his letter of February 13, states that it is an incontrovertible scientific fact that the American people cannot be defended from all-out nuclear attack. There are, however, several reasons not to accept this "incontrovertible fact". Some are listed below.

(a) It is not good to underestimate one's opponent. If the leaders of the USSR believe in the possibility of protecting their people, and are willing to spend vast sums on their defense, they may have sound reasons. According to Mr. Chase, we may undertake similar defense measures only because our Congressmen are unreasonable and the public "refuses to face unpleasant facts". Surely, the Government of the USSR did not have to listen to unreasonable Congressmen or to the clamor of its public.

(b) The summary report of Project Harbor, a study sponsored by the National Academy of Sciences in which more than fifty natural and social scientists and engineers participated, concluded that wholehearted civil defense measures alone could protect the lives of 80 % of our people from a nuclear attack directed against the population. A well-conceived anti-missile program could further improve the protection even against an increased capability of the enemy.

(c) Increased defense of the people would render them an even less suitable target, and the assumption underlying the calculations of the Harbor Project, that the people would constitute the main target, would be even less likely than now.

(d) The nuclear communities, such as Los Alamos and Oak Ridge, have done most toward civil defense. They probably know better than most what may become useful and are not likely to attempt the demonstrably impossible.

(e) As long as this country shows determination to defend the nation and its citizens, the enemy will hesitate to attack. Thus, defense measures not only mitigate the catastrophe of a nuclear war should it occur, they also decrease its likelihood.

This letter is not intended to be an unreserved endorsement of any anti-missile program but as a protest against ridiculing our chosen representatives in Congress by means of half-truths and by refusing to look at the other side of the coin.

Very sincerely yours,

Eugene P. Wigner

Nuclear War and Civil Defense

E. P. Wigner

In: Who Speaks for Civil Defense? (E. P. Wigner, ed.)
Charles Scribner's Sons, New York 1968, pp. 13–27

No defense against weapons is perfect, and civil defense—protection of civilians against the dangers of war and particularly against the effects of nuclear weapons—is no exception to the rule. On the other hand, the harm which any weapon can cause can be diminished by suitable protective measures. This applies also to nuclear weapons. The questions to which we seek answers are, therefore, not whether protection against nuclear weapons is possible, but how such protection can be established, how effective the protection can be, and what the economic and political consequences of the protective measures may be. In the language of the social scientist, our inquiry is directed toward the costs and rewards of civil defense.

Naturally, the effectiveness, as well as the cost, of civil defense measures depends on their character and magnitude. The present expenditure on civil defense in the United States is about 50 cents per person per year; we can say equivalently that, on the average, each working man in the country spends 20 minutes a year preparing against the dangers of a war. At this level of effort, protection cannot be very thorough, though it is by no means negligible. Similarly, the side benefits are rather small. For example, the civil defense organization can function as an

emergency relief organization, and it did so in a number of natural disasters. Its effectiveness at the time of the Alaskan earthquake, in March 1964, received glowing comments. However, the effectiveness and many other aspects of a civil defense effort on a higher level would be quite different. In particular, the protection that a program to which the average working man devoted about 1 hour's work per month would reduce fatalities from nuclear attack by a considerable factor, and the program's effects on the danger of the outbreak of war would also be considerable. There is a wide spectrum of civil defense efforts, both in magnitude and character, and their effectiveness in preventing the rise of hostilities, and in the saving of lives should war come nevertheless, is commensurate with the effort expended.

This discussion will concern first the types of activities, such as shelter building and food storage, which would be parts of a civil defense effort, then their effectiveness and other consequences. The description can be no more complete than can any nontechnical description of a largely technical enterprise. It will be confined to the broad outlines.

Direct Effects of Nuclear Explosions and Protective Measures

What would be the effects of nuclear explosions in the United States? The effects can be divided roughly into two categories: the direct effects and the indirect ones. The distinction between the direct and indirect effects is not sharp but, nevertheless, useful. The direct effects are those caused by the explosion immediately. The indirect effects are usually longer lasting and are caused by the economic and social dislocations which accompany any war but which would be particularly severe after a nuclear conflict. Thus, the blast from the explosion, which injures a person directly, is a direct effect. The unavailability of a person's house that has been destroyed by a fire is an indirect effect.

All direct effects are strongly dependent upon the magnitude of the explosion. This is usually measured in terms of the amount, or weight, of the high explosive which will generate the same amount of energy. Thus, the Hiroshima explosion had a magnitude of 15 kilotons (kt), which means that it liberated the same amount of energy as the explosion of 15,000 tons of the common

high explosive trinitrotoluene, or TNT. This explosion was fantastically large in terms of the explosions witnessed before. Yet it was a small explosion if compared with those of the large hydrogen bombs of today. A hydrogen bomb of 10 megatons (Mt) has the power of 10 million tons of high explosive. Naturally, the damage done by a 10-Mt explosion is not as great as can be done by 10 million explosions of 1 ton of high explosive each. Nevertheless, it is immensely large.

HEAT PULSE, OR THERMAL FLASH. A nuclear explosion manifests itself first in a very bright flash that is an intense light and heat wave. The duration of the flash is measured in seconds: about 10 seconds for a 1-Mt explosion, and shorter for smaller and longer for larger explosions. It was about 1 second for the explosions over Japan. The flash is so bright that in clear weather a 10-Mt explosion to a viewer at a distance of about 75 miles appears as bright as the sun. For a 10-kt explosion, the distance at which the explosion appears as bright as the sun is about 15 miles.

At shorter distances from the explosion, the heating effect is much stronger than that of the sun. A 10-kt explosion can cause second-degree burns of skin directly exposed to the radiation within 1 1/2 miles of the explosion, as at Hiroshima and Nagasaki. For a 10-Mt explosion, the corresponding distance is about 25 miles. Moreover, even second-degree burns can become serious if, in the confusion of the early postattack period, no medical help is available.

Nevertheless, protection against the heat pulse is, in principle, quite easy: not to expose oneself to the flash. This condition is automatically fulfilled for those in a blast shelter and even in most fallout shelters. Most people inside houses will be safe, unless they stand close to a window facing the flash. Even in the open, the chances are that one will be shaded from the flash. A trench, well covered, also provides adequate protection. It is safe to say that the danger from the thermal flash is much smaller than from some other effects of the explosion, to be discussed later. Nevertheless, the number of flash burns can be quite significant unless timely warning is available and unless the people know what to do. In Japan, about 65 percent of all those who suffered injuries had flash burns—in most cases, though, in addition to other injuries.

16 WHO SPEAKS FOR CIVIL DEFENSE?

The thermal pulse is the cause of another source of danger, in addition to flash burns. It may start fires. Whether or not this happens depends on the amount of combustible material that is exposed to the flash and on the transparency of the atmosphere. Smoke and fog decrease the fire hazard by interfering with the propagation of the heat pulse. In clear weather, dark fabric or newspapers in the open may catch fire at just about the same distances from a "small" explosion at which the heat pulse might cause second-degree skin burns. Such fires would occur within 1 1/2 miles of a 10-kt explosion. The distance may exceed, in clear weather, 30 miles for a 10-Mt explosion. Fabrics and newspapers inside houses will not catch fire so easily because the windows reflect some of the light.

Of course, the burning of some curtains or upholstery will be of little consequence in a nuclear war. The burning curtains, however, may set the whole house afire because, if people seek shelter, nobody will be around to put out small fires. Even so, it is doubtful whether fires would start at distances as given above, and even more doubtful how much damage a few isolated fires would cause. The fear is that the fires, even if sporadic originally, may coalesce and convert the community to an inferno. Firemen cannot be expected to extinguish incipient fires under the conditions of nuclear attack.

Very little is known about the spread of fire in cities and suburbs. There were heavy fires both in Hiroshima and Nagasaki. However, whereas the fires in Hiroshima assumed the character of a fire storm, destroying practically all houses within a radius of 2/3 mile of the explosion (rather than the 1 1/2 miles mentioned above), the fires in Nagasaki were more scattered and extended over a wider area. Obviously, houses and cities in Japan and the United States are quite different in materials and structure. Experiments, simulating conditions in United States cities and suburbs, particularly in slum sections, appear to show that isolated fires do not coalesce.

What protection is possible against fires? People can escape fire injury in blast shelters. These are at least 3 feet below ground—usually much deeper—and even an intense fire above ground will not raise the temperature in such shelters significantly. According to the official German report on the saturation

bombing of Hamburg in World War II, no one in the bunkers was killed during the terrible fire storm which followed. "Bunkers" here refer to blast shelters; there were thousands of fatalities in less adequate shelters, similar to our fallout shelters. This is an example of a more elaborate civil defense installation being vastly superior to a more primitive one.

Protection of houses, factories, and crops is more difficult. Smoke generation to prevent the spread of the heat pulse and blast-resistant fire-fighting equipment to extinguish sporadic fires have been proposed, but the utility and effectiveness of neither have been fully established. For the present, we must admit that we have reached the limitations of the effectiveness of civil defense; this does not provide, in the forms considered up to now, protection for houses, factories, and other installations from fires which may be caused by the heat pulse, and the same is true for the blast.

BLAST, OR PRESSURE WAVE. Whereas the heat pulse spreads almost instantaneously, the blast, or pressure wave, has a finite speed. It is fast, nonetheless—faster than sound. Thus, the blast wave from a 10-kt explosion reaches a distance of 1 1/2 miles in about 6 seconds. The blast from a 10-Mt explosion takes about 1 1/4 minutes to travel 20 miles. Thus, if there is no other warning of the attack, one has, at the outer boundary of the second-degree-burn area, about 6 seconds to take cover if the flash comes from a small nuclear weapon, and a bit more than a minute if the explosion is larger but occurs at a correspondingly larger distance.

Among the three principal effects of a nuclear explosion, the thermal pulse, the blast, and the fallout, protection against blast requires most effort and investment. The usual fallout shelters do not offer much protection against it. However, a well-built blast shelter protects not only against blast but also against the radiation from fallout and, as mentioned before, also against the effects of the thermal pulse and of the fires which this may ignite.

What is the blast? It is a sudden buildup of air pressure, produced by an outward-rushing hot wind which violently displaces the unperturbed air before it. The blast lasts a couple of seconds at most, but may do enormous damage. It may displace buildings and hurl people and objects. The pressure may push in walls or

roofs of buildings or may break windows. It can wreak havoc similar to that caused by hurricanes but, close to the explosion, its violence exceeds that of the worst storm.

The strength of the blast is measured in terms of the sudden rise in air pressure—its most important manifestation. The pressure rise is expressed in pounds per square inch (psi). The ordinary air pressure is 15 psi, but at the front of the blast wave it may jump to 115 psi or much more. The pressure rise is largest close to the explosion and decreases as the blast spreads out from the explosion in every direction, and it is larger close to a big explosion than at the same distance from a smaller explosion.

How large are the areas of different blast overpressures? For a 10-kt explosion, the ranges for 1, 10, and 100 psi are about 2 1/2 miles, 3/5 mile, and 900 feet. For a 10-Mt explosion, the distances are about ten times greater: 27, 6, and 1 7/10 miles. All these distances are approximate because they depend on the height of the explosion. For explosions on the ground, or close to it, the ranges are considerably smaller.

The damage that a blast can wreak on structures is great. Windows are shattered by the overpressure of a 1-psi wave, and the flying glass may injure a person. This is one reason to take cover under some furniture when the light flash from an explosion is seen. A frame building will suffer moderate damage from a 10-Mt explosion 15 miles away and become useless if the explosion is within 10 miles; this corresponds to 3 and 4 psi, respectively. For a 10-kt explosion, the distances are about 1/10 as great—still very significant. Other types of buildings are more resistant, but even steel-frame office buildings suffer significant damage at distances of 6 and 1/2 miles, respectively. Earthquake-resistant buildings fare only a little better. Perhaps the methods to protect buildings against fire have been explored only superficially because blast damage becomes serious within a radius that is only a bit shorter than the radius for fire damage. There is no way to protect buildings against blast except by destroying the enemy bomb. This is the task of antimissile and antiaircraft installations, such as Nike-X, Nike-Zeus, and Sprint. The task is technically complex and the results, though very promising, not entirely assured.

In comparison, the protection of people against blast, at least up to a certain pressure range, is quite simple. One proposal,

made originally by Professor Howard P. Harrenstien at the University of Arizona and further developed by the Oak Ridge National Laboratory, is to build a network of tunnels beneath cities and other possible target areas. Located below the streets, these parallel tunnels would be about 1 mile from one another and would be intersected at intervals of 1 mile by connecting tunnels. The tunnels would consist of concrete tubes, 8 or 10 feet in diameter, which have a blast resistance of more than 400 psi. It is questionable, however, whether the entrances, air intakes, and so forth for this system can support such high pressure; but even if the shelters' protection extends only to 100 psi, the area of destruction by the blast is reduced to about 6 percent of the total area covered by 10 psi. It is possible to increase the blast resistance of shelters beyond the 100-psi level, but so far no shelters with a higher blast resistance have been proposed. This is a severe limitation; it permits a determined enemy, bent on destroying the lives of as many of our people as possible, to kill almost one-fifth of the population. This is, nevertheless, a remarkable reduction if compared with Secretary of Defense Robert S. McNamara's estimate of the present situation in which two out of three people could be killed.*

The question then arises of how the number of possible casualties could be further reduced. One means has been mentioned above: to increase the blast resistance of shelters, particularly in densely populated areas. Though possible, very little thought and research have been devoted to it. We are very far from having 100-psi blast shelters in all potential target areas. Another way to reduce possible casualties would be by installing active defense—that is, the Nike-X, Nike-Zeus, or some similar system, which at the same time would protect our houses, factories, and other installations. Such active defense would reduce casualties not only, and perhaps not principally, by destroying some of the

* Any figures referring to nuclear war casualties and survivors must be somewhat speculative, and authorities may differ by a wide margin. Moreover some figures are modified by such factors as the nature of United States antiballistic-missile systems and the probable speed and effectiveness of the nation's retaliation against a nuclear strike. To lend consistency to the figures in this book, we have sometimes taken the liberty of averaging the estimates of the different authorities. In spite of the inevitable variations in numbers, the reader will grasp quite clearly the disastrous proportions of a possible nuclear conflict.

enemy's bombs; they would also force the enemy to use more sophisticated methods of attack, thereby reducing his total explosive power. The Soviet Union's active defense, incomplete as it is claimed to be, forces a reduction of our own "retaliatory power" by a very considerable factor.

Human beings are, even without shelters, much more resistant to blast waves than are houses and other structures. The eardrums seem to be the most sensitive of the organs; they may burst at a pressure of 2 to 3 psi. Probably, however, the ears can be protected by some sort of earmuff. Fatal injuries amount to about 1 percent at 40 psi, but the number rises sharply at higher blast pressures. Hence, the principal hazards to people are collapsing buildings and objects hurled through the air by the pressure wave. Even the hot dust carried by the blast wave can cause injuries. However, outside densely populated districts, it should be possible to prevent such injuries in areas where the blast pressure is below 40 psi, without the relatively expensive blast shelters described above. It has been estimated that such blast shelters would be necessary for about 75 million people at a total cost of about 20 billion dollars—a cost comparable to that of the program to carry a person to the moon. The estimate of 1 hour's work per month to be devoted to civil defense, on the average and by everyone, is based on this figure and a completion time of 5 to 6 years for the installations.

FALLOUT. The heat pulse from the nuclear explosion arrives instantaneously, the blast wave in less than a minute (at the distance where its pressure is 10 psi), but fallout is unlikely to arrive before an hour after an explosion. It can cause more fatalities than the two other factors put together, but these fatalities can be more easily prevented than those from the blast or even the heat pulse. No wonder then that the prime, perhaps even the sole, endeavor of the Office of Civil Defense has been to protect the people from fallout or, rather, from the radiation carried by fallout.

Fallout is formed only if the nuclear explosion takes place either on the ground or underground or in the air at a low altitude. A 10-kt explosion more than 500 feet above ground or a 10 megaton explosion more than 7,000 feet above ground do not create appreciable fallout. Fallout consists of soil and sand that have been vaporized by the heat of the explosion and condensed

again to soil or sand when the heat dissipates. The radioactive atoms produced by the explosion are "built" into the grains during the condensation. The soil or sand is sucked high into the air by the remaining heat of the explosion, but settles down again on the ground as dust, bringing the radioactive atoms back to earth. If the explosion takes place high enough, the soil does not get hot enough to vaporize, and hence no condensation of soil particles occurs. The radioactive atoms produced by the explosion are still sucked up to great heights, but do not come down again (except after a very long time) because they are not built into condensing dust which settles.

If the enemy wishes to create fallout, he has to use bombs which explode at low altitudes, though this decreases the heat pulse and the blast. The magnitude of fallout is still open to some doubt and does probably depend on soil conditions, as well as on wind and weather. Wind would disperse the fallout, rain would bring it down faster. The total fallout may contain, perhaps, as much as a third of all radioactivity produced by the explosion. In nearby areas, fallout may begin to settle 1 hour after the explosion; in more distant areas, several hours after. As mentioned, fallout creates damage only by its radiation, which affects animal and plant cells. If the fallout particles, for example, settle on food and the food is eaten, radiation is emitted by the particles inside the body, and it is the radiation which affects the body. However, if fallout particles are washed or brushed off the food, it becomes perfectly edible.

How large is the area which may contain enough fallout to create a radioactive hazard? Radiation is measured in units called roentgens (r); doses below 100 r do not need medical attention, whereas a dose of 450 r received within a few days has a high probability (50 percent) of becoming fatal. Much higher doses have been received, but spread over longer periods, without clinical effects. It has been estimated that, until rather recently when attention became focused on protection against radiation, the average radiologist in the United States received 2000 r during his life. This probably did have some effect on his life span, but no obvious consequences. One-third of the radioactivity from a 10-kt explosion, if it all comes down in an hour, concentrated in an area of 75 square miles, will give within 10 days a dose of 200 to 400 r, depending on the roughness of the terrain. The higher

figure, 400, assumes a perfectly flat landscape. For a 10-Mt explosion, the area covered by fallout is a thousand times greater. The 1-hour time of arrival of the fallout and its uniform distribution just at the near-dangerous level are, of course, very pessimistic assumptions. However, adopting these pessimistic—and particularly regarding the 10-Mt explosion, unrealistic—assumptions, we find that the area of fallout danger is 65 times, or in the second case 650 times, greater than the area of the 10-psi blast wave. In reality, these numbers will be smaller, but remain large, nonetheless.

To protect against fallout radiation, a shielding material must be interposed between the body and the fallout. If we realize that 100-r radiation will probably go unnoticed, whereas 450 r appears to be fatal for half of the population, we can understand that even a small protection factor may make all the difference. The protection factor indicates what fraction of the radiation gets through the shielding material. Thus, protection factor 40, the smallest of any of the marked fallout shelters, reduces 450 r to 1/40 (that is, about 11 r)—an easily tolerable amount.

How long does a person have to stay in the fallout shelter? Six hours after the explosion, the intensity of the fallout radiation has dropped to 1/10 of its magnitude at 1 hour; 2 days after the explosion, its magnitude is 1/100; and 2 weeks later, it is 1/1000. However, the total radiation to be received after 1 hour, 6 hours, 2 days, and so on does not decrease as fast as the fractions indicate because intensity does not drop as fast after, say, 6 hours as after the first hour. In fact, the total residual dose after 2 weeks is still 1/5 of the total dose after 1 hour. This is, however, a misleading statement; the radioactive dust gets buried, or can be buried, and thereby becomes practically harmless. Even more important, the recovery mechanism of the human body becomes effective in about 3 weeks and throws off 90 percent of the damage. It was this mechanism which protected the radiologists from the results of the radiation hey received. Therefore, radiaion received over an extended period is much less harmful than the same dose concentrated into a short time. It should be safe to leave the fallout shelters even in badly contaminated areas after 2 or 3 weeks. In most locations, a shorter stay in the shelter would suffice.

SUMMARY. The effects of nuclear explosions are manifold, and

the preceding description rather understates than overemphasizes their complexity. It is surprising, therefore, that a simple, solid shelter can give so much protection against all these effects. A good blast shelter gives a very great deal of protection against the blast, heat, and radiation. Actually, a "simple, solid shelter" is not quite so simple; it has to have sleeping and sanitation accommodations, food and water supply, ventilation and, last but not least, a person or group familiar with its structure and functions. This is one of the advantages which an interconnected tunnel system would have: skills and know-how of the whole town would be potentially available at every point. However, experience in World War II shelters, both in Germany and Hungary, has shown that isolated shelters also can function satisfactorily.

Indirect Effects of Nuclear Explosions and Protective Measures

Nuclear explosions are not only a menace to life, but can also wreak terrible havoc to property, especially dwelling places. A large-scale nuclear war would undoubtedly set back economic development several years and would temporarily impoverish the whole nation. Much thought has been given to the problems which would have to be overcome, but our understanding of the economic structure is inadequate for the formulation of clear and definite plans. Perhaps the problems can best be solved when they become apparent; the inventiveness and ingenuity of people can be depended upon to be superior to the best-laid plans. This was the experience in postwar Europe; the countries in which private initiative had a freer play, such as those of western Europe, recovered much faster, and with much less suffering, than the planned economies of eastern Europe. Nevertheless, there are a few preparations which cannot fail to make economic and social recovery faster, and some of these will be mentioned briefly.

STOCKPILING. "He who has time has life" is an old adage. We can buy time for the surviving population by providing for the most essential need of life: food. The United States has even now sufficient food stored to keep us all going, though on an extremely simple diet, for more than 18 months. If this food were distributed so as to be available where needed (rather than being

stored almost solely in the Midwest, as at present), the people could devote their attention more completely to the tasks of reconstruction. The almost daily forage of the townspeople in Hungary, for instance, into the countryside to barter for food not only led to great disruption of the available means of transportation, but also diverted people from rebuilding their houses and factories.

What else should be stored? The storage of medicine should be a relatively easy task. Insecticides, seeds, and fertilizers would aid resumption of agricultural production, as would also a stockpile of spare parts for agricultural machinery. Also, gasoline and oil have become an almost daily necessity, and a large fraction of the meager supplies of these (we have, as a rule, gasoline on hand for only about 6 weeks) might be destroyed by the attack. Local shortages could be relieved only if the means of transportation could be restored to some degree.

A good shelter system would be useful in the postattack period by providing sleeping accommodations until people could be either relocated or provided with new housing.

RESUMPTION OF PRODUCTION. Some of the stockpiling is intended to render the resumption of production faster. There are many other proposals with the same objective, but only a few will be mentioned. If the immediate necessities of life are provided for at least a year, resumption of production can be more successfully planned when the total situation and most urgent needs become apparent—that is, in the postattack period.

Power and transportation are two prerequisites for the resumption of production. As for power, advantage could be taken of the trend of the last few years toward nuclear power. Nuclear power plants could be placed underground—as a Swedish plant is—and "hardened" so as to resist the blast from a nuclear explosion. Ordinary safety considerations also make this desirable. The transmission lines, however, remain vulnerable, and it would be desirable to have repair crews assembled during the sheltering period; it would also be necessary to assemble and safely store the equipment which they would need.

Roads and railroads may be gravely affected. Bridges, in particular, seem to be just about as subject to blast damage as steel-frame office buildings; a blast wave of about 6 psi renders most bridges at least temporarily impassable. However, many of

the bridges are far from probable target areas. As for roads, there is, of course, equipment which can pass over almost any terrain. Nevertheless, restoration of transportation may be one of the most difficult problems which a postattack population would have to face.

SOCIAL ORGANIZATION REESTABLISHMENT. Provisions for physical recovery and reconstruction after a nuclear war are necessary. However, an effective government in which people have confidence is equally essential. The recovery of Germany was aided by the Marshall Plan's economic assistance; it was aided equally by the Germans' realization that the Allies—the de facto government at that time—wanted the nation to recover and wished to help it toward recovery and that recovery was in fact possible.

The efficiency of the government in the postwar period would be a key element in the establishment of public confidence in it. The plans for succession, in case part of the government should be temporarily unable to function, are very important and have received a good deal of attention. Other factors would also play important roles, such as stable and reliable currency and public security. In addition, the conviction that the people's well-being and security are, and always were, the first concern of the leaders would be a prime requisite toward confidence in the future and the restoration of social coherence. That the government had tried to mitigate the consequences of a possible catastrophe, and had tried to avoid it, would be an important support for such conviction.

Indirect Consequences of Civil Defense

It is evident that civil defense could do a great deal toward decreasing the number of deaths and toward alleviating the suffering which would result from any war, but particularly from a nuclear war. It is equally evident that, no matter how perfect the civil defense preparations, a war would bring many deaths and severe suffering to all of this nation.

The recognition of this, and of the well-known human propensity to avoid thinking about the unpleasant, is one of the sources of the frequent aversion toward civil defense. Why think about saving people from suffering and destruction if we can think

about peace and well-being? Another source of aversion is that opposition has become a status symbol in some groups—opposition particularly to those measures which aim at the defense of the nation. Civil defense falls into this category. Opposition to defense is less absurd in this country than it would be elsewhere because our population has experienced no war on our own territory, and it is difficult to imagine such an event in the abstract. Most Europeans felt the same way before World War II. We can only wish that this type of thinking were justified in our world.

There is, however, a more rational apprehension which causes many to oppose civil defense: the apprehension that it would render war more likely. Is this true, or rather the converse: that the present defenselessness of our population might provoke aggression and thereby render war more likely?

If we review the confrontations between the West and Communist powers, we find that these confrontations were caused by moves of the Communist governments toward an extension of their power. This was true even when the United States had a monopoly of nuclear weapons; the Berlin blockade, the occupation of Czechoslovakia, and the breaking of the Hungarian peace treaty took place during that period. Those moves which affected a directly defensible territory, such as the occupation of Berlin, were resisted by the West; the others were not seriously opposed. The history of the postwar period thus shows that the United States has no desire or intention to extend its territory, but that it has both the desire and intention to defend its own land and that of its allies.

If our population is undefended, it will be increasingly difficult for those whose natural inclination is to extend their power —and all dictators and dictatorships have such an inclination— to resist the temptation to pressure us into concessions. France and England were pressured into several such concessions by Hitler. If our people are without protection, it will be very difficult to resist such pressures unless we have an overwhelming military power. This will be increasingly difficult to maintain, and is actually on the wane now. When it will become impossible to make further concessions—at our own expense or at that of friendly nations—a showdown will be very hard to avoid. This was the situation of England and France in 1939, when

they felt forced to fight, and to fight from a materially and morally weakened position. The only way to avoid the danger of such a course of events is to deter aggressive acts by protecting and strengthening our citizenry, particularly in a period when our own armaments are practically equaled in number and quality by those of potential adversaries. By not offering the temptation of an unprotected populace, by instituting a vigorous civil defense program, we would be truly serving the interests of a lasting peace.

Roadblocks to Civil Defense

A renowned physicist and civil defense analyst probes behind the mask of apathy in the United States

E. P. Wigner

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I have often tried to explain the need for a vigorous civil defense effort, why and how such an effort would go far in preserving peace and how it could save many millions of lives if war should come nevertheless. "Why Civil Defense?" would be an apt title for this subject because we *want* the civil defense effort to be strong and vigorous. But my subject is also the opposite: "Why No Civil Defense?". What are the roadblocks? Why isn't the civil defense effort as strong and effective as we would like it to be? Why is there not a popular demand for it? There are, it seems to me, three principal reasons for this.

The first reason is the power of the anti-civil defense establishment. What provides this strength? What are the motives of the establishment?

There are, of course, those who would like to see our country become a second or third-rate power, the nakedness and vulnerability of its people forcing its government to accede to the demands of those governments whose people are better protected or who care less for human life. Persons who have these desires are, however, small in number, and they contribute but very little to the undeniably very great strength of the anti-civil defense establishment. Can this establishment muster valid arguments against civil defense? I think it can, and this is the reason for citing this cause for our lagging civil defense efforts as the first of my "principal reasons".

If we install shelters, store food and other supplies, we make preparations against an attack on our country. Such preparations naturally set us apart from those against whose attack we protect ourselves and render it more difficult to develop a true friendship between the governments of communist countries and ourselves. This is the theory of Festinger, often derided by social scientists, but I do think there is something to it even if not in the extreme form propounded by Festinger. It is, of course, true that the hate propaganda of the other side also interferes with the development of the true friendship, and it is sad – very sad – that this is never criticized by the anti-civil defense establishment.

The second reason why the civil defense effort is not more vigorous and why there is not more public demand for it is that it is unpleasant to think about disasters, particularly disasters as severe as nuclear war. Let us note that insurance policies offering compensation in case of fire are called *fire* insurance policies, but that the policies protecting our families in case of our death are called *life* insurance policies. No similarly euphemistic name has been invented

for civil defense, and it would not help much if one were invented. Building shelters would remind us in any case of a great and terrible calamity that could befall us, and we all are reluctant to think about such calamities. Why dig a hole in the ground where one may have to live for weeks if one can, instead, walk in the sunshine? We have a tradition for work, and many of us enjoy it, but we do not have a tradition of thinking about disasters which may strike us. However, whereas our reluctance to face the temporary nature of our sojourn in this world does not, as a rule, shorten our lives, our reluctance to protect ourselves may bring war nearer.

The third reason that we do not take civil defense very seriously is that we are all too conceited. Sure, other people have been stricken by disasters, other nations have been wiped out or subjugated. But this cannot happen to us, we say. It is not even decent to think about it. I once went to see the now deceased Albert Thomas, who prevented a good deal of civil defense legislation from being enacted in the House of Representatives. He listened to me for a few minutes and then said: "Take it easy, young man, take it easy. This country is so strong it does not need any civil defense." Most of us would express this self-defeating doctrine less clearly and less bluntly than did Mr. Thomas. But what he said is present in the minds of all of us. On a peaceful day like today, when we are absorbed by so many more pleasant thoughts, is it not unreasonable to think about some country attacking us with nuclear weapons?

In a very real sense, I believe, it will be a test of the democratic ideal whether our people can resist burying their heads in sand or not, whether or not they can muster the foresight and maturity to carry out the unpleasant and unpopular task of protecting themselves, their country, and their freedom against dangers which seem far away. Nothing but illusory comfort can be gained by closing our eyes to these dangers.

Civil Defense – Little Harbor Report (Preface)

E. P. Wigner

Division of Technical Information,
U.S. Atomic Energy Commission TID-24609, 1969, pp. V-VII,
P.O. Box 62, Oak Ridge, Tennessee 37830.
Reprinted: EMO National Digest *9*, 3 (Feb. 4, 1969)

Preface

In March 1967, at the suggestion of the Director of Defense Research and Engineering, the Atomic Energy Commission requested the National Academy of Sciences to review and update the Project Harbor Study on Civil Defense. The Harbor Study was sponsored by the Office of Civil Defense and carried out under the auspices of the National Academy of Sciences in the summer of 1963. About 60 scientists (both natural and behavioral) and engineers participated in the six-week study. The final report came to over 600 typewritten pages; its distribution was very limited. A summary report, NAS-1237, was issued in 1964 and had a wider distribution.

I had the honor of assembling the group to be entrusted with reviewing and updating the 1963 report, and I wish to express my gratitude to my collaborators for the sincerity of their efforts to grapple with the many thorny problems of civil defense and for the unstinted nature of their collaboration. I am especially grateful to Richard Park of the National Academy of Sciences and L. J. Deal of the U. S. Atomic Energy Commission for their constant and unflagging help.

The members of the study group were:

Harold L. Brode, Physics Division, The RAND Corporation, an expert on modern weapons and their effects.

Lee Christie, System Development Corporation, social scientist.

L. J. Deal, Division of Biology and Medicine, U. S. Atomic Energy Commission.

William J. Hall, Department of Civil Engineering, the University of Illinois, an expert in structural design and the dynamics of blast.

Harold A. Knapp, Institute for Defense Analyses, defense analyst.

William Osburn, Division of Biology and Medicine, U. S. Atomic Energy Commission, ecologist.

Richard Park, National Academy of Sciences.

John H. Rust, Department of Pharmacology, the University of Chicago, interested in problems of agriculture, health, and medicine, including biological warfare.

Sidney G. Winter, The RAND Corporation, economist. His interest in the problems of economic recovery antedates even the original Harbor Report.

John P. Witherspoon, Oak Ridge National Laboratory, ecologist.

Stephen B. Withey, Institute for Social Research, the University of Michigan, social psychologist. His principal research area is human behavior and public attitudes.

With twelve participants of very different backgrounds collaborating to assess the promise and the problems of civil defense, complete unanimity on every point was not to be expected. We have tried to indicate areas of disagreement in the text.

The study took place at the Oak Ridge National Laboratory from May 23 to June 3, 1967. We are indebted to the Director of the Laboratory, Alvin M. Weinberg, for his interest and for having extended the hospitality and many other courtesies of the Laboratory to us. The Civil Defense Research Project, under the direction of James C. Bresee, made available their library, administrative services, and other facilities. They also gave us a great deal of technical assistance. We are particularly indebted to Dr. Bresee, to Conrad Chester, and to Richard Uher for their help on many difficult questions.

Other consultants and observers were:

Milton Leitenberg, St. Louis Committee for Nuclear Information, represented the point of view opposing civil defense measures.

Julian Levi, Department of Social Sciences, the University of Chicago, advised on problems of urban development.

D. L. Narver, Jr., Holmes and Narver, Inc., advised on the effect of blast from nuclear explosions on structures and construction costs.

Lewis V. Spencer, Department of Physics, Ottawa (Kansas) University, advised on the thinking of the Advisory Committee on Civil Defense of the National Academy of Sciences.

Harry R. Woltman, Planning Research Corporation, advised on defense planning and urban development.

Briefings on the thinking and philosophy of the Department of Defense were given by:

Thomas S. Schreiber, Office of the Director, Defense Research and Engineering.

Robert Rosenthal, Office of the Director, Defense Research and Engineering.

Ivan. Selin, Deputy Assistant Secretary of Defense (Strategic Programs).

The (then Acting) Director of the Office of Civil Defense, Joseph Romm; his Assistant Director of Civil Defense for Research, Walmer E. Strope; and his Deputy Assistant Director for Operations, William E. Crockett, briefed us personally on the policies, problems, and accomplishments of their office. J. M. Googin of the Oak Ridge Y-12 facility spoke to us twice on modern weapons as influenced particularly by the advent of the antiballistic defense installations in the USSR. We are sincerely grateful to all our consultants and advisors for their generous assistance and their patience and willingness in answering our questions.

Eugene P. Wigner
Director

Defense vs. Retaliation

E. P. Wigner

Address Before the American Physical Society, Washington, D.C.
Survive *2*, No. 4, 16–19 (July–Aug. 1969).
Reprinted: Congressional Record (May 1, 1969), p. S4465;
EMO *9*, No. 5, 20 (Oct.–Nov. 1969)
(Reset by Springer-Verlag for this volume)

Dr. Wigner is a frequent contributor to Survive *and a member of its editorial board. Here, in a condensation of his recent address before the American Physical Society in Washington, D.C., he compares plans for America's defense against plans for "revenge" in the light of odds for peace.*

When preparing for the present session I was acutely aware of the great difference between tonight's discussion and earlier discussions of our Society in which I participated. Little responsibility was involved when I argued for one physical theory as against another. The great responsibility for whatever I shall say this evening weighs heavily on my mind. It is not pleasant to recall the considerations which brought me to the stand I am adopting tonight; it would be unwise to forget them.

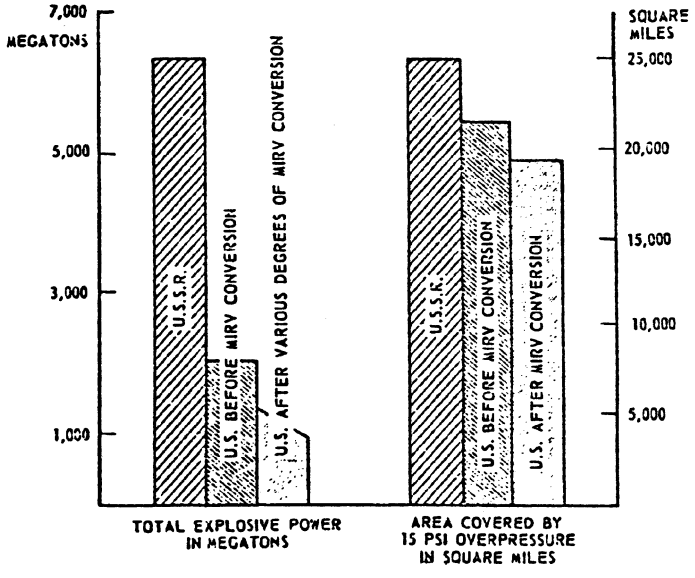

Fig. 1. Comparison between U.S.S.R. and U.S. of total nuclear explosive power and 15 PSI area coverage. (1969 statistics)

It is good, however, first to establish certain facts. The first fact is that the missile strength of the USSR, which has been growing fast in the last two and a half years, is now exceeding that of the United States. This is well known to many in the Defense Department. You see, before we were forced to subdivide our warheads, we had 40 per cent of the USSR strength (Fig. 1). When the conversion to multiple independent reentry vehicles (MIRV) is completed, our explosive power will be around 20 per cent of the USSR explosive power. Since the USSR has mainly large warheads, the comparison is less extreme from the point of view of area coverage. The area covered with a certain overpressure is proportional to the $^2/_3$ power of the size of explosion. Two 5 MT explosions cover a wider area with a certain overpressure than one 10 MT explosion. In fact, two $3^1/_2$ MT explosions have the same coverage as one 10 MT explosion. Hence, the advantage of the USSR in area coverage is smaller than in total explosive power, and it will increase to a lesser extent when we convert to multiple warheads than their advantage in total explosive power will increase. The total explosive power is, of course, a measure of the radioactivity and fallout that the weapons create; the area coverage is a measure of the instant destruction. Nevertheless, even in the latter category, the USSR's missile strength is higher than ours by almost 20 per cent before our conversion, and will be higher by 30 per cent after we succeed with our conversion program.

Figure 2 shows the growth of the number of U.S. and of USSR missile launchers. These numbers are probably the most easy to ascertain: the launchers are visible from above.

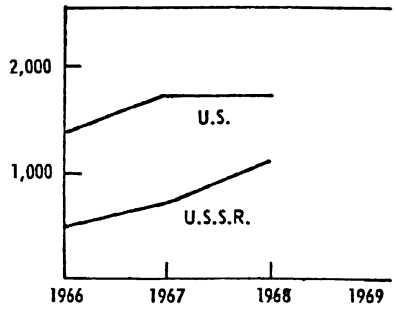

Fig. 2. Numbers of missile launchers, U.S.S.R. and U.S.

On the other hand, one should not forget that the size of the launchers can be very different. The launchers of the USSR can loft, as a rule, much larger missiles than can ours. What the figure shows is that, in the last $2^1/_2$ years, we have hardly increased our missile strength. Our effective strength both with regard to total explosive power and area coverage is now decreasing. The USSR has increased its capability during the same period greatly, by a factor of $2^1/_2$, and is now ahead of us in both these regards. In a way, I am glad that we did virtually nothing in the past $2^1/_2$ years – had we increased our strength,

many people would say that the USSR only responded to our provocation. As matters stand, the reason for the USSR buildup is not discussed.

You will ask me how my data will be reconciled with the statements of our earlier Defense Secretaries, McNamara and Clifford. They gave the impression that our nuclear strength exceeds that of the USSR by a factor of about 4. However, if you read their statements, they say explicitly that they compared numbers of warheads. In this regard, we are really ahead of the USSR. We still are, although the British Institute for Strategic Studies estimates that they (the USSR) will catch up with us by midyear.

It is important, however, to discuss the significance of the three measures: number of warheads, total explosive power, area coverage.

I shall begin with the significance of the number of warheads. This may be decisive for a first strike which should abolish the opponent's retaliatory power. High accuracy has to go hand-in-hand with it, particularly if the missile sites to be destroyed are hardened – as are both the U.S. and the USSR targets. However, the U.S. certainly does not plan such a first strike, and the number of warheads we possess is, therefore, not a measure of our military strength.

How about total explosive power? We have about 25 per cent of that of the USSR. I must hope, therefore, that this is not of decisive importance either. I would have more justification for this hope, if we had at least adequate fallout shelters for everyone, but fallout shelters are opposed just as much, or even more, than is ballistic missile defense. It may not be news to many of you that I would, in fact, prefer civil defense to ballistic missile defense if I had to choose only one, but until recently the Defense Department has been even more concerned about opposition to civil defense than about opposition to ABM. However, as the preceding discussion indicates, at least fallout shelters are a necessity if we do not want the total deliverable explosive power, of which the USSR has 4 or 5 times more than we do, to have decisive importance.

As for area coverage, this might become the decisive factor if we have at least fallout shelters. In area coverage we are only 20 to 30 per cent behind the USSR and this would be to some degree reassuring if the civil defense of the USSR were not much superior to ours. However, before turning to this subject, I should make one further remark. Some will consider the comparison of the U.S. and USSR strengths irrelevant because, they say, both parties have so much overkill that the relative strengths matter little. They say that, even if it were true that the USSR can kill all of us eight times whereas we can kill all of them only three times, this would have little significance. Fortunately, or unfortunately, this argument is not valid. The defensive measures which the USSR has instituted, and is in the course of instituting, have so drastically reduced the fatalities which we can inflict on their people that it is ridiculous by now to speak about an overkill on our part. This is what I shall discuss next. Since we are, in this regard, far behind the USSR, the increase in the effectiveness of defensive measures should perhaps not please me. It does, nevertheless, because the increased power and effectiveness of the defense – if it extends to the U.S.

as well as to the USSR – promises a more relaxed international atmosphere and all of us are surely in need of that.

The Rising Power of Defense

That even a missile defense which the opponents of *our* defense consider very primitive, that even such a defense can be very effective was demonstrated somewhat unintentionally by Secretary Nitze. I am referring to a non-provocative missile defense – that of the USSR. According to an example given in the Congressional testimony of Secretary Nitze, it may prompt us to replace the 10 MT warhead by 10 warheads of 50 KT each. This is a reduction of the total explosive power by a factor 20, of the area coverage to 29 per cent of its earlier value. I have been told that the multiple warheads have not yet been installed – partly for technical reasons, conceivably also for other reasons. The fact that our contemplated response to the very primitive ABM of the USSR involves such a reduction in the effectiveness of one of our weapons certainly proves that the mere existence of some ballistic missile defense can provide a high degree of reduction of the damage that the opponent can inflict. One can say, in fact, that the ABM deployment by the USSR has resulted in the most significant limitation of effective armaments that has been achieved so far.

The reduction of our total power by the Russian ABM was not very great because the changes contemplated for the other missiles are less significant than those for the 10 MT warheads. This is because the other missiles were to carry much smaller warheads to begin with. However, most missiles of the USSR have very large warheads if these were to be modified in the way Secretary Nitze said the 10 MT warheads are modified, the gain would be, indeed, enormous.

The greatest progress that the Soviet Union has made towards defense does not lie, however, in the area of antiballistic missiles. It lies in its renewed emphasis and energetic progress toward civil defense.

My assessment of civil defense in the USSR is based on a rather thorough study of the Soviet literature on the subject, undertaken by Mrs. (Joanne) Levey of Oak Ridge National Laboratory and myself. The Russian literature seems quite open and frank, telling about the shortcomings of the arrangements as well as about their accomplishments. It leaves no doubt in the mind of the reader what the objectives are. Even if these are not yet fully accomplished – and quite likely they are not as yet – there is no question that they can be reached and that there can be no opposition to them in the USSR.

Most of the decrease in the number of casualties which we can inflict on the people of the USSR is due to their civil defense arrangements.

To avoid misunderstandings, I quite agree with Kosygin and do not consider the defense of the people to be objectionable or, as it is often put when our defense measures are considered, provocative.

What I find frightening is their very elaborate plans for the evacuation of their cities. These go into the minutest details. When, in the course of a study (the so-called Little Harbor Study) evacuation of the cities was considered as a possible defense measure, all members objected on the basis that evacuation can

be effective only if it is ordered well ahead of the inception of the hostilities. We felt, therefore, that it is useful only as an aggressive move, as an introduction to the initiation of a crisis, or of an attack. Even though, I believe, all the participants in the Little Harbor Study were, or became in the course of the study, supporters of an expanded civil defense effort, they all felt that the planning of evacuation is not a proper means toward this, just because it is useful only to the initiator of the conflict. Evacuation is, however, the measure which is now at the center of the Soviet program. It may be, one day, terribly effective. It is true that the evacuation cannot be carried out in secrecy; it is equally true that we could do nothing even if we knew that it was being carried out.

How much would the evacuation of the major cities of the USSR reduce the fatalities in a thermonuclear exchange? We have made tolerably accurate calculations on this; let me give only a crude picture. Moscow and its surroundings have a population of about 6 1/2 million. If these are spread over a circle of 50 mile radius, the density of people would become about 850 per square mile. With the area coverage of our missiles (as given in Figure No.1) I showed we could cover the territory occupied by about 9 1/2 million people with a blast wave of 15 psi overpressure. This assumes the usual attrition rate of 1/3 and that we use all our missiles, without exception, for this purpose – an unlikely assumption indeed. The midlethal pressure, from lung damage, is much higher than 15 psi, but considering everything 15 psi is a reasonable value. It disregards any damage which a first strike may inflict on our retaliatory force and also the sheltering which their subways provide.

Hence, actual fatalities would be a good deal below the 9 1/2 million I quoted. Certainly, under no likely circumstances of a conflict can one reasonably speak about overkill on our part.

Conclusions

It is not pleasant to have to admit the weakness of our defenses. It is even less pleasant to admit that we are slower than necessary in affording a proper role to the protection of our people and their values and continue to rely solely on retaliation – that is, the threat of revenge. I feel, however, that in this last regard the blame falls heavily on the intellectual community, part of which has a spontaneous revulsion against all innovations in the defense structure, be these for the better or the worse.

I myself consider the possibility of strengthening the true defense, that is the possibility to protect our people and our installations, one of the most favorable developments that have taken place in the last twenty years. The possibility of mutual annihilation appears to me a most unhappy state of affairs. The U.S. will not start a conflict and, if an enemy destroys our country, what good does it do us to take revenge and destroy his? At the very best, retaliation makes sense only as a threat to deter enemy attack. But it is not even a very plausible threat because the enemy knows it would be purposeless to carry it out. The damage that the mutual ability to destroy the other does to mutual good will

need not be enlarged upon. I do, therefore, advocate, and have advocated for some time, a more defense-oriented strategy.

The argument that any innovation on our part will provoke the USSR military is not new to me. My opinion, however, is the opposite. It is difficult to imagine anything more provocative than not to respond to the very rapid increase of the military and defensive might of the USSR. Such lack of responses would dangle before the eyes of the more adventurous elements in the USSR the temptation, first, to shear the United States of discernible influence in international affairs, and then to go on to much more drastic encroachments on our way of life. One may suggest the status of Czechoslovakia or Hungary.

It is not pleasent to remember or to remind others of such fateful words as those of Marshal Sokolowski, who said, "The war will naturally end in the victory of the progessive social-economic system over the reactionary capitalist socio-economic system which is historically doomed to destruction. The guarantee for such an outcome of the war is the real balance between the political, economic and military forces on the two systems which has changed in favor of the socialist camp. However, victory in a future war will not come by itself. It must be thoroughly prepared for and assured."

Second, it seems to me that the defense measures undertaken on our part will help rather than hinder disarmament and accommodation negotiations with the USSR. The leaders of that country are not afraid of their own weapons – why should they make any concession? If, in the words of Ernest Bevin, we enter the negotiations naked, we will leave them naked.

Third, I do not believe that defensive measures are provocative under any conditions. As for the USSR leadership, we have Premier Kosygin's words: he said, 'I believe that the defensive measures prevent attack and are not causing an arms race."

The same point of view was expressed even more strongly around 1963–64 in the magazines of the USSR. The discussion in these magazines expressed bewilderment that the United States did not take protective measures. They wondered: does the U.S. want to strike first? One could almost claim that the *absence* of true defense is considered provocative by the USSR. To avoid misunderstandings, let me repeat that I do not consider preparations for evacuation to be part of true defense.

Finally, let me consider the effect of a successful opposition to ABM on our own people and our own defense establishment. Doing nothing in the face of the now alarming USSR military buildup would give the impression that the leadership of the country does not consider defense to be important. This would make it difficult for all of us to make sacrifices for our defense. And, let us not fool ourselves, such sacrifices will continue to be needed in the future. The effect on the military would be even worse. Not only would their plans be almost hopelessly dislocated; they would feel alienated, repudiated, and discouraged. And this is the last thing that we want. The path to peace is not an easy one: it will continue to require sacrifice, devotion, willingness to adapt to changed circumstances, and an open mind.

The Objectives of Civil Defense

E. P. Wigner

In: Survival and the Bomb: Methods of Civil Defense (E. P. Wigner, ed.).
Indiana University Press, 1969, Chapter 1, pp. 3–23

¶ The first chapter is of an introductory nature. Whereas all later chapters deal with the technical problems, the limitations, and in particular the methods of the protection of people against the dangers precipitated by a nuclear war, this chapter is devoted to the rationale thereof. It tries to assess the effect of civil defense preparations on the likelihood of the outbreak of a war, on the social structure in peace time, and their effect on the morale and the confidence of the people in their government in case of a war.

Eugene P. Wigner
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¶ Eugene Wigner was born in Hungary in 1902. He started his career as a chemical engineer, but his interests soon turned to theoretical physics. He taught this subject first at the Technische Hochschule Berlin, then at Princeton University and the University of Wisconsin. During the Second World War he was in charge of the group concerned with the theory of chain reaction and the basic design for the plutonium producing reactors at Hanford, Washington. He returned to Princeton University after the war but maintained his interest in nuclear energy and became a member of the General Advisory Committee to the U.S. Atomic Energy Commission. He acquired his interest in civil defense as a result of this membership and was commissioned by the National Academy of Sciences to be the director of the Harbor Project in the summer of 1963. This was a six-week study of

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civil defense in which sixty-two natural and social scientists, engineers, and men of affairs participated. It was brought up to date a few months ago by a similar study. ¶ Wigner has published extensively on theoretical and nuclear physics.

The subject of this book, beyond the present chapter, will be the physical, economic, and human factors related to the protection of people against the effects of nuclear war. Scientists versed in the various relevant disciplines will assess the problems of civil defense, try to evaluate its methods and limitations. This chapter, however, will deal with the rationale of civil defense, why, and to what extent, it is desirable to make every effort to protect people against the dangers of a war. It follows that it will be an "unscientific" one: it will not deal with the methods of, but the motivation for, a vigorous civil defense effort. It will try to articulate intentions, attitudes, and desires more than facts and procedures. Much of it will apply almost as well to active defense—that is, the destruction of the enemy's missiles and bombs—as it will to civil defense, which means protection of the population against the effects of the explosions of these bombs and missiles. The purpose of both defense systems is protection. In spite of its unscientific nature, we feel that the discussion will be useful if it succeeds in illuminating the political and emotional attitudes which are at the bottom of the civil defense controversy. As the reader well knows, this controversy has occasionally assumed a tone of stridency foreign to scientific discourse.

Civil defense is part of the total defense of the country. According to the preamble to the Constitution, one of the purposes of the Union was "to provide for the common defense." It seems difficult to think of defense without making every effort toward protecting what is most important: the lives of the people. It is, furthermore,

difficult to avoid the conclusion that this defense is a federal responsibility. Why is it, then, that proposals to invigorate the civil defense effort have found so little response in the past? Is it that those who believe in the vital importance of civil defense do not make their voices heard because they are reluctant to espouse a cause for which others—the federal authorities—have been given responsibility? Is it that the federal authorities are reluctant to advocate a vigorous program which is passionately opposed by some, even though only a small minority? Do they, in particular, hope to be able to discharge their responsibilities without incurring the wrath of this minority? What motivates the opponents? Are they opposed only to civil defense, or to all defense of this country?

These are difficult questions, as are all questions concerning human motivation. Furthermore, the answers may, and in this case surely do, differ from person to person. Before trying to propose such answers, we shall give a very brief description of what civil defense means in terms of installations and arrangements; why such installations and arrangements appear desirable—in fact, necessary—to us; what the objections to civil defense are and to what extent they are valid. This description will then be followed by a discussion of the problems confronting civil defense and of the image of civil defense in our country. If an important decision has to be made, one should try to visualize the consequences of the various courses of action and choose the one with the most desirable consequences. I will try to analyze three such consequences: (a) the probable effect of civil defense preparations on the likelihood of war, (b) the effect of such preparations on the national morale in peace, and (c) their effect in the event of war.

What Is Civil Defense?

Before considering the question of how civil defense preparations, or the absence of such preparations, might affect our future, it is well to state in a few words what such preparations could consist of. Since much of the rest of this book is devoted to a more or

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less detailed description of civil defense, its purposes and functioning, I can be very brief at this point.

Three types of preparations can be distinguished: those which are intended to protect people and their livelihood during an enemy attack, those which render the postattack period easier by securing the availability of the physical necessities of life (principally food, shelter, and means of communication), and finally, those which should facilitate the preservation of our social institutions and of our government. Shelters—fallout shelters in rural areas and preferably blastproof shelters in cities and near military targets—form the principal means for protecting the lives of people from the attack itself. Safe and accessible storage of food, medicines, and of some other materials, such as tools and gasoline, could greatly abbreviate the period of severe privation and render the resumption of production faster and easier. Clear and well-thought-out plans for maintaining lines of communication and of succession, including the establishment of a chain of command for the postwar period, would reduce the confusion accompanying any catastrophe.

Clearly, the effectiveness of all these preparations would depend not only on their extent but also on a variety of other circumstances such as the magnitude of the enemy attack, the time of year, and many other factors. The remainder of this book will try to set limits on the effectiveness of the preparations. Even so, a large uncertainty is bound to remain. This uncertainty has been used as an argument against the preparations. This appears to me to be unjustified: even a somewhat uncertain future is preferable to a certain but entirely bleak one.

Civil Defense Preparations and the Likelihood of War: The Effect on Possible Causes

The effect of the civil defense posture on the likelihood of a war should be easiest to foresee. Nevertheless, it has been argued both that preparations to protect the people against the effects of a war render the war itself more likely and that they make it less likely. I

shall first present the two views sharply formulated and then try to analyze them and the actual situation as objectively as I can.

Accepting the realistic point of view that conflicts of interest will inevitably arise in the future, the opponents of civil defense maintain that the U.S. Government would be more intransigent if it were assured that most of our people will survive a war than in the absence of such assurance. Such intransigence and lack of willingness to yield or compromise might well induce an exasperated opponent to mount an attack or at least to threaten one. The attack would trigger retaliation by the United States. Even the threat of it could precipitate a war with all the devastation that this would entail. Hence—to continue their argument—it is better if the U.S. Government is not in a position to be intransigent: we should have no civil defense. And the opponents go further:

Even the preparations themselves could precipitate the war. Should an inimical government view our civil defense effort as an indication that we are planning to attack, it could well "jump the gun" while our cities are still more vulnerable than his. At the very least, an inimical government may fear that its power to coerce the United States will diminish as a result of the defense efforts, and it may want to use its power while it is still unopposed.

The supporters of civil defense, on the other hand, believe that the protection of our civilian population afforded by shelters, and the other plans of civil and antiballistic defense, will decrease the danger of blackmail by possible antagonists, will contribute to the easing of tensions, will enable our government to negotiate slowly and calmly, and thus will decrease the possibility of war. They support this point of view by historical precedent, by studies of the temperament of nations, and by their greater faith in our own people and government.

It is in their faith in the United States that the two sides differ most markedly. Both agree that the power of the United States would be raised by civil defense, and admittedly power often leads to aggressiveness. However, the United States had a much more

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dominant power position in the years following 1945 when it alone possessed the atomic bomb, a superiority that no amount of civil defense would assure. Yet even under dire provocation such as the Berlin blockade, the occupation of Czechoslovakia, the breaking of the Hungarian peace treaty, it showed no tendency to exploit this power. It stood by while Russia annexed Estonia, Latvia, and Lithuania, yet pointedly refused to annex any people or territory for itself.

In fact, all the conflicts between East and West since the termination of the Second World War have been initiated by some move of the East toward an extension of its power. This has either been unopposed by the West as in the case of the occupation of Czechoslovakia, the breaking of the peace treaties with Hungary, Rumania, etc.—or has been resisted by the West, as in the case of the invasion of South Korea, the Berlin Blockade, etc. No conflict has been started by the West to extend its sphere of influence and there is no sign to indicate that the United States has any desire to extend its territory. It does wish to protect its own and that of its allies, and civil defense would greatly help this endeavor.

Civil Defense Preparations and the Likelihood of War: The Possibility of Nuclear Blackmail

A particular enemy tactic that may become very dangerous is called nuclear blackmail. If our people have little protection so that a hostile government could cause large losses of life in our population, this government might be tempted to make demands on us and to back them up by threats. They could demand that we evacuate Berlin, or that we withdraw our protection of the Philippine Islands—many similar demands are conceivable. Our present "defense" against such threats is the counterthreat of retaliation. This, however, seems a very fragile defense because no retaliation would bring back to life those who would die as a result of the enemy attack. Hence, our opponents may not take our counterthreat too seriously. They might figure, and perhaps rightly so, that we would,

let us say, rather evacuate South Korea than exchange the lives of millions of Americans for the lives of any number of people of the hostile country. Let us assume, therefore, that the absence of protection of our people does induce us to yield and to do our opponent's bidding. If it does not, we may as well have protection for them—the enemy is less likely to attack protected than unprotected people and the protection would not increase the chances of war.

However, if we do give in to a threat, the opponent will have learned that he can impose his will on the United States by threats. He will be tempted to repeat the procedure, and every repetition, if successful, will make us weaker both physically and in our determination. In order to avoid foreign domination, we would be forced ultimately to fight[1]—and fight after having lost our allies and much of our vigor.[2]

The set of events just described, ending in war under very adverse conditions, need not come true even if the U.S. population is left unprotected. All of us hope that it would not. However, the grim possibility discussed above is not unlikely. World domination is a nearly irresistible temptation for some, especially rulers not bound by a tradition of accountability to their people.

If the United States made a vigorous effort to provide protection for its people against the dangers of a nuclear war, the course of events just described would become much less likely, if not impossible. The threat which a hostile country could pose would be much less severe physically and therefore would be less likely to succeed. Hence, the probability that it would be attempted would be reduced[3]—"Politics is the art of the possible." Not only the physical but also the emotional conditions for nuclear backmail would become less favorable. The defense preparations would make it clear that the United States is prepared to face threats.

The opponents of civil defense claim that, while civil defense would decrease the danger of nuclear blackmail being attempted against us, it would increase the chances that the United States might become too aggressive. This possibility appears to me to be

remote. There is every reason to believe that the United States has no desire to impose its rule on other countries. In this regard, there is a great difference between the United States and the dictatorships. The contrast between the attitudes of the United States and the USSR at the conclusion of World War II was mentioned earlier. The USSR increased its territory by 266,000 square miles, extending its rule over 22,700,000 people—more than 10 percent of its prewar population. The United States granted independence to the Philippine Islands. The independence of the countries liberated by the United States is complete—those "liberated" by the USSR are still under tight rein.

It is in consonance with this difference that our government does not engage in hate propaganda against the East—it is by hatred that people can be motivated to a war of conquest.[4] If there is in our country an incitement to hate the opposite side, it is restricted to a small fringe, does not represent our government, and all of us have an opportunity (and hence an obligation) to counteract hatemongering. A glance at the news media of communist countries shows the fundamental difference between the two sides in this regard. There is a similar difference between the treatment of those who want to leave the country: the contrast between our open borders and the six-mile-wide mined strips with barbed wire fences guarded by machine gunners could not be more obvious. The argument that assuring a reasonable chance for survival to our people would tempt our government to precipitate a nuclear war is far-fetched indeed.

Civil Defense Preparations and the Likelihood of War: The Accidental War

If no civil defense preparations have been made, a single enemy weapon can wreak tremendous damage and the report of an attack is likely to be answered with a heavy counterattack. This is the pic-

ture of accidental war which has often been projected. Similarly, in a very tense situation, people may start to flee from probable target areas, such as large cities, and thereby aggravate the tension. The enemy may feel compelled to act, lest his "hostages" disappear. These dangers are less grave if there is reasonable protection for the population. However, even if one does not consider specific contingencies, it is clear that the greater the danger which threatens the people, the more tense their leaders will become and the more likely they will be to make an error. The assurance, provided by civil defense preparations, that most of the people can find protection on short notice, would lessen this danger.[5]

In order to assure that the shelter taking—either haphazard or organized—does not increase tension, it is important that it does not worsen the opponent's strategic position. It is important, therefore, that the sheltering response time be short; that is, that people *can* take shelter even if they start to do so only when the attack is underway. In this case, the bargaining position of the opponent does not deteriorate even if some people do take shelter ahead of time and a spontaneous movement to shelter in a severe crisis—which may be unavoidable—would not induce the opponent to take precipitate action.

City evacuation has often been proposed as an effective way of reducing civilian casualties resulting from a nuclear war. Planning and organizing such evacuation would be significantly less costly than the building of shelters. However, city evacuation, though strongly advocated by the civil defense authorities of the USSR,[52] does have the disadvantage that it may aggravate the crisis—and an organized evacuation would aggravate it more than a spontaneous exodus of people from the cities.

In summary, I find little to support the facile conclusion that, if one makes preparations to decrease the effects of a war, one makes the war more likely. Least of all is this true if the preparations are made with due consideration for all their effects, in particular their

effects to precipitate or aggravate a crisis. If this is done, the preparation will allay fears, ease tensions, and can become a powerful force for the preservation of peace.

Both civil and active defense—that is, antimissile missiles and other installations designed to destroy the enemy's antipopulation weapons—can decrease the effects of a nuclear attack. Hence, much that was said above about civil defense and about shelters, applies also to active defense. The relation and possible joint employment of active and passive defense will be discussed in Chapter 6.

Effect of Civil Defense Preparations on Our Society, Our Freedoms, and on the East

Since the effect of civil defense preparations on the likelihood of war led to widely divergent opinions, it is not surprising that their less clearly specifiable effects are also subject to controversy.

According to the anti–civil defense opinion, effective civil defense preparations would be accompanied by severe regimentation of the whole population and destroy our freedoms and our democratic way of life. This argument has been carried so far as to claim[6] that a truly adequate protection of the people (at a cost of about twice that of our space program) could be accomplished only at the expense of building programs for schools and hospitals. A second fear sometimes voiced is that the shelter program would evoke enmity toward the Soviet people and their form of government. Simply having to accept the idea that our freedom, our country's independence, must be defended might well hinder us in making genuine overtures toward peace and friendship. A third line of argument is that the daily sight of the grim reminders of war would insidiously affect people's peace of mind. They would become nervous and irritable, wanting perhaps to "get it over with," i.e., to attack the potential enemies now. Fourth and last, the proposed civil defense preparations would put the communist governments at a considerable disadvantage, consigning them to a permanently inferior and impotent position. They would feel, as Henry Wallace

said, like a "caged lion" and would be inclined to act accordingly. This is not in the interest of anyone.

The large majority of people has little sympathy with the last two arguments. As to the fear of consigning communist governments to a feeling of impotency, most of us feel that their striving could be directed toward bettering the fate of the people under their care. As to the adverse effect of civil defense preparations on the attitudes of our own people, most of us believe that these are not children who should be kept happy by concealing from them the facts of life. Communist aggression will not go away if people close their eyes to it. If civil defense preparations remind them that our way of life is in danger, they should be reminded of it. The awareness that freedom sometimes has to be defended rather than simply taken for granted may even have the salutary effect of causing people to value it all the more.[7]

This last point also illuminates the different evaluations of the effect of civil defense preparations—and of defense preparations in general—on our democracy. The opponents of civil defense, particularly the extreme opponents, fear that, in order to conform with reasonable defense requirements, the average citizen would have to be strictly regimented. They do not describe the type of regimentation that would be necessary but propose, instead, that our fellow citizens be kept innocently oblivious of the dangers which may threaten their lives and also our democracy from the outside. Similarly, people must not be told that there are measures which would provide significant protection against nuclear weapons.[8] People may demand such protection. Those holding to these views set themselves up as seers and claim the privilege of determining what the people should; and what they should not, be told. Their ideal seems to me to be an elitist state—a system which I find repugnant.

Those holding the pro–civil defense point of view visualize an enlightened citizenry, well aware of the dangers to the nation and the cause of freedom, but courageously facing these dangers and willing to make the sacrifices which the defense of these freedoms

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requires. Surely, in peacetime, these sacrifices are not very grave, would be willingly made, and no regimentation would be necessary. The pro–civil defense view implies confidence in the sound judgment of most of our citizens and in their sober realism, even if most of the majority cannot articulate the basis of their judgment. If we refuse to make sacrifices for our ideals now, these ideals will be permanently discredited.[9]

Hand in hand with the different evalution of our fellow citizens, there is a difference in the evaluation of the probable behavior of communist governments. While those holding the anti–civil defense view do not go so far as to endorse the "dictatorship of the proletariat," many of them tend to forget recent history, greatly to magnify the benevolence of the Soviet leaders both toward the people at home and toward the foes of yesterday. The advocates of civil defense have a longer memory. They recall the extermination of conquered nations; the Katyn massacre; the fate of Nagy, betrayed to his death; the fate of Tibet; the economic exploitation of the conquered satellites. They may realize that these are transient phenomena and that the initial savagery of the conqueror is likely to subside later. However, they are determined to avoid the "period of transition." As Maynard Keynes said, "Things may adjust in the long run, but in the long run we are dead."

The point of the anti–civil defense opinion which surely has a certain validity is the second one, that if extensive preparations, visible to all, are used to resist the threat of aggression of the communist governments, this may make the transition to conciliation and friendship more difficult.[10] It is not easy to tell how large the effect of civil defense preparations would be in this regard —checking the account submitted to us by our bank, also an operation designed to prevent the infringement of our interests, fails to induce in most of us a permanent distrust or enmity toward the bank. But again there is an asymmetry, and I find it saddening not to be able to evoke, on the part of most advocates of this argument, any criticism of the hate propaganda fostered by the communist gov-

ernments. Such hate propaganda surely prejudices conciliation and friendships much more than sober preparations against specific acts which are, furthermore, not directed against any particular government.

The two points of view regarding the effects of civil defense preparations on our society in peacetime which were described are extremes. This applies particularly to the picture given of the anti–civil defense point of view. Many shades of opinion between the two extremes exist, but the two extremes do illuminate the nature of the fundamental choice to be made.

Actually, it is quite possible, or even likely, that a modus operandi might be found which does not offend the sensibilities of either group. If shelters can be designed so that they are useful in peace and solve some of the emerging problems of urban life, they will not offend those who fear that the antagonism of people toward the communist governments will harden as a result of the daily awareness of defense installations. At the same time, the defense will be provided and this should not only reassure those of our citizens who feel the need for such defense, but should also give pause to the governments which might be tempted to abuse the "naked defenselessness" of our people. The most urgent problem of urban life with which the solution of the shelter system may be connected is the problem of transportation. The streets in cities are becoming ever more crowded and it is increasingly difficult to accommodate both vehicular and pedestrian traffic. If one of them could be shifted, at least in part, underground, the congestion could be relieved considerably. Some cities, such as Chicago, are planning underground passageways for pedestrians, others (such as Dallas) similar passageways for trucks and some (e.g., New York) for cross-city traffic. Several cities will install new subways. If the underground roadways can be made blast-proof, they can serve a double purpose.[11] Actually, there is every indication that the subways in the USSR are so designed as to be able to serve also as shelters; at least those in Moscow, Leningrad, and Kiev are about 120 feet under-

ground and are provided with blast-proof doors 1½ feet thick. Here is an example well worth imitating by the West.

Effect of Morale During and after Hostilities

Opponents of civil defense rarely discuss the situation after the end of the war, except perhaps to make comments such as, "The living will envy the dead." Those favoring a vigorous defense program point to the enormous help which even modest preparations toward recovery can make. In particular, if food for a reasonable period were safely stored throughout the country, people would be relieved of the worry of the next day's bread and could devote their energy more completely to longer range plans for recovery. The same holds true for medicines. Recovery itself would be speeded enormously if key materials, such as gasoline and essential tools, were stored; and if people were kept in readiness to repair electric transmission lines, and for similar functions. All these questions will be discussed in more detail in the last part of this book (Chapters 11, 12, 13).

Even more important than the effect of preparations on economic recovery might be their effect on the morale of the people. Should disaster strike with no provision having been made to help the people recover, their faith in their leadership would be irrevocably shattered; they would feel betrayed, abandoned. (See in this connection particularly Chapter 13 by Peter G. Nordlie.) To restore the economy, the social system, and the unity of the country under these circumstances would be much more difficult not only because the situation would be so much worse physically, but also so much worse emotionally. "To a very large extent, the morale of the survivors of an atomic attack will be determined by the effectiveness of civil defense measures," as Irving Janis tells us in Chapter 3.

The Public Image of Civil Defense

I have attempted in the preceding discussion to give an appraisal of the effect of civil defense preparations on the likelihood

of war, on the morale and attitude of the people in peacetime, and on the overall situation in the event of war. My approach is different from the highly dramatized discussions so prevalent in the literature.[12] These usually start with a description of the horrors of nuclear war, which are real indeed, and are based on the situation which would prevail in a country which entirely neglected its civil defense. This circumstance is, however, not pointed out,[13] and the reader is almost left with the impression that civil defense causes rather than mitigates the horrors of war. These articles show considerable artistic skill, but it is difficult to escape the conclusion that they intend to scare rather than to inform the public. The articles, essays, and speeches in question are not the only causes of the warped picture that much of the public has of civil defense. Those of us who advocate civil defense have to share some of the blame. Few technical problems proceed in a straight line from setting to solution. Errors and false starts accompany most overtures, a valid solution coming only after some paths are explored which do not lead to the goal. In most cases, the eventual user knows nothing about the unfertile attempts and sees only the success of the final effort. There are only a few cases, such as the history of the reciprocating engine,* in which the false starts are well recorded.

Civil defense preparations cannot be kept in the dark, and the public becomes aware of all the errors in judgment, all the false starts, that are made. This is unfortunate because it undermines the confidence of the people in the competence of those concerned with their protection. Even if the rocket designers did not have more technical insight into their problems than those working on civil defense, their competence would be more highly regarded by the public because their false starts are not subject to everyone's scrutiny. It is, however, appropriate to recall in this connection that the original errors in the design of the reciprocating engine—

* This is the old-fashioned steam engine, still in use in coal-fired locomotives.

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attempting to use the boiler also as a cylinder—did not detract from the usefulness of the final product.

At present, there are several thorough and, we believe, unprejudiced studies on the technical feasibility and on the social impact of civil defense preparations. The purpose of the present book is to present an analysis of the problems involved: physical, economic, and social. Some of the older analyses—much more detailed and technical than the present one—are still classified. The conclusions of the Harbor Study, undertaken in the summer of 1963 and sponsored by the National Academy of Sciences, are available to the public and are still interesting reading.[14] So is the record of the hearings in the 88th Congress by a committee which actually held an adverse opinion toward civil defense when the hearings started. However, "a slow but easily perceptible change was evident in the attitude of the committee members. Opposition to the program melted and then hardened into an attitude of firm belief in the support of the fallout shelter program."[15] It should be noted, however, that the subject of the hearings (fallout shelters) was a more modest program than those which are primarily considered in the present book. We wish to quote, finally, from the report of the civil defense panel of the President's Science Advisory Committee: ". . . the possibility of survival and recovery may depend on the adequacy of civil defense."[16]

Summary

"The need for an effective system of civil defense is surely beyond dispute. No city, no family, nor any honorable man or woman can repudiate this duty." These words were spoken by Winston Churchill on March 1, 1955—more than ten years ago. His attitude was not the result of a careful analysis of the favorable and unfavorable consequences of a vigorous civil defense effort, but derived from his instinctive appreciation of the simple realities of life. Yet I believe that an analysis of the probable consequences of providing or of failing to provide protection for the people against

the dangers of a war supports his conviction. In particular, it is difficult to avoid the conclusion that better protection would render the contingency against which we protect, that is, a war, less likely.

As to the effect of civil defense preparations on the structure of our society and on our democratic institutions, certain groups claim that such preparations are harmful, even destructive, but the reasons they cite differ greatly. The most extreme frankly want the United States to forfeit its present position of power, "to be shorn of discernible influence in international affairs, say, put in the position of Finland."[17] They seem to distrust any evidence of international goodwill ever shown by the United States. Fortunately, those who hold this view are as few in number as they are voluble in expressing themselves. I am opposed to these views and consider our present position of power as a responsibility and a privilege which we should cherish and use for the furtherance of international goodwill. We admit mistakes. However, on the whole, we trust our elected representatives and can cite much evidence to support our opinions. It is also good to remember that, had the United States in the past followed the policy now advocated by those who do not trust its present intentions, it would not have been able to offer effective help against national socialist Germany. These arguments do not convince those who view a courageous and self-assured United States with apprehension and of course, no country's attitude can be foretold with absolute certainty. What continually surprises me is that those who distrust the future intentions of the United States so often do not show similar distrust of the intentions of those governments whose professed purpose is the domination of the world.

There remains, of course, the argument that if one cannot foresee the results of a decision with certainty, one should refrain from making that decision. This argument has considerable emotional attractiveness. It should be remembered, though, that not making preparations for mitigating the effects of a dreadful danger is also a decision and a very grave one.

There is little question as to the effect of civil defense preparations on the suffering, and also on the morale, of people during and after a possible war. This point is disregarded by those who are opposed to civil defense because the war is too dreadful to contemplate. Nor is it one of the arguments particularly stressed by those who are in favor of civil defense because they consider the principal purpose and hoped-for effect of civil defense a decrease in the likelihood of war, not a decrease in the losses and suffering caused by a war. The difference between the lives lost without effective civil defense preparations, and the difference in the morale of the people who would feel forsaken and betrayed in one case, or resigned to the necessity of their suffering in the other case, is too great to be simply overlooked.

The reasons for the United States not having undertaken effective civil defense preparations in the past are difficult to assess. No matter what these reasons were, they should not prejudice the future. Rather, a fresh look should be taken at the problem, and the purpose of this book is to provide such a fresh look.

Notes

1 This is what actually happened to France and was one of the bases of Hitler's expectation that he would be victorious in the Second World War.

2 The alternative of complete surrender—though it has also been proposed as a choice to be considered seriously (cf. e.f., A. Rapoport, *Strategy and Conscience* [New York: Harper & Row, 1964], p. XX), and even advocated (e.g., Erich Fromm, *Daedalus*, 89, 1,015 [1960])—is not discussed here. It is questionable that it would bring peace to this country; more likely, the United States would become the staging area for a conflict between the conquering and another government. In addition, it is, of course, deeply repugnant to most of us to see the precedent established that the more humane governments are replaced by less humane ones because the former are unwilling to assert themselves.

3 Eugene Rabinowitch said in the *Bulletin of the Atomic Scientists* (VI, 266 [1950]) that "The fourth (i.e., civil defense) was—and re-

mains—the only fully effective means of reducing the consequences—and thus the likelihood—of an atomic attack if rational attempts to make it impossible prove futile," thus linking the unlikelihood of an attack to the reduction of its consequences.

4 It is not very pleasant to quote such statements nor it is easy to make a choice. The Sunday, June 27, 1965, New York *Times* describes the propaganda to which children in China are exposed. The article starts, "Recommended reading for children in Communist China today centers on stories stained with blood and tears." The article contains a lurid description of the kind of literature which Chinese children are given to read. The intensity of the hatred which shows in some of the Chinese propaganda is nearly incomprehensible to the average American. As compared with it, the USSR hate propaganda is relatively mild. For this writer, the most memorable remark dates from the zenith of coexistence. It is Khrushchev's praise of certain authors for their "irreconcilable hatred" of the West, ironically enough in his address on culture (see *Encounter* pamphlet 9; London: Society for Cultural Freedom, 1964). A more recent statement in a similar vein was made by Leonid I. Brezhnev on July 3, 1968: "The social and political order which engenders political banditry arouses contempt and revulsion throughout the world. The rotten society, the degrading society, the decomposing society—this is the United States called even by those who recently lauded the American way of life." However, one can also find much more conciliatory utterances. The pronouncements of the satellite regimes are somewhat in between those of the Chinese and USSR leaders. "Boundless hatred for the enemies of the German Democratic Republic is an indispensable qualification for the socialist soldier."—Admiral Verner, Deputy Minister of Defense of GDR (East Germany). "The mere existence of imperialist states is a menace to peace."—Czinege, Minister of Defense of Hungary. "Imperialist" in official pronouncements in communist countries means "Western." "The flame of retribution must not be limited to urban buildings and centers but the countryside must go up in smoke also. Remember the forests, the fields, the crops. Remember the pipelines and oil storage tanks."—Havana Radio.

This is not to say that the propaganda is fully effective—at least not yet—nor that the people of the East hate the West (some time ago a man, freshly arrived from Hungary, inquired whether there really had been a McCarthy). However, the propaganda does show

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what the leaders want their people to believe and the purpose, if possibly distant, is not really doubtful.

5a See J. Levey, *Survive*, Vol. 2, No. 2, (1969), 2.

5 According to Thomas C. Schelling (*Daedalus* 89, 896 [1961]), "We both have—unless the Russians have already determined to launch an attack and are preparing for it—a common interest in reducing the advantage of striking first, simply because that very advantage, even if common to both sides, increases the likelihood of war." Civil defense decreases the disparity between offensive and defensive weapons and hence decreases the advantage of striking first.

It may be remarked that it also renders disarmament easier by the same token: the possession of a few nuclear weapons does not assure a dominant position. Hence, the control of the possession of such weapons need not be absolute.

6 Dean D. F. Cavers of the Harvard Law School during the Panel Discussion on Civil Defense, organized by the American Nuclear Society. The verbatim report of the discussion appeared as a report (*Panel Discussion on Civil Defense* [ORNL–3865; Gatlinburg, Tenn., 1965], p. 34), issued by the Oak Ridge National Laboratory and obtainable from the Clearinghouse for Federal and Technical Information, U.S. Department of Commerce, Springfield, Va.

7 This point of view has been eloquently stated in E. Teller's *The Reluctant Revolutionary* (University of Missouri Press, 1964).

8 This point is well illustrated by the discussion about the effect of fires on shelters in connection with the Harbor Report (Publication 1237; Washington, D.C., National Research Council, National Academy of Sciences, 1964) conducted in *Scientist and Citizen* for May and August 1965, and February 1966. *Scientist and Citizen* is a publication of the St. Louis Citizens' Committee for Nuclear Information, an organization strongly opposed to civil defense. There are eight physicists on *Scientist and Citizen*'s Advisory Board who should be able to make calculations on heat conductivity. However, similarly erroneous views on technical questions, made in authoritative tone by nontechnical people, are too numerous to quote.

9 It may be of some interest to note that there are conditions under which pacifist Einstein observed: "I consider military preparedness in these countries (the democracies) the most effective means, in times such as these, of making progress toward the goals of pacifism." (*Einstein on Peace; His Diaries and Letters*, eds. O. Nathan and H. Norden [New York: Simon & Shuster, 1960], p. 247.)

10 In a form which appears to me somewhat exaggerated, this argument was particularly espoused by L. Festinger, under the title, "Cognitive Dissonance." The dissonant elements are the defense against possible aggression and the striving for true friendship.

11 The dual uses of shelters are discussed in some detail in Chapter 9. Another "dual" use refers to the whole civil defense organization, not to the shelters. It is to cope with natural disasters, such as floods, earthquakes, etc. The civil defense organization has not always been successful in this regard. However, it has earned high praise for its activities during and after the earthquake in Alaska. During the Arizona flood, January 1966, the mayor of Phoenix (M. Graham) said: "Phoenix pays $29,000 per year for civil defense; it is worth $29,000 per hour today."

12 See, e.g., *On the Beach, Fail Safe, Seven Days in May.* These books depict the hopelessness of the survivors, their will power completely paralyzed. Actually, every evidence points in the opposite direction: adversities stimulate people to greater effort and inventiveness toward self-preservation. This was the experience also during the siege of Budapest, to be described in Chapter 4. There are, of course, also books depicting the terrible suffering of conquered people, for instance, John R. Hersey's *The White Lotus* (New York: A. A. Knopf, 1965).

13 See, e.g., "Medical Aspects of Civil Defense," Victor Sidel's contribution to the symposium sponsored by the American Association for the Advancement of Science in Berkeley, December 1965 (Publication 82; Washington, D.C.: AAAS, 1966).

14 *Civil Defense; Project Harbor Summary Report* (Publication 1237; Washington, D.C.: National Research Council, National Academy of Sciences, 1964). This report was updated recently. The "Little Harbor Report" is obtainable from the Division of Technical Information, U.S. Atomic Energy Commission, Washington, D.C.

15 88th Cong., 1st sess., House of Representatives Report 715, p. 3.

16 P. I–1 of the Report of the PSAC panel on civil defense.

17 A. Rapoport, Moderator's Remarks at the meeting on n. 13.

PART III

The Soviets Deploy an Effective Civil Defense System: Urban Evacuation 1969–1976

With the publication of the 1969 Soviet civil defense manual (and its subsequent translation and publication by the Oak Ridge National Laboratory), it became apparent that Mutual Assured Destruction was no longer mutual. Wigner was one of the leaders in publicizing this situation. Wigner became a proponent of "counter evacuation".

The Myth of "Assured Destruction"

E. P. Wigner

Survive *3*, No. 4, 2–4 (July–Aug. 1970).
Reprinted: Congressional Record (Feb. 19, 1971), p. 1

Facts of modern Soviet defense reveal a drastically different picture than that of an obliterating second strike by the United States in the event of Soviet nuclear attack. Here Princeton University's Dr. Eugene P. Wigner, renowned physicist and civil defense authority, examines these facts and arrives at the conclusion that the Soviet Union would not be crushed by our counter-attack. It would, thanks to effective survival plans, lose fewer people than it lost in World War II—probably less than half as many.

A large part of our public and much of our military consider civil defense preparations unnecessary because they believe we can rely on the "assured destruction" doctrine. This doctrine tells us that, even after being subjected to a first strike, our forces can inflict such damage on the assailant that his destruction as a nation is assured. Hence, no nation will ever attack us or ever threaten us with an attack. The purpose of this article is to expose this doctrine of "assured destruction" as a myth. It became a myth principally as a result of the elaborate preparations which were undertaken by the USSR to evacuate its cities. If such an evacuation were carried out before a confrontation is precipitated, our deterrent based on the threat to the Soviet urban population would have evaporated.

Underestimating the effectiveness of defense—in the present case the civil defense and city evacuation plans of the USSR—is almost as common a mistake as preparing defenses against the enemy tactics of the *preceding* war. Thus, before the First World War, it was taken as axiomatic that the outcome would be determined one way or the other within three weeks because the offensive power of at least one of the parties would overwhelm the defense of the other. Yet the trenches protected the troops of both sides and stalled the progress of the attacker for four years. As to the Second World War, psychologist Janis observes,[1] "prior to World War II, government circles in Britain believed that, if their cities were subjected to heavy air raids, a high percentage of the bombed civilian population would break down mentally and become chronically neurotic. This belief, based on predictions made by various specialists, proved to be a myth." Indeed, the stories of horror, the subject of a variety of books before the Second World War, depicting the utter hopelessness of people roaming the streets, their disorientation and helplessness, must have deeply affected every reader. Yet, when the attacks came, the air raid shelters proved to be very effective—effective not only emotionally by preventing the breakdown of morale anticipated by Janis' "specialists," but also physically by providing a remarkable degree of protection.

THE EFFECTIVENESS OF DEFENSE: U.S. DOUBTS VS. SOVIET CONFIDENCE

The situation now is somewhat similar to that before World War II. Both our military and our public give credence to statements by those who grossly exaggerate the power of offense over defense. They tell us that we can do little or nothing to protect the civilian population against the effects of nuclear weapons. In the USSR, on the other hand, civil defense has the wholehearted endorsement of the military, and belief in its effectiveness with which the Soviet government has developed protection for its people.[2]

The publications in the USSR do not conceal the terrible nature of nuclear weapons. Thus, the article of General Chuykov,[3] which forms one of the bases of this article, gives a fair and, in fact, unusually clear picture of the effects of these weapons. One can only wish that all our people were familiar with this article. However, it then goes on to say that "there is no poison for which there cannot be an antidote, nor can there be a weapon against which there is no defense. Although the weapons we have examined are mass weapons. . .they will not affect masses but only those who neglect the study, mastery, and use of defense measures."

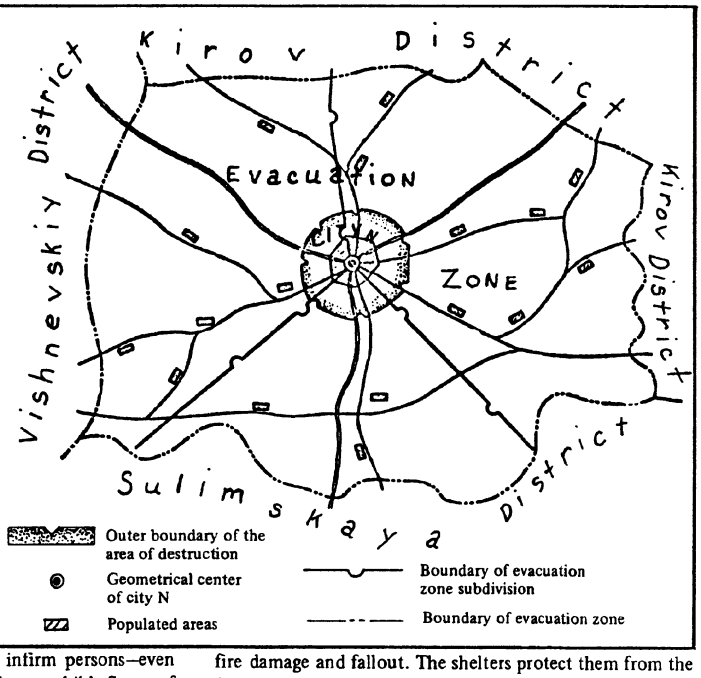
SOVIET SURVIVAL MEASURES

Indeed, as readers of *Survive* well know, the Soviet Union

is well ahead of us in shelter construction. According to Podchufarov,[4] the length of their subway tunnels is by now 130 miles. Even though they surely exaggerate when claiming that all the subways in the USSR are "safe" in the case of nuclear attack, it is true that they have hardened subways and these provide not only fallout but also very good blast protection—*much better than any of the public shelters in our country.*

The public shelters in the cities of the USSR are, nevertheless, designed to protect only a small part of the total population—those whose services would remain indispensable even during a conflict. What then renders our theory of assured destruction truly a myth? The USSR's extensive plans for evacuation of cities. These are barely more than two years old, yet they extend to all details—often, it seems, to a ridiculous extent. However, their principal lines are simply and clearly formulated. The decision to evacuate "will be announced by radio, television, published in the press (note this), or brought to you at your place of work or residence." People are expected to take along only what is most necessary, not more than 110 lbs. per person. The evacuation plans, communicated to all city residents, specify the collection point where transportation will be provided for them. At the destination, food, lodging, shelter, work, medical services, will be available. Mail will be automatically redirected to reach people at the evacuation point rather than at their city residences. Plans are also formulated for the evacuation of sick and infirm persons—even for women who have just given birth to a child. Some of the plans appear to be too detailed.

TYPICAL SOVIET EVACUATION ZONE



EFFECTIVENESS OF EVACUATION

How effectively would the evacuation, if carried out completely, reduce the casualties and thus negate our "assured destruction"? It is difficult to give an exact figure for this because the total number of casualties depends on several factors. Chief among these are (a) the extent of the success of the USSR first strike in reducing our retaliatory capability, i.e., in destroying some of our missile sites.[5] (b) the effectiveness of the USSR ballistic missile defense in destroying the missiles which we can launch after absorbing a first strike. (c) our own targeting doctrine, whether, under the conditions outlined, we would aim at the remaining missile sites in the USSR, at their evacuated cities to cause industrial damage, or at the evacuated population.[6]

Clearly, the maximum number of casualties would be caused under the least likely assumption: that (a) the USSR first strike against our missile bases is without any effect, (b) that the ABM of the USSR is entirely inoperative and (c) that we aim only at the evacuated people, disregarding the cities and industries, the people sheltered there, as well as the remaining missile sites in the USSR. This last assumption is, of course, least credible.

Under the assumptions just made, the USSR hostage level is easily estimated. The evacuated people are immune to two of the most important effects of nuclear weapons: fire damage and fallout. The shelters protect them from the fallout radiation and no large fires can spread in the countryside. They are subject to the blast. Anyway, if fallout is to be caused, the area subject to a certain blast damage is reduced to about one-half. The total area which we can cover with a blast wave of 15 psi overpressure is 19,000 square miles.[7] This overpressure, 15 psi, is far from the "mean lethal overpressure"[8] of about 50 psi, as established by extensive studies.[9] Hence, one might claim that the number of fatalities which the USSR leaders have to fear is considerably less than the number which we shall obtain, using the adverse assumptions (a), (b) and (c). To some extent this may be true. However, if one considers additional effects, such as initial radiation, flying objects, as well as damage to the eardrums which (though by no means lethal)

occurs at *much lower* overpressures, the 15 psi may be a good estimate for a "practical mean lethal overpressure."

If evacuation has taken place, how many people will there be within the area of 19,000 square miles in which we may be able to create the "practical mean lethal overpressure"? This depends on the area into which the people of the cities will be dispersed. Chuykov's aforementioned article[3] gives an indication for this. He mentions a "city A," which we can assume to be Moscow, with a population density of 7000 per square kilometer (18,000 per square mile). After evacuation, the density would drop to one tenth of these figures. Since the population of Moscow is about 7.5 million, one obtains an evacuation area of 3900 square miles or a maximum evacuation distance of about 35 miles.[10] This area then can be destroyed by less than one half of our missiles even though the "area coverage" needed for this is, since circles do not cover an area without overlap, about 4700 square miles.

How to use the remaining missiles, with an area coverage of 19,000-4,700 = 14,300 square miles? The next largest city in the USSR is Leningrad and, since it lies on the sea, its population cannot be dispersed as well as that of Moscow. The dispersal area for its 4 million people is closer to 2000 square miles (again using the maximum dispersal radius of 35 miles), requiring an area coverage of about 2400 square miles, leaving an area coverage of 11,900 square miles for the other large cities. These–Kiev, Baku, Karkov, Gorky and Tashkent–have populations of about 1.4 million each. The dispersal of these people into areas similar to that given by Chuykov for "city A," would give an average density of 1.4 million/3900 square miles, that is 360 per square mile. There would be no point in covering any of these dispersal areas with an overlapping pattern so that the remaining 11,900 square miles would place an additional 4.3 million people at risk. Together with the populations of Moscow and Leningrad, this gives 7.5 + 4 + 4.3 = 15.8 million people at risk. If we accept the official estimate that about two-thirds of our missiles function as expected, the total number of hostages we may have in the USSR becomes just about 10.5 million people.

This estimate is obtained under the unrealistic assumptions (a), (b), and (c), as explained above. Actually, the loss of some of our missiles to a first strike, the destruction of others by the missile defense of the USSR, and the fact that at least some of our own missiles would be aimed at industrial and military installations, would reduce the number of "hostages"–would reduce it to perhaps one-half of the 10.5 million figure.[11] The total number of casualties suffered by the people of the USSR in World War II was about 11 million.

EVACUATION–A PRELUDE TO CONFRONTATION?

There is a question that must have arisen in the reader's mind concerning the real effectiveness of evacuation in negating our "assured destruction" capability. It concerns the time needed for evacuation as contrasted with the warning time of a missile attack. The flying time of the land-based missiles is about 20 minutes, that of submarine-based missiles may be shorter. Evacuation of cities takes at least a day–according to General Chuykov, the *press* is one of the means of communicating the order to evacuate. Hence, evacuation is not a valid defense measure[12] against a first strike, certainly not against an unanticipated first strike. Does this circumstance revalidate the doctrine of assured destruction, and is it reassuring in this sense?

The answer is, in this writer's opinion, rather the opposite. City evacuation may not be a valid defense measure but, should a first strike or a confrontation be planned, evacuation would give the initiator a tremendous advantage. While 5½ million lives lost is a terrible retribution, is it "assured destruction"? Is it sure to deter a nation that lost twice that many in World War II? Can a President of the United States bargain with this deterrent against the threat of a first strike which can kill *many* millions of Americans?

We are spending less than 35 cents per person per year for civil defense. We have hardly any blast shelters, no plans for evacuation, and most of our fallout shelters are located in cities, exposed to destruction by blast. We have 5½ million Russian hostages; the USSR can threaten the destruction of more than 80 million American lives. In a confrontation, our President would be in a very, very inferior position.

Assured destruction has become a myth. ■

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1. I. Janis, Bull. At. Scientists, VI, 256 (1950).
2. See various articles in *Survive* by J. Levey, later J. Gailar.
3. Marshall V. I. Chuykov, Nauka i Thizn (Science and Life) No. 1, p. 43 (1969), Marshall Chuykov may be known to the American public as a representative of the USSR at President Eisenhower's funeral.
4. I. I. Podchufarov, Kommunist Vooruzhennykk Sil (Communist of the Armed Forces) No. 8 (April, 1968), p. 52.
5. See "Last To Be Eaten," by Edward Teller, page 8, this issue of *Survive*.
6. See "They Bet Your Life," by Arthur A. Broyles, page 6, this issue of *Survive*.
7. See, for instance, this writer's article in *Survive*, Vol. 2., No. 4, p. 16.
8. The "mean lethal overpressure" is the pressure of the blast wave which causes fatal injuries in 50 per cent of those exposed to it.
9. See various publications of the Lovelace Foundation, in particular Report LF-1242-1 by Clayton S. White. See also DASA report 2113 by I. G. Bowen, E. R. Fletcher and D. R. Richmond of the same Foundation.
10. This writer's estimate for the evacuation area, before the article of reference 3 became available, was 50 miles. The resulting estimate of the maximum casualty figure was then 7.5 million, instead of the 10.5 million to be arrived at here. Actually, the book of reference 11 supports the original, higher estimate of dispersal area (p. 63).
11. The estimate given in the USSR textbook on Civil Defense (edited by N. I. Akimov) is about four times lower if I understand this passage correctly.
12. According to the opinion of the authors of the Little Harbor Study, it is not a valid defense measure to be initiated by the U.S. See "The Threat" chapter of Civil Defense, Little Harbor Report, TID-24690, published by the Division of Technical Information, U.S. Atomic Energy Commission, 1969.

Blast Shelter Effectiveness and Cost

E. P. Wigner

EMO National Digest *10*, No. 1, 27–28 (Feb.–March 1970)

Winner of the scientific world's highest accolades, including the Nobel Prize, Eugene P. Wigner, scientist and engineer, directs much of his endless store of interest and energy toward alerting his fellow Americans to the need for a strong civil defense as a basic survival means in the nuclear age. Here he reviews the elements of the blast shelter question and comes to grips with the cold-blooded equation of offensive-defensive cost ratios. (Reprinted from Survive)

The present program of the Office of Civil Defense has two principal objectives:

1. To bring to the public, and especially to those in certain occupations, a better understanding of the effects of nuclear weapons and of the modes of protection against them.
2. To provide protection for the population at large against fallout radiation.

Fallout is caused by nuclear explosions if they take place close to the ground; explosions at high altitudes, such as those of ABM missiles, do not create significant fallout. The fallout radiation emanates from particles of earth and other debris to which the radioactive atoms produced in the explosion have attached themselves. This material first rises in the mushroom cloud accompanying the explosion, then falls, bringing the radioactivity down to the earth. Fallout shelters are designed to protect against radioactivity from these particles.

Protection against the other effects of nuclear explosions is discussed in this article. The most dangerous of such effects are the blast wave and the heat pulse. The present very economical program of the Office of Civil Defense does not include protection against these effects. This protection would be much more costly than the present program, and the effects in question extend over a much smaller area than that covered by the fallout. Nevertheless, blast and heat can destroy countless lives in cities where many people are concentrated in a relatively small area.

The best protection against blast and heat—and the only one which we now envisage—is provided by blast shelters, which also protect against heat and radioactivity. The rather high cost of blast shelters gave rise to the objection that such shelters are purposeless; the enemy can overcome their effect by increasing his arsenal and the size of its explosions. Furthermore, it is said that the enemy can do this at a cost which is lower than the cost of the protection. We shall see that, under the most widely prevailing conditions, this objection is erroneous.

The blast wave itself is described in the article of Hall and Haaland[1]. It is a sudden increase of the air pressure, followed by an intense gust of hot wind. This can hurl a man against a wall or other solid object. It can throw solid objects at him. These are the principal dangers to avoid. In addition, the air pressure itself, if it exceeds 40 psi (pounds per square inch), may result in lung damage; the eardrums will burst at a much lower pressure. However, if a shelter has a 100 psi blast resistance, the area in which those in the shelter are endangered is reduced to about 1 square mile in the case of a 1 MT (megaton) explosion, to about 4 square miles for a 10 MT explosion, to about 9 square miles for a 25 MT explosion. These figures apply if the weapon is an airburst, in which case the effect of fallout—the most widespread effect—becomes negligible. The area of blast damage for ground burst weapons is considerably smaller. Needless to say, a good blast shelter also protects against the heat radiation and all other effects of the explosion.

Many types of blast shelters have been designed and proposed. Some of these serve only as shelters to be used solely, or at least principally, to protect the people against nuclear weapons. A particular example is the tunnel-grid system, the design of which has been developed in some detail by the Oak Ridge National Laboratory. It consists of two parallel sets of tunnels, situated as the avenues and streets of a typical city are. The advantage of such an arrangement is that one can enter the shelter system anywhere and proceed within it to any other part of the system. The husband and father in the business section can walk toward his home and join his wife and children there. Other designs are for multipurpose shelters. These may serve as garages or conduits for utilities in peace and assume the role of shelter only in an emergency. The proper type of shelter will depend on various circumstances, such as the density of population, the need for utility tunnels or garages, etc.

A comparison of the cost of a blast shelter with the cost of a weapon to overcome its protection was given recently in the *Little Harbor Report*. Tjos report presents the conclusions of a committee of the National Academy of Sciences which was convened to study the effectiveness of various civil defense measures. It estimates the cost of a blast shelter with a 100 psi blast resistance as $300 per shelter space. It also estimates how much our government spends for missiles with

[1] *In the Shadow of Ground Zero, by Wm. Cornelius Hall and Carsten M. Haaland.*

various explosive powers. Since it has been variously claimed that the Soviets can produce their most powerful missiles, the so-called SS-9, at a lower price than the U.S. spends for its missiles, we shall use for the cost of the USSR missiles less than half of what our own costs would indicate. We assume that an SS-9 exploded over our country costs $35 to $40 million to the USSR (we pay about $50 million for a weapon of half the explosive power). This will render our conclusions most conservative.

An SS-9, if an air burst, may cover an area of 7 to 9 square miles with a 100 psi overpressure. In case of a ground burst (to produce fallout also), the area becomes 5 to 6½ square miles. For $35 to $40 milliomn one can build 100 psi shelters for 115,000 to 135,000 people. If the 5 to 9 square miles in question contain more than about 125,000 people, the defense is more expensive than the offensive power necessary to overcome it; otherwise, it is cheaper. Only about 15 million of our people live in areas with a population density exceeding this. Thus, even if one uses our adverse cost estimates, one must conclude that only for a small part of our urban population (of about 75 million) does the cost of protection exceed the cost of overcoming the protection. Of course, if humanitarian rather than cost-effectiveness considerations control the decisions, one will try to save lives at almost any cost.

What are, then, the principal limitations of, and valid objections to, blast shelters? The principal limitation is that they protect only the lives of people, not their houses and property. This is a serious limitation—ballistic missile defense is more effective in this regard. In addition, ballistic missile defense can be always on the alert, ready to shoot at incoming missiles. People need time to reach shelter. This last point is particularly serious if the attack comes from submarines: the warning time may be not more than a few minutes. On the other hand, shelters are less subject to obsolescence than the highly sophisticated antiballistic missiles, and technical innovations of the offense are less likely to endanger their effectiveness. They also would support the morale of the people better than the physically more distant, and emotionally and intellectually more remote, active defense. The two could, of course, be combined to give the most effective protection that is possible.

Why Civil Defence – 1970

Responsibilities, Costs and Rewards of Civil Defence

E. P. Wigner

EMO National Digest *11*, No. 4, 16–18, 20 (Oct.-Nov. 1970)

It is not necessary for me to tell you that I felt greatly honored when Mr. Patterson invited me to address your Seminar. At the same time, it was not clear to me what I should hope: that you already agree with what I'll tell you about the necessity and usefulness of civil defence, or that some of my message should be, at present, foreign to you. In the first case, if you already agree with what I'll say, I may bore you. Nevertheless, I would prefer it that way because, if you disagree with my message, my hopes of convincing you are modest. One can convince a disbeliever of a theorem in mathematics with a well formulated proof; one can well hope to convince a doubter in physics with a well conceived experiment. In human affairs, our subconscious is decisive; persuasion and arguments rarely affect it. Thus, my hope is that my discussion will bore you.

One cannot logically and consistently discuss a question of policy without specifying its objectives. These are, in this case, the national objectives and, as a rule, a stranger should not tell you what they are or should be. On the other hand, to a very considerable degree, defence, and civil defence is an integral part of this, has ceased to be a purely national affair. If a dictator can impose his will on Canada, the United States cannot long survive. Conversely, your independence could not last long, should the United States fall. As was said in another context, we either stand together or hang separately. I am very deeply conscious of this fact and hope that you also not only know but feel it.

The speaker from your External Affairs department has already told us that the national objectives include maintaining the independence of the country, its democracy and freedom. They also include every effort to avoid a war and all the suffering which even a just war entails. We do not want to force our ideals on other nations—a certain variety of human societies may, in fact, be desirable. However, surely, if dictatorships ruled the world, it would be disastrous from the point of view of the human values which are dear to us. An ant society would result, a degradation of human life and initiative, much worse than any now existing even under dictatorships. We are, and should be, willing to pay a very high price to avoid this. Some say that the possibility of a nuclear was is too high a price: "better red than dead". It may have been possible to claim this some time ago, but it surely is not true now. If we submitted to one of the great dictatorships, we would hardly avoid the devastation of a nuclear war: our countries would probably become the staging areas for an attack by one against the other great dictatorship. We have no choice but to defend ourselves, defending thereby also our ideals.

It was probably unnecessary to say all this: none of us wants a dictatorship to take over our country; all of us want to avoid war. The question is only, how to achieve both, how large an effort do we have to devote to our defence, and what fraction of this effort should go into civil defence? To what extent should we stand by our friends and how much should we accommodate our enemies? In order to form some ideas on these questions, I will try to envisage the consequences of two alternative attitudes. The first one implies trying to accommodate our opponents, to neglect civil defence and, as is often said, to offer up our people as hostages for our good behavior. The second alternative is to face up to the dangers, protect our people as much as possible, make it clear that we have no aggressive intentions, but also that we'll resist aggression.

Neither of the two pictures which will emerge will be rosy. It would be, however, not only unfair—it would also be illogical—to look only at one of the pictures and, since it is not rosy, decide on the other one. Yet, this is often done by opponents of civil defence, who then usually turn out to be opponents of all defence.

Neglecting Civil Defence

What can happen if we neglect to provide protection for our people against the threats of a nuclear war? If

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He worked on the Plutonium Project at the University of Chicago, 1942–45 and was on the Board of Directors to the Oak Ridge Institute, 1947–50. He was Director of Research and Development at the Clinton Laboratories. Oak Ridge. 1946–47, and was again at Oak Ridge as Director, Civil Defence Project, 1964–65.

Dr. Wigner is and has been a member of numerous national and international Mathematical, Physical and Scientific Societies during which time he served in such capacities as Director, Vice-President and President.

He holds honorary degrees from many American and European Universities including one awarded by the University of Alberta. Other awards include the Medal for Merit; Fermi Award; Atoms for Peace Award, 1960; Medal of German Physical Society, 1961; Nobel Prize for Physics, 1963; George Washington Award; Medal of American Hungarian Studies Foundation, 1965; and the U.S. National Medal of Science, 1969.

His publications include *Nuclear Structure* (with L. Eisenbud) and *Theory of Neutron Chain Reactors* (with A. M. Weinburg), both of which were published in 1958.

the threat materializes, our people will not only be helpless and disoriented, they would also feel abandoned. They would feel bitter and resentful toward their leaders of yesterday—they would feel bitter even if the actual war can be averted at the last minute. It is true that our people do not press now for shelters, for providing protection for them. But if an emergency arose, they would blame the leadership for the lack of foresight which it exhibited. The fact that they do not demand shelters now is a sign of their confidence in your foresight, in your understanding of the dangers that may threaten them sometime, and in your having done all to avert and to render as innocuous as possible those dangers. And if the danger should materialize, then, in the words of Yale psychologist Janis, To a very large extent, the morale of the survivors will be determined by the effectiveness of the civil defence measures." This morale is of decisive value after a catastrophe.

There are three remarks to be added to the preceding dark picture which may develop if the threat of a nuclear war should become more acute. The first is a reservation to the statement made before, that the reason people do not demand a more effective civil defence is that they now have confidence in their leaders —confidence that they will see to it that no catastrophe will strike them unprepared. This is true, according to opinion polls, of a very large majority of all the people. There is, however, a very strongly dissenting minority, of about 5%, which says it fears that civil defence measures will alarm the leaders of Soviet Russia and will make them fear an attack from the United States. Both Kosygin and Krushchev contradicted this view—contradicted it not with the intent of supporting our civil defence, but contradicted it nevertheless. I could quote them, but will not do so because this argument surely does not apply to Canada and it is, in fact, probable that the opposition party to civil defence in this country is less vocal than in the U.S.

The second remark concerns the attitude of the Soviet Union toward civil defence. Do they try to protect their people? Do they inform them of the dangers of a nuclear war? The answer is definitely "yes" to both questions. The physical protection which is being provided will be discussed later. Its character is, as you'll hear, an alarming one. As to keeping silent about the threat, about the possible dangers that may threaten their people in the case of a confrontation with the imperialists or the Maoist camp of brigands and propagandists, this is opposite to their policies. As Marshall Chuikov said, in 1965, "Civil defence units have been set up at all enterprises, in cities and rural areas." There is compulsory civil defence instruction in all high schools, in grades five, six, seven and particularly eight, and also for factory workers. An excellent textbook in civil defence has been published, which we just had translated in the hope that it will be distributed in our country also. No, the USSR does not consider its civil defence to be "provocative".

My third remark relates to the question whether a conflict is made more likely by our protecting our people from the effects of it, or less likely. Clearly, this is a crucial, a decisive, question and, in fact, I believe that the principal calamity which the absence of adequate civil defence preparations implies is the increased danger of war. Why is that so?

Civil Defence and the Likelihood of War

If we continue in the present situation of inadequate protection of our population while that of the USSR becomes increasingly well protected, we give the impression to the leaders of the USSR that we do not care for our freedoms and independence. This would provide a terrible temptation for them to exploit. It is not necessary to accuse them of ill will on this account, and I do not do so. They are convinced that their way is best, with an almighty central organization at top, with dissent suppressed below by means of prison or lunatic asylum. And, if we look about at the senseless dissent that we can observe around ourselves at so many places, they may be not as far wrong as we used to think a few years ago. To this comes the natural tendency of dictators to extend their power. All men want to do something; just to rest and let things happen is not truly *living* for a human being. When one sees animals peacefully resting if there is no outside stimulus, one begins to believe that this is the principal difference between animals and men: that men always want to accomplish something. And the most obvious objective for a dictator—the one most natural to him—is to extend his power over wider areas. Nor does he conceal this: Hitler did not, the leaders of the Soviet Union do not. "Capitalism must be destroyed" is what Suslov said. "The existing situation demands united action of the communist and all other anti-imperialist forces so that maximum use may be made of mounting possibilities for a broader offensive" is what the final document of the 1969 convention of 74 communist parties proclaimed. I could go on quoting similar statements.

Perhaps I should add that the wish to extend his power is very naturally greater in a dictator than in most of us—otherwise he would not have striven to become a dictator. It is illuminating in this connection that aggression by China and by the USSR were discussed yesterday, but not that by Canada or the U.S. No one is afraid that either of us will become aggressive, least of all the leaders of Soviet Russia or China.

This is a grim picture in some ways, but not a hopeless one. It seems to me that our obligation is clear: not to dangle the temptation of a possible conquest before the eyes of dictators. Politics is the art of the possible; and if the leaders of totalitarian countries had not realized this, they would not have succeeded in becoming the leaders. Conquest may be a natural objective for them; if it does not appear to be possible, they'll find others, such as the betterment of the material life of their subjects.

I have often been asked how I believe the attempt at a conquest may be made, whether I believe that there

will be a sudden attack, unprovoked and, as they say, out of the blue. No, I do not believe that. Hitler's tactic is a much more tempting one: to demand a relatively small, and perhaps almost justifiable concession under a dire threat and to repeat this tactic until the enemy is demoralized. We, the United States, could be asked to withdraw our protection of "warmongering Germany", otherwise many millions of Americans will die tomorrow. Activities of the New Left could further increase the effectiveness of such threats. You could be asked, as a first demand, to permit the installation of an Army base somewhere in the North, in a territory which is hardly populated anyway. A tactic similar to this seems to me the principal danger which the present lack of protection of the people causes, the diminishing of this danger the principal reward of an adequate civil defence structure.

Civil Defence — It's Cost and Effectiveness

The picture of what could happen to our countries and ourselves in the absence of a more adequate civil defence structure is grim enough so that it would be easy to conclude that the other path must be chosen—a strong civil defence structure. A similar tack is chosen by the detractors of civil defence: they show the costs of civil defence, the remaining dangers, the incompleteness of protection, and conclude that no, the other path must be chosen, we must not defend our people.

Before comparing the situation of our countries with and without civil defence, it may be well to describe what we may consider a truly adequate civil defence, what its price would be and how much protection it would give against nuclear attack. Much of what I will say was derived from studies based on the situation in the United States. The situation in Canada may be better, partly because of the lower density of the population and also because a surprise attack on Canada would make even less sense than one on the U.S.—the purpose of conquerors is to rule over people, not to kill them.

There are two recognized methods of civil defence: sheltering is one, evacuation of cities and dispersal of their populations the other. Until recently, most of us interested in civil defence were opposed to evacuation because it takes time and, if undertaken during a crisis, it would aggravate the crisis and may even precipitate an attack. Also, we did consider preparations for evacuation and dispersal provocative: since evacuation is not useful in a crisis, it can well serve only as a prelude to a confrontation. It would be natural to put forward a demand, as described before, after evacuating the cities and thus reducing one's vulnerability. As I said elsewhere, this could reduce the opponent's retaliatory power to a myth.

Lately, my attitude, at least toward evacuation, has changed. The reason is that the Soviet Union's civil defence effort, as far as the physical protection of their people is concerned, is centered on an evacuation program. Preparations for evacuation cannot be undertaken in secrecy and, in fact, they describe their plans and arrangements in full detail. Furthermore, if carried out, their evacuation and dispersal would very, very effectively protect their people: even if all the U.S. missiles were retargeted on the dispersed population and all its missiles were used this way, the casualties which these could cause would number around six million. Our retaliatory power would be severely impaired.

This is the reason for my changed attitude. It seems to me that the best counter to an opponent's evacuation plans are plans for what I call counter evacuation—dispersal of our own people. For a variety of reasons, political and emotional, this is much more difficult for a democracy to achieve than for a dictatorship but it would be, nevertheless, the best response. Also, preparations for evacuation are quite inexpensive.

Most of the thinking on civil defence in which I have participated in the past was concerned, however, with shelters—blast shelters for people in cities. These are quite costly—about $300 per person. In the United States, more than one-third of all the people should have blast shelters and it is possible to plan them in such a way as to render them quite effective, even in case of sudden attack. Nevertheless, they are not as effective as the evacuation plans of the USSR could be; the total fatalities in case of a full scale Russian attack directed solely against the population might remain about 10% in spite of these shelters. However, as I said before, their principal function and usefulness would be to discourage the attack.

The high cost of the blast shelters has been much criticized and, of course, the 23 billion which they would cost is a great deal of money. If the building of these shelters is spread over a four-year period—which seems to be quite reasonable—it would mean that everyone has to work about 14 minutes longer each week in order to increase the national product by the cost of these shelters. Some people say, of course, that we have other tasks, more important than the building of shelters, that we should abolish poverty first, etc. They remind me of the cook who saw his master in the water, struggling with the waves, but did not go to his rescue because, he said, he had to cook dinner for him. Let me add, though, that cooks are, as a rule, more reasonable than to behave this way.

Naturally, blast shelters for the cities is not the only task of civil defence. Even more important, and very much less expensive, is rural civil defence, the instruction of people in how to protect themselves from fallout radiation, etc. The Russian civil defence book deals with these questions extensively; that is why we had it translated and hope it will be widely distributed. No one can accuse us of warmongering by advocating civil defence this way.

Needless to say, this was a very quick and incomplete review of the technical aspects and effectiveness of civil defence measures. It was intended to give an orientation, and perhaps to arouse the curiosity for details in some of you. May I add only that, like all other defence, in order

to be fully effective civil defence must be a continuing effort. Let me come, last, to what we can expect from civil defence measures as to how they might influence our future.

Embracing Civil Defence

Let me begin with the darker side of the picture. One factor here is that the preparations take a very long time —I mentioned four years, and that may have been optimistic. The preparations would undoubtedly be resented by the leaders of the USSR as a hindrance to their most natural goals and as a renewed sign of the desire of "capitalists to retain power and to save monopolistic imperialism and fascism". Even if we eventually persuade the leaders of totalitarian countries to change their goals from world conquest to the economic betterment of their subjects, this will undoubtedly take time, and that time will not be pleasant. Perhaps I need not discuss this in full detail, since there is a large literature drawing attention to the subject.

What can we hope for when that conversion has taken place? I do think a great deal. It is natural for two nations to distrust and dislike each other if, by a sudden attack, each can do irreparable harm to the other. Men, under similar circumstances, would not feel otherwise. This is, however, our present situation. If, however, the defences of both are built up to such a degree that they do not have to fear each other, that they cannot by a sudden attack destroy the other party, and if neither then wishes any more to destroy the other, in due course of time a degree of understanding of the other way of life and even sympathy therefor may develop. This, I believe, is the great promise of civil defence—a promise which one may well hope to be realizable; its great dangers come in the years during which this is brought about.

Military Research and Development

E. P. Wigner and R. K. Adair

Letter to Science *175*, 356–357 (1972)

Advertising material received in November and December from the Federation of American Scientists (FAS), who are currently trying to increase their membership and raise funds, quotes the 6 May report of the prominent FAS Ad Hoc Committee on Military Research and Development (*1*). This report was also the subject of a news story in *Science*. The passage quoted in the advertisement reads, "This entire episode [the presentations of John S. Foster, the Defense Department's director of research and engineering, to various congressional committees] has been a classical numbers game featuring selective disclosure, questionable assumptions, exaggeratedly precise estimates, misleading language, and alarmist, non sequitur conclusions."

Such an intemperate statement on the part of some of our nation's most respected thinkers about a person whose unselfish devotion to his duty is almost proverbial surely needs some explanation. We know some of the members of the FAS committee, and also John S. Foster, and have long tried to understand the reasons for the disparity between their views. We have finally concluded that the reasons for the disagreement are not susceptible to logical analysis, but are based on different appraisals of what is best for the stability of our world. Foster wishes to assure the defense of this country even against threats which are not absolutely sure to materialize but which *may* materialize. The FAS committee wants no defense measure adopted unless the threat which such a measure is to counter can be shown with certainty to be in the offing.

Foster wishes to expand our defense research in order to "minimize the possiblity of a technical surprise" (*2*). He is particularly afraid of such a surprise because of "the remarkable secrecy maintained by the Soviet Union over their R & D efforts" which "often leads to uncertainty about some areas of the longer term threat." In other words, he wants to be *sure* of our capability to defend ourselves—a difficult task but part of the responsibility of the officials of the Department of Defense. Foster cautions that his data are not precise, but he wishes to act in spite of the lack of absolute certainty. The FAS committee, on the other hand, demands that the motivation for defense expenditures be free from assumptions (assumptions, by their very nature, are questionable) and be based on precise numbers.

The four-man FAS committee does not oppose defense research under all conditions. The first page of their statement of 6 May (*1*) contains the passage "The Federation of American Scientists supports a vigorous program of research, and of development (R &

D), on those weapons that are necessary to maintain a deterrent of unquestioned power." In view of this, we are unable to interpret the rest of the FAS statement, and its general tone, unless we assume that the committee insists on an *absolute* proof that the research to be undertaken be truly "necessary." Other parts of the FAS statement support this assumption. Naturally, in view of the tightness of the Soviet and Chinese security, immensely more effective than our own, such proof is very difficult to furnish—a point not brought out in the FAS statement. Nor does it bring out two other facts which support our need to stay, at least in research, well ahead of the Soviet Union. These are, first, the Soviet Union's shorter lead time, due in part to their more extensive building of prototypes—a practice resolutely opposed by the FAS committee. Second, the report does not mention that the Soviet government has the power to assign its scientists at will to military research. It is small wonder then that some Soviet scientists are terrified by the thought of a future in which some leader will say "The strategic balance has changed. We must exploit it."

We believe that the controversy between Foster and the FAS committee is the result of a difference in desires. If there is a chance that we are safe, the FAS committee does not want to strengthen our defense research. If there is a chance that we are in danger, Foster wants to strengthen our defenses.

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Will Soviet Civil Defense Undermine SALT?

Two noted experts on Soviet civil defense preparations warn of the danger the U.S. could face in the event of the threat of a Soviet first strike

E. P. Wigner and J. Gailar

Human Events *32*, No. 28, 9–10 (July 8, 1972)
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Proponents of the recent SALT accords say the agreements have considerably lessened the temptation for the Soviet Union to launch a first strike against the United States.

Because the Soviets (like the United States) have agreed to limit their anti-missile sites to two, thus leaving population centers unprotected from offensive missiles, it is argued that neither side dare launch a nuclear war, knowing that almost its entire population would be left vulnerable to a retaliatory attack. But the negotiators of the SALT accords, suggest Dr. Wigner and Mrs. Joanne Gailar, may not have reckoned with the Soviet Union's vast civil defense network.

Dr. Wigner has previously estimated that if the Soviets evacuated their cities, a nuclear exchange might result in the deaths of 100 million Americans, but only 10 million Russians.

Throughout the entire Soviet Union, since 1971, all second-grade children are learning to use gas masks and respirators. They are also learning how to conduct themselves in a shelter. This introduction of civil defense training into the second-grade curriculum, in accord with a joint directive of the USSR Minister of Education and the USSR Civil Defense Chief, is just one indication of the seriousness with which the Russians take civil defense.

There are many other indications as well:

- Children in grades five, six, seven and nine, as well as grade two, receive compulsory civil defense instruction.
- There is a mandatory 21-hour training program for adults.
- In the Soviet Union, articles on civil defense are carried in all the central newspapers, in the official magazines, as well as in semi-popular journals, such as *Science and Life*.

Dr. E. P. Wigner is an expert on Soviet civil defense preparations and currently teaches at Princeton University. He was the recipient of the Nobel Prize for Physics in 1963 and was awarded the U.S. Medal for Merit in 1946, the Enrico Fermi Prize in 1958 and the Atoms for Peace Award in 1960. Mrs. Joanne Gailar, Research Associate at the Oak Ridge National Laboratory of the Atomic Energy Commission in Oak Ridge, Tenn., is an editor of *Civil Defense, Moscow*, 1969 – a major work on the Soviet civil defense system.

- According to a Soviet source, "More than a thousand persons have participated and are participating in providing television broadcasts on civil defense".
- Most important of all is the content of the Soviet civil defense program with emphasis on the protection of the population through evacuation to the rural areas and the dispersal of essential workers to outlying districts from which they may commute to work in 12-hour shifts.

To understand and appreciate the Soviet civil defense program, it is essential to realize that the keystone of Soviet civil defense is the evacuation and dispersal of most of the urban population to rural areas in anticipation of a confrontation.

Preparations have been made to provide good fallout shelters for all who would be in rural areas after the completion of the evacuation and dispersal. Blast shelters are provided or will be provided for on-shift workers in vital industries in target cities. (And the Soviets do fully expect that cities would be targeted in the event of a third world war.)

The authors note that in the event a decision were made by the Soviets to launch a first strike, the populations of cities such as Moscow (above, the Kremlin) could be evacuated under the Soviet's vast civil defense network

Soviet rationale for moving people to the country is simple and, we believe, accurate. They quote Lenin: "The primary productive capacity of all humanity is the laboring man, the worker. If he survives, we can save everything and restore everything ... but we shall perish if we are not able to save him." Little wonder that measures of dispersal and evacuation are carefully delineated!

Every city, every Soviet of workers' deputees' councils (comparable to our city councils), every industrial enterprise, educational institution, and housing

office has its evacuation commission, each responsible to the chief of civil defense and each working in close cooperation with the civil defense staffs of the city districts. Their assignments include:

(1) Registering the population, enterprises and organizations that are subject to dispersal and evacuation;
(2) Determining the regions for dispersal and evacuation and their capacities for absorbing the population;
(3) Tabulating the means of transportation and their distribution over the various points from which dispersal and evacuation are to take place;
(4) Solving the problems of material, technical and other essential services for dispersal and evacuation;
(5) Developing, publishing and storing evacuation documents and supplying these documents to all evacuation organizations of the city; and
(6) Determining the time necessary for dispersal and evacuation.

Some of the arrangements for evacuation go into surprising detail. We read long descriptions about the evacuation of mothers who just gave birth to a child, the mode of evacuation, the protection of people against bacteriological and chemical weapons, the arrangements for old people and sick ones, and many other subjects.

Evidently, the principal concern of the USSR civil defense effort is the protection of the people from nuclear and also from chemical and bacteriological weapons. Nevertheless, attention is also paid to the protection of agricultural resources, to rescue and emergency repair operations, and – this may be surprising – also to the maintenance of industrial production. In order to facilitate this, workers of the same factory are to be dispersed into adjoining areas – areas outside the range of blast damage resulting from bombs exploding in the cities.

The dispersal areas should be, if possible, near railroad stations or highways. This arrangement is intended to facilitate their travel to work – to work on a 12-hour shift during the emergency. Taking into account a commuting time of four to five hours, this would leave "seven to eight hours for rest and personal activities."

What kind of arrangements await the evacuated people at the dispersal points? The most important, and most difficult, problem is that of providing shelters for the evacuees which would protect them from the radiation resulting from ground-burst nuclear bombs ("fallout"). Before the attack, they will be assigned, principally, to private homes, but all sorts of public buildings will also be used in case there are not enough private houses. When the attack is imminent, people will be ordered to move to cellars or "radiation-proof" shelters.

There are elaborate directions on how to dig and construct these shelters. We have tried out these directions by giving their translations to several resident families in the rural area near Oak Ridge and also elsewhere. On the whole, this was successful, and we now have about half-a-dozen "hasty shelters" in

this area. Their construction took about three to five working hours per shelter space if mechanical excavation equipment was used. In case of only manual work, it took around 10 hours.

The Soviets do not soft-pedal the effects of nuclear explosions. The civil defense courses fully inform the people at large of the dangers presented by nuclear, chemical and biological weapons. However, they wish to convince people not only of the need but also of the possibility of protecting themselves from the effects of these weapons.

As Marshal V.I. Chuykov writes in *Science and Life*, "Without slighting the serious consequences of a possible war, we should in all responsibility state that there is no poison for which there cannot be an antidote nor can there be a weapon against which there is no defense. Although the weapons we have examined are called mass weapons, with the knowledge and skillful use of modern defense measures they will not affect masses, but only those who neglect the study, mastery and use of these measures."

Evidently, the leadership also realizes that, just as there is no absolute offensive weapons, there is no absolute defense either – some of the shelters may be destroyed by direct hits or near misses. Hence, civil defense brigades are organized and are taught to go into disaster areas as soon as possible after attack to perform rescue and reclamation operations; to use cranes, bulldozers and other heavy equipment to dig people out of caved-in shelters; to build emergency passageways to buried shelters; to extinguish fires; to administer first aid; to evacuate the injured; and to engage in decontamination operations when possible.

The training exercises are often realistic with actual protective clothing, gas masks and heavy equipment being used.

There are also realistic exercises in evacuation and dispersal. There is a brief description, for example, of "operational demonstration and installation exercises" carried out at the Electrosignal Plant and at a radio parts plant, "wherein the tasks of evacuation and dispersion were carried out in a very practical manner."

Summing up, there seems to be little doubt that "the study, mastery and use of civil defense measures" is not neglected in the USSR.

* * *

We can see three alternative scenarios for a nuclear confrontation. The first is a sudden attack, or a sudden threat of an attack, entirely unforseeable by the receiving side, an attack out of the blue. Against this, and this should be clearly stated, the evacuation and dispersal program would be entirely ineffective.

The evacuation takes many hours, surely more than a day; whereas the flight time of ballistic missiles, from the USSR to the United States, or the opposite direction, is 20 minutes. Evidently, the USSR evacuation plans would

be completely ineffective either against a first strike by the U.S., or against a retaliatory strike in response to a sudden, unanticipated Soviet attack.

The second scenario envisages an escalating crisis, escalating probably against the wishes of both parties. If, in the course of the escalation, one of the parties evacuates its cities and disperses their population in the countryside, the bargaining position of the non-evacuating party would be seriously impaired. This may, or may not, induce this party to attack. If it does so, the evacuation becomes completely ineffective, possibly even counter-productive.

On the other hand, if the non-evacuating party has sufficient hopes for a peaceful resolution of the controversy and permits the evacuation to take place, this will be enormously effective in reducing this party's bargaining position. It appears, therefore, that in the second scenario the evacuation may be quite hazardous for the nation initiating it, but may also be very effective. At any rate, the ability to evacuate its cities would provide the USSR with a very powerful option.

The third alternative is what we consider most alarming. If the USSR can foresee a crisis, either because it intends to precipitate it itself, or for some other reason, it could put its civil defense plans into effect. If the crisis then materializes, either because the USSR advances some Munich-like demands, or for some other reasons, our bargaining position would be virtually destroyd.

In order to appreciate how poor our bargaining position would be if the population of the USSR's cities were dispersed, ours remaining in the cities, it is necessary only to compare the losses the two parties could inflict on each other, or threaten to inflict on each other.

We hesitate to mention our own losses, their magnitude is so frightening – all estimates imply losses exceeding one half of all our people. On the other hand, our own calculations, as published in *Survive* magazine (Vol. 3, No. 4), indicate a fatality rate of about 5 per cent that we could cause with all our missiles directed against the dispersed people of the USSR and disregarding possible defense of the Soviet people by their antiballistic missiles.

The estimate given in a recent Civil Defense handbook published in the USSR gives an even lower estimate. "Calculations show that in case of a rocket-nuclear attack, the losses to the population in a large unprotected city may constitute 90 per cent of the population, while in case of a timely and complete dispersal and evacuation of the population, the losses may be reduced down to several per cent of the total population."

We conclude that the evacuation and dispersal plans for the Soviet Union could be highly effective in this last scenario – a scenario which could quite conceivably be brought about by a future Soviet leadership.

In contrast to the Russian wholehearted effort, our own civil defense is in a very rudimentary stage. The total civil defense budget of the U.S. is around $60 million a year – a little lower than that of Switzerland, with a 32-times smaller population. When, at a civil defense conference in Switzerland, one

of us pointed to this discrepancy, our Swiss colleague, trying to be modest, remarked, "I do not believe we spend more, per capita, on civil defense than does the Soviet Union."

What is the reason for our almost unbelievable backwardness in this area? It is difficult to tell, but one possible reason is that a great many of our leaders, and even some of our elected representatives, do not want to bring home to the people at large the fact that our country could be threatened and that we can and should do something about it. This aversion toward letting the average person face the facts, to make him realize the need for serious efforts toward the defense of our country and particularly to actively participate in such defense is, strangely enough, strongest in some of our intellectual circles. They feel that the adage "Eternal vigilance is the price of freedom" is not for common consumption.

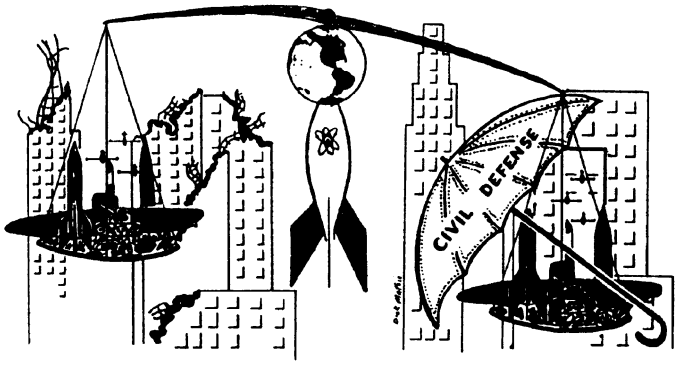
Is there a chance that this situation may change, that we may become less concerned about alarming the people with the information that defense is needed? The SALT agreement limits most military measures, but it does not limit civil defense. Hopefully we will now pay more attention to it.

Without Civil Defense We Are in ... *A Glass House**

A. A. Broyles, E. Teller and E. P. Wigner

Survive *6*, No. 5, 1–2 (Sept.-Oct. 1973)
(Reset by Springer-Verlag for this volume)

Three American scientists examine the rationale behind the widespread feeling of defense "hopelessness" vis-à-vis nuclear attack possibilities – and expose the unprecedented position of weakness to which it has today condemned the United States.



ANALYSIS OF DEVELOPMENTS AFFECTING THE NATIONAL SECURITY

It took the world only a few days to learn of the explosions of atomic bombs over two Japanese cities in World War II. The realization of the terrible effectiveness of these weapons spread more slowly. The development of a nuclear bomb was an achievement of the most advanced components of British and American science, and it was the scientist who understood the catastrophic nature of a nuclear war. These scientists felt a strong responsibility to warn the people of the world of this great danger to all mankind. As a consequence, they launched a campaign to convince everyone that the use of nuclear weapons meant death to all concerned.

Just as in all similar scientific developments, our knowledge of nuclear weapons at that time was extremely limited. No defense against them seemed possible, and this was emphasized in the educational campaign. At that time, certain organizations opposed to a military confrontation with the communist powers for various reasons, vocally exploited what seemed to be the truth and left in the minds of the general public an impression that still persists today. There was, for example, some opposition to the program to develop the hydrogen bomb. It failed when President Truman made the decision to push ahead with our research.

**Reprinted from* The Washington Report *with permission of the American Security Council.*

Pacifists Exploit Defenselessness

The belief that no defense was possible particularly served the purposes of pacifist organizations. They thought that the fear of the destructiveness of nuclear war would stop people from going to war. Unfortunately, their efforts were far more successful among the free nations than in the communist world. A few of these people have considered this defenselessness to be such an advantage that some of them have actually opposed civil defense itself, preferring to chance millions of deaths in an attack than to give up this argument for their cause.

Because of the belief of the hopelessness of a defense, the United States government chose a nuclear strategy that called for the building and maintaining of a nuclear attack force that would inflict unacceptable losses on any nation that chose to attack. There was no point in spending hard earned money on nuclear defense if that expenditure was hopeless, and there was no need to fear that an enemy could prevent his utter destruction under our retaliation if he chose to strike.

Balance of Terror Concept

At the time we developed the "A" bomb, it was recognized that other nations would eventually acquire nuclear weapons. This would prevent our use of these weapons in a first attack, but our retaliatory capability could still dissuade anyone from attacking us. Fear of a counter-strike led to

the concept of the "balance of terror" – each nation being capable of destroying the others.

Although the danger in the existence of nuclear weapons was realized, the balance of terror seemed to provide some measure of security and safety. But the inevitable advance of science in the U.S. Atomic Energy Laboratories and in similar establishments in other countries began to disturb this feeling of security. The human tolerance of radiation was learned, and the amount of shielding necessary to reduce radiation to a safe level was established. The force of the explosive blast wave was determined, and shelters were designed and tested that would allow human survival much closer to a nuclear explosion than had been previously considered possible. An anti-ballistic missile (ABM) was invented to destroy approaching enemy nuclear missiles.

Facts About Defense Spread Slowly

This new information about means of defense against nuclear weapons was made available to the public, but its dissemination was much less rapid than had been the knowledge of nuclear danger. Developments in defense had no dramatic introduction such as the termination of a great war by powerful explosions. In addition, it did not receive support and was in fact actively opposed by a few anti-military groups because it ran counter to their interests. Since there were no politically motivated organizations distributing information about nuclear defense its technical nature was not appreciated by the public and there was no widespread expression of concern from the public.

House Approved Fallout Shelters

Nevertheless, a bill was presented to the Congress in 1963 to provide approximately 100 million dollars for the development of fallout shelters for the general population. Extensive hearings were held by Congressman Hébert's Committee. The Committee concluded that ". . . 25 to 65 million lives would be saved by providing reasonable protection against fallout radiation." The bill was passed by an overwhelming vote in the House. It never reached the floor of the Senate.

In 1969 after a very heated debate, a bill providing for the deployment of an ABM system passed the Senate by a very close vote. Opposition was again strong in 1970. In addition, the civil defense budget was being reduced from 240 million dollars in 1962 to 70 million in 1969.

Defense Is Feasible

Why has opposition in the U.S. Government continued to be so strong despite increasing evidence that nuclear defense is feasible? There are two reasons. One is misinformation. One senator has stated that the United States could destroy the cities of the Soviet Union ten to twenty times over. This is in the face of the fact that careful calculations of U.S. losses in a typical heavy nuclear attack under present conditions would probably leave 35% or more of the population surviving. There would probably be more Soviet survivors because of a lower concentration in cities. These losses can be greatly reduced by a shelter program. For example, one calculation indicated that U.S. population survival in a heavy attack on U.S. cities could be increased from 35% to 90% if $15 billion total were spread out over five years on a shelter program. Estimates also indicate that any increase in an enemy attack force will be more costly than the cost of civil defense measures to counter it.

Some other members of Congress are well informed on the life saving possibilities of nuclear defensive measures. Why do they continue to oppose civil defense? The answer is that they have bought the theory of the balance of terror. They realize that nuclear defense threatens this balance. But if no nation builds shelters, the theory may still hold. The population of each country will remain as hostages to the other nuclear powers. They are determined to see that America does its part. This is done in the face of the fact that both the Soviet Union and Communist China have made extensive civil defense preparations.

We stand today with a large nuclear attack force but with almost no means of surviving a nuclear war. We live in a glass house. It is hard to imagine the circumstances under which we would launch all these expensive attack missiles when a counter blow could cost over half our population.

USSR Has Civil Defense

The Soviet government, on the other hand, had prepared its people to carry out a very effective civil defense plan. Both their estimates and ours indicate that this plan will reduce their population losses to less than half of those in World War II. They plan to evacuate their cities to the outlying areas. There the people will construct hasty shelters in a short time that can provide considerable fallout and blast protection. We have built shelters from their plans and have proved that they can be constructed in less than 48 hours.

There is one drawback to their plan. It takes a period of 2 to 3 days to execute it. But if they are going to attack first, they can take the time to evacuate before they launch their missiles. *Who is going to attack them during this period with the knowledge that the counter-strike would kill over 50% of his population?* Even if the Russians do not plan to attack, once they have sheltered their people a threat of attack should be sufficient to persuade an opponent to give in to their demands.

Offense But No Defense

We see then, that the United States nuclear strategy leaves us in the position of having a strong offense but essentially no defense. No strong nation has ever been in this position before. We have no historical precedent to tell us what will happen if someone calls our bluff. We are clearly unprepared to fight a nuclear war. What is the use of our powerful attack force without the corresponding defense? ■

Excerpts from E. Wigner's Address to the USCDC Conference, St. Paul

E. P. Wigner

Excerpts from Address to the USCDC Conference on October 11, 1973, in St. Paul, Minnesota. Survive 7, No. 1, 8 (1974)
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Introduction. Why I Consider Civil Defense So Important

First, let me thank for the great honor of having been invited to address this gathering. I very much appreciate this opportunity, the opportunity to share some thoughts with you, the leaders of our civil defense effort. I equally appreciate something else that I received but did not foresee: the many new ideas and observations which were given to us, myself included, by the speakers at our gathering. I hope I'll remember long most of what struck me as new and very, very relevant.

I have been involved in civil defense activities now for more than ten years and the present occasion is a good opportunity to review the reasons of my interest in this endeavour. There are two reasons of which I am strongly aware. The first is my fear for the future of this country and the future of what we mean by freedom. Most of you do not share this fear with me – the possibility of the loss of the independence of this country is as far from the thoughts of most people of this country as was the similar possibility for France in the eyes of most Frenchmen when they spoke of Hitler's objectives before the Second World War. Having seen the loss of independence of so many countries, and being gravely aware of so many similar events in the course of history, I do not share this absolute confidence. I do not share it even though I know that these fears do separate me from most of my American friends and make me unpopular. As to the damage which mankind would suffer by the loss of our independence, I hesitate to go into that in detail. It would be infinitely greater than was the damage caused by the loss of the independence of Hungary or the present dismemberment of Lithuania – two events which fall into the category about which Solzhenitsyn said: "The disappearance of nations would have impoverished us no less than if all men had become alike, with one personality, one face." In fact, I believe, though this belief does not make me popular, that if the whole Earth came under one government, man would be reduced to the status of ants. The government would have absolute power, and, as Ionescu said "Political leaders do not love men, they want to make instruments of them".

This is then the first reason for my interest in defense, and of course the reason for my belief in the prime importance of civil defense will be discussed in much detail later. The second reason for my devotion to civil defense is, in contrast to the first one, I believe, shared by most people. It is the abhorrence

of the doctrine of assured mutual destruction. A world in which nations can destroy each other and are deterred from such destruction only by the fear of their own destruction, is not a world of peace. How much better, how much more truly peaceful would be a world in which countries are safe from destruction by their neighbors. The impossibility of destroying the neighbor would also abolish the thought and desire to do so – as Mao Tse Tung said: "The fight against odds is not a mark of the revolutionary, it is a mark of the fool." As to the doctrine of assured destruction, and its acceptance by the other parties, let me remind you of Marshall Chuykov's characterisation of this as barbaric and I can not truly disagree with him. And there are only two ways to change this: by making the weapons fewer and weaker, that is disarmament, or by making them less effective, that is protective measures, principally defense of the civilians. The former does not seem to be possible now – we have to concentrate on the latter. This is the second reason for my interest in civil defense and is a firm conviction of my mind.

Why Is Our Civil Defense Such a Stepchild?

When Swiss civil defense workers showed me the shelters in Interlaken and I commented on the size of their budget, they remarked that it is only slightly higher than that of the United States. This means, though, that it is about 30 times higher per person. When I remarked on this discrepancy, they told me, very modestly, that they did not believe their civil defense budget per person is higher than that of Soviet Russia. That means that they estimated the Russian Civil Defense budget to be more than thirty times higher than that of ours. Perhaps I remark here that Western Germany's annual civil defense budget is about 153 million dollars for a population that is less than a third of ours.

Why is this so? Why is our defense budget one thousandth of the total military budget? My guess is that some of our intellectuals, realising that the civil defense effort naturally involves the whole populatiom, oppose it because their involvement would make the people at large aware of the need for defense and would lead to their involvement in the defense effort. They want to avoid this and they are vocal and influential enough to influence the leading circles. On the opposite side, in favor of an effective civil defense effort, there are few but ourselves. As I said, this is a guess but we should try to understand the reasons for the stepchild treatment of our civil defense in order to counteract it, and in order to find these reasons, we must make guesses. If my guess is correct, we must try to approach the common people, and I'll return to this point at the end of this discussion.

Naturally, I tried to discuss these points with some of the opponents of civil defense. Their answer to my points was, almost invariably; oh, that is all unnecessary, nuclear war is impossible. When one then asked them why the military expenditures of the Soviet Union amount to more than 25 percent of their gross national product, one obtains, at best, an evasive answer. Oh, that is irrelevant, or something similar.

As against these, I tried to draw attention to typical statements of high Russian officials. Let me quote two of these. Marshall Sokolovsky said, in his book *Military Strategy*:

"The war will naturally end in a victory of the progressive communist socio-economic system over the reactionary socio-economic system which is historically doomed to destruction. The guarantee for such an outcome of the war is the real balance between the political, economic and *military* forces of the two systems which has changed in favor of the socialist camp."

Or the passage contained in the final document of the 1969 Moscow convention of 74 communist parties:

"The existing situation demands united action of communist and other anti-imperialist forces so that maximum use can be made of the mounting possibilities for a broader offensive ..." and so on.

The answer to such quotations is, usually, "I don't know, I did not read them." The correct answer would be, of course, "Let me wait until tomorrow, so that I can forget them." I am afraid, we cannot get far by discussing these questions with our opponents, if one wants to close one's eyes, one usually succeeds. You all recall Kruschev's words, "We will bury you" or those of Brezhnev, "The United States is the chief imperialist power. Let us step up the offensive against imperialism."

Can Civil Defense Be Effective?

If we cannot convince our opponents and convert them to be our supporters, let us look at the other side of the coin and ask ourselves: can defense be effective? How can we make it effective?

In this connection I cannot help blaming even our highest authorities for making erroneous statements. The view that a nuclear war would mean the end of civilisation has been voiced not only by those who do not care for our defense, it has been voiced also by our highest authorities. If this were really true, there would be no alternative to the mutually assured destruction doctrine. In fact, if it were true and if our adversary could convince us that he is determined to destroy us, we would have to give in to his demands, no matter what they are. It would do us no good to destroy him, to wreak revenge, after he has destroyed us – we would be only killing a few million innocent people.

I would like to quote three rather general and non-technical reasons for believing in the effectiveness of defense. The first of these is that, historically, the effectiveness of defense has always been underestimated. I recall that, before the First World War – yes, I can recall that time – everyone was convinced that the war won't last more than three or four weeks. One of the armies was expected to destroy the other – with the modern rifles, machine guns and cannons there was no question that in a very short time enormous losses will have been inflicted. The effectiveness of the trenches which, for a very long

time, caused an effective stalemate, was not visualised at all. It was broken only by the entry of the United States Army into the conflict. Prior to the Second World War, as Professor Janis of Yale observed, "government circles in Britain believed that if their cities were subjected to heavy air raids, a high percentage of the bombed civilian population would break down mentally and become chronically neurotic. This belief, based on predictions of various specialists, proved to be a myth. Already – Professor Janis continues – there are some indications that a similar myth is beginning to develop with respect to future A-bomb attacks".

There is little point in further stressing this point. The effectiveness, in fact the possibility, of defense has always been underestimated, it is underestimated now.

In fact, and this is the second point I wish to make, the fatalities caused by the wars decreased with the technological advance of the offensive weapons. Surely, the Second World War caused many, in fact millions, of casualties but what was that, as compared, let us say with the so called thirty year's war which reduced the population of Germany to one third of its prewar level.

Third, let me quote what leaders of nations with more experience say on this question. Chuykov, the Russian marshall wrote in his Our Common Task:

> "Although the discussed means of destruction are called mass means, with knowledge and skillful use of modern protective measures they will not destroy masses of people but only those who neglect the study, mastery and use of these measures."

I hope he did not refer to the United States. But let me not continue this but mention, as a last point, the one which should have been mentioned, perhaps, first, that detailed calculations show that the USSR evacuation would reduce the casualties which our missiles could inflict, to *about* 7.5 million people, assuming that their ballistic missile defense is totally ineffective and that we aim all our missiles at their evacuated people. Both assumptions have the effect to exaggerate the possible number of casualties; the actual ones – which I hope will never be caused but which could be caused – would be considerably lower. Shelters which, in contrast to evacuation, are a true defense measure, are less effective. Under similar assumptions, the losses which the Russian missiles could cause in the U.S. would be reduced by shelters only by a factor of 3 or 4. It was suggested that I mention where the details of the calculations can be found: the former in an article in *Survive*[1], the latter in the *Harbor Report*, a report published by the National Academy of Sciences[2].

It may be useful to say a few words on the roles of the two defense measures, evacuation and sheltering, as I view them for our country. Evacuation appears to me the proper countermeasure to the city evacuation by a possible opponent. It should be carried out while he evacuates his own cities. In this way, it would largely eliminate the disparity between the number of casualties with which he

[1] Vol. 3, No. 4.
[2] Publication 1237.

could threaten us, and the number of casualties which our retaliatory strike could cause – a disparity by a factor around 10 if we do not evacuate our cities. Therefore, I call, our evacuation "counter-evacuation" it is to be aimed at eliminating the temptation to use "nuclear blackmail" in order to subdue us. Evacuation and dispersal are, on the other hand, not effective against a sudden, unforseen, attack or the threat of it. Shelters, solid blast shelters as envisaged in the *Harbor Reports*, are the valid defense against these.

Before coming to my last subject, what activities I advocate, let me quote a statement of Eugene Rabinowitch, made as editor of the Bulletin of Atomic Scientists – Eugene Rabinowitch, surely not a war-monger:

"The fourth (that is civil defense) was, and remains, the only fully effective means of reducing *the consequences, and thus the likelihood* of an atomic attack."

How Could We Contribute to the Strengthening of Our Civil Defense Effort

It is clear from the foregoing that the real problem of our civil defense effort is not technical. We know what installations and other measures would reduce our casualties in case of a nuclear war, reduce them drastically. The same measures and installations would also reduce the danger of a nuclear war decisively and reduce also the danger of what is called nuclear blackmail. We know what we *should* do. Our problem is not to determine what we should do but to persuade the citizens at large of the necessity to do it and our leaders to advocate the necessary measures with a clear and ringing voice. What could we do to bring this nearer to reality?

I am afraid that a large part of our intellectual community is resolved to remain as opposed to civil defense as were so many French intellectuals to the strengthening of their military powers before the Second World War. It follows then that we must turn to those who have not yet decided to close their eyes to the dangers which threaten us, the people at large. I know in fact, both from personal experience, and also from the results of opinion polls, that a large majority of all people are strongly in favor of civil defense. Most of them expect, however, that leadership in this will be assumed by our government and that it will be an organised effort, organised by our leaders and directed by men with technical knowledge.

What could we do to bring this about? The first measure which I'd like to advocate is the civil defense instruction in schools. The young people still have an open mind and if the methods, the effectiveness, and also the objectives of civil defense are clearly explained to them, they will advocate an effective civil defense effort. This has, apparently, happened so far only in two states, Maine and Alabama, but it has been quite successful there. There is some civil defense instruction in other states but I fear that the pursuit of the objective of a "low profile" makes them much less effective. As to Alabama, they have issued two excellent books on civil defense, for the use of the teachers of the subject and,

altogether, in Governor Wallace's words "Alabama is privileged to have been given the opportunity to develop a pilot program for our Nation as well as for our State." The efforts in Maine are quite similar to those in Alabama.

Are the civil defense courses in Maine and Alabama successful? I must admit that I have no direct knowledge of their effectiveness, and it would be difficult for me to acquire such knowledge. However, those engaged in the work assure me that they are very effective, that the children learn and understand the actual situation. I am indebted to my informers, Mrs. B. Rideout in Maine and Messers Sullivan and Berry in Alabama, to have shared some of their experiences with me. And I am not surprised: the child of one of our very antidefense neighbors learned about civil defense and eventually persuaded his parents to install a shelter! I understand that, similarly, the children have an effect on their parents' thinking wherever they become truly convinced of the effectiveness of civil defense.

Civil defense instruction in the schools is then the first activity the fostering of which I advocate. And not on a "low profile" but in a clear and technically accurate and reasonably advanced level. As to the "profile", the USSR instruction, in its schools, could serve as an example!

My second advice is to divest ourselves of our modesty, to take an active role in all community affairs. When the people see that you are interested in all their problems, that you have a reasonable view about all public affairs, they will realise that what you say about your principal interest, about civil defense, is also worth listening to. Even if those who disagree with you on some issues, will take your view more seriously on questions of defense than if they thought that your interest is confined to a very narrow area.

I cannot help, at this point, to forego accusing some of our highest authorities, who surely should know better, of painting a false picture. We all have heard statements such as "nuclear war would be the end of civilisation". First of all, this is surely untrue – and Lenin's words, often quoted now in the USSR, are worth listening to by us also – and second, if our possible opponents hear how scared we are, the temptation to exploit our scare grows. How much more reassuring is point 3 of the Young Republican Defense Platform.

> "We support a Civil Defense program that will protect to an absolute maximum the citizens of our country and governmental command, thereby releasing our population from the threat of being held hostage in the event of nuclear blackmail."

Let us hope that the other parties will adopt a similar attitude as a result of a greater clarity in the minds of all people! Let us do everything we can to bring this about!

Russian Evacuation Plans – the Fears They Create

E. P. Wigner and J. S. Gailar

Survive 7, No. 5, 4–5 (Sept.–Oct. 1974)

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Our article in the May-June issue of *Foresight*** discussed the evacuation plans of the USSR, the importance attributed to them, and the modes of evacuation. As to their effectiveness, we cited our calculations which show that, if the evacuation plans were carried out, the casualties that our missiles could inflict would be well below those suffered by the USSR in the second World War. In fact, even (1) if no Russian first strike which damaged our missile sites were to take place, or if such a strike were completely ineffective, (2) if the Russian missile defense were totally ineffective, and (3) if we were to aim all our missiles at the evacuees — three very unlikely assumptions — the losses caused by our missiles would not exceed 10 million. (The calculations were presented in the July-August 1970 issue of *Survive*. They have been confirmed since by other sources.) The effectiveness, if any, of our Air Force to cause "destruction" is much harder to estimate. Its magnitude is highly controversial.

The loss of 10 million lives remains a terrible punishment, and one may well ask why we are so deeply alarmed by the USSR preparations for evacuation. There are two causes for our alarm: the first concerns its possible effects, the second its motivation. We'll discuss the possible effects first.

POSSIBLE CONSEQUENCES OF RUSSIAN CITY EVACUATION

Let us consider a relatively minor controversy, such as one over the free access to West Berlin. If no agreement were forthcoming within a short time, the USSR might well order an evacuation of at least its largest and most vulnerable cities. Such an evacuation would be fully within the rights of the Russian authorities, and we could hardly even protest against it. Nevertheless, it would be a gravely threatening act and an indication of the seriousness

with which the Russian authorities view the subject. It could induce both our government and the Germans to give in. Or, if that did not happen, one of the Russian missiles might be launched "accidentally." Since the military establishment would be on alert, this would not be too surprising. The missile would probably not land in a city, since it went off "accidentally," and even an apology might be offered. Nevertheless, the going off of the missile would make it evident that a war is possible. Moreover, since the evacuation of the USSR cities would entail, in case of a war, an enormous disparity of losses to the two countries, it would be suicidal for us to retaliate. We would not know what to do — another missile might go off "accidentally" any minute — except to give in, abandon the free access to West Berlin.

Some people may say — after all, it would be a minor issue on which we would simply have to give in. Actually, the freedom and self-esteem of more than a million people would be at stake. Worse than that, having achieved success with one demand invariably encourages the victor to make further demands, whereas the precedent of having given in once discourages resistance to further demands.

The situation would of course be much worse if a crisis of graver proportions should arise. In this case the evacuation could be followed by an open threat of nuclear attack — much more open than was advanced against the British at the time of the Suez Canal crisis. The demoralization which would follow our yielding to such a threat would be devastating. Naturally, one does not like to think of such a possibility, but guarding against it is infinitely preferable to "not thinking about it."

The third and last situation is the most unpleasant of all to contemplate. If the leadership or the attitude of the USSR should change and become more aggressive, it would have, under the present circumstances, a terribly tempting option: to stage an evacuation and to provoke a confrontation when this is completed. There is every indication that the present Soviet leadership is not planning such a move, but we have witnessed enough unexpected and unhappy changes in the policies of autocratic powers to realize the possibility of such a change, however unlikely we hope it is. To guard against the consequences of such a change is only wise precaution. In fact, we believe that the present USSR leadership would approve of our removing an unfortuante temptation from its possible successors.

The three situations just described are increasingly unpleasant to contemplate. It would be unwise, however, to ignore them, and they do constitute the material causes of the alarm which we experience when thinking about the evacuation plans of the USSR.

THE MOTIVATION OF THE RUSSIAN EVACUATION PLANS

Why is the Soviet civil defense effort so largely centered on evacuation plans? The case against city evacuation was eloquently stated by Representative Aspin, actually when opposing our Defense Department's counterevacuation studies: "If we started to evacuate our cities, they would think we were getting ready to strike, and they might conclude they had better hit first." In other words, evacuation planning is not useful as a defensive measure — if it is undertaken in the course of a crisis it may induce the opponent to strike. And his missiles would arrive much before the evacuation has progressed to any significant level. Representative Aspin recognizes evacuation as a probable precursor of a confrontation, and his statement would be fully valid if his warning had been directed — years ago — against the USSR evacuation plans.

The consideration articulated by Representative Aspin played a decisive role also in the two studies on civil defense in which one of us participated: the two Harbor studies, both of which clearly abstained from advocating evacuation as a civil defense measure. Why does the USSR civil defense planning disregard this consideration? The only explanation we can see is that they do not expect the U.S. to respond to their city evacuation by a first strike. We hope that they are right in this expectation though we hope that we will have some response: counterevacuation. But this does not explain the purpose of their planning. Can we hope that they chose an evacuation program simply because it is much cheaper than equally effective blast shelters? Or is it that they anticipate some crisis and wish to resolve it in the way indicated above? Is it possible that they even want to preserve, at least for their successors, the option of an evacuation followed by a confrontation, the situation described above as third and "last"? We hope this is not the case, but its possibility gives us the deepest concern.

In a final article, we will present our recommendations for minimizing the dangers described in the present article. Among the recommendations we will make, counterevacuation (as a response to the evacuation of Russia's cities) will play a major role. ■

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Civil Defense in the Soviet Union

J. S. Gailar and E. P. Wigner

Foresight *1*, No. 3, 9–11 (May–June 1974)

The Soviet Union has a large-scale and substantial civil defense program–a program which is endorsed and supported by top Party and government officials and which embraces every man, woman, and child in the land.

INDICATORS OF IMPORTANCE

There are many indications of the importance of this soviet civil defense program:

■ – It was Party Chief L. I. Brezhnev himself who called for strengthening civil defense at the 23rd Party Congress, held in 1966.

■ – Brezhnev's mandate was translated into law which linked civil defense with the overall defense of the land and required civil defense instruction for students in all secondary, vocational, and technical schools and a compulsory minimum of 20 hours of civil defense training for the entire adult population. At present all second, fifth, and ninth grade children study civil defense in school, and all workers in factories and other installations receive specialized, on-the-job civil defense training.

■ – With the appointment of A. T. Altunin in 1972, the position of CD Chief of the USSR was upgraded to that of a Deputy Minister of Defense.

■ – Marshal A. Grechko, Defense Minister of the Soviet Union and member of the Politburo, continues to attach "particular significance" to the civil defense program.

■ – As recently as December 25, 1973, a top level conference of civil defense staff was held in Moscow, presided over by CD Chief Col. Gen. Alexander Altunin and attended by high ranking participants. It decided to give further emphasis to the civil defense program and to make it part of the thinking of the people at large.

THE 'WHY' OF SOVIET CD

There are many reasons why civil defense occupies so important a position in the Soviet Union. The experiences of World War II constitute one reason, and the loss of 20 million people and 30% of the national wealth continue to be cited today.

But it is not only a backward look that contributes to the importance of Soviet CD today: it is the view of a

Mrs. Gailar, a member of the staff of Oak Ridge National Laboratory, has been studying the Soviet civil defense program since 1968, using as source material unclassified Russian military publications, transcripts of daily Soviet broadcasts, and comprehensive handbooks on Soviet civil defense. She is the author of a number of published articles on the subject of Soviet civil defense.

Dr. Wigner, nuclear physicist, is the holder of many honors, including the Nobel Prize. But to this modest, courteous native of Hungary, one of his highest honors is that of American Citizenship which he acquired in 1937, seven years after coming to this country and to the staff of Princeton University. Dr. Wigner has long been a proponent of a stronger civil defense program.

This article represents the personal research and views of Mrs. Gailar and Dr. Wigner.

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future war as well. Soviets quote statistics to show that in successive wars the civilian population bears ever-heavier losses–5% in World War I, 48% in World War II, and they claim, 84% of the Korean War. (This last figure is, of course, incorrect.) In a future war the Soviets believe that the enemy would launch a nuclear attack not only on strategic facilities, administrative-political centers, and weapons factories, but also on industrial plants, large cities, and rear areas. Distinctions between front and rear would disappear.

A third reason why civil defense is important in the USSR is that the military leaders believe, in the words of Marshal V. I. Chuykov, that "while CD alone is not capable of assuring the protection of the population and material resources," in the event of nuclear war, civil defense is vital to the "achievement of victory."

The sunny climate of detente, which was felt so strongly in the United States in the first half of 1973, seems not to have affected Soviet Defense Minister A. Grechko. According to an article written by him during this so-called era of detente, in spite of "the peace program advanced by the 24th CPSU Congress . . . the antipopular class nature of imperialism remains unchanged. It has not and will not renounce its aggressive aims. As before, due to imperialism acute crises are arising in the world, able at any moment to shake the entire system of relations."

While defense-policy makers in the United States have counted on a nuclear stalemate to deter both sides from initiating a nuclear war and have insisted that there would be no victor in such a war, Soviet defense-policy makers claim that their side would not only survive a nuclear war, but would win it. Defense Minister Grechko maintains: "Were the imperialists to unleash another war, we are firmly convinced that victory . . . would come to us, to the socialist system."

According to Civil Defense Chief A. Altunin, "Protection against any weapon–even the most modern" is possible, but he emphasizes that such protection depends on a population that knows what to do.

OBJECTIVES OF SOVIET CD

Essentially, the objectives of the Soviet civil defense program are fourfold:

(1) to protect the population from weapons of mass destruction;

(2) to increase the stability of vital industries so that they could continue to function in wartime;

(3) to protect crops and livestock from nuclear, chemical and biological weapons; and

(4) to perform rescue and emergency operations in stricken areas.

Protecting people is the foremost goal of Soviet civil defense. The principal means for accomplishing this objective is the Soviet dispersal and evacuation plan. According to this plan, the personnel of essential industries, both operational and supervisory, would be *dispersed* with their families to small towns, villages, and collective farms outside the anticipated blast areas around the cities. The zones in which these towns, villages, and farms lie are selected on the basis of being sufficiently far away from target areas to be safe from the blast effects of nuclear weapons exploding over those areas, but near enough so that the workers and staff members could commute to work with a round-trip travel time no longer than 4 to 5 hours. Retired people, educators, and workers in non-essential industries, and sometimes light industries as well, would be *evacuated* from large cities to rural areas, where they would remain until the crisis subsided. Both evacuated and dispersed persons would be quartered with the rural residents and would be protected from fallout in high-protection-factor expedient shelters, which they would help their rural hosts to construct or improve.

According to Soviet estimates, ". . . in a nuclear rocket attack the losses to the population in a large unprotected city may constitute 90% . . . whereas in the case of a timely and complete dispersal and evacuation . . . the losses may be reduced to several percent of the total population." Our own calculations indicate that they would lose about 4% of their people–very much less than they lost in World War II.

The employees subject to dispersal would go on a two-shift system and continue production during the confrontation, blast shelters being provided for the on-duty shift at its place of work. Should attack occur, the off-duty shift would advance in formations to its stricken facility to perform rescue and repair operations or, if its own facility were undamaged, to a damaged neighboring one. Employees are trained for this purpose at their place of work and organized into such units as reconnaissance teams, fire-fighting brigades, rescue units, and repair crews.

PLANNING, TRAINING CARRIED OUT

Well aware of the complexities of a full-scale evacuation and dispersal, the Russians have planned the entire procedure in advance: billeting the urban population among their rural hosts, transporting them there, assembling them in small groups to be brought to large transport terminals, and processing them along the way. There are also plans for meeting the material needs of the evacuees and dispersed persons in the country–food, water, and other essential items; medical service; and even mail delivery and the assignment of jobs.

The administrative machinery for handling the task of evacuation and dispersal has already been set up within the existing organs of county, local, and regional government, and also at plants, educational institutions, and housing offices. Dispersal exercises for the command staff personnel at a number of plants have been carried out, and several enterprises, together with an entire fishing village, were "evacuated" by sea in a well planned, elaborate exercise at Sevastapol.

Not only is the machinery set up to evacuate the population, but people are also instructed in their conduct when the evacuation-dispersal order is given by their government: what to do before leaving their apartments,

where to go, and what to take along. They learn all this in their factories, schools, and housing complexes, as well as through radio, TV, movies, and newspapers. Sixty million copies of the popular Soviet civil defense manual, "Everybody Must Know This," were printed in 1972 alone.

The goal of protecting industry so that it could continue to function in wartime ranks second only to protecting the population. There is some overlap here since the worker is indeed part of the population. According to Lenin, he is "the most important element . . . the primary productive factor of all humanity . . . If he survives, we can save . . . and restore everything . . . but we shall perish if we are not able to save him."

There are other ways in which the Soviets hope to reduce the vulnerability of essential industries. One way is to disperse them, locating them in medium-sized and small towns. The other way is to strengthen the buildings which house them, with particular emphasis on protecting unique and costly equipment; assuring a continuous supply of electricity, gas, steam and water; preventing fires; stockpiling vital materials; and placing important individual components in underground structures.

Top billing in the overall civil defense scheme is also given to protecting livestock and crops, and performing rescue and emergency-reclamation operations in stricken cities. Both subjects receive full-scale treatment in the Soviet civil defense literature.

What appears to us most surprising is that very few American leaders know about all these preparations, and fewer yet have formed an estimate of their effectiveness.

Population Vulnerability: The Neglected Issue in Arms Limitation and the Strategic Balance

C. V. Chester and E. P. Wigner

Orbis *18*, No. 1, 763–769 (1974)

A FACTOR conspicuous by its absence in public discussions of the strategic balance is the highly developed Soviet civil defense plan for urban evacuation and expedient shelter construction. This plan would, if implemented during an international crisis preceding a full nuclear exchange, reduce the vulnerability of the Soviet population to about one-tenth of that of the U.S. population under present circumstances.[1] In this event Soviet losses would be less than were suffered in World War II.

Thus, it appears that under the most probable circumstances the vulnerability of civilian populations to nuclear weapons can be reduced by an order of magnitude through relatively inexpensive measures. It is surprising to us that this reduction has not been an issue in discussions of arms limitation. Properly used, a drastic reduction in population vulnerability might make it easier to reach an agreement with the Soviet Union on limiting strategic offensive arms. In addition, some arms control issues are simplified when viewed from the standpoint of population vulnerability: for example, MIRV, first-strike accuracy, land-based ICBM's, manned bombers, and submarine-launched cruise missiles.

Civil Defense

Unlike most of the strategic community in the United States, the Soviets regard civil defense as a strategic system on a par with their strategic rocket troops, air defense, ground forces, air force and navy.[2] This is formalized by the assignment of each of these activities to deputy defense ministers.[3] Their official attitude, based on experience in World War II and observation of Germany and Japan after the war, is that with a healthy, well-organ-

[1]E. P. Wigner, "The Myth of Assured Destruction," *Survive*, July 1970.
[2]Leon Goure, *Soviet Civil Defense—Urban Evacuation and Dispersal* (Washington: Research Division, Center for Advanced International Studies, University of Miami, May 1972).
[3]A. O. Ghebhardt and W. Schneider, Jr., "The Soviet High Command: Recent Changes and Policy Implications," *Military Review*, May 1973, p. 3.

ized, surviving population, damage inflicted on their industry by a nuclear war could be repaired in an acceptable period of time.[4]

In contrast, a high official of the U.S. government recently stated that the combined nuclear arsenals of the United States and the Soviet Union could destroy humanity. This is theoretically true in the sense that the superpowers' inventories of small arms ammunition—or for that matter, kitchen knives—could also destroy humanity. But at present levels of nuclear armament, the concept of a nuclear holocaust as "the end of civilization" or "the end of mankind" can only be realized with the cooperation, or at least acquiescence, of the victims. This cooperation was implicit in the U.S. policy of "mutual assured destruction."

The difficulty of destroying a population which has taken steps to protect itself can be demonstrated by the following theoretical calculation. The number of people in the coterminous United States divided by its total area is seventy per square mile. Using only the most accessible third of the area, it is theoretically possible to reduce the maximum population density by urban evacuation to less than 250 people per square mile. Field experiments have demonstrated that, with only written instructions and available tools and materials, untrained civilians can within two days construct expedient shelter enabling them to survive at least fifteen-psi shock overpressure and the most intense fallout radiation likely to be encountered.[5] Using the numbers and yields of Soviet warheads given in the 1972-1973 edition of *The Military Balance* issued by the International Institute for Strategic Studies in London, a common assumption about reliability (65 per cent), and the data in *Effects of Nuclear Weapons*,[6] one can calculate that the entire Soviet strategic force can cover an area of 40,000 square miles with fifteen-psi overpressure. If the entire Soviet strategic force were retargeted from military and urban industrial targets to the *evacuated* population in expedient shelters, U.S. fatalities *would be under 5 per cent.* A more likely situation is that Soviet weapons would remain aimed at military and industrial targets, and population losses would consist principally of people who were unable or unwilling either to evacuate or to construct suitable shelters.

[4]Akimov, editor, *Civil Defense* (Moscow, 1969); translated by Oak Ridge National Laboratory (Oak Ridge, Tenn.: ORNL, ORNL-tr-2306, April 1971).
[5]C. H. Kearny, "Hasty Shelter Construction Studies," Chapter 21 of *Annual Progress Report—Civil Defense Research Project, March 1970-March 1971* (Oak Ridge, Tenn.: Oak Ridge National Laboratory, ORNL-4679).
[6]Samuel Glasstone, editor, *Effects of Nuclear Weapons* (revised edition; Washington: U.S. Atomic Energy Commission, February 1964).

POPULATION VULNERABILITY

Most serious estimates of losses of U.S. industrial capacity from a large nuclear attack run under 50 per cent.[7] Once production bottlenecks were cleared away, the surviving capacity would translate into a 1951 gross national product in constant dollars,[8] with the prospect of reasonably rapid improvement. This assumes that the work force has been protected by a well designed civil defense program, which also provides a properly distributed, adequate food supply.

An example of the concern and misinformation about the long-term effects of worldwide fallout was the movie *On the Beach,* which predicted great loss of life from this effect. In reality, a nuclear war of five thousand megatons yield from fission could result in a radiation dose over ten years of about two rads to the bone marrow and one rad to the whole body of people outside the primary fallout. A pessimistic estimate of the consequences is that up to 200 fatal cancers per million population might be induced by this dose in the ten years following the attack.[9] While any increase is regrettable, this additional death rate corresponds to slightly more than one per cent of the present death rate from cigarette-induced lung cancer and clearly does not affect national survival.

The radiation hazard in the primary fallout is much greater; as high as 25,000 rads, forty or fifty times lethal, over a few square miles near a ground burst. However, the expedient shelters mentioned above can reduce exposure by a factor of several hundred, to the point where no clinical symptoms of radiation sickness would be experienced by their occupants even in the most intense fields.

The great reduction possible in projected losses of their productive population suggests that the Soviets' concept of civil defense as a strategic system is the correct one. In effect civil

[7]L. J. Bickley, J. F. Crane and E. S. Pearsall, *Estimates of the Potential of the U.S. Economy Following a Strategic Attack in 1975* (Arlington, Va.; Institute for Defense Analyses, S-305, November 1967). See also J. H. Karlson, E. K. Langer and F. J. Wells, "Postattack Research," in *Vol. VI, Reviews and Abstracts of Research on Critical Postattack Resources and Industries* (Bedford, Mass.: The Mitre Corporation, M68-22, August 1969).

[8]U.S. Department of Commerce, *Historical Statistics of the United States, Colonial Times to 1957* (Washington: GPO, 1960), p. F 1-21. Also, U.S. Department of Commerce, *Statistical Abstract of the United States, 1972* (Washington: GPO, 1972), p. 313.

[9]R. S. Russell, B. O. Bartlett and R. S. Bruce, "The Significance of Long-Lived Nuclides After a Nuclear War," *Survival of Food Crops and Livestock in the Event of Nuclear War,* Proceedings of a symposium held at Brookhaven National Laboratory, Upton, Long Island, N.Y., September 15-18, 1970, sponsored by the U.S. Atomic Energy Commission (Washington: GPO, December 1971), p. 561.

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defense acts to reduce the other side's offensive forces, by reducing the effectiveness of its warheads. This can be equivalent to a highly significant form of arms reduction.

It is the potential of civil defense to change the nature and outcome of nuclear war qualitatively that may give it great importance for arms control. If fatalities are in the neighborhood of 5 per cent rather than 50 per cent, "destroying the country as a viable society" or "destruction of the national entity" is no longer a feasible strategic objective. This should permit much greater freedom in reaching agreement on equivalence of different types of delivery systems, assessments of reliability of different systems, and other factors difficult to quantify. Furthermore, sensitivity to cheating is proportionally reduced. Subsequent reductions in offensive systems become much easier if one is not worried about maintaining some arbitrary threshold level of damage for deterrence.

We argue that reducing the vulnerability of the U.S. population to that of the Soviet population should not increase the likelihood of nuclear war. One would expect the prospect of the political and economic costs of an evacuation alone, *without* war, to be a sufficient deterrent for most national leaders. A risk of actual nuclear strikes against even the evacuated major cities of a nation would be acceptable only because of the gravest of issues.

It should be noted that urban evacuation is not the only possible civil defense system. It is the cheapest and most effective if there is time to carry it out. Nations without a sizeable deterrent force may be less than confident that an opponent will, in a severe crisis preceding the attack, evacuate his cities or give some other timely unambiguous warning. Such nations can opt for an urban blast shelter system, as the Chinese and Swiss have done.

MIRV

Multiple independently targeted re-entry vehicles multiply the number of point targets a given delivery capability can bring under fire. Subdividing a booster payload into MIRV's reduces the area that can be covered with a given overpressure by about 30 per cent due to the loss of efficiency and the additional weight required for the extra ablators, fuzing and firing sets, and guidance. The total yield of nuclear explosive in the payload is reduced more severely, by a factor which for many practical cases is roughly the number of MIRV's per booster divided by two. The fallout

for a given type of weapon is proportional to the yield of nuclear explosive.

Thus, once a strategic force of given payload contains a sufficient number of warheads to assure the destruction of practically all of the separate targets to be attacked, further subdivision into MIRV's can actually reduce the damage done to the target. This is especially true of area targets such as a nation's economy, which is made up of its workers and its industrial installations. In this sense, MIRV can be considered a form of arms reduction. It is desirable to the offensive planner because it provides the redundancy to assure that even a damaged force that has absorbed a first strike will still have enough warheads to attack all the targets.

Recently much has been written about the threat presented by the development of MIRV's by the Soviet strategic rocket forces. It should be pointed out that this threat is only to fixed land-based missiles—Minuteman and Titan. The Polaris/Poseidon SLBM force at sea is not threatened by Soviet ICBM's with or without MIRV's. Bombers, once they take off, become area targets which rapidly become intractably large. The U.S. economy consists of so many point targets that it must be considered an area target, and is likely to suffer less overall damage from a MIRVed force. Thus, even without the verification problem, there are reasons why no limitation on MIRV should be attempted.

However, MIRV and inexorable improvements in guidance accuracy eventually are going to reduce to three the options for viability of land-based missiles: mobility, launch-on-warning, and active defense. While mobility has difficult command and control problems, launch-on-warning would be very destabilizing in a crisis, and active defense has proven to be extremely expensive. If the problems of mobility cannot be solved, serious consideration will have to be given to dispensing with land-based missiles altogether and relying on a corresponding increase in the combined bomber- and submarine-delivered payloads.

Manned Bombers

Manned bombers carry the major share of the U.S. strategic payload, and presumably would be covered by an agreement limiting offensive nuclear weapons. Any confidence on the part of the Soviets that their air defenses could reduce the penetration ability of bombers to levels significantly below the reliability of ICBM's

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should have been shaken by the B-52 raids on Hanoi in December 1972. The addition of the short-range attack missile (SRAM) to the armament of some 200 of the later models of B-52 should further reduce the effectiveness of air defense. The B-1, the replacement for the B-52, is designed specifically to penetrate air defenses.

If the bomber force levels are fixed by treaty at approximately their present payload capacities, the U.S. B-52 force has the potential to counterbalance the Soviet SS-9/18[10] force. The intercontinental payload of the bomber force is somewhat greater. Weapons delivered by the U.S. bomber force can equal the explosive yield, and hence the fallout threat, of those of the SS-9/18's if, for the near term, approximately 200 of the older models of B-52 are each armed with a single weapon of the largest yield—a few tens of megatons—that can be carried internally along with a combat fuel load. A weapon adapted to low-altitude, laydown delivery would be required.

Matching both the payload and explosive yield of the Soviet missile force would restore some symmetry to the fallout problem each force presents to the other. The fallout threat of several thousand additional megatons might provide an incentive for subsequent arms reduction agreements.

Submarine-Launched Cruise Missiles (SLCM's)

Unclassified accounts in the public press of the development of the Harpoon cruise missile and the short-range attack missile suggest the feasibility of a small submarine-launched cruise missile with an intermediate-size nuclear warhead and a range of several hundred miles. It may well be possible to develop such a missile to be launched from the twenty-one-inch torpedo tubes of a nuclear attack submarine (SSN). This would give SSN's a significant capability for strategic bombardment of targets near a seacoast. There is no possibility of verifying by "national technical means" the number, if any, of such missiles carried internally by attack submarines. Hence, even if SSN's were not a counterweapon to Polaris, they must be considered in any strategic arms agreement.

However, each cruise missile carried in the torpedo room reduces by at least one the number of torpedoes (or other antiship missiles) carried, thus reducing the ability of the submarine

[10]SS-9/18 is used to indicate the Soviet SS-9 force in which some fraction of the SS-9's has been replaced by the larger SS-18.

to attack other submarines or surface ships, its primary mission. If we assume that an inventory of three SLCM's per SSN is the upper limit of a reasonable average over an operational fleet of about 100 boats, from the standpoint of population vulnerability each submarine has approximately the strategic potential of one Minuteman against coastal targets. Under these assumptions, uncertainties in SSN armament and mission will introduce errors that are small compared with the present capability of other strategic systems. Therefore, this system might be adequately regulated by an agreement limiting the number of SSN's deployed by each side.

Conclusion

The measures considered above, while retaining and temporarily even increasing the U.S. deterrent, really amount to a change of U.S. strategic policy from "assured destruction" to "assured survival," or perhaps "mutual survival." The monetary costs of the measures considered are small in the scale of costs of strategic systems. More important, assured survival *is* the strategic policy of the Soviet Union.

The most difficult step will be to educate U.S. public opinion to the realities of nuclear war and population survivability and to discredit current clichés about "the end of civilization." This change should improve the position of the United States in negotiations with the Soviet Union, which has no pessimistic illusions about its own ability to survive a nuclear conflict.

Perhaps more important than the possibilities for arms limitation are the possibilities of arms reduction that a coherent policy of assured survival or mutual survival offers. Once the myth of "destroying the enemy as a viable society" is relinquished, more realistic levels of deterrence can be sought. One can reasonably argue that a few hundred Poseidon-size payloads carrying a few thousand warheads aimed at military bases and industrial targets provide all the deterrence that can be comprehended by the human mind. The lower level of deterrence, provided it is observed by both sides, is cheaper and, with an adequate passive defense system, removes many millions of people from under the nuclear sword of Damocles.

Civil Defense in Limited War – A Debate

In Favor: A. A. Broyles and E. P. Wigner – Opposed: S. D. Drell

Physics Today *29*, 44–47, 50, 52, 53, 55–57 (April 1976)

Have recent developments in strategic weapons given us reason to look at civil defense in a new context?

Civil defense, once a hotly debated issue of the 1960's, has again surfaced as a topic of controversy. It reappears amid the discussions of possible new strategies being proposed by the Defense Department. In January 1974, the then Secretary of Defense James R. Schlesinger announced the intention of the US to develop long-range ballistic missiles of unprecedented accuracy. Because such weapons would have a relatively small error radius their yield would not have to be as large to be effective against military targets such as land-based offensive missiles. Hence the Defense Department has raised the possibility of a limited nuclear war with counterforce strikes (that is, against the opponent's offensive force) coupled with a program of civil defense to ensure a minimal level of civilian casualties.

We present here two different viewpoints regarding civil defense in this context. Arthur Broyles and Eugene Wigner will argue that civil defense can be effective as a defense against a nuclear attack. Sidney Drell will argue that the price of civil defense is too high in relation to the degree of protection it buys.

In favor:

Arthur A. Broyles
and Eugene P. Wigner

Should the American people be protected from the effects of nuclear war? Let us first narrow that intensely studied question[1] to one that lies within the realm of physics to answer—namely, can such protection be effective? Evaluations of various evacuation and shelter systems show that they can greatly reduce the number of casualties in a nuclear encounter. Our response thus agrees entirely with the statement by V. Chuykov in the *Civil Defense Handbook* of the USSR: "Although the discussed means of destruction are called mass means, with knowledge and skillful use of modern protective measures, they will not destroy masses of people, but only those who neglect the study, mastery and use of these measures."[2]

The question then broadens into one with psychological and political aspects and cannot be answered precisely or completely. Nevertheless we feel that

continued on next page

Opposed:

Sydney D. Drell

The strategic doctrine of "limited nuclear counterforce strikes" has been revived in the United States during the past few years. This return to a policy that was discarded more than a decade ago is accompanied by a renewed interest in extensive and organized civil-defense programs, which would require massive relocation and evacuation of populations during crises. Official government statements during the past two years allege that this combination offers the prospect of low levels of facilities and casualties resulting from the immediate blast, thermal, radiation and subsequent radioactive fallout effects. In particular the former Secretary of Defense, James R. Schlesinger, in the Annual Defense Department Report for FY 1976 stated that "Relocation of the populations from high risk areas near key military installations and the protection of the rest of the population against fallout could reduce nationwide fatali-

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our nation's civil-defense preparations may determine the balance of power in some future nuclear crisis. Civil defense is more important than ever at a time when other nations have extensive civil-defense plans and when the balance of terror that has reigned to date is being upset by the development of new tpyes of weapons.

The protective measures against nuclear explosions and their effectiveness can be evaluated on the basis of a wealth of data gathered by the Atomic Energy Commission in its nuclear testing program. Besides making quantitative measurements of such phenomena as blast-wave pressures, fallout intensity patterns and heat-ray intensities, the AEC constructed buildings and other structures in the vicinity of nuclear explosions and observed the resulting damage.[3] This information has been used by the AEC (now ERDA) laboratories, Stanford Research Institute, RAND Corporation, the Hudson Institute, the National Research Council and other institutions to devise and determine the effectiveness of methods for protecting people. Their results are in surprising close agreement.

Unfortunately the general public is not well informed about such studies, probably because a large fraction of the physics community as a whole is not aware of them. And yet so much physics is involved that physicists bear a responsibility to understand it themselves and to pass on the information through the classroom and other contacts. A clear presentation of the facts is essential because it is possible, as we shall see, that a nation's civil-defense preparedness may determine the balance of power in some future nuclear crisis.

The principal sources of danger and the most effective measures against them are listed in the table on this page. (Of course, a far more convincing display of the data requires something like the elaborate descriptions in the USSR

H-Bomb major immediate effects

EFFECT	CAUSE	DAMAGE	DEFENSE
ELECTROMAGNETIC PULSE	Expanding charged particles from bomb explosion	Damage to electronic equipment up to hundreds of miles; power stations at shorter ranges	Special protective equipment related to lightning security devices; no effects on humans
PROMPT NUCLEAR RADIATION	Nuclear reactions during bomb explosion	Normally less than blast	(Normally negligible compared to blast)
HEAT RADIATION	Radiation from the hot fireball generated by the explosion	Fires ignited a few tens of miles but greatly reduced by clouds or smog and dampness	Eliminating exposed inflammable material; shelters including large public buildings
BLAST WAVE	Expansion of hot bomb material pushes air into a wave of wind and high pressure	Destruction of buildings as well as serious injuries to people from flying objects and falling buildings from five to ten miles	Evacuation blast shelters; reinforced public buildings
FALLOUT	Radioactive products of nuclear fission mixed with vaporized earth	Heavily wind dependent; can be the order of one hundred miles	Sheltering by large public buildings or special shelters for a few days or weeks until the radiation level has died down

handbook.) Because of the short time available for action to protect against effects of nuclear weapons, survival depends very heavily on previous planning and preparation. The effectiveness of all the protective measures would be much increased if the population were familiar with them well before the attack. The stockpiling of relatively simple tools can also help in the long-term recovery effort. Because this subject is complicated and requires extensive considerations, we shall limit our discussion to the problems of survival of the initial effects of the attack that are listed in the table.

The most obvious way of protecting against all these effects is to prevent the bombs from exploding. For example, the US might attack the enemy launch site before the missile leaves it. Such an attack is the purpose of the "smart bombs" bemoaned by Bernard T. Feld in the July 1975 issue of PHYSICS TODAY. Or, the US might destroy the incoming missile with its own missile—the Anti-Ballistic Missile. Despite extensive debate over the ABM, it cannot be generally implemented now. As a result of the SALT I treaty, the ABM is restricted, as far as nonmilitary defense is concerned, to Moscow (with a population of 4.5 million) and Washington, D.C. (population of 1.5 million). Nevertheless, even a small ABM system could be very effective. By destroying the first wave of incoming missiles, it can give time to the people to enter shelters or to protect themselves in other, although less effective, ways.

Once a bomb does strike, the first effect is the electromagnetic pulse. This pulse threatens electric power transmission rather than human lives, although the disruption of radio transmission is of concern during an emergency.

The protection against the other effects of nuclear explosions can be provided in two ways—evacuation and shelter. Evacuation takes very much longer than the missile flight time and hence can not be considered to be a truly defensive measure. If evacuation is undertaken during a crisis, it will greatly aggravate the situation. It can be effected before provoking a showdown and serve as an aggressive move. Hence, since the advent of missiles, our country did not seriously propose it until the elaborate evacuation preparations of the USSR became known. Now it is being seriously planned as a "counterevacuation," that is, as a response to a possible evacuation of the cities of the USSR. The Ponast study, which was organized by the National Security Council,[4] considered a nuclear attack in which the USSR aimed two thirds of its destructive force at civilian targets. This attack would destroy 45% of the US population under present circumstances. The preparation for the "counterevacuation" would cost about $500 million—one day's welfare expenditure—and would reduce the population loss to 11%. Because the USSR population is less crowded into cities than ours, their losses would be smaller yet—less than 5% according to our calculations.[5] This loss is half of that experienced by the Soviets in World War II.

Shelter design

The defense measure advocated in the US, and installed by the Chinese, is the provision of shelters. The technical problem is to design a shelter with maximum blast resistance, minimum access time and minimum cost. The Chinese appear to have conquered the problem, as shown in figure 1. US scientists, during a 1970 study at the Oak Ridge Civil Defense Project,[6] estimated that effective shelters could be built at a cost of $23 billion. In similar conclusions four years later, the Ponast study found that a $35-billion investment—very much larger than that needed for preparation for counterevacuation and one tenth of one year's federal expenditures—would reduce the casualties caused by an attack by the USSR to 5.5%.[4] For this reason we can not pos-

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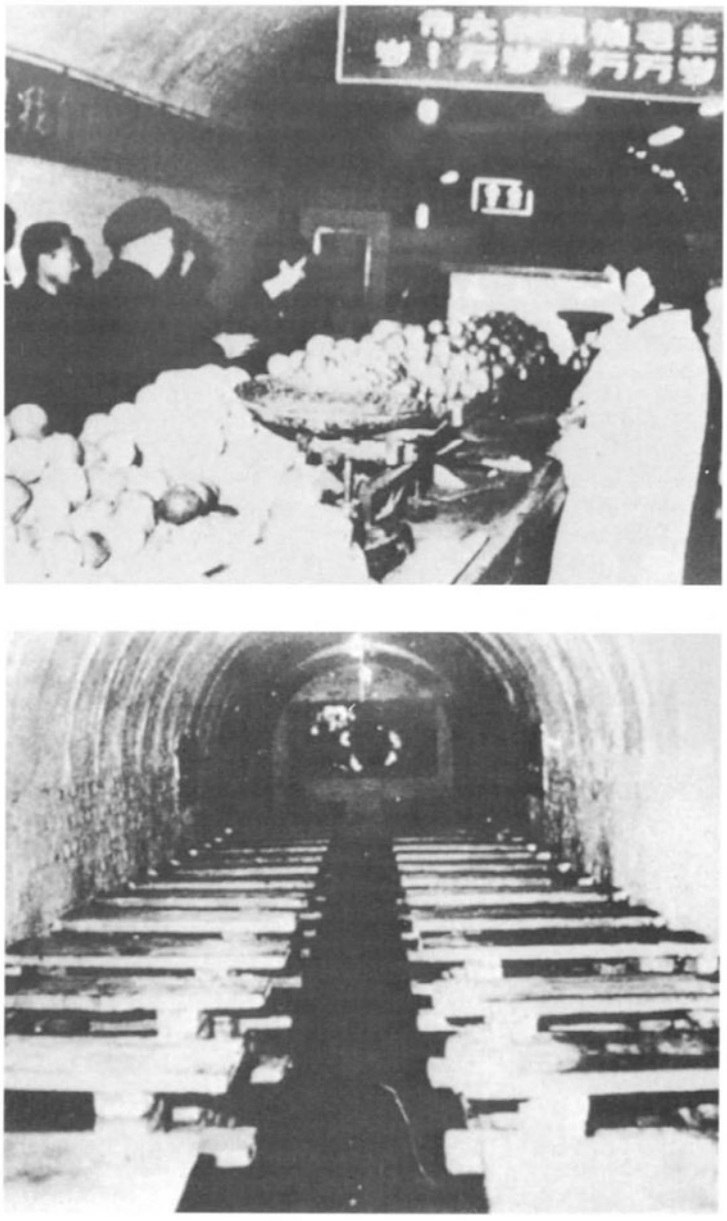


Peking tunnel shelters double as storage vaults for vegetables (left) or as conference halls (right). The authors argue that such shelters can be effective in reducing US casualties in the event of a nuclear attack to about 5.5% of the total population. Figure 1

sibly accept Feld's conclusion in PHYSICS TODAY that "there is no defense against nuclear weapons, now or in the forseeable future." Actually, as we have just described, the effectiveness of shelters should not be surprising: If shelters were ineffective, the expenditure on their construction by the government of China, the government of a nation much poorer than ours, would be entirely unjustifiable.

A third intermediate arrangement for defense, also indicated already in the Soviet handbooks on civil defense,[2] is to move most city dwellers away from densely populated areas but not as far

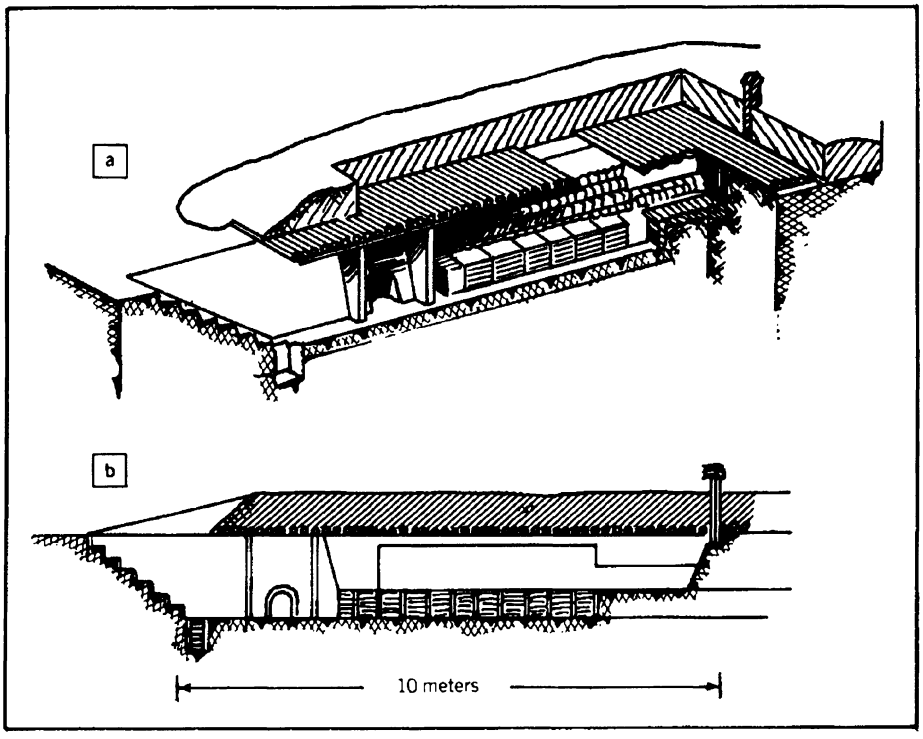
as the pure counterevacuation proposes. Instead, the Soviets would build "expedient shelters" using materials at hand. Rather ingenious designs, which can be built by untrained prospective occupants, give a blast resistance of 30 pounds per square inch. A sample plan is shown in figure 2. Such a system, not significantly more expensive than the simple evacuation plan (not much over $500 million, according to the Ponast study) could reduce the fatalities as well as does the elaborate and rather expensive shelter system referred to above. However neither one can provide protection against a sudden attack.

In the design of shelters, prompt nuclear radiation can generally be ignored in comparison with the blast wave unless the blast protection is very good or the weapon is very small. The reason is that prompt-radiation effects decrease much more rapidly with distance than do blast effects. To see this, note that the blast pressure in pounds per square inch from a W kiloton explosion at a distance r in kilometers is given approximately by

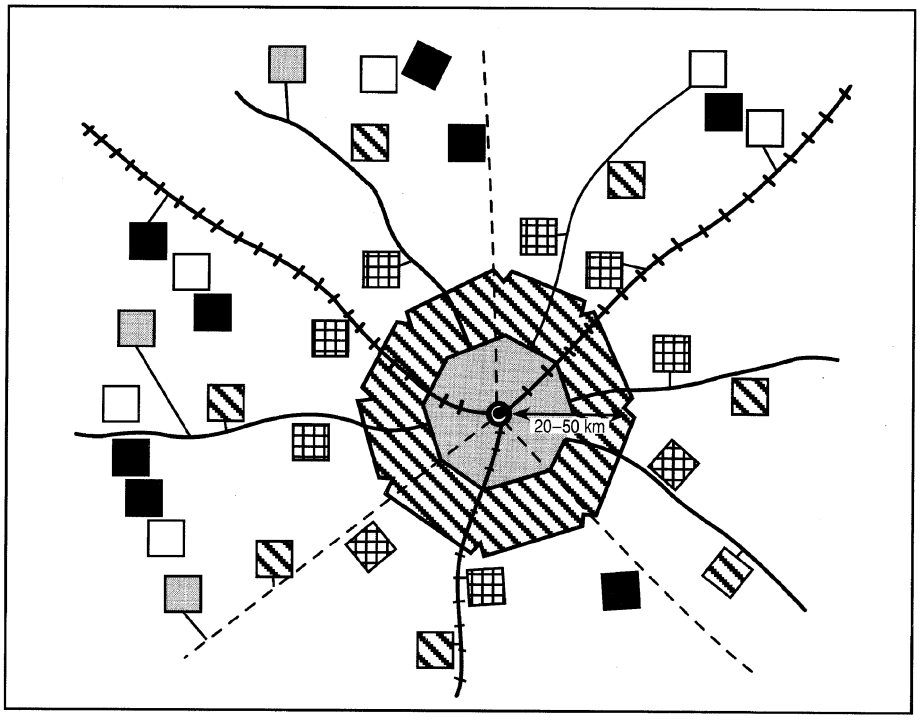
$$p = \frac{1.6\ W^{2/3}}{r^2}$$

The intensity of the prompt radiation decreases more rapidly than $1/r^2$ because of the absorption by air. Thus, according to the equation, blast shelters designed for 100 psi will be effective against a 1-megaton weapon for distances greater than about 1¼ km. The area within which the pressure exceeds a given amount is inversely proportional to this pressure. Thus the area where the pressure exceeds 5 psi—the pressure often considered as the survival pressure for unprotected people—is twenty times the area for 100 psi.

The effects of blast decrease more rapidly with bomb yield than do those from prompt nuclear radiation. For very small nuclear weapons, prompt ra-



Hasty shelter plan of the Soviets is a dugout in dense soil with a ceiling of pine poles. The plan shows the general view (a) and cross section (b). From reference 2. Figure 2



Soviet evacuation scheme illustrates their detailed planning. Safe zone is outside light colored region surrounding populated district of city (dark color). Map shows districts for relocation of workers of plants that do not stop their operation (dark colored squares) and for those that temporarily suspend operation (light color). Also shown are relocation sites for evacuees (light gray) and for plants and organizations (open squares). Black squares are existing communities. Colored lines denote operational control limits. Figure 3

diation can be more harmful than the blast. Thus for a 1-kiloton bomb, neutron and gamma radiation at 750 meters are 700 and 400 R if no protection is provided. The blast pressure at that distance is 5 psi—quite tolerable. Indeed the mid-lethal blast pressure for a well instructed person, who knows how to protect himself from flying objects, is well in excess of 30 psi.

Blast shelters are designed not only to diminish the air pressure to which a person is subject, but also to protect him from flying objects. A properly designed blast shelter will also place sufficient mass between a person and the outside fallout particles to shield him adequately from the radiation. One foot of earth cover reduces radiation perpendicular to it by a factor around ten, and more than that for slanting rays. Shelters also provide cover against heat radiation and external fires. Two feet of earth will provide adequate protection from actively burning fire.

Global consequences

Worldwide effects from the detonation of a nuclear explosion naturally demand as much concern as the immediate effects. Many wonder whether the global consequences such as fallout might not be so severe as to deter any nation from even precipitating an attack. The most recent investigation of this question, the Nier report by the National Academy of Sciences,[7] verified previous conclusions that world-wide fallout produced in a nuclear attack would not be sufficient to deter the attack. It found, however, that the de-

pletion of the ozone layer could be more serious. Increased radiation might force people to adopt special protection against sunburn, and it would lead to an increase in the skin-cancer rate by a factor of almost two. The depletion of ozone would also upset some ecological systems in important ways. Although this study calls for additional research to answer some remaining questions regarding world-wide effects, Philip Handler, President of the National Academy, makes the following statement in his letter accompanying the Nier report:

> "At the same time, the governments of the United States and of other major nuclear powers should be alert to the possibility that a geographically distant, populous other nation might determine that the degree of short-term damage to itself in this report, would be 'acceptable' and that, since long-term recovery would be highly likely, might conclude that its own self-interest is compatible with a major nuclear exchange between other powers."

In other words, we cannot count on global effects in themselves as deterrents.

Even though civil-defense measures can be effective as population protection, the US lags behind many nations of the world in building such systems. The Chinese have installed extensive blast shelter systems; the Russians have preferred an evacuation procedure that removes the city population to outlying areas where hasty shelters are to be constructed from materials at hand. A sample evacuation plan from the USSR handbook is shown in figure 3. Admittedly, this system would lose effectiveness if another nation initiated the war: It takes two or three days to evacuate cities and to build emergency shelters. However, if such time is available, the USSR system is cheaper and probably more effective than the Chinese blast shelters. The Chinese, however, can occupy their shelters in a very short time and thus be prepared for an attack with very little warning. Evidently the Chinese are afraid that someone will attack them with little notice, while the Russians believe that they are in a position to determine when the nuclear exchange will come and that they can carry out their evacuation and construction in time.

Political aspects

The United States, on the other hand, has essentially no civil-defense system. This lack is deliberate, and the reasoning behind it is clearly evident in the hearings before Congress on military matters.[8,9] Our leaders recognize that, if the nuclear powers have the capability of destroying the opposing nuclear attack forces, they will be tempted to strike first. If they wait, their own weapons may be destroyed first and they would be defenseless. Thus the US, until quite recently, carefully designed its nuclear strike force to be effective against the population of an opponent but ineffective against his weapons. We also did not protect our people. This inaction assured him that we would not attack first and therefore, that he need not strike a preventive blow.

The trouble with our strategy was that the Soviets, and more recently the Chinese, have not accepted this "balance of terror." The Soviets' large missiles are effective against our land-based missiles and their killer submarines can attack our Polaris submarines. In addition, our population is so exposed that it is doubtful we would accept the casualties required to participate in any stage of nuclear war through a second, third, or any strike with our missiles. Perhaps such considerations led Secretary of Defense James R. Schlesinger to propose the addition to our arsenal of missiles that would be effective against sheltered enemy ICBM's.[8] However we are disappointed that Washington has not given strong support for measures that will protect the US population from the effects of a nuclear war.

As a final remark we wish to add that it disturbs us greatly that passionate opponents of the protection of our own civilians against nuclear attack do not oppose, and do not even mention, the

elaborate preparations of the USSR in this direction. The Soviet handbook on civil defense is circulated in millions of copies. (It has been carefully studied at the Oak Ridge National Laboratory.) The USSR gives instruction on civil defense in the high schools, they carry out exercises in their factories and, most distressingly, they have made elaborate preparation to evacuate their cities preceding a confrontation. If the opponents of the civil defense feel that these preparation are not even worth mentioning, why do they consider the protection of our own civilians objectionable and even provocative?

Drell: continued from page 170

ties due to fallout from a limited Soviet counterforce attack to relatively low levels well under 1 million—provided that the people in the communities that would be most exposed by fallout from such an attack make effective use of the shelters available."

The conclusion drawn from these claims and analyses is that limited nuclear war may be palatable and need not escalate to the level of an all-out nuclear exchange, which would cause unimaginable horror. In fact, on 11 September 1974, Secretary Schlesinger testified[8] to a subcommittee of the US Senate Committee on Foreign Relations that "the likelihood of limited nuclear attacks cannot be challenged on the assumption that massive civilian fatalities and injuries would result."

Because the basis for this change in strategic doctrine is the relatively low fatality level, we must examine not only the total civil-defense implications of this doctrine but also the assumptions about the nature and effectiveness of the weapons used in the attack.

Civil defense in the larger context of an all-out nuclear strike against population centers will not concern us here, not only because it is not being proposed at present but also because most who have studied the financial and societal costs, not to mention the technical challenges, of such a program have concluded that it is not practical. But how practical and how effective is civil defense in a limited counterforce context?

The resurgence of the doctrine of limited nuclear counterforce has been spurred by progress in weapons technology—in particular, the development of accurate and reliable MIRV's (multiple independently targetable reentry vehicles), which enable a single missile to attack several different targets with high accuracy. These MIRV's can selectively attack hardened military targets such as underground silos containing the fixed land-based ICBM forces and at the same time can cause relatively low casualty levels. Indeed this combination of factors forms the basis for the military value and strategic credibility that are claimed for such an attack.

Of course the effect of weapons against both military targets and civilians depends critically on such factors as the numbers and yields of incoming warheads, their height of burst and the level and extent of civil-defense protection. One example described by Secretary Schlesinger in his Senate testimony envisioned an attack against all the fixed ICBM's—1000 Minutemen and 54 Titan missiles—with a single one-megaton warhead incident on each silo and with the warhead fuzed to detonate in air at the optimum height of burst. The attack would result, he claimed, in fewer than 800 000 dead and 800 000 injured or ill from radioactive fallout.

The fatality levels for such an attack are calculated by making certain assumptions about the civil-defense protection provided in terms of the protection factors of various shelters. These numbers are the reciprocals of the frac-

Sidney D. Drell is deputy director of the Stanford Linear Accelerator Center. This text is adapted from his testimony presented on 18 September 1975 to the Subcommittee on Arms Control, International Law and Organization of the US Senate Foreign Relations Committee.

tion of radiation that penetrates the shelter. Thus the existing civil-defense program requires that, for a shelter space to be identified as such and stocked, it must have a protection factor of 50–100. That is, it must shield against all but 1–2% of the radioactive fallout. This factor is equivalent to a dirt cover of approximately two feet or a concrete wall of about 16 inches. By comparison,[3] a single-story residence has a protection factor of three, and a residential basement, a factor of 25.

In the attack described by the Secretary, the Department of Defense assumed that for 30 days roughly 35% of the US population remained in designated shelters with protection factors of 50–100, that 20% sought residential-basement protection and that the remaining 45% were protected by the average residential protection factor of 3. These calculations were stopped after this thirty-day period and thus do not include the final 6% of the fallout nor the long-range effects.

However, the Secretary did not describe the military effects of this attack, which was designed to cause such low civilian casualty levels. Straightforward calculations show that the nuclear attack assumed in the above calculations would destroy well under one half of our fixed ICBM force if carried out by missiles with the targeting accuracies projected for the Soviet ICBM force. This conclusion follows even if we assume that the Soviet missile systems have a perfect 100% reliability, which is surely a gross overestimate, particularly when you recall that we are talking of a massive attack coordinated in time so that all 1054 US ICBM silos are hit essentially simultaneously. I can see no practical military value to such an attack. On the contrary it would surely invite lethal retaliation.

In response to these and other DOD calculations on collateral civilian damage related to counterforce attacks, the Senate Foreign Relations Committee in September 1974 asked Congress's Office of Technology Assessment to review the DOD analyses. A panel convened by OTA for this purpose raised questions about the sensitivity of the DOD analyses to various assumptions, including a range of possible weather conditions, civilian protection factors and parameters of the incoming attack.[8] The DOD responded with more calculations, which showed that the expected fatalities are indeed very sensitive to the nature of the attack and can vary by large factors. In particular, the DOD now finds that fatalities in the range of 10 to 20 million will result from prompt effects and fallout alone if the attack is delivered by the nuclear weaponry of today or of the near future and is designed to destroy the majority of the attacked ICBM force.[8] Figure 1, which is based on DOD calculations, illustrates the fatalities as a function of the percentage of ICBM silos destroyed. (Note that the DOD reduced the civil-defense protection factors assumed for the last two attacks by 25% relative to that described earlier; otherwise, with identical protection factors, one would expect the one-megaton ground burst to cause more fatalities than two 550-kiloton bursts—one in air and one on the ground.) Even at the highest level in figure 1 a healthy retaliatory force of some 210 ICBM's would remain as well as all the SAC bombers and missile submarines.

Naturally the predictions of figure 1 are subject to such uncertainties as the weather and winds at the time of attack, and are sensitive to the degree of civil-defense protection and to the ability to provide medical care to the ill or injured. Nevertheless, one can clearly not contemplate an effective strategic attack designed to decimate our ICBM force in terms of casualty levels of one million civilians, but rather must consider it in terms of upwards of tens of millions, even assuming extensive protection of the population.

The price of civil defense

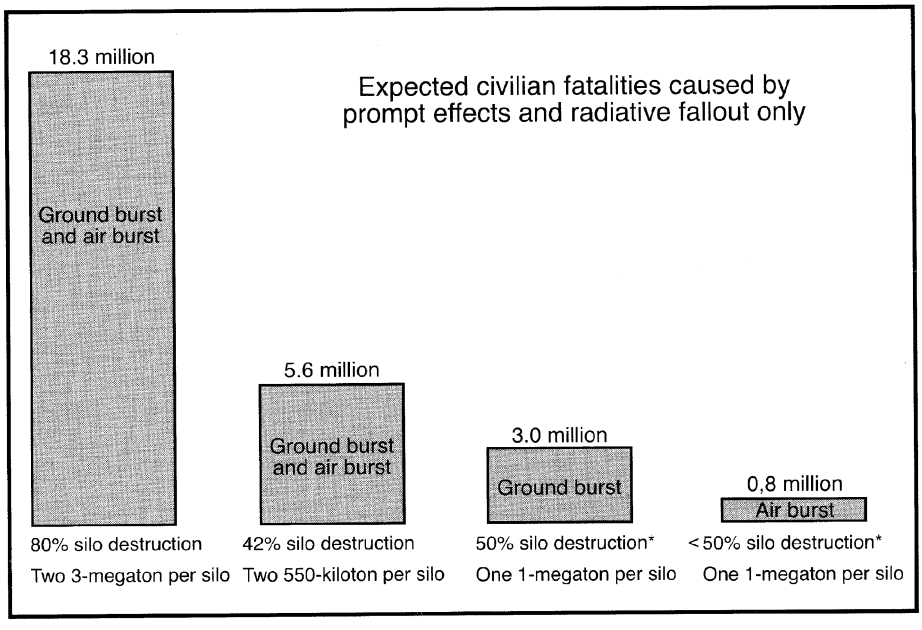
The most recent DOD reports also make clear that civil defense would be a central element of our policy of flexible response, with emphasis on limited nuclear counterforce. Indeed the justification for the civil-defense budget was expressed in the report for FY 1976

largely in terms of its role as a necessary adjunct of our policy emphasis on flexible response. The DOD report also argues that we must have the same population-evacuation options as the Soviet Union for two reasons:

- "to be able to respond in kind if the Soviet Union attempts to intimidate us in time of crisis by evacuating population from its cities," and
- "to reduce fatalities if an attack on our cities appears imminent."

This position marks a major shift in emphasis of the civil-defense program since the 1974 Annual DOD Report, when it was largely justified by Secretary of Defense Elliott Richardson to help recovery from peacetime disasters. I personally endorse this previous objective and furthermore I support the existing program of identifying and stocking shelters as a prudent insurance program against a wide range of incidents, including the accidental launch of nuclear weapons, a severe nuclear-reactor accident or natural disasters such as hurricanes. However, a comprehensive civil-defense program involving both sheltering and evacuating the population on a very large scale is a different thing. Undoubtedly it can be demonstrated to have a great lifesaving potential in the event of a nuclear attack against specific military targets. But the issue is in essence an issue of the price one has to pay for a civil-defense program in relation to the degree of protection one buys against specified attacks: What price in our priorities, values and style as a society? What price in dollar costs?

Investment in a civil-defense program could, as one function, protect the population from the blast, thermal and radiation effects in the immediate vicinity of a nuclear explosion—roughly within a radius of four miles for a blast of one megaton. Such protection against the close-in effects is either impossible or tremendously costly.



Casualty toll varies with the type of nuclear attack, among other parameters. All the calculations were done by the DOD in its analysis "Sensitivity of Collateral Damage Calculations to Limited Nuclear Scenarios," sent to the Senate Foreign Relations Committee on 11 July 1975, except for the two with asterisks, which are by the author. Figure 1

Another function of civil defense is to reduce casualties from fallout generated at distances well beyond several miles. This effect of dangerous fallout levels, extending many hundreds of miles downwind from nuclear explosions, plus the long-range effects of radioactive contamination to extensive areas, differentiates nuclear war from all other previous experience. The range and extent of the threat to life of radioactive fallout depends critically on many factors including the height of burst (that is, whether or not the fireball from an explosion near Earth's surface scoops up and spreads an enormous cloud of radioactive debris); the fraction of fission yield in the bomb design and the weather.

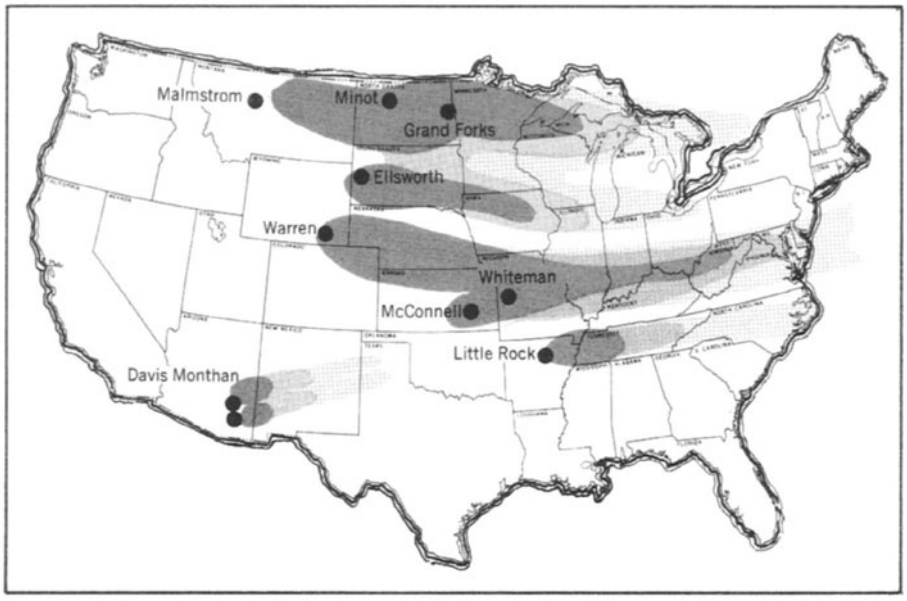
The biological effect of fallout is measured in terms of the standard dosage unit of the roentgen-equivalent mammal (the rem). Whole-body exposures to less than 100 rems cause blood changes but no disabling illness. Experience following the Hiroshima and Nagasaki blasts shows that doses of 100 to 200 rems cause a certain amount of illness including fatigue and perhaps some nausea, but are rarely fatal. However, levels of about 450 rems of whole-body exposure can cause severe illness and produce a 50% fatality rate. This scale is the basis for assessing how much protection must be provided for an effective civil defense. As is shown in figure 2, an unsheltered person as far away as several thousand miles downwind from an attacked missile field or military base would be exposed to an expected 600 rems.

The time scale of the radioactive fallout is also of great importance in considering protection. For how long a period of time after an explosion must one be sheltered from fallout in order to survive? For typical burst altitudes in the atmosphere a human body totally and completely shielded from fallout during the first hour immediately following a nuclear explosion will still receive 45%, or almost half, of the total fallout if exposed thereafter. Twenty percent of the total dose is deposited after the first day, and a person emerging after four weeks of complete protection from fallout will still be subject to 6% of the total dosage. The decrease in rate of fallout follows a $1/T^{1.2}$ law, and evidently the required time scale for protection is measured in weeks.

This discussion of fallout effects shows the required physical parameters of civil-defense shelters. Few dispute the technical facts concerning the means to protect large populations for one to four weeks after an attack from the physical effects of blast, fire, radiation and fallout. However, major social parameters and costs are also involved because identified shelter spaces and evacuation plans do not by themselves make an effective civil-defense program, in my judgment. A total system must be organized and interwoven extensively into civilian life through training programs, rehearsals, and volunteer activities. The pre-attack shelter organization envisioned by the 1962 Office of Civil Defense Guide planned that a shelter accommodating 100 civilians would require an operating cadre of 25, of which 10–12 would need prior training. This number constitutes 10% of the sheltered or 20% of the adult population.

To recruit the required large cadre of trained personnel the government would have to look beyond existing community safety personnel such as policemen and firemen. Perhaps the military reservists and National Guard units could play a central role in organization and training, but they would still have to rely on a large functioning organization involving a much larger number of trained civilians.

One task of trained personnel would be to operate communications systems over large distances in order to deal with shortages of food, water and medical supplies. They would also have to know how to use radiation dosimeters, because in the immediate post-attack period the fallout levels can vary greatly from one locale to another. Like the snow, radioactive debris accumulates where driven, depending on wind and weather conditions as well as on the location and shadows of tall buildings.



Fallout patterns for an attack on US ICBM silos (black dots). Two inner contours show radiation doses of 450 and 200 rems for a person with a protection factor of 3. In the lightest colored regions strontium-90 contamination exceeds 2 microcuries/meter^2. Data are for a winter day and will vary with wind patterns. (From R. L. Garwin, reference 8.) Figure 2

Local pockets of relative safety may exist amid areas with lethal levels of radioactivity. Finally the trained cadre would have to provide leadership in the long period of extreme social duress after the attack and would have to reestablish requisite services for a society with a large proportion of ill and injured citizens.

Beyond the training of these special leaders, the plans for massive population relocation and evacuation out of high-risk areas near the possible counterforce target system require a heightened level of public awareness and concern, and a willingness to rehearse the evacuation plans. Without them, surely a chaos spawned by panic will ensue at the time of implementation. How can one draw public attention, much less commitment, to such plans without "overselling" them by a sustained escalation of apprehensions from the mood of today *vis-a-vis* the dangers of nuclear exchange between the US and the Soviet Union? Is not such an escalation of apprehensions more to be feared than desired as the US and Soviet Union move further from the brink of a nuclear conflict due to misunderstanding, misapprehension or mistake and strive mutually at SALT for a more stable nuclear balance at lower levels of nuclear armaments? Indeed one of the lessons of the civil-defense shelter exercises in 1961 and 1962 was that the large expenditures for civil defense and the general dislocations accompanying a major shelter program could only be sold to the American public by presenting the very real threat of nuclear war.

Strategy

Consideration of civil defense as an element of strategy has been given renewed importance by the new emphasis on fighting a limited nuclear war. This policy changes our nuclear doctrine of the past decade, which has been dominated by the recognition that once a nuclear weapon is detonated on US or Soviet territory there would be substantial probability that nuclear exchanges

could not be terminated before both nations were destroyed and the casualties numbered hundreds of millions. The new strategic doctrine raises the issue of whether this unpleasant "balance of terror" and mutual hostage relationship might be changed by the adoption of new tactics and the development and purchase of new weapons for fighting limited nuclear wars at acceptably low casualty levels. I believe such a policy would cause the following deleterious effects:

▸ Harm to strategic stability. The development of a new missile force designed specifically as hard-silo killers would fuel concern on both sides about the vulnerability of the fixed ICBM's to a preemptive first strike. It would emphasize the importance of striking first and could thereby destabilize a crisis situation. Furthermore the development and rehearsal of civil-defense plans involving evacuation and relocation of large populations could be viewed with alarm by an opponent as preparation for executing a first strike.

▸ Harm to SALT talks. The development and testing of the required new missiles will create pressures against quantitative reductions in the numbers of strategic forces and against such verifiable qualitative restraints as missile test-flight quotas and limits on the rate of deployment of new systems that would slow down the pace of progress in the arms race.

▸ Waste of resources. The plans justified by this year's rhetoric may materialize into the multibillion-dollar weapons systems of the next decade unless the rationale behind them is rejected.

▸ Shift of values. Implementation of an extensive civil-defense system through massive training will affect the priorities of our society and will require heightened concern about nuclear war, which would counter the progress that has been made toward reduced international tensions.

Finally, what will prevent the eventual escalation of an initially limited nuclear war to an all-out nuclear holocaust? Once nuclear weapons are used in war at all it will be very difficult, if not impossible, to verify yields, sizes, numbers and types of the nuclear explosions on both sides. However, the one technically unambiguous fact is whether or not nuclear weapons have been used at all. Therefore it is wisest for the US to adopt as a national policy the highest possible nuclear threshold. We should maintain a gap between nuclear and non-nuclear warfare that is as clear and wide as possible, and resist the temptation to develop doctrines and civil-defense programs that understate, on dubious technical and strategic premises, the collateral damage and the casualty levels of nuclear conflict.

Broyles and Wigner reply to Drell

Our own discussion is principally concerned with the technical question of whether defense against nuclear weapons is possible. We feel that as physicists we should be able to judge the extent to which such defense is possible and we also feel that the physics community at large should have a degree of familiarity with this problem. Sidney Drell's article is less concerned with the physical problem than with the more important but less precisely ascertainable one concerning the political implications and consequences of a vigorous civil-defense effort—a subject to which only the last section of our own article refers. Nevertheless, we would like to comment, first, on a problem of physics concerning which our opinions differ.

We differ with Drell in our estimation of the radiation danger from fallout after a reasonably long sojourn in shelter, let us say two weeks. First of all we calculate that the total radiation dose from the fallout after two weeks amounts to less than 7% of the total ra-

diation of the fission products from 1 minute on to infinity. In addition, the radiation becomes softer as time goes on, so that it becomes easier to protect against it. More importantly, the radiation after two weeks is stretched out over a rather long period—six months or so. Although the damage done to Man by 10% of this radiation is not reversible the damage done by the remaining 90% appears to decrease by 2½% per day. As a result, by the end of the half year, the effect of the radiation received in the early period after emergence from the shelter has decreased to 11% of its initial magnitude. Altogether, the damage caused by the radiation received after the two-week sheltering period hardly exceeds 4% of the damage that a person outside would receive in the initial two-week period. Even more importantly, because the radiation intensity after two weeks is only one thousandth of its intensity at one hour after the explosion, after two weeks the shelter can be abandoned for reasonably long periods. Thus survivors can possibly clean up surroundings or, in extreme cases, move to a less contaminated location. We conclude that the danger from the fallout radiation can be easily guarded against after a period of two weeks from the time of the explosion and that the emergence from the shelter after that period produces much less difficulty than indicated in Drell's article. We do not wish to deny, of course, that it is even better if no nuclear explosion takes place.

The second, still somewhat technical, point to which we wish to take exception is the statement that "Protection against the close-in effects (blast and heat) is either impossible or tremendously costly." The gross national product per person of China is a small fraction of ours, yet most visitors to their land return greatly impressed by the very effective and easily accessible civil-defense shelters that were proudly shown to them. More concretely, the implementation of the counter-evacuation plan would cost $2.50 per person and the Chinese-type shelters $175 per person (or $35 per person per year, because their construction may take about five years). Surely, neither of these figures can be called "tremendous;" yet they would really buy each of us a great deal of security and would discourage attacks or threats of attacks—an equally important accomplishment. In fact, the Swiss civil-defense book says that the most important accomplishment of civil-defense preparations is that they will never have to be used.

On the other hand, we agree with Drell that an unlimited nuclear exchange between the USSR and the US would result in more than one million casualties on both sides. But in our opinion, we must strive for an approximately equal casualty rate—not 2 or 3% in the USSR and about 45% here. We also note that as Drell points out, the US Secretary of Defense believes that nuclear attacks on military targets may be feasible. Unfortunately the Soviet government may share this view.

Our last objection to Drell's statement is nontechnical and is in the spirit of his own article. He says "Furthermore, the development and rehearsing of civil-defense plans involving evacuation and relocation of large populations could be viewed with alarm by an opponent as preparation for executing a first strike." If that is so (and we believe it is) we do not understand the failure of his article to mention the USSR development and rehearsal of civil-defense plans involving evacuation and relocation of large populations. Evidently, he is not concerned by these plans and does not view them with alarm; he does not even think that they are worth mentioning. What he sees with alarm is that we may duplicate these efforts, that we put an end to the situation in which we may have to face an enemy who can destroy fifteen times more citizens in the US than we can destroy of his. Frankly, this current situation is what alarms us and is what we wish to terminate.

Drell replies to Broyles and Wigner

Although Arthur Broyles and Eugene Wigner frequently allege that the Soviets have extensively interwoven a civil-defense program into their society, to the best of my information no evidence exists that they have in fact exercised a civil-defense system capable of massive population relocation or evacuation. A large number of emigrés from many parts of the Soviet Union have been received in the West; had there been any widespread civil-defense rehearsals in the Soviet Union we surely would have heard about them by now. The Soviets have indeed written much on the subject and have given their population a more intensive exposure to civil defense. Apparently they have spent much more money on plans and organizations and involved small numbers of people with key skills in exercises. However, I believe that in view of the unprecedently large scale of the nationwide disaster we are considering, an effective civil-defense program must also include, as one of its essential components, full-scale rehearsals and survival living exercises involving the population.

Selective quotations from civil-defense manuals are not reliable guides to the effectiveness of a civil-defense program. If it were, we might cite from their manuals the removal of anti-Western polemics in the 1974 edition. We might also cite the fact that their civil-defense manuals for 1970 and 1974 (see reference 2 for the former and ORNL-tr-2845, 1975, for the latter) contain elementary substantive errors such as the translation, from US sources,[3] of miles directly to kilometers without the conversion factor of 1.6 in giving ranges of destruction from given bomb yields. Furthermore, the Soviet analysis of minimum requirement for air supply in shelters has not changed from old manuals. Thus the US editor of the translation is led to comment, in the preface, that "The Soviet Union has not conducted mass shelter living experiments or even simulated ones as has been done in the US." The editor then comments

further: "We believe that this is the most serious flaw in the whole Soviet Civil Defense planning." In my judgment, plans and manuals, on one hand, and an effective operating system, on the other, are very different things!

In referring to the Nier report Broyles and Wigner stated that it "verified previous conclusions that worldwide fallout produced in a nuclear attack would not be sufficient to deter the attack." In fact the report contains no such conclusion, nor does it address questions as to what will or will not deter war. Its task was the much more narrow one of considering the consequences of a nuclear conflict "by examining, independently, possible effects upon, respectively, the atmosphere and climate, natural terrestrial ecosystems, agriculture and animal husbandry, the aquatic environment and both somatic and genetic effects upon humans," as remarked by Handler in his letter of transmittal. In my reading of the Nier report I was more impressed by how extensive are the unknowns that will determine the scale of the disaster result-

ing from a major nuclear conflict and by how little can be predicted with confidence.

I believe there is no basis in fact for the statement by Broyles and Wigner that "the Soviets' large missiles are effective against our land-based missiles and their killer submarines can attack our Polaris submarines." This allegation is also at variance with assessments given by our civilian and military leaders. To quote Secretary Schlesinger, for example, in the Annual Defense Department Report for FY 1976, "Our sea-launched ballistic-missile force provides us, for the foreseeable future, with a high confidence capability to withhold weapons in reserve."

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Surviving a Nuclear War

C. M. Haaland and E. P. Wigner

National Review *28*, No. 35, 1005 (Sept. 17, 1976)

SOVIET LEADERS probably get a lot of laughs out of the frequent comments made by well-meaning but grossly misinformed Americans concerning the vulnerability of mankind. For example, Walter Cronkite, whose business is to inform, has declared on his nationwide news telecast that there are enough nuclear bombs on hand to "obliterate the world a hundred times over." Secretary of State Kissinger has also fallen for this line. When asked why the Soviets agreed to the Vladivostok pact concerning SALT II, Mr. Kissinger replied: "I would suppose that the General Secretary [Brezhnev] has come to the same conclusion that we have: that whatever level you put at the ceiling, it is enough to destroy humanity several times over, so that the actual level of the ceiling is not as decisive as the fact that a ceiling has been put on it."

The Soviets rejoice at such comments because their strategic planners realize that the propagation of this error, loaded as it is with emotional concern for the fate of mankind, will stir up resistance against any proposal for arms development by our Defense Department. Worse than that, this gross misconception may promote a false feeling of security in America because of the belief that no national leader will start a nuclear war if all of humanity is going to be destroyed. Worst of all, this line of propaganda conveys the idea that nothing can be done to protect mankind from the effects of nuclear weapons—that efforts at civil defense are futile.

Meanwhile, the Soviets devote about 25 per cent of their production (30 per cent according to Solzhenitsyn) to the further strengthening of their military power, including the development of one of the greatest navies in the history of the world and the expansion of what is already the world's greatest ICBM nuclear striking force. Why do they bother, if a nuclear war will obliterate mankind? Because the leaders know that a nuclear war will *not* destroy mankind. And if their elaborate civil defense plans are executed, the entire U.S. striking force will not be able to destroy more than a small fraction of the Soviet population, much smaller than the number of Soviets killed in World War II.

American engineers, like their Soviet counterparts, have studied the effects of nuclear weapons, but the Soviets have surpassed us in designing effective countermeasures. Their plans include the design and construction of shelters, some for protection against all effects of nuclear weapons (except for areas very near the fireball) and some for protection against the effects of radioactive fallout.

MORE IMPORTANT, the plans include a massive evacuation of cities and other likely targets. According to these plans, during the presumably inevitable crisis period preceding a potential war, evacuees would be ordered to predetermined rural areas where fallout shelters would be quickly constructed if perma-

nent-type shelters did not already exist. Far too widely dispersed to be the subject of any direct weapon attack, the great majority of the Russians would be completely unaffected by the initial nuclear radiation, blast, thermal radiation, and ensuing fires. Furthermore, sheltered underground with two or three feet of earth shielding them against radiation from fallout, many of these people would be exposed to less radiation from a nuclear attack than most of us encounter in the course of our normal lifetime.

Thanks to these plans, it appears that 240 million or more Soviets would survive the short-term effects of an all-out nuclear attack by the U.S. and its allies. And to assure the continued survival of this population, the Soviet Union is busily constructing facilities for storing 2.5 billion bushels of grain in rural areas, enough to feed its entire population of 250 million people for three hundred days—long enough for the time-cycle of events after a nuclear attack to go through, first, the natural decay of the radiation from fallout to livable levels, then the planting of crops, and finally the harvesting.

The total picture of Soviet military might—superlative nuclear striking power and a realistic civil defense—indicates that the Soviets have given much thought to the "unthinkable." They are preparing, if "necessary," to fight and win a nuclear war. Russian leaders have never adopted the strategy that our policy-makers wishfully called "mutual assured destruction." Unless the American people are awakened to this situation, within the next few years the Soviets may very well engineer a serious confrontation in which they would be ready to emerge the victor.

Will the U.S. be forced to concede in such a confrontation without firing a shot? Will the spirit of liberty and the morale of the United States be eroded to the level of Better Red than Dead? Former Secretary of Defense James Schlesinger is aware of the Soviet civil defense efforts, and the Defense Civil Preparedness Agency (DCPA) is laying plans for what is called a "crisis relocation," a counter-evacuation of endangered areas in the United States in the event the Soviets should begin to execute their massive evacuation plan. Such counter-evacuation plans, if they appear credible to the Soviet leaders, will go far toward preventing a serious confrontation from occurring until well into the 1980s, if at all—depending on a softening in the inevitable replacements of the current aging Soviet leaders. However, our civil defense plans are not likely to have a strong influence on the Soviet leaders if our top officials and newsmen continue to make demoralizing overstatements about the vulnerability of mankind. □

Mr. Haaland is a physicist at Oak Ridge National Laboratory and a member of the American Federation of Musicians. Mr. Wigner, a member of the Princeton University Department of Physics, received the Nobel Prize for Physics in 1963.

More on Civil Defense

T. Y. Palmer, C. E. Friedberg, E. P. Wigner, A. A. Broyles,
W. Murphey, and S. D. Drell

Letter to Physics Today *29*, pp. 11, 13, 15 (December 11, 1976)

The "debate" on civil defense by Arthur Broyles and Eugene Wigner versus Sidney Drell (April, page 45) ignored the major role that fire will play in any nuclear war, be it large or small. The tendency of the physicist to assign the most familiar effect the greatest importance was apparent in this article. Thus, the electromagnetic pulse, thermal radiation, blast and fallout were given major roles, whereas fire was relegated to two short sentences in the section on shelter design.

The effectiveness of the incendiary air raids on Japan and Germany in which firestorms developed far exceeded that from the high-explosive air raids in terms of damage and casualties.[1,2,3] Even in the attacks of Nagasaki and Hiroshima, between 50 and 65 percent of the deaths and casualties are attributable to fire. There were 68 000 killed at Hiroshima and 38 000 killed at Nagasaki. The interesting comparison can be made, that a firestorm developed at Hiroshima and not at Nagasaki. However, even in Nagasaki, fire played an important role in inflicting damage and casualties.

As a further basis for comparison, the great Tokyo air raid of 9–10 March 1945 killed 83 793, the Dresden fire raids of 13–14 February 1945 created a firestorm in which 135 000 died, and the Hamburg fire raids from 24 July to 3 August 1943 generated firestorms that killed more than 43 000. These fires created firestorm winds[1,3] over areas up to 16 km^2. The Dresden firestorms were the most severe, and they probably most nearly approximate the fire that will develop from the large-area ignitions generated by a thermonuclear weapon. In this raid, the shelter ventilation systems, in many cases, collapsed and there is evidence that the intense fire whirls associated with the firestorm generated pressure differential fluctuations that caused injected lethal concentrations of carbon monoxide into some of the shelters.

Theoretical studies[4,5,6] of the fires generated by a five-megaton thermonuclear weapon, clearly indicate that almost all buildings from ground zero out to 8 km will be destroyed by fire. Many of these will start as a result of events other than thermal radiation. The rate of postulated destruction decreases to near zero at a range of 17.5 km; however, these studies largely ignore the spread of fire due to fire fronts and firebrands. These studies also show that the use of fallout shelters in large public buildings will result in the death by fire of large numbers of people, if the shelters are not especially designed to withstand the burning of the building. Even in this case, if there is a full-fledged firestorm development, the probability of survival is small. In the large, experimental fires of Project Flambeau, some were designed to produce firestorm-fire-whirls. The areas in which they occurred were scoured clean, down to rocks the size of pebbles (about 1 cm) and all combustibles were burned off flush to the ground. It is possible to generate such large fire-whirls by igniting 27 hectares or more[7] simultaneously with a fuel loading of dry fuel greater than about 35 kg/m^2.

It has been indicated that as much as 10% of the United States would be destroyed by fire, even in the most modest nuclear exchange. Some areas are more vulnerable than others; for instance a modest nuclear attack in Southern California during a Santa Ana wind would effectively destroy much of the area.

It is probable that nuclear weapons will be used again against civilian populations. It behooves the planners of strategy to make realistic analyses of the impact of

even limited use of nuclear weapons and to provide for the protection and preservation of the population. Otherwise, the destruction of our major cities by bomb and fire is highly probable.

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THOMAS Y. PALMER
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Some of the points raised by Broyles and Wigner are misleading or erroneous. First, the use of numbers implying precision (that is, 11% and 5.5% casualties) conceals the extreme uncertainty in any estimates of human loss in a nuclear conflagration. Second, there is a gross misstatement (page 46) of the US annual welfare cost ($500 million a day would be $182 *billion* annually). One could hope that such a distinguished physicist and mathematician as Nobel Laureate Wigner would honestly state his political bias, which is implicit in, for instance, his comparison of the dollar cost of "counter-evacuation" with that of the welfare program. The authors' political bias also is apparent in the comparison of Soviet World War II casualties (page 47) with projected losses in a nuclear holocaust, which seems to imply that somehow the losses which the Soviets suffered then were acceptable or tolerable.

To those of us who recall the civil-defense hysteria of the early 1960's, which was fueled by the Berlin and Cuba crises, such political abuse of the weight of scientific authority is unacceptable. Drell, in his reply, has done an excellent job of presenting a rational analysis of a complex problem, which must be viewed in a global political context.

CARL E. FRIEDBERG
Berkeley, California

THE AUTHORS COMMENT: Thomas Palmer is quite right; our analysis of the fires that may be caused by nuclear explosions is quite incomplete. The same applies, of course, to the rest of the discussion, which had to be short also. We did quote two more elaborate discussions: those of the Russian handbook on civil defense and Glasstone's *The Effects of Nuclear Weapons*.

As to the ratio of fire-caused fatalities to those caused by the other effects of nuclear weapons, we disagree with Palmer. The cases he cites apply to unprotected people. Surely, if the people are removed to distances around 50 miles from the explosions, the chances of fires at their new locations become very small. If good shelters are used, even close to the nuclear explosions, the lives of the people in these shelters are not severely endangered by fires. One can easily calculate the temperature increase in a shelter under a two-foot earth cover, as caused by a fire storm: it is around 2 degrees. In conformity with this, it was found that the Second World War's bombardments caused no fatalities in the well constructed shelters of Germany, called "bunkers." We repeat, no fatalities in the bunkers. The claim of the USSR handbook that their subway stations are "safe against nuclear weapons" may be exaggerated, but points in the same direc-

tion. Let us repeat; fires can have disastrous effects on unprotected people. However, the protection provided by the shelters is even greater against the life-endangering effects of fires than against other effects of nuclear weapons.

What has been said above applies to the lives of the people. The material damage caused by fires can well exceed the damage caused by other nuclear-weapons effects. Our underemphasis of the material damage may be excused by Lenin's words, much quoted in the USSR: "The primary productive factor of all humanity is the laboring man. If he survives, we can save and restore everything . . ."

Carl Friedberg is also quite right: it is not possible to foresee accurately the number of casualties in a nuclear war. The numbers we gave and he quotes are, as we mentioned, those of the Ponast II study and we assumed that all physicists would realize that they cannot be precise. Most of us hope, in fact, that with careful and detailed planning an even greater effectiveness of the proposed measures can be achieved. We are glad to note that he did realize that no entirely accurate forecast can be made—and the main purpose of civil defense is, as the Swiss say, that no test of the numbers ensue—but we are a bit surprised that he assumes that the other readers of the article would not realize this.

The annual "income maintenance" expenditures of the US are given, for instance, in the Social Security Bulletin issued by the Department of Health, Education, and Welfare. The last year for which data are given is 1974 (page 35 of the March 1976 issue). If one extrapolates these data linearly, one obtains for 1976 an average daily expenditure of $450 million; if one takes the curvature into account, the result is $575 million. Our estimate of $500 million is surely not precise but one may consider it reasonable. Actually, even a significant change of this number—which was given only for comparison purposes—would have little effect on our argument.

Let me add to all this that I continue to be surprised how some critics deplore all our defense measures, speak of our civil-defense hysteria, but do not even mention the much more elaborate, and much less defense-oriented, civil-defense measures of the USSR.

Friedberg accuses me of not stating my political bias, which is a strong desire to defend our country and our freedom. I admit it now and surely I cannot accuse him for not making *his* bias evident.

EUGENE P. WIGNER
Princeton University
New Jersey

The danger from fire in a nuclear attack is analyzed in an article in *Survive* (P.O. Box 910, Starke, Florida) **2**, 14 (March–April 1969) and in documents referenced therein. That article notes that 43% of the people in the Nippon Building, Hiroshima survived the fire storm of over a mile radius although the building was located ⅕ mile from the center. These people had no warning and would have been much better off in a shelter. To obtain maximum fire-ignition effects from a nuclear bomb, it must be exploded at an altitude higher than that for optimum blast effect and, therefore, will produce negligible local radioactive fallout. Fire effectiveness of a bomb depends heavily on local atmospheric conditions, because clouds, fog or smog can greatly reduce the range of the heat radiation. Rather simple measures, such as cleaning up papers and wetting dry leaves, can greatly reduce the fire ignition range. In my opinion, we would be much better off under an enemy attack directed towards starting fires than one designed to maximize blast or fallout *provided* civil-defense preventive measures are taken beforehand.

Carl Friedberg draws the conclusion that our article implies that Soviet World War II losses were "acceptable." Our point is not this, but rather that it is *unacceptable* to leave the United States population exposed to the terrible losses that it would suffer if a nuclear attack should occur. The saving of human lives is our objective.

ARTHUR A. BROYLES
University of Florida
Gainesville, Florida

We are glad to see that Sidney Drell, in opposing civil defense, makes really an excellent case *for* it.

Drell outlines well and at some length a number of well-known difficulties inherent in achieving a meaningful civil-defense program—difficulties which are among the basic planning problems of civil-defense staff workers.

Then he strongly and repeatedly alludes to the admitted effectiveness of civil defense. (For instance: "Few dispute the technical facts concerning the means to protect large populations for one to four weeks after an attack from the physical effects of blast, fire, radiation and fallout.") These admissions of effectiveness—although to some extent contradicted elsewhere in his presentation—complement his final warning not to develop civil-defense programs on unrealistic premises. That warning merits close attention. It is where we are today.

Drell's serious objection he defines as one of cost. If the protection of American lives against the known, poised, devastating threat of nuclear missiles is considered *not* to be important, then his cost-oriented anti-civil-defense stance smacks of a certain validity. We would, to be sure, if we chose to defend our people against nuclear attack, be forced to commit ourselves to costs similar to those borne by Russia, China and other nations whose leaders have opted for citizen survival (nations whose GNP's are much less than ours). These costs, however, would be considerably less than many of today's much-criticized "frivolous" government adventures.

Such a program would mean a contribution of anywhere from one-half cent to seven cents a day per capita for the next five years, depending on how well we wanted to do the job. Survival and peace might just be worth it.

WALTER MURPHEY
Editor
Journal of Civil Defense
Starke, Florida

THE AUTHOR RESPONDS: Walter Murphey misrepresents my opposition to an expanded civil-defense program when he states my "serious objections" as being based on dollar costs. I am very puzzled by this characterization of my arguments, because my article analyzed the "cost" of civil defense in all its aspects *other* than the dollar costs. The concerns to which my entire discussion was devoted were the *costs* to strategic stability of developing and deploying new missiles to implement a strategy of limited nuclear counterforce strikes and the social and human *costs* if we were to implement the massive training programs required to construct an effective civil-defense system in this context.

Murphey's letter completely ignores these issues, which formed the basis of my opposition to developing massive population relocation and evacuation schemes beyond our present civil-defense system.

SIDNEY D. DRELL
Stanford University
Stanford, California

PART IV

The U. S. Government Discovers Soviet Civil Defense 1976–1979

Publicity of the disparity in vulnerability between the U.S. and Soviet Union led to Congressional hearings on the subject. The Carter Administration commissioned another large study of the cost-effectiveness of civil defense, consolidated government civil defense functions into the Federal Emergency Management Agency, and began preparations for a Crisis Relocation Planning Program. Wigner contributed to the impetus behind CRP.

Civil Preparedness and Limited Nuclear War

E. P. Wigner

Hearings before the Joint Committee on Defense Production, Congress of the United States, Ninety-Fourth Congress, Second Session, April 28, 1976, pp. 143–147

Statement of E. P. Wigner[1] for the Joint Committee on Defense Production

As will soon become evident, the present writer is strongly in favor of a great enhancement of the civil defense effort of the United States. He appreciates the opportunity to communicate his views to the distinguished readership of the Congressional Record.

The discussion which follows assumes that the conviction that our country needs an effective defense is shared by the readers. Actually, this conviction is most effectively communicated by the writings and statements of the leadership of the U.S.S.R. These strongly express the intention to extend their reign over the whole earth. It is, I hope, unnecessary to enlarge further on the necessity of our maintaining a strong defense system and I'll proceed to the other subjects of interest in the present context: the effectiveness of civil defense measures, the need for the United States to institute such measures, the validity of arguments against these measures, and a few final recommendations.

The Effectiveness of Civil Defense

This writer became convinced of the possible effectiveness of civil defense measures when he served as a member of the General Advisory Committee to the U.S. Atomic Energy Commission. The Committee met four or five times a year and was briefed at almost every meeting on the progress of nuclear weapons development and on the effectiveness of these weapons. These briefings convinced me of the fact, so aptly stated by V. Chuykov: "Although the discussed means of destruction (nuclear weapons) are called mass means, with knowledge and skillful use of modern protective measures they will not destroy masses of people, but only those who neglect the study, mastery, and use of these weapons." Indeed, an easy calculation shows that if the U.S.S.R. carries out its city evacuation plans, the total number of casualties that all the nuclear weapons in our missiles could cause would be a good deal less than one-half of the losses they

[1] Dr. Wigner is a Nobel Laureate and an emeritus professor of physics at Princeton University and has long been associated with civil defense issues. He edited a 1968 study *Who Speaks for Civil Defense?*

suffered in World War II. A reasonable estimate, based on the Oak Ridge tests of the blast resistance of the "expedient shelters" described in the U.S.S.R. civil defense handbooks gives, for the loss which our missile carried nuclear weapons could cause, about 3 percent of the U.S.S.R. population. It is true that if their very elaborate but hopefully incomplete air defense system lacks in effectiveness, this loss could be very significantly increased by our air power. However, very naturally, we cannot foresee the future development of their air defense installations. It may be useful to mention at this point that a recently published book, by L. Gouré, describes the Soviet civil defense very closely and deals with all aspects thereof – not only the immediate survival of the attack but also with its longer time effects.

What is our own situation? According to the published part of the Ponast II study, the missiles of the U.S.S.R. could inflict, in the present situation, a population loss of 45 percent. An evacuation plan, similar to that of the U.S.S.R., would reduce that loss to about 11 percent. Its cost is estimated by Ponast II as $1.2 billion. The evacuation of our cities would thus be very effective, but less effective than that of the cities of the U.S.S.R., partly because of their greater missile power, partly because a larger fraction of our people live in cities than of those of Russia. Still according to the Ponast II study, a blast resistant shelter system, similar to that of China, would reduce the number of people exposed to mortal danger to about 5.5 percent – it would cost around $35 billion.

Are the U.S.S.R. and China the only countries with elaborate and well developed civil defense systems? No – most of the peace-loving countries also have such systems, based on blast shelters, and their yearly expenditures per person on such defense is about 15 times greater than ours. This has been, so far, about 40c per person a year. Incidentally, the Swiss civil defense repeats our President Kennedy's message: (Civil defense) "is insurance we trust, will never be needed" – its greatest accomplishment is, according to the Swiss, that it will *not* have to be used, that it will divert the aggressive instincts of possible opponents.

It is easy to conclude that an effective civil defense is not only desirable, it is also possible.

Is Civil Defense Necessary?

What is the principal danger that threatens us in the present absence of an effective civil defense? It is the possibility of the U.S.S.R. evacuating its cities, dispersing their population, and then making demands on us, under the threat of a nuclear attack, approximating those made by Hitler or Czechoslovakia which led to the Munich pact. This left Czechoslovakia essentially defenseless.

Could we resist such demands? The lives of almost half of our people would be at stake and the threat of our retaliation, which would affect a relatively small part of the U.S.S.R. population, might be quite ineffective. The natural response to the treat envisaged would be either a "counterevacuation", to be

undertaken as soon as the U.S.S.R. evacuates its own cities, or, even better, the movement of our people when the threat arrives, into blast resistant shelters, similar to those available to the Swiss, or even the Chinese. It is hard to imagine any other countering of the "nuclear blackmail" threat envisaged, and the ones proposed would, in fact, have the effect that the threat would not arise. As the Swiss were quoted, the most important accomplishment of a potentially effective civil defense system would be that it never will have to be used.

What would be the other consequences of effective civil defense preparations of our country? One can well maintain that they would further a more sincere peace between ourselves and our antagonists than the much advertised "mutual assured destruction". If of two people each can kill the other, but is then endangered by the threat of being killed himself, they may resist murdering each other. But their relation would remain much more strained than if neither would have to fear being murdered by the other. Further, an effective civil defense system would also have a very favorable effect on the morale of our people – they would feel very directly that our government does have their welfare and life in mind and the universal contribution of the people to the aversion of dangers to themselves would greatly improve their morale. Civil defense is not only necessary, it is also desirable in its effect on the morale of the people and also in its effect on our relation to countries at present antagonistic.

The Arguments Against Civil Defense

It may be worthwhile, finally, to review the objectives against our installing an effective civil defense. About 15 years ago, before the U.S.S.R. civil defense efforts became clearly apparent, it was claimed that the installation of effective civil defense measures would create the impression in our opponents that we are planning a first strike. This argument, that our civil defense effort would be provocative, had to be abandoned when the U.S.S.R. organized its own civil defense. Interestingly, and incidentally, the U.S.S.R. was never criticised for these efforts – naturally not by the supporters of our own program in this direction and strangely enough also not by the opponents thereof. The argument which we heard after the U.S.S.R. civil defense efforts became generally apparent was that our installation of protection for our people would only induce the U.S.S.R. to augment its aggressive capability. We now know that such augmentation took place even though we did not organize a vigorous civil defense effort. One of the two arguments we now hear, the civil defense is too expensive, seems almost ridiculous. If Switzerland, Sweden, etc., *even China*, can afford the more costly, the blast shelter method, we with the highest per capita national wealth, can also surely afford the defense of our people. The other argument, in the words of one of the most learned opponents of civil defense, S. Drell, is that it would lead to an "escalation of the apprehension from the mood of today, vis-a-vis the dangers of a nuclear exchange between th U.S. and the Soviet Union". Should the apprehension of the danger not be greater now, where we have no effective defense, than it would be when we

have such defense? Or is it proposed that we should lull the common people into ignorance of the true situation? It is remarkable also that the U.S.S.R. is not criticised for fostering the "apprehension" of its own people. One must conclude that the varying arguments against civil defense have little validity.

The first change I would advocate is to stop maintaining that a nuclear war would be the end of mankind. Such a statement may give the impression to an opponent that he can achieve anything by threatening with a nuclear war. After all, he would argue, the opponent (that is us) will make any sacrifice to avoid the "end of mankind". Hence, if he is threatened with extinction he will give in, particularly if the threat comes from a party which does not believe that the war precipitated by him will lead to the "end of mankind". Instead, of such a blatantly incorrect statement, it would be better to subscribe to Chuykov's doctrine that "knowledge and the skillful use of modern protective measures" will make it possible to provide effective protection. At least, we could adhere to Kissinger's earlier (1957) statement: "While it (civil defense) cannot avert the traumatic effect of vast physical destruction, its efficient operation may make the difference between the survival of a society and its collapse."

The second measure which I consider to be urgent is to establish better contact with the people at large. This makes it desirable for DCPA to expand its staff by the employment of people who can establish a contact with the population at large, who can speak and write the truth convincingly. One of the functions of these advisors would be to help the high schools to give instruction on the nature of nuclear explosions and the defense against the effects of these. This is a subject which is foreign to most present high school teachers, and the advisor could and should help them to acquire the necessary knowledge. After all, the Federal Government now intends to support the local schools and can well suggest that these contribute to the protection of the country. The high school instruction on civil defense – obligatory in the U.S.S.R. – would be very useful since, after all, we learn best when we are young and we learn most non-elementary facts from our teachers. But even more generally, the establishment of a close contact between those who protect our freedom, and those whose freedom is protected, would be very desirable; and acquainting people at large with the methods and effectiveness of civil defense would provide an avenue toward this goal. It may not be easy to find people who know about the methods and effectiveness of civil defense and who are also able and interested in communicating this and much other knowledge to the people at large, but every effort should be made to find such people and support them.

The last suggestion I wish to make is that the DCPA budget should certainly not be cut. It should steadily be increased until, in a few years, it reaches the per capita level of other peace-loving and non-expansionist countries, such as Switzerland, Holland, Sweden, etc. For reasons given in the rest of my statement, this would be of decisive importance for maintaining a valid, widely endorsed, and vigorous defense effort for our country – and it would support all freedom-directed nations. Their independence does depend to a certain degree on our strength and our ability to stand up for them. The examples of

Hungary, Czechoslovakia, Poland – to mention only a few – show that such independence does not come freely.

Let me end on a bit more hopeful tone which is, however, as sincere as was the rest of my statement. This is the hope that an effective civil defense may not only protect our country and our freedom, but it may also lead to a more true peace than the present one, which is based on the fear of destruction. I hope such a peace in which no rulers are tempted to increase their domains will come into being!

Soviet Civil Defense

C. H. Kearny and E. P. Wigner

Letter to Science *195*, No. 4275, 243 (January 1977)

Deborah Shapley's article "Soviet civil defense: Insiders argue whether strategic balance is shaken" (News and Comment, 10 Dec. 1976, p. 1141) provides information that should prove useful to scientists and others concerned with the strategic significance of realistic civil defense preparations.

Her description of the Soviet civil defense installations is quite comprehensive. The only relevant point that we found lacking is the instruction of the people in civil defense measures. Every schoolchild has 3 years' instruction in the effects of nuclear weapons and in the civil defense measures to minimize them. A total of about 135 hours is devoted to the subject. There is similar instruction in factories, and hundreds of thousands of handbooks on civil defense are published and distributed.

Another factor, mentioned by Shapley but in our view underemphasized, is the plan for evacuation. If this is carried out and followed by a set of demands resulting in a confrontation, the bargaining position of our country would be miserable. The Soviet Union could threaten to destroy half of the U.S. population; we could destroy only a small fraction of theirs. The Soviet losses would be well below those suffered in World War II. Such a threat, "nuclear blackmail", is the danger many of us fear most. The first of the above numbers is confirmed in the published part of the Ponast II study (1). Soviet losses are estimated to be between 2.75 and 4.5 percent in their civil defense handbooks, but some of the U.S. estimates, though still quite low, are considerably higher. The estimate of one of us (E.P.W.) agrees with the Soviet estimate.

To discover the "motives behind Soviet population defense" one should read what Soviet leaders have clearly and repeatedly told their own people. One key to the understanding of these motives is Lenin's often quoted dictum: "The primary productive factor of all of humanity is the laboring man, the worker. If he survives, we can save everything and restore everything – but we shall perish if we are not able to save him" (2). Of course, if they can push us by threats into repeated concessions, just as Hitler pushed Czechoslovakia, there would be no need to rebuild their factories. The Soviets, like the majority of mankind, always have believed that a primary responsibility of any nation's government is making preparations to save the lives of its citizens if war occurs. Soviet military and civilian leaders have always rejected the concepts of "mutual assured destruction", a strategic theory based on the United States and the

Soviet Union leaving their populations vulnerable. One of the Soviet responses to U.S. threats, first of "massive retaliation" and then of "assured destruction", is their comprehensive preparations to survive even an all-out war.

Let us observe, finally, that we cannot quite understand Panofsky's and Garwin's fear, quoted in the article, that a U.S. civil defense effort would alarm the Soviet leaders and would be destabilizing. If the Soviet civil defense does not alarm them and is not stabilizing, why would our emulation of some of these measures be alarming and destabilizing? Did Krushchev not say, "Don't be afraid. If I offer my embrace, you will not refuse it"?

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Must We Leave Our People Unprotected Against an Attack?*

The World's Greatest Ostrich**

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The American people are constantly bombarded by NEWS. The evening paper, the 6 o'clock news on television, magazines, journals, bulk mail, and numerous other sources constantly tell us about everything (?) that is going on in the world. But there are *some* things that just don't get told.

One of these ignored items is the fact that many of the nations of the world have been working for years to provide their people with some hope of survival in the event of a nuclear war. Our people get such statements as "nuclear war – the end of mankind", "better Red than dead", "there are enough nuclear weapons to kill the world's population 12 times over", etc.

In China, tunnels have been constructed under many of their cities. These tunnels are equipped with blast-resistant doors, radioactive-dust filters, restaurants, hospitals, rest and recreation centers, and protected water supplies. It is said that the entire population of Peking can be sheltered within 5 minutes. One of Chairman Mao's most famous dictums is "Dig tunnels deep", and they have done just that.

In Switzerland, their civil defense program (which was voted in by the people) has provided, over an extended period, each family with a shelter equipped for up to a two-month stay, underground hospitals, and military installations burrowed into the Alps.

In Sweden, underground shelters, industries , and power stations are not exceptional.

The Soviet Union has an on-going civil defense program which calls for participation by all of the population. Second-grade school children are taught civil defense as a regular subject. All factories, institutions, plants, educational facilities, collective farms, and state farms are required to maintain a civil defense organization. The 1976 plans require that each enterprise must hold exercises for the purpose of training all of their employees, along with non-workers who live nearby. These exercises are conducted under realistic crisis conditions and involve the performance of complicated tasks such as evacuation and dispersal, firefighting, reconnaisance, decontamination, rescue and restoration, shelter

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**Webster's Dictionary: a swift-footed, flightless bird ... who attempts to avoid danger by refusing to face it.

building and occupancy, and other activities necessary in the event of an enemy attack. The main element of the Soviet CD plan has been the evacuation of their people from areas deemed vulnerable to attack; however, it is becoming apparent that a certain amount of shelter capability has been created over the last several years.

Perhaps all of the people in the countries have memories which make them more receptive to civil defense planning than we here in the United States. A great number of them have experienced the horrors of war, first-hand. Also, they have been told that it is possible (in fact, it may be necessary) to survive a nuclear attack, and they have reacted accordingly.

It has been the general consensus of opinion here in the U.S. that efforts to protect the population from the effects of nuclear weapons are either useless, warlike, or ridiculous, or perhaps all three. However, the actions of the above-mentioned nations do not seem to indicate a similar attitude.

We are constantly referred to as an "imperialist aggressor" in the Soviet literature – this tries to paint us as if it had been the United States which occupied Estonia, Latvia, Lithuania, and subjugated Czechoslovakia, Hungary, Poland, Rumania, and part of Germany. One may well wonder whether this is the end of their ambitions for conquest – their literature does not give this impression, nor do statements of people who know them and are free to speak, such as Solzhenitsyn, neither does the fact that about one-quarter of their national production goes into defense. We, on the other hand, have traditionally been extremely naive in our relationships with other nations, e.g., the attack on Pearl Harbour when we were negotiating with Japan and expecting to resolve our problems. It is regrettably typical that we should sit by idly while other countries openly prepare their defenses.

The U.S. does not become disturbed about the Chinese tunnels or upset that the USSR has detailed, published plans for the evacuation of their non-workers and dispersal of the employees of their essential industries. Of course, the average American citizen does not even know about these things. Instead, the good old USA frets about the possibility that similar actions *by us* might interfere with the progress being made in reducing international tensions.

Effective civil defense cannot be attained instantly. The Swiss program has been in effect for more than 15 years. The Russian program has been actively chipping away at the problem since the end of World War II. The Chinese tunnels have taken several years, and the work on improving them is still going on.

The attitudes of other nations toward civil defense are basically very realistic. The Swiss feel that the best thing about it is the possibilitiy that it will *never* be needed. The Russians feel that it is absolutely imperative that the nation's greatest resource – the worker – be protected. The Chinese just do not trust their neighbors and do not wish to risk being unprepared. Of course, preparedness is expensive. However, China (with a GNP about one third that of the U.S.) can afford to protect her huge population. Switzerland reportedly has attained an excellent civil defense posture at an expense of approximately

$ 12 per person per year over a 15-year period. It is not known what the Russian program costs might be because civil defense is included in the Ministry of Defense whose real spending levels are a closely guarded secret.

Regardless of the cost, it seems reasonable that a reduction of casualties in a nuclear war from 45 % to 5.5 % (as pointed out in the PONAST II Study) would be a good investment of U.S. dollars

Defense of Cities by Antiballistic Missiles*

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Abstract. Given a number of short-range anti-ballistic missiles (ABM), one would like to distribute them among the possible targets in such a way as to minimize the fatalities which an attacker can cause. We have solved this mini-max problem by an elementary mathematical method. We found that there is an optimal distribution of the defending missiles which remains optimal independent of the size of the attack, provided the total number of defending missiles and the number of targets are reasonably large. Calculations for the U.S. indicate that the number of fatalities can be further reduced by a factor of 4 to 7 by means of passive defense, i.e., blast shelters, similar to those under Chinese cities.

1. Introduction. There are many articles in the literature describing the allocation of the defending missiles to the various sites to be defended so as to minimize the total damage that an attack can cause. Samuel Matlin has compiled a list of 38 papers dealing with the subject and added brief remarks on them [1], and R. Soland has also published a paper on them [2]. The reason that we add our own thoughts to literature is twofold. First, our derivation of the optimal distribution of the defending missiles is entirely elementary and thus gives an intuitive grasp on the overall picture. Second, we find that the damage which the attacker can inflict is within a certain range independent of the distribution of the defense if the attack is powerful enough to extend to all targets. The problem of the most effective distribution of the defending missiles has a unique solution only if the most effective attack bypasses some of the targets. We found that, in this case, the customary "double-Lagrange-multiplier" method [3], [4] may well have either no solution or to give an incorrect one. (We have been informed that this conclusion has been arrived at also, independently from us, by Harvey Smith). Our work plays, therefore, particular attention to this situation.

One of our results is that the proposed distribution of the defending missiles is independent of the size of the attack, i.e., remains for any size of the attack, at least as effective as any other distribution. The proposed distribution depends, of course, on the character of the targets, that is, their population and vulnerability. Hence, if these are altered, for instance by the introduction of passive defense in the form of shelters, the optimal distribution of the defending missiles also changes.

We first discuss the assumptions which we make concerning the general character of the attacking and defending forces, then present the proposed

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optimal distribution of the defense. Finally, we apply our results to the specific case of the defense of the cities of the United States.

2. Assumptions. The following assumptions, implicit in our model, are common to nearly all the papers referenced by Matlin [1]:

1. Each interceptor has a 100% kill probability against an attacking missile.
2. Interceptors are limited in range to defend target areas of moderate size such as an American city.

These first two assumptions together imply that no damage can be inflicted on any portion of a city area unless all of its defending missiles have been exhausted.

3. The attacker knows the value of each target, how many missiles are allocated to defend each target, and that each interceptor has a 100% kill probability against the attacking missile.
4. The attacking missiles are 100% reliable, with negligible error for city targets, they all have the same yield. Their number will be denoted by N.
5. The city targets will be labeled by letters **a**, **b**, **c**, $\cdots$ and the maximum damage which ν_a missiles can inflict on the undefended city, **a**, will be denoted by $f_a(\nu_a)$.

It is assumed, naturally, that

$$f_a(\nu_a+1)>f_a(\nu_a), \tag{1}$$

and also that the missiles are fired in such a way as to inflict the maximum possible damage. It then follows that

$$f_a(\nu_a+1)-f_a(\nu_a)<f_a(\nu_a)-f_a(\nu_a-1). \tag{1a}$$

The right side represents the damage caused by missile ν_a, the left side by missile (ν_a+1). If the latter damage were greater than the former, a damage greater than $f_a(\nu_a)$ could be caused by ν_a missiles by replacing the target of missile ν_a by the target of missile (ν_a+1). Since $f_a(\nu_a)$ is the greatest damage that ν_a missiles can cause, (1a) follows. Both (1) and (1a) are valid for all cities **a** and all values of the ν_a.

It is useful, though not necessary, to generalize the functions $f_a(\nu_a)$ by extending them smoothly also to noninteger values of ν_a. The mathematical literature contains prescriptions for constructing the smoothest function $f_a(\omega_a)$ which coincides with the damage function $f_a(\nu_a)$ for integer values of ν_a but it will not be necessary to go into that question here—$f_a(\nu_a)$ cannot be known precisely even for integer ν_a; it may vary with the time of the day, the season, etc. However, if the domain of the $f_a(\nu_a)$ is extended to noninteger ν_a, one can give (1) and (1a) simpler forms

$$\frac{\partial f_a(\nu_a)}{\partial \nu_a}>0, \tag{2}$$

$$\frac{\partial^2 f_a(\nu_a)}{\partial \nu_a^2}<0. \tag{2a}$$

The number of missiles defending the city **a** will be denoted by s_a, the total number of missiles aimed at it by n_a. Because of assumptions 1 and 2, the number

of missiles aimed at the city a is

$$n_a = \nu_a + s_a, \tag{3}$$

the sum of the missiles s_a destroyed by the defense, plus the number ν_a of those exploding at their target. Figure 1 illustrates the general shape of the damage on an undefended city as a function of the number n of missiles aimed at it.

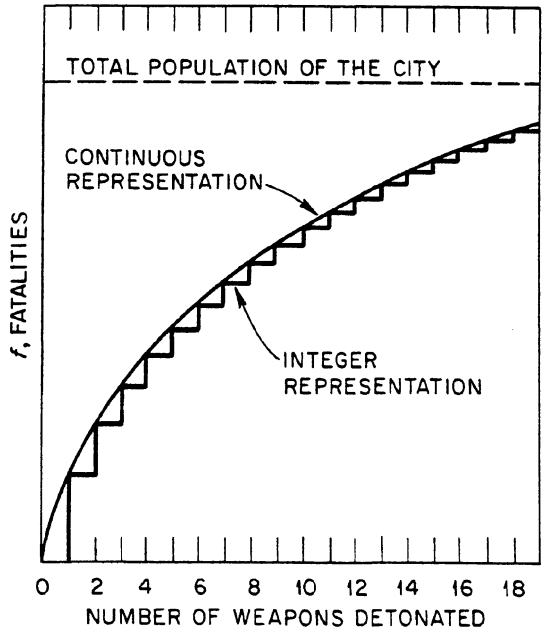

FIG. 1. *Typical shape of damage to a city in terms of fatalities as a function of number of weapons detonated*

This completes the enumeration of our assumptions. In our opinion, it would be most desirable to generalize the fourth assumption. If the attacker has both large and small missiles, our discussion which follows does not provide the best defensive tactic if the attacker were to first use his smaller missiles, in order to exhaust the defense with these. Evidently, if the smaller missiles are very small, the defense should keep its missiles in reserve against bigger missiles which may arrive later. If the "smaller" missiles are not really small, the defense should try to destroy them—the bigger missiles may all be targeted at other cities. However, as implied by assumption 4, the questions whether and under what circumstances the defense should destroy "smaller" incoming missiles will not be discussed here.

3. Tactics of the attacker. Naturally, the attacker will not attack any city with a smaller number of missiles than the number of interceptors protecting that city. The missiles so employed would all be destroyed without causing any damage. However, as will be shown below, the relation

$$f_a(\nu_a+1)-f_a(\nu_a) < C < f_a(\nu_a)-f_a(\nu_a-1) \tag{4}$$

will hold with the same C for all cities **a** which are attacked. Because of the inequality (1a), the left side (and also the right side) of (4) is a monotonically decreasing function of ν_a so that, for given C, (4) determines ν_a uniquely. If even $f_a(1) < C$, set $\nu_a = 0$. However, if the sum

$$\sum(\nu_a + s_a) = \sum n_a \tag{5}$$

extended over all cities to be attacked is larger than the number N of missiles available to the attacker, he will have to choose a larger C to determine the number of missiles n_a to be aimed at city **a**. If he has more missiles than the sum (5), he can use a smaller C, resulting in an increase of at least some of the n_a.

In order to solve (4) and to obtain the sum in (5) equal to N, one makes a table of $f_a(\nu_a + 1) - f_a(\nu_a)$ for all cities. One then chooses a C and obtains, for each city, the ν_a which satisfies (4). One then calculates the sum which appears in (5) and, depending on whether it is larger or smaller than N, one chooses a smaller or larger C to repeat the calculation therewith.

That (4) should hold *for all cities attacked* is evident: If the attacker transfers a missile from city **a** to city **b**, the effectiveness of this missile changes from $f_a(\nu_a) - f_a(\nu_a - 1) > C$ to $f_b(\nu_b + 1) - f_b(\nu_b) < C$; i.e., it decreases. The same is true, a fortiori. if several missiles' targets are changed. The question which remains, therefore, concerns only the choice of the cities to be attacked, i.e., the **a** for which (4) is to determine $\nu_a + s_a$. This will be discussed in more detail even though the situation is much simplified if the defender uses the "optimal defense" to be described in the next section. This will become evident in the course of that description.

If city **b** is bypassed in the attack, $s_b + \nu_b$ missiles become available for redistribution among the other cities which are attacked. The additional fatalities which can be caused by these missiles may or may not be less than $C(s_b + \nu_b)$. City **b** surely should *not* be bypassed if

$$\frac{f_b(\nu_b)}{s_b + \nu_b} > C. \tag{6}$$

Note that the left side is the average effectiveness of the missiles aimed at **b**.

If $f_b(\nu_b) < C(s_b + \nu_b)$, it is likely that **b** should be bypassed because the missiles which become available can be distributed among the many cities which remain on the attacking list so that the additional missiles' effectiveness will not be much below C.

The only truly rigorous way that we know of to ascertain the list of the cities to which the greatest aggregate damage can be caused by a fixed number of attacking missiles involves, as long as the s_a are arbitrary, some trial and error. The situation is different if the s_a form an optimal defense, to be discussed in our next section. If the trial and error method is to be used, one will eliminate from the original list first all cities for which $f_b(\nu_b)/(s_b + \nu_b)$ is smaller than, let us say, $0.9C$, repeat the calculation involving (4) and (5) for the remaining cities, obtaining a smaller C and a total damage which may be larger or smaller. If the damage is smaller, add a few cities to the list, perhaps those for which $f_b(\nu_b)/(s_b + \nu_b) > 0.95C$. If it is larger, explore both lists, for $f_b(\nu_b)/(s_b + \nu_b) > 0.85C$ and the $f_b(\nu_b)/(s_b + \nu_b) > 0.95C$, and, in both cases, continue in an obvious way. However, considering the

inaccuracy of the functions f, as mentioned before, one may as well carry out the calculation by means of the functions f extended to noninteger values of the arguments, in terms of which (2) and (2a) are formulated. If one does this, (4) will be replaced by

$$\frac{\partial f_a(\nu_a)}{\partial \nu_a} = C, \tag{7}$$

and the ν_a obtained rounded off to the nearest integer. As to the list of cities to be attacked, one may note that the missiles becoming available by bypassing city **b** will make it possible to increase the missiles for the remaining cities. If the number of missiles aimed at city **a** is increased by $\delta\nu_a$, the total fatalities will increase to a good approximation by

$$C\delta\nu_a + \frac{1}{2}\frac{\partial^2 f_a}{\partial \nu_a^2}(\delta\nu_a)^2. \tag{8}$$

The sum of these, for all a, will assume a maximum if the increments $\delta\nu_a$ are inversely proportional to $\partial^2 f_a/\partial\nu_a^2$. Since their sum must be $s_b + \nu_b$, one must set

$$\delta\nu_a = \frac{s_b + \nu_b}{\sum_a (\partial^2 f_a/\partial\nu_a^2)^{-1}} \left(\frac{\partial^2 f_a}{\partial \nu_a^2}\right)^{-1}, \tag{9}$$

the summation to be extended over all cities to be attacked. Thus, the total damage which the $s_b + \nu_b$ missiles can cause is, approximately,

$$C(s_b + \nu_b) + \frac{1}{2}\frac{(s_b + \nu_b)^2}{\sum_a (\partial^2 f_a/\partial\nu_a^2)^{-1}}, \tag{10}$$

and one obtains the criterion for bypassing **b** that

$$\frac{f_b(\nu_b)}{s_b + \nu_b} < C + \frac{1}{2}\frac{s_b + \nu_b}{\sum (\partial^2 f_a/\partial\nu_a^2)^{-1}}. \tag{11}$$

As (2a) indicates, the second term is negative. However, it is generally quite small and, as a rule, **b** will be bypassed by the attacker unless (6) is satisfied. Figure 2a illustrates the case in which (6) is satisfied, Fig. 2b when it is not valid. Of course, cities for which even $f_a(1) < C$ will also remain unattacked.

Before summarizing the calculation leading to the most efficient tactic of the attacker's missiles, it will be useful to adduce mathematical evidence for two properties of this tactic. The first is that an increase in the total number N of the attacker's missiles either increases, or at least does not decrease, the number of missiles ν_a striking any of the targets. The second appears equally evident: an increase in the total number of missiles does not lead to bypassing any of the cities which would be attacked when a lower number of missiles is used. The equally evident converse statements, referring to the situation created by a decrease of the total number of attacking missiles, follow from the ones given. All will be used in our next section when proving the optimal nature of the distribution of the defending missiles.

As to the increase or no decrease of the ν_a when the total number N of missiles is increased, we have seen that C decreases when N increases. Hence, the

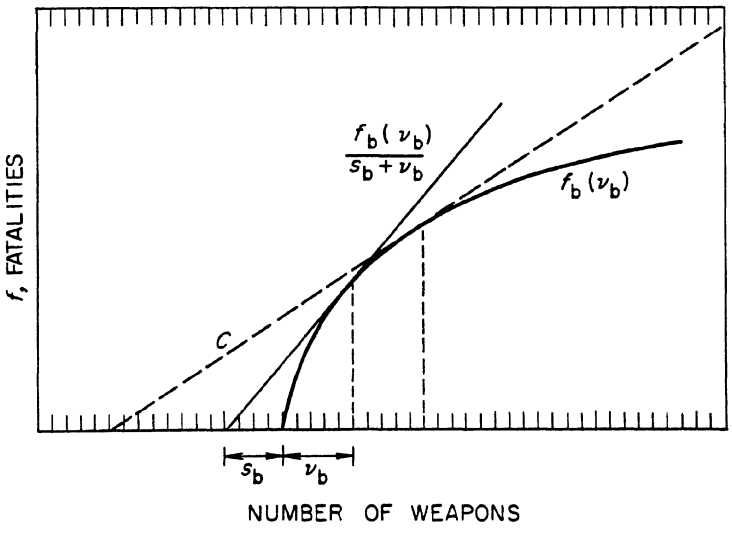

FIG. 2a. *Fatalities vs. number of weapons. In this case* $f_b(\nu_b)/(s_b+\nu_b) > C$, *and city* **b** *should be attacked.* s_b *is the number of interceptors,* ν_b *is the number of weapons to be detonated.*

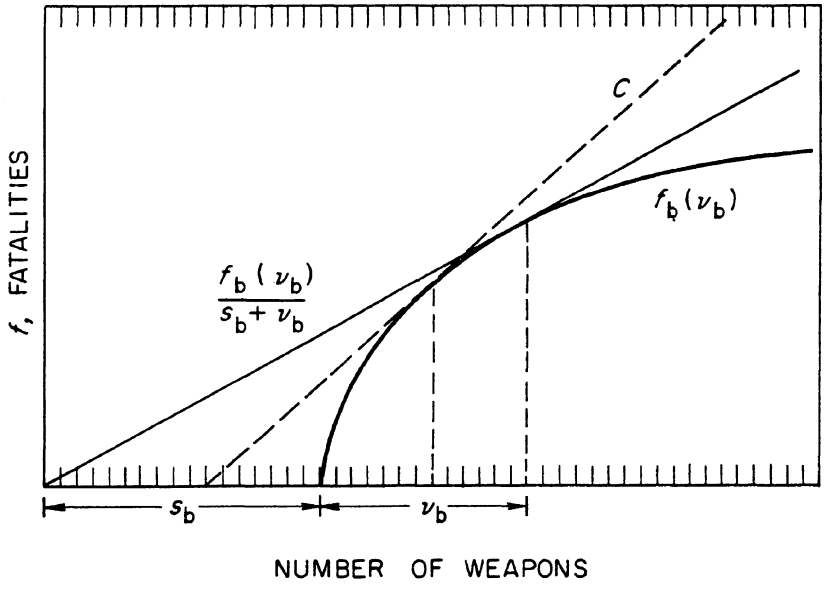

FIG. 2b. *In this case* $f_b(\nu_b)/(s_b+\nu_b) < C$, *and city* **b** *will be bypassed in the attack. The weapons can be used more effectively on other targets.*

second inequality of (4) will hold a fortiori. The same conclusion can be arrived at by differentiating (7) with respect to C, obtaining

$$\frac{\partial^2 f_a(\nu_a)}{\partial \nu_a^2}\frac{\partial \nu_a}{\partial C}=1, \tag{12}$$

and since the first factor is negative ((2a)), so is $\partial \nu_a/\partial C$.

Again, with regard to an increase in the total number N of missiles, it would be contrary to the most efficient tactic to bypass a city which was attacked when the total number was lower. That the city **b** was targeted at the lower value of N implies that the effectiveness of the ν_b+s_b missiles, additionally targeted at the other cities, could not produce more than $f_b(\nu_b)$ fatalities. At the higher total number of missiles, the ν values of some of the other cities became greater, none smaller, so that the ν_b+s_b additional missiles targeted at them would cause less damage than they would have at the lower value of N. Hence, it is even more true at the higher value of N that a greater damage $f_b(\nu_b)$ can be caused by targeting the $n_b=\nu_b+s_b$ at city **b** than by distributing them over the other cities. As mentioned before, n_b may even be increased when N increases. The same conclusion can be arrived at, somewhat arduously, by a mathematical derivation involving (11).

To be accurate, it must be admitted that one of the assumptions of the preceding argument may not hold in every case. The assumption in question is that the n_b missiles made available by excluding **b** from the list of cities to be attacked will be used principally to increase the size of attack on cities already on the list. It is possible that those n_b missiles can be used more advantageously principally for attacking cities not on the attack list and that this leads to an increase in the attack's effectiveness. Thus, if attack on only two cities is considered and if their fatality curves are as indicated in Fig. 3, for a total attack with $N<N'$ missiles, attack on **a** alone is the most effective. However, as N becomes larger than N', the most effective attack shifts to **b**, and **a** joins the bypassed list. However, such a decisive role of the cities added to the attacked list when N is increased is entirely exceptional (partly because only two cities are involved) and will be disregarded. It may also have the consequence of invalidating the independence of the optimal defense from the size of the attack. Certainly if we denote the total number of available defense missiles by S, as long as $N<\frac{1}{2}S$, the best defense is $s_a=s_b=\frac{1}{2}S$, leading to no loss. The distribution of S indicated in Fig. 3, on the other hand, guarantees that the loss per incoming missile is limited to $f_a(n_a-s_a)/n_a=f_b(n_b-s_b)/n_b$. All this will become more evident when the optimal defense will be discussed.

In summary, the calculation of the attacker who wishes to maximize the opponent's fatalities will proceed as follows:

1. Choose a C, calculate all ν_a from (7), namely

$$f_a'(\nu_a)=C. \tag{7}$$

Only the sizes, population densities of areas, and vulnerability of the population are needed for this calculation.

2. Disregard all areas for which (7) has no solution (for which even $f_a'(0)<C$).

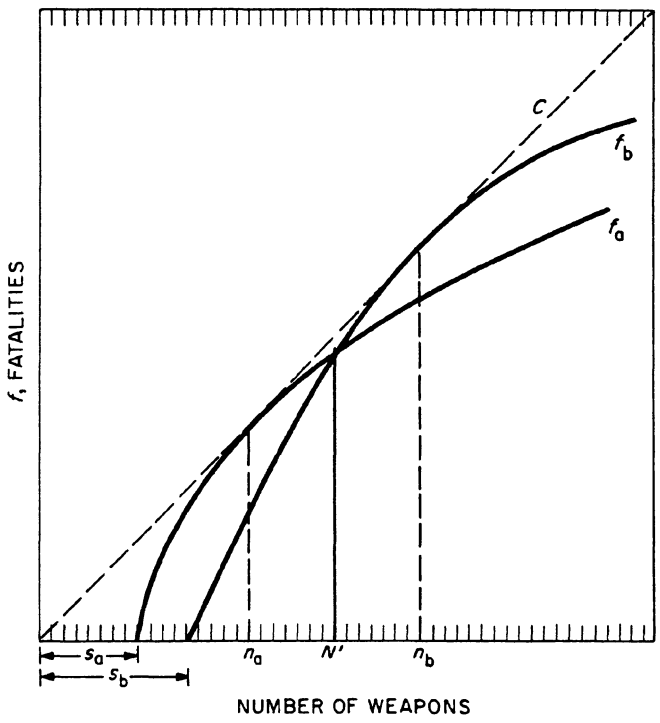

FIG. 3. *Fatalities vs. number of weapons for an attack limited to only two cities* **a** *and* **b**. *If the total number of weapons, N, is less than N', only city* **a** *is attacked. If* $N' < N < n_b + s_a$, *only city* **b** *is attacked.*

3. Classify areas to be attacked or to be kept unattacked by (11). Note that the strengths of the defense of the different areas, s_b, are needed for this determination.

4. Compare $\sum \nu_a + \sum s_a$, both sums to be extended over the cities for which (11) is *not* valid, with the number N of offensive missiles which the attacker intends to use. If the sum is larger than N, repeat the calculation with a larger C; if $\sum (\nu_a + s_a) < N$, choose a smaller C.

5. Repeat the calculation with a new C until the C has been found for which the expression (5) is equal to the number N of missiles to be used in the attack.

A more efficient method of calculation will be to calculate the ν_a and N for a number of values of C from which graphs can be plotted and solutions obtained at a glance. Graphs for specific cases involving the United States will be presented later.

4. The strategy of the defense. If the set of cities to be attacked were predetermined and if they were attacked with many more missiles than the number of defending missiles, the distribution of the missiles defending these cities would be immaterial: the number of arriving missiles would be equal to the difference between the total number of attacking and of defending missiles. These, then, could be distributed over the cities the way the attacker wishes. The damage he could cause would be independent of the distribution of the defending

missiles: it would be the same as if the attacker had only $\sum n_a - \sum s_a$ missiles, and the cities were undefended. This shows that the principal problem of the defense is to make the attacker's choice of the cities he will attack as ineffective as possible.

It is also clear that the optimal defense to be derived may not be optimal if the attacker does not use the most effective offensive tactic described in the preceding section. The number of casualties he can cause with a different tactic will surely not exceed the number of casualties he could cause with the tactic given above; it will almost certainly be lower. However, if the defense knew ahead of time how the attacker would distribute his missiles over the various cities, he could, in all likelihood, design an even more effective defense than the one most effective against the most effective attack. To mention a very obvious case: if the defender knew that all the attack would be directed at city **c**, he would defend only that city. However, such a defense would be very much worse than the one to be derived below if, for instance, the attack is the most effective one described in the preceding section.

The observation at the beginning of this section shows that the damage the attacker can cause with a very large number of missiles is insensitive to the distribution of the defending missiles. The optimal distribution of these is, therefore, determined, principally, by their ability to decrease the effect of an attack in which not all of the defended cities are targeted. If the efficiency $f_a(\nu_a)/(s_a+\nu_a)$ of the highest efficiency attack on different cities **a** is different, the attacker will concentrate on cities at which the efficiency of his attack can be made highest. Hence, the total efficiency of his attack can be decreased by shifting more defense to cities for which the highest efficiency attack is high—shifting until the maximum efficiency attacks on all defended cities are equal, i.e.,

$$\frac{f_a(\nu_a^D)}{s_a+\nu_a^D}=D. \tag{13}$$

The quantity ν_a^D in (13) is so determined that the expression on the left side will be a maximum. As indicated by the discussion of the attack given in the preceding section, this will be the case if ν_a^D satisfies the inequality (4):

$$f_a(\nu_a^D+1)-f_a(\nu_a^D)<D<f_a(\nu_a^D)-f_a(\nu_a^D-1). \tag{14}$$

Indeed, if the attacker increases the number of missiles aimed at **a**, the efficiency of his last missile $f_a(\nu_a^D+1)-f_a(\nu_a^D)$ is smaller than D, hence decreases the total efficiency. The same is true if the last missile is removed: according to (14) its efficiency is higher than D.

Hence, the defense can be planned the following way: one chooses an arbitrary D and determines the ν_a^D by (14), the analogue of (4). Then, one determines the s_a by (13), setting it, however, equal to 0 if $f_a(\nu_a^D)/\nu_a^D \leqq D$. Then, one calculates the sum of the s_a and if this exceeds the number S of defending missiles available, one repeats the calculation with a larger D. If the sum is below S, one chooses a smaller D. Eventually, one finds a D such that, with the ν_a^D given by (14), and hence the s_a given by (13), one also has

$$\sum s_a = S. \tag{15}$$

We will show, next, that if (13), (14) and (15) could be satisfied, and if the attacker has enough missiles to attack a reasonably large number of cities, or in fact all defended cities, the defense would indeed be optimal. The reservation of this statement is due to the fact that the s_a given by (13) will not be, in general, integers but as long as the s_a are reasonably large, this should not matter and, for the present, we disregard this fact.

Let us observe, first, that the efficiency of every missile directed at the undefended cities, i.e., for which $s_b^D = 0$, is less than D, since $f_b(\nu_b^D)/\nu_b^D < D$, and the same applies for missiles in excess of $s_a + \nu_a^D$ directed at defended cities. Hence, if the number of attacking missiles N exceeds $\sum (s_a + \nu_a^D)$, the attacker will direct $\sum (s_a + \nu_a^D)$ missiles at the defended cities, causing a damage $D \sum (s_a + \nu_a^D)$, and distribute the rest in the most efficient way but with efficiencies below D. This means that all the defense will be exhausted, but will decrease the number of missiles arriving at the targets as much as possible. In the case of $N > \sum (s_a + \nu_a^D)$, the defense is perhaps not better than any other defense but at least as good as any.

If the number of attacking missiles is just equal to $\sum (s_a + \nu_a^D)$—we call this a "tuned attack"—all the missiles will be aimed at defended cities and the number of fatalities will be $D \sum (s_a + \nu_a^D) = DN$.

If the number of attacking missiles is just equal to $\sum (s_a + \nu_a^D)$—we call this a keep the efficiency of his missiles at the level D by attacking some of the defended cities, and, if city **a** is attacked, target $s_a + \nu_a^D$ missiles at it. In order to make his attack most efficient, he will choose the cities in such a way that the sum of $s_a + \nu_a^D$, extended over the attacked cities, is equal to the number N of missiles he employs. This will be possible with a good approximation as long as the number of defended cities is quite large. If he attacks any city with a number of missiles different from $\nu_a^D + s_a$, the efficiency of his attack will decrease. In order to see that the defense given by (13), (14) and (15) is optimal, let us observe that if the defender should change the distribution of his missiles from that given by these equations, shifting some missiles, let us say from **c** to **d**, the attacker will bypass **d** and use his missiles on **c** with increased efficiency.

To put this more formally and also more rigorously, let us denote the shift of missiles to target **a** by δ_a so that this target will have $s_a + \delta_a$ missiles defending it. Some of the δ_a will be positive, some negative, and $\sum \delta_a = 0$. The attacker can then select targets in such a way that the sum of their δ_a is negative and the sum of their $s_a + \nu_a^D$ equal to the number N of missiles he intends to use. Denoting the sum in question by $\sum^1$, one has

$$\sum\nolimits^1 (s_a + \nu_a^D) = N, \qquad \sum\nolimits^1 \delta_a < 0. \tag{16}$$

The attacker can aim $s_a + \nu_a^D + \delta_a$ missiles at each of the selected targets, causing the same damage DN which he could have caused, at worst, at the arrangement we want to prove to be optimal. He will have left over $\sum^1 \delta_a$ missiles with which he can cause additional damage: the changes in the distribution of the defending missiles made the defense less efficient; the original distribution given by (13) was optimal.

The preceding discussion uses two assumptions in addition to those stated in the § 2. The first of these is that the number of targets is so large that the attacker can select from them a set on which the maximum efficiency attack will require just

about as many missiles ($\sum^1(s_a+\nu_a^D)$ in our notation) as he wishes to use. This means that the defense cannot make use of the attacker's possible inability to select just the number and size of targets which will absorb the intended attack size. Since the efficiency of the attack changes very slowly in the neighborhood of the maximum efficiency, this is not a very restrictive assumption. The second assumption, obviously incorrect, is that (13) can be satisfied, i.e., that the s_a given by (13) are integers. However, the shift of the s_a, as given by (13), to the nearest integer is surely of very little significance if s_a is reasonably large—and a defense force consisting of only one or two missiles appears impracticable anyway. It may be worthwhile, nevertheless, to propose a definite method for the determination of the defense allocation. The simplest of these is, evidently, to replace (13) by

$$\frac{f_a(\nu_a^D)}{s_a+\nu_a^D+\frac{1}{2}}<D<\frac{f_a(\nu_a^D)}{s_a+\nu_a^D-\frac{1}{2}}. \tag{17}$$

Another, slightly more advantageous, variant of (13) and (14) is

$$\frac{f_a(\nu_a^D)}{s_a+\nu_a^D}=D_a, \tag{18}$$

$$f_a(\nu_a^D+1)-f_a(\nu_a^D)<D_a<f_a(\nu_a)-f_a(\nu_a-1), \tag{18a}$$

admitting again that the maximum efficiency on the different targets cannot be made precisely equal. However, it is then postulated that

$$\sum(D_a-D)^2 f_a(\nu_a^D) \quad \text{be a minimum} \tag{18b}$$

where D is, naturally, given by

$$\sum(D_a-D)f_a(\nu_a^D)=0, \tag{18c}$$

and (15) remaining, equally naturally, unaltered.

These variants of the equations determining the allocation of defense missiles may be of some theoretical interest. Explicit calculations indicate that the difference between them and the ones discussed in some detail, that is, (13) and (14), is surpassed by the variation due to the inaccuracy caused by the uncertainty of the functions f_a and their variation depending on the time of the attack. It is, perhaps, useful to observe, nevertheless, that if there are only two targets, the calculation of the optimal s_a can be carried out easily, leaving (13) essentially unchanged but modifying (14) significantly. The optimal s_a do depend, in this case, on the size of the attack. The violation of the assumption that the number of targets is large causes the optimal s_a to depend, in this case, on the size of the attack.

5. Defense of U.S. cities. We used the square-root-law damage function [5]

$$f_a(\nu_a)=P_a[1-(1+k_a\sqrt{\nu_a})\exp(-k_a\sqrt{\nu_a})] \tag{19}$$

to represent the fatality function, in which P_a is the population of city **a**, and k_a is a constant, called the k-factor. The constant k_a was determined for (19) by using a value of ν_a to produce $f_a \approx 0.5\, P_a$ as calculated from an independent and more detailed method. This method consisted, in brief, of a blast-damage matrix

calculation with a log-normal mortality function, in which the aim point of each weapon was the center of a 5-km quadrangle, based on population data from SRI (Stanford Research Institute) [6], selected such that the fatalities from each successive weapon would be the maximum, after the fatalities from the preceding weapon had been subtracted. For further details, the reader is referred to the report of Haaland, Wigner and Wilson [7].

The difference between fatalities calculated by (19) and those obtained by the lengthy matrix method were negligible for nearly all of the 410 cities in the SRI data base for which we made computations. An example is shown for Houston, Texas in Fig. 4, in which the scale of the ordinate is chosen to provide straight lines for curves following the square-root-damage law.

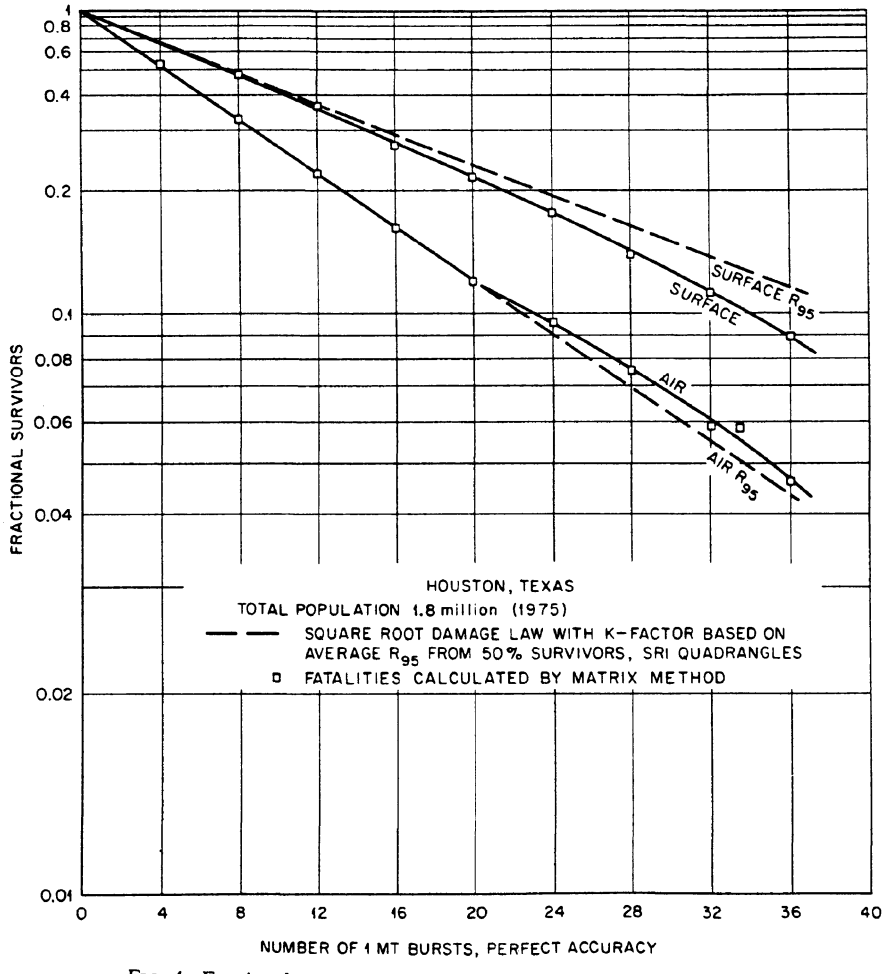

FIG. 4. *Fractional survivors vs. number of* 1-MT *bursts on Houston, Texas*

After the k-factor has been determined for a city, the effective radius for 95% destruction, R_{95}, can be determined, from which k-factors for other weapons yields, height-of-burst, and target vulnerabilities can be obtained, as described by Haaland et al. [7] using the methods developed by Galiano and Everett [5] and Goodrich [8].

As mentioned earlier, graphical displays of a range of solutions to the algorithms provide the quickest answers to questions concerning the major parameters. Our calculation of a range of solutions proceeded as follows:

1. Select a value for D.
2. Calculate ν_a^D from (7) with $C = D$ for each city with the k-factor selected for the weapon yield, type of burst, and vulnerability of population. Round off ν_a^D to the nearest integer.
3. Calculate s_a from (17) for each city and drop the decimal fraction.

Our solutions for a range of parameters are shown in Figs. 5–8. Values of D were specified from 3×10^{-4} to 0.3. All solutions shown pertain to 0.1 MT surface bursts. Vulnerabilities of population ranged from 4 psi MLOP (Mid-Lethal Over Pressure) valid for an untrained population remaining in their usual domiciles), to 100 psi MLOP, as can be provided by blast shelters.

We assume that the highest vulnerability of 4 psi MLOP represents the outcome from a combination of early weapon effects, including blast, thermal radiation, initial nuclear radiation, and subsequent fires in a situation where people have no warning whatsoever and do not know how to take protective measures after the thermal flash. In this situation there would undoubtedly be additional fatalities resulting from fallout radiation, which are not included in our calculation.

Our second category of vulnerability of 7 psi MLOP is assumed to represent the situation where the public is given adequate warning several minutes before the first nuclear detonation, and people are trained to take rudimentary protective measures, but protective shelters are not available to them within the time remaining between warning and detonation. Again, additional fatalities would result from fallout radiation, although less than in the 4 psi MLOP case, because some of the survivors of the early effects would presumably have the knowledge and be able to construct expedient shelters, or would know where to find a fallout shelter.

The remaining categories of vulnerability shown in Fig. 5, extending from 10 psi MLOP to 100 psi MLOP, correspond to situations in which the entire urban population of 157 million people within the data base we used are located in protective structures at the time of the detonations. The minimum vulnerability of 100 psi MLOP may correspond conservatively to the protection afforded by some of the tunnel shelters below the cities of China [9]. In each of these situations, the additional fatalities due to fallout radiation are negligible because of the protection afforded by the structures. We assume that a defensive program of this nature would include fallout protection for the rural population, as well as thorough planning for post-attack recovery, including reserves of food, medicine, insecticides, fertilizer, petroleum, and additional equipment for reestablishing communications, transportation, and critical industries.

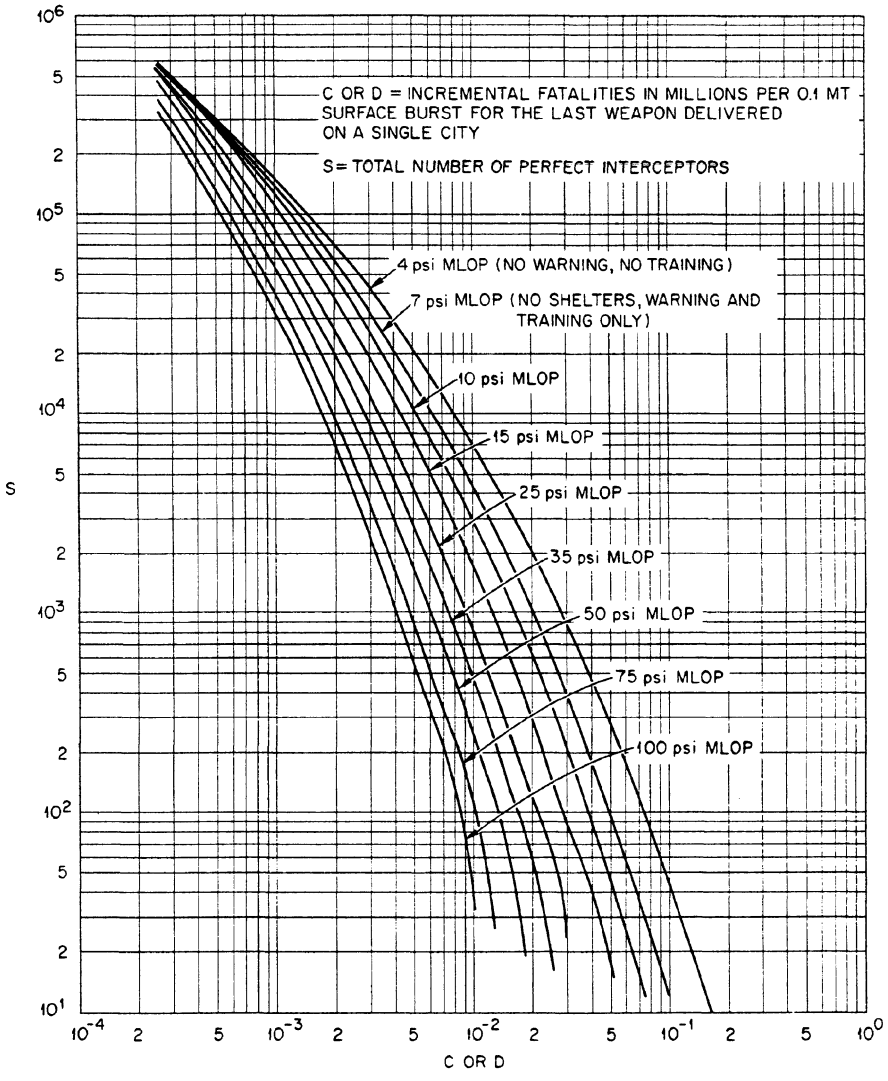

FIG. 5. *Total number of interceptors vs. attack or defense parameters, C or D, for a tuned attack for various vulnerabilities, for* 410 *cities of the U.S. In a tuned attack the number of attacking missiles is just equal to* $\sum (s_a + \nu_a^D)$ *and all the missiles will be aimed at defended cities.*

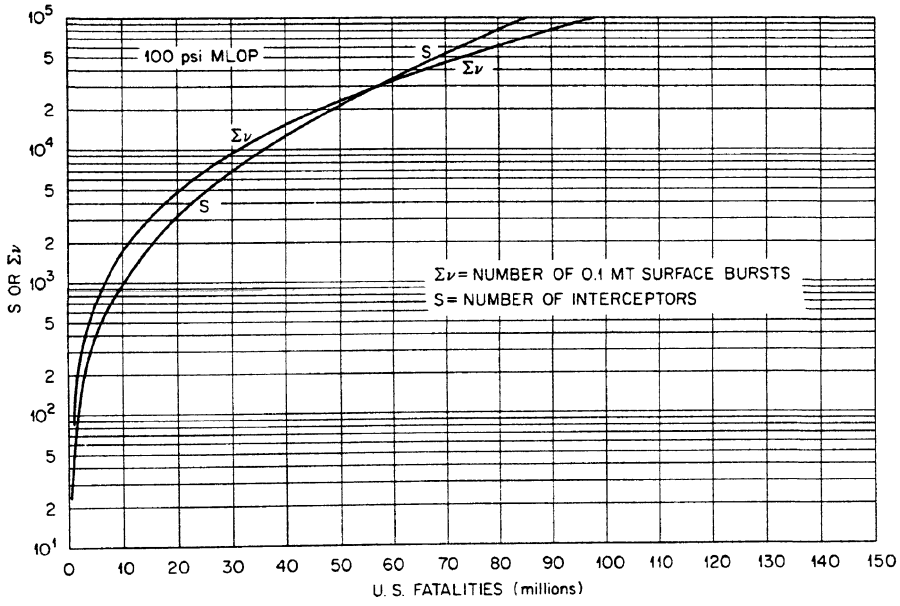

FIG. 6. *Number of interceptors, S, or number of detonating* 0.1-MT *weapons vs. U.S. fatalities, at* 100 psi MLOP *vulnerability*

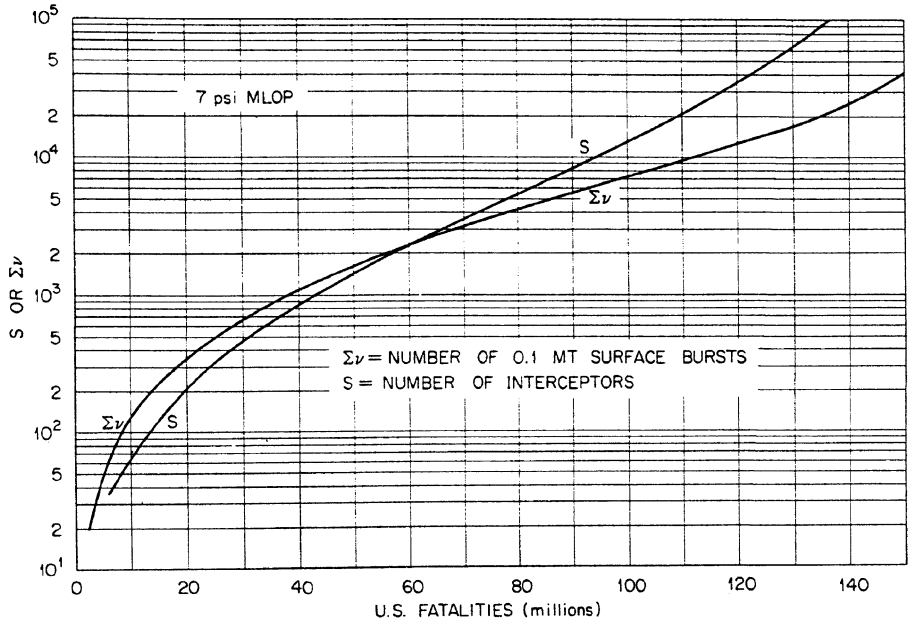

FIG. 7. *Number of interceptors, S, or number of detonating* 0.1-MT *weapons vs. U.S. fatalities at* 7 psi MLOP *vulnerability*

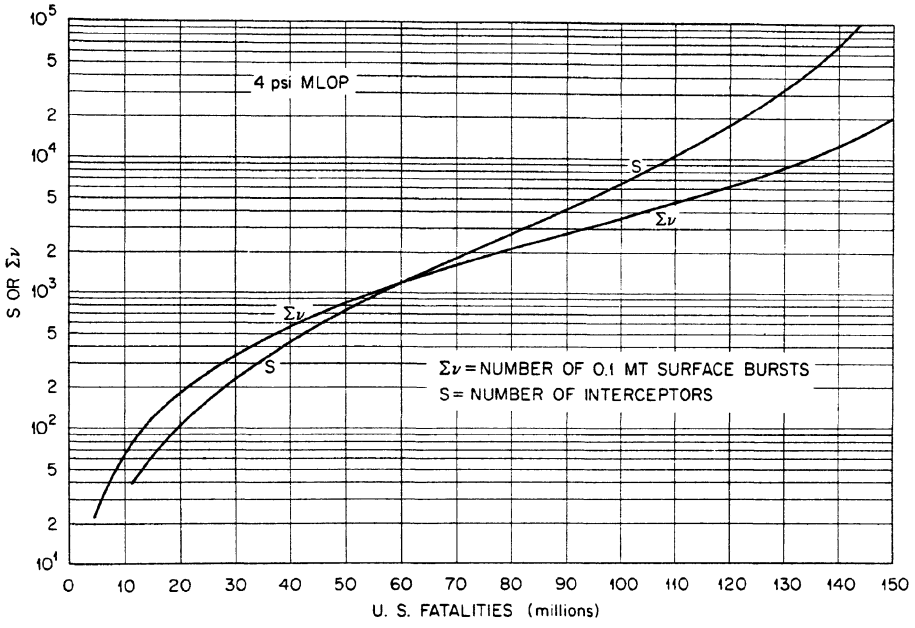

FIG. 8. *Number of interceptors, S, or number of detonating* 0.1-MT *weapons vs. U.S. fatalities at* 4 psi MLOP *vulnerability*

The curves in Figs. 6, 7 and 8 correspond to vulnerabilities of 100, 7 and 4 psi MLOP respectively, and these are to be used in conjunction with Fig. 5. The values of $\sum \nu_a^D$ and S at a given value of the abscissa (U.S. fatalities) are those for which $C = D$; in other words, for a "tuned attack".

It may be instructive to consider a few examples in which the graphs are used. Suppose the U.S. has a total defensive force of 1000 interceptors. From Fig. 5, we read, corresponding to $S = 1000$, values of $C = D$ of 0.028, 0.020 and 0.004 for vulnerabilities of 4, 7 and 100 psi MLOP, respectively. If the vulnerability of the people is 4 psi MLOP, we read from Fig. 8 that the prompt fatalities from a "tuned" attack would be approximately 56 million, and $\sum \nu_a^D$ for this attack would be about 1000; hence the total attacking force would be $N = S + \sum \nu_a^D =$ 2000 missiles.

For the same vulnerability, if the defense has 1000 interceptors and the attacker has only 1000 missiles the maximum prompt fatalities the attacker can achieve is $DN = 28$ million. If the attacker has 3000 missiles, then from the value $\sum \nu = N - S = 2000$ in Fig. 8, the maximum fatalities would be about 77 million. In the latter case the value of $C = 0.018$ for the attacker can be obtained by reading the value of S at the same abscissa for $\sum \nu$ in Fig. 8 and then by finding C for that value of S in Fig. 5.

In similar fashion the numbers for a large range of parameters can be obtained from Figs. 5–8, of which some are summarized in Table 1. Three general observations on Table 1 are of interest:

TABLE 1

U.S. fatalities for various attacks against optimized distributions of defensive missiles*

Defending force S	Vulnerability psi (MLOP)	D	"Tuned attacking force		Other attacking force strengths		
			N (tuned)	Fatalities (millions)	N = 1000	N = 2000	N = 4000
					Fatalities (millions)		
1000	4	0.028	2000	56	28	56	92
	7	0.020	2200	43	20	40	66
	100	0.0040	2800	10	4	8	15
2000	4	0.020	3800	72	20	40	77
	7	0.015	4000	56	15	30	56
	100	0.0032	5500	16	3.2	6.4	13
4000	4	0.015	6800	89	15	30	60
	7	0.010	7400	72	10	20	40
	100	0.0025	10000	23	2.5	5	10

* 0.1-MT surface bursts positioned for maximum fatalities.

1. Fatalities at 4 psi MLOP vulnerability are reduced by factors of 4 to 7 when 100 psi MLOP blast shelters protect the people. The area over which a weapon can produce the midlethal overpressure is reduced by a factor of about 25 by providing these blast shelters, according to a relationship between the overpressure and the radius from the detonation point [10]. However, the fatalities are only reduced by the factors of 4 to 7 because the attacker uses a higher value of C (Fig. 5) for the 100 psi MLOP vulnerability than for the 4 psi MLOP, indicating that the attack in the 100 psi case concentrates more on densely populated areas.

2. Fatalities are reduced by a factor of about 0.8 for each doubling of the number of interceptors, for the range of numbers considered here.

3. Fatalities can be doubled by the attacker simply by doubling that number of attacking missiles, as long as the total number remains less than that for a "tuned" attack.

6. Nonoptimum distributions. Our algorithm for optimal deployment of interceptors assigns single interceptors to many small cities. Such deployment is impractical for radar-guided interceptors because of the high cost of the radar relative to the interceptor.

We have explored nonoptimum distributions in which we take away interceptors from the cities with less than some number x interceptors assigned to them in this optimum distribution and redistribute these interceptors to the remaining cities which have x or more interceptors. The new distribution requires a lower value of D such that all cities remain on the list of attacked cities. For the few cases we have tested, the increased fatalities resulting from such nonoptimum distributions is less than 2% for $x < 3$ and less than 5% for $x < 10$.

As an example, one optimal deployment of 1814 interceptors distributed them among 80 U.S. cities. When those cities with 4 or less interceptors assigned

to them had these interceptors taken away and these were redistributed among the 40 U.S. cities which remained with active missile defense, then fatalities from the same number of attacking missiles increased by 2%.

We conclude from these explorations that the outcome to the defender is not highly sensitive to certain changes in the distribution of defending missiles.

7. Concluding remarks. We have avoided the subject of costs, partly because the costs of future ABM systems may differ greatly from current systems, and partly because we feel that costs will not be the primary factor if and when the U.S. decides to build an effective strategic defense system. We feel certain that even a short-warning defensive system, including blast shelters at least as good as those under the cities of China, will cost less than one-tenth the sum spent by the Nation since World War II on maintaining offensive capabilities.

Acknowledgments. We are grateful to Michael T. Heath for preparing the computer program for this study and to John V. Wilson for helpful comments and suggestions.

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Soviet Nuclear Strategy

E. P. Wigner

Letter to The New York Times, July 7, 1977, p. A18

To the Editor:

This reader wishes to congratulate The New York Times on the very informative report on Soviet nuclear strategy, by Drew Middleton (news story June 25). The U.S.S.R. newspapers and their official statements certainly do not subscribe to the mutual assured destruction doctrine or to the statement so often heard in our country, that "a nuclear war would be the end of mankind". They claim that their civil defense would reduce their casualties in a nuclear war to a small percent of the population – this is perhaps the principal point not sufficiently emphasized in the report – and the calculations of those losses available in our country indeed estimate their losses at between 2 and 4.5 percent. This against our losses of 45 percent because of the absence of similar civil defense preparations.

Eugene P. Wigner

Dept. of Physics, Princeton University
Princeton, N.J., June 28, 1977

We Heartily Disagree

E. P. Wigner and A. A. Broyles

Journal of Civil Defense *10*, 4–8 (July–Aug. 1977)

Scientific American's *editor, Dennis Flanagan, declined to publish the following letter rebuttal to an eleven-page feature article which contained questionable defense data. The letter-written by Dr. Eugene P. Wigner and Dr. Arthur A. Broyles – "sets the record straight" with an exposure of part of the article's misinformation and the alarming disparity between Soviet and American civil defense capabilities.*

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December 16, 1976

Mr. Dennis Flanagan, Editor
Scientific American
415 Madison Avenue
New York, New York 10017

Dear Sir:

In the November, 1976, issue of the *Scientific American,* there appeared an article entitled, "Limited Nuclear War" (LNW). It is somewhat surprising to find in the pages of this publication an article that is more political than scientific, but there it is. We have requested an opportunity to present an article giving more completely the scientific aspects of nuclear warfare, but since this request has been denied, we write this letter to answer the main political thrust of the article, one with which we heartily disagree.

The authors of LNW (Sidney D. Drell and Frank von Hippel) have written their article to defend a national defense policy that has influenced a large number of our government officials. It proposes to maintain a situation where "We and the Russians are each others' nuclear hostages." In order to keep US citizens in a hostage state, many members of the Congress have opposed antiballistic missiles (ABM) and civil defense shelters. These devices would prevent American deaths in case of nuclear attack and thereby rescue our people from being hostages.

The proponents of holding American hostages point out that, if losses to *both* sides are unacceptable in a nuclear war, this war will not occur. They fail to note, however, that if one side keeps its population vulnerable while the other does not, the weak side is likely to be forced to capitulate to the strong, probably without the need of an attack. It will have to succumb to what is called a "nuclear blackmail." This point is consistently disregarded in the article we are referring to.

"ONLY THOSE WHO NEGLECT"

Evidence has been accumulating for a number of years at an ever increasing rate that the Soviet Union and the Chinese have no intention of leaving their people unprotected. Indeed a reading of statements by their leaders indicates their intention to, if nuclear war comes, survive it and fight it through to a victorious conclusion. As the Final Document of the 1969 convention of the 74 communist parties of the world announced "The existing situation demands united action of Communist and all other anti-imperialist forces so that maximum use may be made of the mounting possibilities for a broader offensive. . .". And, in this "offensive" the protection of the people from nuclear weapons should play a crucial and effective role. As Marshal W. I. Chuykov, former Chief of Soviet Civil Defense, said: "Although the discussed means of destruction are called mass means, with knowledge and skillful use of modern protective measures they will not destroy masses of people but only those who neglect the study, mastery and use of these measures." (Did he refer to us?)

The defense of the hostage theory is often based on the statement (see LNW), ". . . in the event of nuclear war neither this country nor the USSR would be able to defend itself against virtual annihilation." This is a belief that has enjoyed enormous popularity in the press. It is totally incorrect as it stands. It was denied by (former) Secretary of Defense Schlesinger and is at variance with a number of careful calculations. One of us (EPW) has published such a calculation, well known to at least one of the authors (SDD) of the article we criticize and uncontradicted in the literature, showing that if the USSR evacuates its cities before a confrontation, the losses our missiles could produce would be well below 4 per cent of the population.* The PONAST study, organized by the National Security Council, considered a nuclear attack in which the USSR aimed two thirds of its destructive force at civilian targets, This attack would destroy 45% of the US population under our present inadequate civil defense system. Is this an acceptable situation? The same study shows that if we equal the Swiss defense expenditure per person for about 10 years, these losses would be reduced, *by these measures alone,* to about 5½ per cent of the people.

*T. K. Jones of the Boeing Aerospace Company estimates Soviet losses at 2% — well below our 4% estimate.

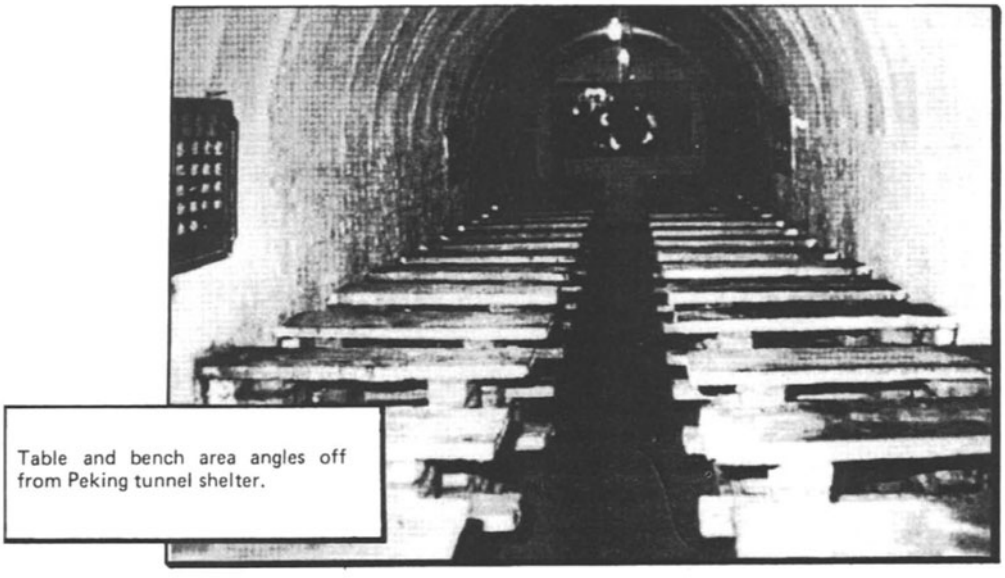


Table and bench area angles off from Peking tunnel shelter.

The protection of a civilian population from the effects of nuclear war can involve four primary elements: (1) a capability of destroying enemy ICBM's before they are launched, (2) an ABM system to destroy them on the way in, (3) a dispersal procedure to remove the population from direct blast and fire, (4) and a shelter system that places a shield between people and the blast wave, fire, and radioactive radiation.

As we shall see, all of these elements appear in the Soviet and Chinese systems taken together, but one system emphasizes some elements while the other chooses others. It is interesting to note how the difference in the two civil defense systems reflects on national intentions in the next few years.

For years, the United States built its ICBM's to carry a small pay load as a deliberate contribution on our part to maintaining our population in a hostage condition. In order to destroy ICBM's before launch, it is necessary to penetrate their shielded silos even though the explosion may be several tenths of a mile away. The small bombs, for which our missiles were designed, were unable to accomplish this. One way to make small bombs effective is to improve their guidance system to place the explosion nearer to the silo. The LNW article states that the U. S. does not have silo destroying missiles but is conducting research and development along these lines. The Soviets have had for many years, however, large ICBM's capable of destroying hardened silos even with relatively poor guidance. Their SS-9's carry a single 25 megaton pay load or three mirved 5 megaton bombs. Former Assistant Secretary of Defense Packard said as long ago as 1969, "The Soviets are testing multiple warheads on the SS-9. And if they give the SS-9 three individually guided warheads with high accuracy and high yields — which they are fully capable of doing — then they triple their threat to Minutemen (our ICBM's) and remove our confidence that that portion of our deterrent can survive in adequate numbers."

Of course there are submarine based ICBM's, and these are harder to locate. The Soviet answer to our Polaris fleet is a large number of "killer" submarines. These submarines are faster than our Polaris ships. They are designed to wait off our coastal naval bases and to stay with our subs when they leave port. They are then in position to destroy them by torpedo.

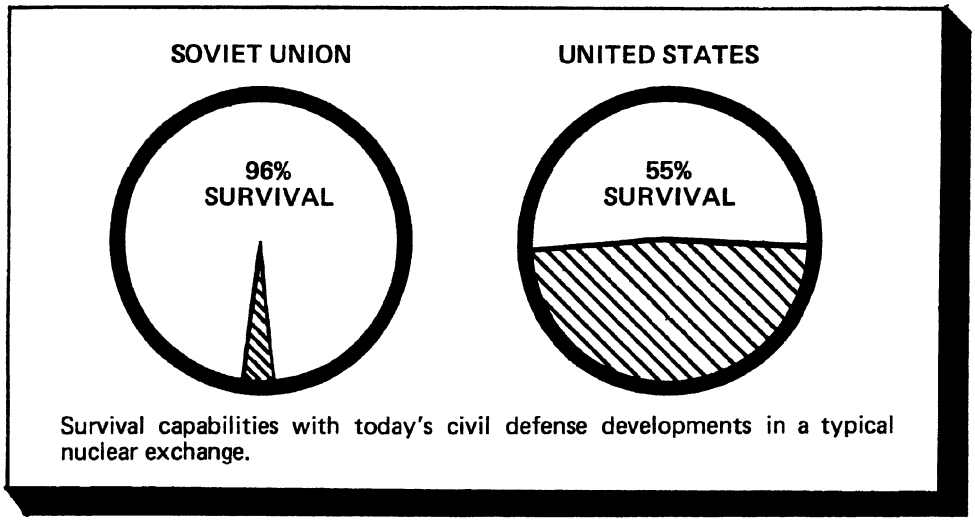
ABM — EVACUATION — SHELTER

The United States has developed the world's most effective ABM's. As a measure of this effectiveness, we note that Professor Hans Bethe of Cornell University studied the ABM system proposed in 1968 and favored the deployment of the thin system (with twelve sites) which was under consideration at that time. It is not surprising that the Soviets have been willing to sign a treaty to restrict ABM bases to one locality. They have chosen to defend Moscow. We have declined to defend any city. There is no evidence in the published literature at this time of a Chinese ABM system.

The Soviet Union has adopted a highly effective civil defense plan that provides for the evacuation of their city populations to outlying areas. These people then construct "expedient shelters" using materials at hand. For example, where forests are nearby, a trench is dug and lined and covered with small logs. Earth is then piled on top to provide a blast resistance of 40 pounds per square inch, (Tested by the Oak Ridge National Laboratory). These shelters also provide quite adequate protection from fire and fallout radiation. They also reduce the midlethal blast distance from a one megaton explosion from about 4 miles to less than 1.5 miles, thus reducing the area covered by this pressure by a factor 8. Soviet estimates are that this program can be expected to reduce the loss of life in a large city from "90% of the population . . . to a level between 5% and 8%." The calculation referred to before shows that their nationwide losses would be less than 4% of their population even if all our missiles were directed at their people and their ABM totally ineffective. This is less than half of what they suffered in World War II and raises the question of whether they are effectively deterred from attacking us. One may well wonder whether the LNW statement that 200 surviving missiles, less than one fifth of our inventory, would constitute an "overwhelming retaliatory force" was meant seriously.

The Chinese plans are quite different. They have constructed blast shelters in their cities in the form of tunnels. They are readily accessible and provide good and rapid protection for the people. Many photographs were taken of these shelters. The Chinese in a sense boast of them. They were also shown to President Nixon on his visit to China.

It is interesting to compare the Soviet civil defense system with the Chinese. The Soviet plan requires two to three days to put into effect. We have checked by actual trial that an average family can construct an expedient Russian designed shelter in about two days. Where do they find those two or three days? They have them if they are planning to precipitate a confrontation, with a threat to attack. The Chinese system, on the other hand, requires only a matter of minutes to reach shelter. It is ready immediately if they are attacked without warning.



Survival capabilities with today's civil defense developments in a typical nuclear exchange.

ODD ARGUMENTS

The "Limited Nuclear War" article raises the question of whether the Soviet government is actually serious about its civil defense plan. In answer to this, we can cite the fact that they printed 130,000 copies of their 1969 civil defense manual of 351 pages. They published, since, a new edition. Plans for expedient shelters have been distributed. Civil defense training has been implemented in the schools so that, by the time a child completes the tenth grade, he has received a total of 115 hours of civil defense instruction. Adult civil defense training is also mandatory. There is little doubt that over 100 million people have taken their intensive training course. Blast shelters have been constructed particularly to protect factory workers. Blast doors have been provided for subways. The television, radio, and newspapers continually remind the Soviet populace of the need for civil defense. One Soviet source indicated in 1969 that "more than a thousand persons have participated and are participating in (providing civil defense) television broadcasts in all studios." Every town has an evacuation transport commission headed by the deputy chairman of the local Council of Workers' Deputies. Detailed plans for evacuation are available to him.

Evacuation exercises are expensive. They bring factory production to a halt and increase the chance of accidents. Nevertheless, individual institutions and factories are required to conduct frequent evacuation drills and at least one sizeable city, Sevastopol, has been evacuated. The success of this drill showed that the evacuation plans can be implemented and also taught them how to improve them.

The LNW article opposes a US civil defense program because it would remove our citizens from a hostage status – a status designed to prove to the Russians that we will never attack them. The argument is also presented that an improvement of our civil defense would stimulate the Soviets to further upgrade their civil defense. But they are already far ahead of us in this area. Are we to simply abandon the arms race and leave it to them to obtain overwhelming superiority with all the dire consequences to our life and freedom? It is pointed out that an armed nuclear truce has existed for many years without an American civil defense. This ignores the fact that, until the last few years, US superiority in nuclear weapons was great and evident. That superiority is now gone and the balance is heavily tipping toward the Soviet Union.

We find in LNW a rather strange statement. "In the 1960's the US adopted a strategic policy giving top priority to the prevention of nuclear war through deterrence rather than to preparation for fighting nuclear wars if deterrence should fail."

How do you deter an attack unless you convince an enemy that you will fight the war that he is starting? We find it extremely doubtful that any one can be convinced that we will retaliate unless we are prepared to protect our population from the consequence of that retaliation.

It may happen that the American public will awaken some morning to learn that, for the past six hours, a Soviet city evacuation has been underway. Our President will then face three alternatives: (1) launch a nuclear attack against the Soviet Union, (2) order the evacuation of our cities, (3) or do nothing. If he chooses the first alternative – we surely do not advocate this – he can expect the loss of 45% of America's unprotected population in the Soviet retaliatory attack. If he chooses the second alternative, without the planning that should go beforehand, American roads will soon be jammed. Those people lucky enough to reach the countryside will not know where to go to find food, other necessities, and how to build expedient shelters. If he chooses the third alternative and does nothing, the President will soon be faced with Soviet demands under the threat of a nuclear war where American losses can be expected to be almost half the population while the Soviets will suffer a population loss of less than half of that in World War II. We propose to make the second option a reasonable one by preparing the American population to carry out a civil defense plan like that in the Soviet Union. If we can evacuate and construct shelters as they can, they will see that they cannot gain by executing their plan, If they do set evacuation into motion, we can maintain the nuclear balance by doing the same. If, finally, they do attack, we can save a maximum number of

COMPARATIVE DEFENSE CAPABILITIES

	1	2	3	4
	ICBM Silo Destruction	**ICBM Destruction in flight**	**Population Dispersal**	**Sheltering of Population**
USSR	Good	Poor	Good	Good
China	Poor	None	None	GOOD
USA	Good	None	POOR	POOR

American lives to rebuild our country after the war.

These are not the only points of criticism that we have of the LNW article but our letter is long enough as it is. On the other hand, we wish to approve this article for communicating a good deal of useful information and compliment its authors for having raised a very important question in *Scientific American*.

Sincerely yours,

Arthur A. Broyles

Arthur A. Broyles
Professor of Physics, University of Florida

Eugene P. Wigner

Eugene P. Wigner
Professor of Physics, Princeton University

Atoms, Arms, and Apathy

An Interview by E. T. Tildon

Journal of Civil Defense *12*, 24–27 (Nov.-Dec. 1977)

For well over a decade, one of the world's foremost physicists, Dr. Eugene P. Wigner of Princeton University, has worked ceaselessly for a stronger system of civil defense in the United States. More than 30 years ago he was an important member of that elite band of scientists who developed the first atomic bomb. Holder of many awards, including the Nobel Prize, this intelligent, sensitive man, born in Hungary 75 years ago, cherishes one award above them all: the freedom provided by his American citizenship (granted in 1937). Here Dr. Wigner talks about his life and views with Earl T. Tildon of DCPA Information Services.

EARL TILDON — Dr. Wigner, tell us something about your early backgound.

EUGENE WIGNER — I was born in Hungary. I studied in Germany, where I was trained as a chemical engineer, which was very useful in my later life. I later became a physicist, and was employed for a little while in Germany, when suddenly, in 1931, I received an offer from Princeton University as a visiting professor. I accepted it, and from then on I essentially lived in this country.

My early views of this country were greatly influenced by the contrasting lifestyles of the very formal Princeton, and the less formal University of Wisconsin where I taught beginning in 1937. At Wisconsin I made friends more easily, and felt more at home than I had earlier at Princeton. I learned to love the openness of the Midwest, which I still prefer to the crowded cities of the East Coast.

Tildon — What are some of your thoughts regarding your early involvement with the atomic bomb?

Wigner— We were all so afraid of Hitler, who was a dictator, and who said as clearly as the Russian leaders do today that he wanted to conquer the world. When fission was discovered in 1938, we all realized that this might give rise to new types of weapons. We feared that the Germans would develop it first, and that would make it much easier for them to conquer the world. That worried us deeply, and we decided that it would be good if the United States developed that weapon so that it would not be unprepared in case of a confrontation.

When the weapon was ready for use, Germany was already defeated in the Second World War. And most of us that worked on the weapon felt that the U. S. should not use it against Japan, and we circulated a petition to this effect. However, I am now convinced that lives were saved. Had we not used the bomb, the war would have been continued and it would have been very difficult to defeat the Japanese in their homeland. They were ready to sacrifice their lives for the defense of their country. A few years ago I read a book by Feis which said that the use of the atomic weapon in that case saved 1.5 Million Japanese

lives and about 150,000 or 200,000 American lives because it made it possible for the Japanese to surrender. I have some Japanese friends and colleagues, and I asked them, "Is this true?" They all said "Yes."

I think we did the right thing in developing the bomb. The atomic bomb was bound to be developed. The discovery of fission was a great discovery. To make atomic weapons from that was perhaps more difficult than we realized, but it was evident a bomb could be made. Almost every physicist who heard about fission realized that this was possible. It was good that a peace-loving country like ours developed it first, and not a country bent on conquest.

I am most proud that we did not ever threaten Russia with an attack with the atomic weapon, and that we used it as moderately as possible. A Russian once told me: "We wanted to go much farther in Western Europe, and we could not do it because the U.S. had the atomic weapons."

Tildon — How did you become involved in civil defense?

Wigner — When I was a member of the general advisory committee to the U. S. Atomic Energy Commission, I learned about the effectiveness and the possibilities of atomic weapons. But, I came to realize also that there was a defense against them. And I decided that it is better if the two countries can defend themselves, rather than both annihilate or destroy the other. And that is why I started to work on civil defense.

Tildon — What were your early views of civil defense, and what are some of your present observations?

Wigner — My early views were not very different from my present views. I believe we should build shelters, and good blast-resistant shelters. The Oak Ridge National Laboratory had a project on it, and developed a system — the Tunnel-Grid System — which was reviewed many times. At that time we thought it would cost about $115 per person in the U. S. Now the view is that it costs $170, which is $35 BILLION for the whole country. But, according to the PONAST II study (Post Nuclear Attack Study of 1973, conducted by the Joint Chiefs of Staff and involving participation by more than 30 military and civilian agencies) it would reduce the fatalities which a Russian attack could inflict on the U.S. to about 5 percent of the population. It is now 45 percent. There is an unbelievable difference between 45 percent and 5 percent.

We have done far too little in civil defense, and we have not even seriously tried to interest the common people in this effort. This is a great mistake. We should make the common people realize that they can defend themselves, that they can do a great deal to make their lives more secure.

We (the Wigners) have built a shelter here in Princeton. We have a shelter in our summer home in Vermont. And the people around us in Vermont know this, and they know that you can produce a good deal of defense against nuclear weapons. But in the cities, people do not know, and many people deny it on the basis of entirely incorrect information.

Tildon — Dr. Wigner, you have frequently spoken out against some of your scientific colleagues who oppose civil defense. What are some of your views in this regard?

Wigner — This is a very interesting story. The original argument against civil defense was that if we install civil defense, the Russians will believe that we are preparing a first strike, and we don't want them to believe that. Surely it was never true. Then came the time when the Russians prepared civil defense. So this argument had to be abandoned. The next argument was that if we prepare civil defense, the Russians would increase their armament and our civil defense would not be effective. The Russians increased their armament, even though we did terribly little on civil defense.

The last argument that I heard was essentially the sincere, true reason — that they don't want the average person (non-scientist) to be thinking of the possibility of a war. You know what Marx said: "What keeps us loyal to our cause is not what the cause does for us. It is what we do for the cause." Some people in our country do not want the average person to have too much zeal and too much loyalty to the country and its institutions. I am sad to say that, but I am convinced it is true.

The state of awareness in the scientific community has increased partly because we learned a great deal from Solzhenitsyn (Alexander Solzhenitsyn, Soviet dissident and Nobel Prize-winning novelist) and others. From Solzhenitsyn we learned that the West has to defend itself, has to be on the alert if it wants to survive as an independent State, as a State in which there is freedom and freedom of expression of opinion. He realized that there is a desire in the heart of the dictators to conquer the world.

I think that scientists should instruct people. They should explain to them what a nuclear war means, and how we can defend ourselves. They should also point to the enormous differences between a free society and a totalitarian society. Most people do not fully realize that.

It is not easy for scientists to communicate with the average person, but when they communicate, they should tell the right thing, and it will have the right effect. I know. In Vermont we communicate very well with the people in the same village. It's a very small village, but we understand each other, we speak the same language, not only in that we speak English, but we understand what the other one means, what his emotions are, what his desires are, what he enjoys in life, and what causes him trouble and discomfort.

I am moderately optimistic that the scientific community, in time, will do its job.

Tildon — Is Russia's civil defense superior to ours, and as costly as is claimed?

Wigner — Their civil defense is unbelievably superior to ours, even though it is not the civil defense I am most in favor of. It is largely an evacuation plan, though not entirely. However, as far as the cost is concerned, much if not most of it consists in diversion of people from other types of work to this type of work, to civil defense work work — to teaching it in schools, which takes a lot of energy of the students who could learn instead much that is more useful in peacetime, of the teacher's time who also could teach something that, in peacetime, is more useful, more valuable. The same applies to the construction of shelters in the factories, when they could produce goods for the consumption of people. A Russian worker works for almost everything four times longer than a

U. S. worker. The only important exception is the rent of his lodging, which is cheaper than ours. But for almost everything else, he spends four times longer at work to pay for it than we do.

Tildon — There is a contention by some in high places in the United States, Dr. Wigner, that the United States could easily overcome any advances in Soviet civil defense simply by retargeting our weapons aimed at Russia. What's your reaction to this point of view?

Wigner —I reject it completely. I made a calculation on the fatalities that we could inflict on the Russian population in case of an evacuation by retargeting completely, shooting at all the evacuated population, and assuming also that the Russian first strike is totally ineffective, and that their ballistic missile defense is totally ineffective. Under these assumptions I arrived at the result that we could destroy something between 2 3/4 percent and 4 percent of their population, which is not terribly much. There is another calculation carried out by T. K. Jones of the Boeing Company, who came to the conclusion (he used more realistic assumptions, I used very pessimistic assumptions) that we could destroy only 2 percent of the Russian population.

Tildon — Would a U. S. civil defense buildup cause Russia to react, thinking we're planning a nuclear attack?

Wigner — Certainly not. As you know, Brezhnev said: "Don't worry. If I offer you my embrace, you will not refuse it." They know very well the U. S. does not want to extend its power or its territory. We have a resistance against immigration and not against emigration. We don't want to grow unreasonably. We want you to have children. We want you to have a happy life. But we don't want more territory.

Tildon — Almost a decade and a half ago, you responded to the argument that the military situation of the U. S. was so strong that we do not need any civil defense. You said that "even if we need no civil defense now, this may not be true in 5 years." The recently appointed DCPA Director, Bardyl Tirana, is saying essentially the same thing now. He said: "We don't need nuclear attack preparedness on this specific day, but I don't know about 3, 5, or 10 years from now. Civil defense planning is long-lead in nature." When is the right time?

Wigner — I think the right time is to start as soon as possible. Because the threat will increase, and we should work hard and devotedly on the defense of freedom in this world. Because that is what we are defending. It is often said that, even if we don't destroy much of the Russian population, we can destroy much of their wealth and industry. And that is probably true. But you know what the Russians say, and what they repeat again and again. It is what Lenin said: "The primary productive factor of all humanity is the laboring man. If he survives we can save everything and restore everything, but we shall perish if we are not able to save him." In other words, the Russians consider the saving of the population to be the decisive factor. And you see, they are right, because even if we destroy their productive capacity, once they have defeated us they can force the rest of the population of the earth to supply them with everything. Seven percent of the population of

the world is Russian. The rest of the people can supply them with their livelihood for years. Ninty-three percent can support seven percent for many, many years, and certainly for a few years, so that they can restore everything as Lenin said.

Tildon — As you look back, how do you view your personal life, Dr. Wigner, especially your life here in America?

Wigner — I have had a very happy life on the whole. Science gave me immense pleasure. When I could read an interesting article — when I could add a tiny bit to the knowledge of mankind — this was a wonderful thing. And this was made possible for me by Princeton University and also by the University of Wisconsin.

I also have a very happy family life, and our daughter is now living close to us and we see her often. This makes my my wife and me very happy.

When I understood the spirit of this country — and I understood this for the first time in the few years that I spent at the University of Wisconsin — I realized what an enormous difference there is between this country and the country which I left and which was under the Hitler dictatorship of Germany. And how much my love of this country has increased. Some of my friends were communists. A few of them thought they would have a happier life in a communist country and moved to countries under communist dictatorships. They all came back completely cured. □

America Needs a Better Civil Defense Program

E. Teller and E. P. Wigner

Congressional Record – Senate, August 2, 1979, pp. 22402–22403. In: United States of America, Congressional Record. Proceedings and Debates of the 96th Congress, First Session, Vol. 125, Part 17, July 31 to August 3, 1979. U.S. Government Printing Office, Washington, 1979

An increasing number of Americans realize that the future is uncertain and threatening. Modern technology has wiped out our ocean barriers; the world has become a small neighborhood and not a peaceful one. The military power of the U.S.S.R. is steadily increasing; the total explosive power in their transcontinental missiles surpasses those of ours fourfold. These are weapons of attack, intended to harm the opponent.

The situation is much worse as far as defensive measures are concerned, weapons intended to protect the country and its people. We have no defense against their missiles; they have missile defense at least for Moscow. They also have widely spread anti-anticraft defenses; we have virtually none.

But the gravest disparity prevails in the area of population defense. They have an elaborate civil defense system; ours is tragically ineffective. They spend more than $1 billion annually on civil defense; our civil defense budget is less than one-tenth of this. Will this improve when all of our emergency relief efforts come under the same roof? We hope so.

The U.S.S.R. has elaborate plans for the evacuation of their cities. Children receive instruction in schools on this subject and it continues for the workers in factories. They are taught where to go and how, what to take along, what to do at the location of evacuation, how to build improvised shelters and how to act if they see the flash of a nuclear explosion.

All this is very effective: the estimates of fatalities from our missiles after evacuation range from 2 percent (which may be a bit low) to 6 percent of their population (which we believe to be too high). Our own estimates are around 4 percent.

At the present stage of our civil defense preparations—which are hardly in existence—their missiles could destroy the lives of half of our people.

The evacuation of cities takes time; the Russians claim it could be done in two days, but it may take longer. Hence, the evacuation plans would not be effective in the case of an atomic surprise attack from America. But the Russian leaders know there never will be such an attack.

Nevertheless, in the last few years, they started building elaborate shelters which are easily and immediately accessible for those whom they do not want to leave their jobs even for a short period. These shelters would provide protection not only against radiation but also against the other effects of nuclear explosions. The U.S.S.R. also started to accumulate food reserves and to build secure places for food storage.

Russian plans contain blueprints of shelters that protect against fallout and can withstand more than two atmospheres overpressure, sufficient for a dispersed population. The Russians also claim that people can erect these shelters in two days.

An experiment was tried near Oak Ridge, Tenn. Six farm families who volunteered were given translated Russian blueprints and no other help. They were promised $600 if they built the shelter, with a bonus of $200 if completed in two days. All six families built the shelters; five finished in two days; the sixth took three days.

We have not even informed our people about the Russian civil defense preparations, manifested not only in their school and factory instructions but also by their civil defense handbook, of which more than a million copies were printed. It is easily accessible and has even been translated into English.

How much would it cost us to organize an evacuation plan at least as elaborate as the Russian one? The estimates are all below $1 billion, less than 1/1,000th of our government's yearly expenditures. To create effective and rapidly accessible shelters would be much more expensive. The cost may amount to about 4 percent or even 5 percent of the yearly expenditures of our government, but it would be a single expenditure, not a yearly one. Our city evacuation would not be as effective as that of the U.S.S.R.: they have more powerful missiles than we have, fewer of their people live in cities than live in ours, their cities are not so close together as many of ours are.

Nevertheless, the evacuation, to be undertaken as a countermove to the evacuation of the Russian cities, would reduce the casualties they could cause to such an extent—by a factor of about five—that our president

would not be forced to give in to their demand. This would be recognized by the leaders of the U.S.S.R. and, presumably, the demand would not be made. As the Swiss (who have an excellent civil defense system) say, the greatest advantage of a good civil defense effort is that it never will have to be used. Of course, a shelter system would be even more effective.

Why do we have no evacuation plan and no shelter system? Why are our people not even informed of the Russian measures in that direction? The only explanation that we could think of is that such measures would irrevocably inform our people that a danger exists. It is understandable to want to avoid telling people of the existence of danger. Yet we believe that if one has to choose between pleasantly forgetting a danger but incurring it, and unpleasantly knowing about it but protecting against it, one must choose the latter.

THE ALASKA EXPERIENCE

Civil defense, small as it is our country, has proved helpful when disaster struck. In the spring of 1965, the Alaskan legislature in Juneau abolished civil defense in order to save $100,000. One week later, the biggest earthquake in U.S. history struck Alaska. But their civil defense was still in existence, and went into action.

On Kodiak Island, fishermen live along the shore; there is also a small naval station. Minutes after the earthquake, the naval station got a telephone call from a civil defense worker: "Use the radio station, send out sound trucks. Warn the population to leave the shore. A tidal wave may be coming." In half an hour the tidal wave arrived and killed seven people. Without the warning, the loss in human life would have been at least 10 times greater.

Total property damage in Alaska amounted to $400 million (in today's dollars that would be $1 billion.) Anchorage, with its population of 50,000, was hit hard, yet the death toll was relatively small, some 150 killed.

The greatest loss of life in San Francisco in 1906 was due not to the earthquake but to fire. In Anchorage, too, there was fire; the danger was there; the earthquake caused big oil spillages. But civil defense personnel roped off the danger zones and erected warning signs. The armed-forces also helped in Alaska, but that help came late, eight hours after the earthquake. Civil defense was small, but alert and effective.

There was as happy an ending as there can be after an earthquake: The legislature in Juneau mended its ways. The budget for civil defense was reinstated, even doubled to $200,000.

Civil defense and disaster preparedness belong together. The new organization that is to embrace both has, so far, unfortunately, only an acting head and no significant budget.

Against any kind of disaster, an effective evacuation plan can be valuable. Developing techniques of weather observation make it possible to predict floods further in advance than in the past, and the paths of hurricanes will be predicted with increasing reliability. Even earthquakes need no longer be completely unexpected, although earthquake prediction remains an art, not yet a science.

More lives will be saved if there is organization for evacuation. In our country, of course, evacuation will have to be voluntary. A governor or the president could issue the warning. People could then call an appropriate, preassigned phone number. In each section of a city, callers would be advised where and when to go. All traffic would be one way, and predetermined locations would be prepared to receive the evacuees. Food and medicine could be stored in advance; much must depend upon hospitality.

If people know there is a plan, they would be less likely to panic. That enormous emergency, nuclear war, should never come; if it does, though, it should find us prepared. If we are unprepared, it is probable that we will be hit; if we are prepared, most probably the preparation will not have to be used.

PART V

Recapitulation 1979–1983

Wigner's papers, in this period reiterated his themes, including the need for civil defense training in schools, the need for civil defense to allow a citizenry to remain resolute in the face of threats from a dictator, and the desirability of a peaceful world in which governments' primary concern is the well-being of its citizens.

Civil Defense in USA and Elsewhere

E. P. Wigner

In: International Seminar on the World-Wide Implications of a Nuclear War,
First Session, Aug. 14–19, 1981, Ettore Majorana Centre for Scientific Culture,
Erice, Italy. E. Etim and S. Stiptich (eds.). Servizio Documentatione
dei Laboratori Nazionali di Frascati dell'INFN, July, 1982.
Reprinted: World Scientific, Singapore 1992, pp. 43–50

My subject, civil defence, is a somewhat specialized one, and I would like to begin, as Dr. Teller also did, with a more general subject. I am afraid I will repeat a few things that have been said before, but I cannot avoid this. Even if one makes mathematical calculations one often rederives theorems which have been established before.

Let me begin with the fact that wars have existed since antiquity and apparently since antiquity there were two extreme kinds of wars. The first type of war was motivated by the fact that some people were short of food and other necessities of life, and had to chase away the people who occupied some land nearby so that they could have the food that was available there.

One of the wars which was motivated by the fact that the people needed some land where they could live and where they could grow food was the occupation of Hungary in 896. Another one was the settlement of the Israelis in the present Palestine after they could leave Egypt. But there were many such wars. I often wonder whether the fights between the tribes in the present United States were wars of this nature – there were many, many of them. The other question which is in my mind is how justifiable it is to resort to aggression, if one needs it to provide the necessities of life. After all, those whom you defeat also need the necessities of life.

The other type of war is motivated by the desire of the ruler of a nation, or of a community, to extend his power and to become the master of a larger number of people, of a greater community than he is at the time. There are many, many examples of wars which were motivated this way. Perhaps I mention the war of the Persians against Greeks which did not benefit the Persian people, the war of Hannibal against Rome, and the effort of Rome's rulers to occupy the whole world. There are more recent examples: the Tartars wanted to occupy Europe, the Turks wanted to occupy Hungary, Napoleon and Hitler – you know their story. This is evil. But it is very difficult for a dictator not to strive that way – man lives by his desires and he wants to do something, and it is natural for him to want to extend his power. If a dog has eaten enough he lies down and goes to sleep, but man does not do that. A man wants to accomplish something, and what else should a dictator accomplish? He is already ruling his own country, so he wants to extend his power. Of course, the two types of wars which I mention are two extremes but they both exist. There were

also wars with characteristics in between, which served some purpose useful for their people but also the extension of the power of their rulers.

What is the effort of a war? Well, it certainly shortens the life of many people, but the different nations and the different cultures have very different attitudes towards this shortening of the lives of very deserving people. In our culture, most people try to stay away from the war and not participate in it. In Japan the attitude of people is different. You remember about the Kamikazis who were quite happy and willing to commit suicide, and this was very effective and had a great deal of effect on the war. In Iran they just boasted how wonderful it is to die for the country and what pleasure it gives. It is difficult for us to accept and understand this. The worst is of course that in earlier wars the loss of lives was enormous, in fact greater than in present wars. It even happened that the lives of practically all members of a nation were extinguished. The thirty-year war reduced Germany's population to one third. In the Second World War Russia suffered enormously, but the total loss was about 6% of the total population and not 60% , which would have been different. We now believe that war is a crime and it should not be undertaken under any condition, no matter what the purpose is.

How large are the total losses of life caused by a war? The difference, it appears, is enormous between the two kinds of wars I mentioned. In case the attack aims at the acquisition of the means of living, food and land, it is often in the attacker's interest to cause large casualties, essentially in order to exterminate the earlier owners of the land. He does not wish to share much of the land with the earlier owners. If the war is started by an aggressor, or more than one aggressor, as was the Second World War, the aggressors are happiest if the losses of lives in the nations attacked are small, if these surrender soon. The aggressor can justify his actions more easily if that is the case. In such a war the defender, if victorious, is also happiest if the aggressor becomes discouraged early, when his and the aggressor's losses are not yet too high. Thus, when the nuclear weapon was to be used against Japan, many of us thought this would be terrible and I even circulated a petition asking that it should not be used. Actually, it now appears that we were wrong – it appears from Feis' book (Japan Subdued) that the Hiroshima and Nagasaki explosions saved about one and a half million Japanese and about two hundred thousand American lives by making it emotionally possible for the Japanese to give up. My Japanese friends concur with Feis' point.

There is another case which illustrates the last point: it is often referred to as "Munich". This is Hitler's acquisition of mastery over Czechoslovakia – a conflict which ended, unhappily, with the victory of the aggressor. We must admit that Hitler's first set of demands was not totally unreasonable. But when Czechoslovakia agreed to these, this made its defence so weak that it had to submit to the second set of demands which postulated complete surrender. In this case the aggressor could extend his power without a war, without suffering any losses, and extend his rule over the undiminished population and wealth of the conquered nation.

It is this second type of aggression that I fear. The USSR does not truly need our land or food but its rulers may want to extend their powers – as did so many dictators before. One day they may put their civil defence into action, order the "dispersal" of the population of their cities – in my opinion this would reduce the population losses which our missiles could cause to about 4 percent. It would be possible then to threaten the US that unless it permits the stationing of their troops at some places in the US, or more likely that unless it dismantles its airforce, tomorrow sixty percent of its people will die. What should the President of the US do if such a threat is made?

Perhaps I will mention that I once gave a talk at the University of Delaware about my participation in the uranium project, and I spoke a little about the later events, including my interest in civil defence. The Professor who invited me said "Nonsense! if the Russians threaten us, we should give up and we should surrender to them." And this is an opinion which I cannot accept. Perhaps I will add one more point to my second subject. This is that I believe that the so-called Mutual Assured Destruction is nonsense, because suppose even if the attacked nation could retaliate, if the other nation pretends it does not believe it and makes a demand, is there any point in resisting? What good does it do to it if it can destroy hundreds of thousands of the aggressor's lives if its own nation is exterminated? As a result, I am very convinced that defensive weapons are terribly important, that they are the only ones which can protect peace, and civil defence is a vital element of the defence.

What would happen if we surrendered? We do not know, but I am not absolutely sure that it would be terrible. You know that Louis XIV of France was a dictator of France and he said "l'Etat, c'est moi", but he was not very cruel. So we do not know. But it is sure that if a single dictator acquired power over the whole globe, the world would develop into an ant heap, in which everybody would be told what he has to undertake, perhaps even whom he should marry. But perhaps they would not go that far. You know that when a student finishes his thesis in Russia, he has the freedom to say what he would *like* to do. But he is also told what he *has* to do. And this is not a good situation. If he cannot make decisions, he feels like an ant and feels oppressed. Perhaps I mention that I had many such complaints when I visited a country which is under Russian domination.

What would I like to see the world develop into? I would like to see, and this may be controversial, I would like to see different countries with different kinds of cultures, and freedom of the people to move from one culture to another culture. You know that the United Nations has a demand that "everybody has a right to leave his country, even the country of his birth" and that even the Soviet Union subscribed to it. And this would be very important. Our culture and our world have changed very much in the last three centuries, terribly much. In particular, the physical problems of man are essentially solved so that the purpose of man, the purpose which was still present very much when I was a child, has changed very much. And the changes may be very good but we cannot be entirely sure. All fundamental changes are dangerous – we

do not know the future. It would be terribly bad if the whole world had one culture and the same kind of structure, for some cultures may be suicidal and, anyway, it is important for man to have choices. This would also induce the governments to think more intensely about the happiness and about the desire of their people.

These questions are, of course, present in many peoples' minds, but a dictator, in particular the present big dictatorships, really want to conquer the world. I can give many reasons why I am afraid that this is so. The first one which I mention is very old. There was a Pugwash conference at which I participated. You must have heard about the Pugwash conferences. Some Russians also participated and they accused us of having invented the nuclear weapons and they were right in this. Of course, they soon imitated our invention. Anyway, I said when they accused us of this that "you must admit that we used the nuclear weapons with restraint and discretion". And the Russian who made the accusation said, "I do not know, if you did not have the nuclear weapons, we could have conquered all of Western Europe". And this is not a good sign. Of course, the Russians who participated had the full confidence of the Russian government so they were not average Russians. The average, probably, or even surely, had no such desires.

The second example I will mention is the statement which Kruschev made, "The war will end with the victory of the socialist power and the extinction of the capitalist system which is doomed to destruction". Brezhnev also said "Do not worry, if I offer my embrace you will not refuse it", which is an indication that he does not want to offer this embrace. Another statement which he made was, "We stopped increasing our weapons supply extensively around sixty-five", yet this was the date when they started to extend their weapons supply enormously. According to the British survey of weapons supplies, the Russian missiles carry four and a half times more explosive power than the American missiles, and this is not good. But anyway I believe that the world which I describe, with different cultures, different nations, living at peace with each other, but competing with each other for the well-being and happiness of their people, for the attractiveness of their country, is a much better world than an ant heap in which all the earth is dominated by a single power, by a single dictator who wants to impose his will on everyone. And, fundamentally, not even he would have a valid and interesting purpose.

Well, the question arises then: how should we defend our freedom and our ideals? I know that many people believe that we should not defend them, but I know we should, and in my opinion it would be much better to defend them with defensive weapons, and Dr. Teller told us how effective some of the active defensive weapons can be. Perhaps they are so effective that we do not need anything else, no other defensive weapons, no civil defence. I do not believe this. If we can invent weapons which destroy the enemy's aggressive weapons, the enemy can probably invent weapons which destroy our weapons which are intended to destroy their aggressive weapons. I think it is important to have a real double defence so we can be reasonably sure that we can resist a threat.

Well, what I recommend is essentially a disarmament, but disarmament not of ourselves, but of our opponent. He can interpret, of course, our preparation that we want to disarm his weapons.

It can, and probably will, be said that our civil defence destroys the retaliatory power of a nation which we may want to subject to our rules. But this argument is refuted by the fact that the USSR already has an effective civil defence which is never criticized (and which I will discuss later). We can also remember Brezhnev's words: "If I offer my embrace you will not refuse it" which shows that he knows that we do not want to conquer. At any rate, a world in which neither of two opponents can destroy the other is much, much more stable than one in which each can destroy the other. Again, this is confirmed by Brezhnev's words: "Which weapons induce tension, offensive or defensive weapons?"

Before going on, I would now like to say a few words about a much argued question, the problem of the N-bomb. I am convinced that this is really a defensive weapon because it is much less effective, it has much less power, than an offensive weapon of the same size and cost would be. It has a much smaller range of effectiveness. It has so little effectiveness because it is to be used only in territory which we want to defend and where we want to make the destruction as small as possible. It is, of course, easy to say, as many people do, that it kills only people and does not destroy material, but it kills fewer people than the same size and cost weapon would kill in a country attack. It is really designed with the purpose to discourage an invasion or at least make it a less tempting undertaking. But this is not my principal subject. I wanted to mention it but I would like now to go on to my last subject: what are the "methods" of civil defence, what measures can significantly decrease the effectiveness of an attack against the civilian population and to what extent are these measures realized in the various countries. I will not discuss the Swiss civil defence because we will have a much more effective and knowledgeable speaker on that subject.

There are three methods of civil defence, three measures which can greatly reduce the loss of life which nuclear weapons would cause. Perhaps I mention that I once attended a conference on civil defence in Switzerland in Interlaken. I arrived about four hours before the start of the conference and they took me around and showed me one of their shelters in a mountain. I was very much impressed and I congratulated and complimented them. And I said: one sees that your budget of civil defence is much larger than that of the United States. My guide answered: "Oh, it is hardly larger than yours". And I said that it means that it is fifteen times larger per person – which is incorrect, it is thirty times larger. And he said, "Oh I do not think it is larger per person than that of Soviet Russia". I think he was a little mistaken on that, but anyway, it was an interesting experience.

Well, the first method of civil defence is to organize an evacuation and the dispersal of the population of the cities. The USSR has gone very, very far in that direction and on the whole, I believe it has been successful. It is true that Moscow was never evacuated and I do not think Leningrad was either. Some

cities, including Sevastopol were, and they are thoroughly prepared to carry out evacuations, or "dispersal of the population" as they call it. Surely, it is the least expensive and easiest method of civil defence to evacuate cities and not leave any high density population.

The second method in much more expensive, but much more effective also. It is to build shelters and there are elaborate plans how to build them and, as I mentioned, the Swiss have very good shelters. Every new house must have a shelter in it, also in Sweden. The Swedes have very good civil defence also and so does China. The USSR is also engaged in building shelters on an extended scale. Perhaps I also mention that they have one hundred and thirty miles of subways, the tunnels of these have added protection. They claim that the people in these are absolutely safe against nuclear attacks which is not entirely true. Their subways do, however, furnish *much* protection for about one million people, which is more than nothing. Now they also build other shelters on a reasonably large scale.

The third method of civil defence is teaching. Particularly in democracies people should make, and do make, the important decisions. Therefore, they should know what is possible, what is desirable, what is likely, how much it would cost, and so on. And some of such teaching goes on on a rather large scale in the Soviet Union, both in grade school and in high school. But we have nothing of it – most people know terribly little about the weapons' effects. They do not know what to do if they see a flash in the sky which is probably the explosion of a weapon – that they should lie down and close their ears, and many other little things they do not know. I think it would be terribly important to thoroughly inform them. Perhaps I mention one more thing before giving up on the subject, no two more things. First, that civil defence preparations would require the collaboration of the whole population to a greater extent than any national activity that our people now engage in. It can lead to some local gatherings and other similar activities which can give pleasure to people just as participation in societies and clubs gives pleasure. Thinking of and discussing a joint defence effort can also create a sense of community. It can increase patriotism and I believe the possibility of this is one of the motivations of some of the opponents of civil defence.

But, second, let me admit that the introduction of civil defence measures would remind people that dangers do exist, that there are uncertainties in the future against which defence are necessary. And it is unpleasant to realize this. But in a democracy the people make the decisions and they cannot make the right decisions unless they realize the actual facts. Of course, we all realize that there are diseases and we must try to protect ourselves against them. This realization is also an unpleasant experience but we do adjust to it. Similarly, we must adjust to the fact that we have an obligation to defend ourselves and freedom in general. I hope we will.

Education – Key to Civil Defense Success

From An Address to The American Civil Defense Association on October 9, 1981 in Washington, D.C.

E. P. Wigner

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Defense against nuclear attack, says Eugene Wigner, is not by any means an agreeable subject. But it is a NECESSARY subject. Like the study of crime and disease — also highly disagreeable — it needs attention for the good of mankind. Just as criminology and health classes tend to control crime and disease so will classes in civil defense pay off in lifesaving preparedness. Logical focal point: the high school classroom.

Can We Create an Effective Civil Defense Structure?

Should we? Well, as you know, I am very concerned about the future of our country. I owe terribly much to this country, and I became devoted to it when I was grown up. You know, when we are children and we learn that we should be grateful to some organization or some institution we soon forget that because we take it for granted that they will help us. But the favors we receive when grown up stay with us and we remain grateful for them. Since I received so much from our country as a grown-up, I do think perhaps more of its future than the average citizen. And there is another factor why I am so devoted to civil defense. Most people may intellectually know that civil defense is important, that the country is in danger. They know it, but they don't *believe* it. But I have seen countries perish, and so I not only know that this is possible, I even believe it.

The situation I am most afraid of would be precipitated if the Soviet Union "dispersed" as it calls it — the population of its cities and threatened our country with the destruction of a large part of the population (and you heard numbers given which are in fact unpleasant to repeat), *"unless"* . . . And this "unless" could be that they are allowed to station troops in, I don't know, at least in Alaska and perhaps in northern Washington state and so on. And they would threaten that if we do not agree to all that a large fraction of our people will die tomorrow. What should our President do then? This danger is always in my mind. And this is why I try to support the realization of the dangers, not only intellectually, but also emotionally, and do something about them.

To know of a danger, to fully understand it, is a disagreeable thing. And it is not pleasant to tell people: "There is a danger. You should install protections against it because otherwise something very bad can happen." And I see on your faces that it is difficult also for you to accept such things. But, actually, it is not impossible to communicate this. Thus, we all learn early in our childhood that there are diseases, that we have to go to doctors to help us against them. And there are other problems. We learn this early in our lives and we do adjust to them. And if we adjust to them we don't feel them as a pain. In fact, several of us know that our lives will have an end.

But we adjust to it and close our eyes to it. And that is so, but it is not possible to fight against it as it is now possible to fight against the existence of disease. It is for this reason that it is best to learn about problems and difficulties early in life. It is easier to adjust to them. That is the principal reason for the proposition which I want to communicate to you: namely to teach about civil defense in schools and make the young people acquainted with the fact that there is a danger to the country and that we must protect it and that it is not only necessary, but also possible to protect it.

Also, we learn in school that there are some things we should not do because it may endanger our health. Similarly, I think it would be good if they learned early in their lives some means of protection against the effects of nuclear weapons and the dangers which nuclear weapons produce.

Well, this is my principal proposition — that we should introduce teaching on civil defense in our schools and get the young people acquainted with the fact that a danger may exist and that we should prepare against it as much as possible. Of course, I also hope that the children who learn this communicate it to their parents. And I am sure they would do it.

Is It "Wicked" to Have Civil Defense Teaching in Schools?

Some people say, and some people maintain, that it might be provocative against the Russians if we introduce civil defense instruction. Well, you know that the Russians have elaborate teaching about civil defense in their schools, in all their factories and in many institutions. Everybody is told where to go, what to do. Those who abhor the proposal of our protection of our people do not criticize the USSR that it does it. The Russians are allowed to do that perhaps because they are in a dictatorship. But certainly, we shouldn't do it some people say. I think we should contradict this vigorously.

You know from the Pentagon publication that the Russians spend every year the equivalent of 2 billion dollars on civil defense. And Mr. Chipman told me that these $2 billion are salaries of full time civil defense employees. In other words, the fact that every factory director has the duty to devote some of his time to the instruction problem of the members of his factory, that is additional to the $2 billion.

But if we spend $130 million a year on civil defense and the Russians spend $2 billion, if they have 115,000 people directly employed in civil defense effort, while I think we have less than 5,000 then it is evident that we are terribly much behind.

Well, I told you something that is not good. But let me now tell you that I was very pleased when I learned a couple of months ago that the FEMA now has plans to make possible the teaching of civil defense in the schools. The proposal has not been made very public. Otherwise, I would have found out about it perhaps even earlier. I don't know how many of you know about it. Most FEMA people do know. They have prepared four books for instruction and one for the teaching of the instructors. I brought along the last one. And I was very, very glad when I heard about this.

When I read the book I was not fully satisfied with it. And I will tell this because I think it is good to know that there are problems. The book has 76 pages, but only 12 of these pages are devoted to civil defense. There are altogether 11 subjects treated within it. I won't enumerate them all — hurricanes, floods, tornado and so on — fire, volcano, and the last one is nuclear radiation disaster. And this section is not terribly clear. It concentrates on subjects such as that the x-rays were discovered by Roetgen in 1885. But this does not really help very

much in protecting against radiation. (Roentgen did not protect himself sufficiently.)

Well I have gone to the FEMA people who worked on this and offered my criticism, and I very much hope that, contrarywise, the FEMA people will offer their criticism of my proposal so that both will be improved. Their book will be even better, and my proposal will have more completeness.

The Instruction of Civil Defense:

My proposal for the teaching of civil defense in the schools consists of three parts. And , you know, it is good if we make definite proposals and not only proposals to increase the budget. The increase of the budget is good, but if you have something definite to propose, it is even better. And, as you will see I don't want to increase the budget greatly.

Well, how should we arrange the teaching of civil defense and of the dangers of a nuclear war in the schools? I think that the procedure, and this is what should be criticized, should consist of three parts:

1. We should organize a set of what I call instructors, and these instructors should really be familiar with the problems of nuclear explosions and defense against them — civil defense, *real* defense. These instructors should go around the country and give classes to teachers selected from the schools. I think principally of instruction of high school teachers.

2. From every high school about two teachers should attend the classes of the aforementioned instructors and become familiar with the ways and also the effectiveness of civil defense measures so that they can impart this knowledge to the students and not only *can* impart it but *wish* to impart it.

3. The last step would be of course just the imparting the knowledge to the youngsters in the school. And the youngsters will accept it just as they accept that there are some diseases, some contagious diseases, some ways to decrease the danger of this contagiousness, and many other things which are also unpleasant to know. It would be much better if there were no diseases in this world.

There are in our country around 29,500 high schools. And I feel, therefore, that about 60,000 teachers should be instructed. The classes which these instructors give to the teachers should have about 15 teachers in every class, and it would be necessary to have altogether 4000 courses for preparing teachers for all high schools. Each course should take perhaps six hours and about three instructors should be present most of the time. This means that in order to convey the needed information to the teachers, about 70,000 instructor-hours are needed.

The instructors can teach on the average about 6 hours per week and can teach during perhaps 40 weeks per year. This means that we need about $70{,}000/240 \approx 300$ instructor-years to provide the initial preparation of teachers in our high schools.

This means that if we extend the initial teaching period for two years — then about 150 instructors would be needed. Of course, teaching should also be done after that because one forgets things, and if one relies only on one's own knowledge that is not good — one should get together with greater experts and learn again. And this means an expenditure, according to my estimates, of about $15 million per year — which is not very much. But this is only for direct expenditures. Of course, the mere fact that they occupy rooms and take up times of teachers can be counted as expenditures, but shouldn't.

But let me mention two serious problems. First, how to choose the

instructors and how to teach them. Of course, there are some people who know a great deal about civil defense. There is a very good book written by Cresson Kearny about civil defense: *Nuclear War Survival Skills*. It describes the effects of nuclear explosions, and not only describes but also recommends possible protective measures against them. But whether this is final I don't know.

But even more serious is the second problem which I will admit exists, namely how to choose two teachers from every school to attend these classes and then transmit their knowledge to the students. First of all, they should be able, not only to accept, but to incorporate into their knowledge — really incorporate — some facts about nuclear explosions and civil defense. And second, they should be interested in the subject and devoted to it so that they can do some really good teaching and not only talk quickly. There is a tremendous difference in the acceptance by the students whether the teacher is apparently interested in doing the teaching, or whether he just goes there in order to do something. And this is not easy —to find the teachers who are really good for this, who can impart the knowledge to the young people and know and believe that they are doing something very important.

I believe, civil defense officials should get to know the schools and get better acquainted with them. But this is a problem. Perhaps somebody will propose a good solution. It is a *serious* problem which should be on our minds, and we should try to solve it.

Well, what do I hope? What do I hope the result will be? The result I hope will be that we wake up, that we adjust to the necessity of civil defense just as we adjusted to the necessity of police even though it is unpleasant to know that we have to be protected against crime. It would be much better if crime didn't exist. Similarly it would be much better if there were no need for civil defense, if the Russians didn't write in their books that "the war will end with the destruction of the capitalistic countries which are doomed to destruction". It would be better if no crime existed, but we have to adjust to the necessity to have a police, and we should adjust to the necessity to defend our nation.

And, as I mentioned, we also adjust to the possibility of the necessity of medication. And just as this adjustment reduces the necessity of its use, civil defense can be fully expected to reduce the necessity of using it.

You know that the Swiss say: "The greatest advantage, the greatest accomplishment, of civil defense is that it will never have to be used." Similarly, the chances for the effort to create a new Munich, to subject us to a so-called "nuclear blackmail," would be very much decreased if it were clear that we can defend our population just as well as they can defend theirs, and that we are doing it.

I cannot imagine anything worse for mankind but that we come under a single domination, that we become an ant heap, a single ant heap where there is one dictator on top who tells everybody what to do. And this is what we should avoid. □

A Case for Civil Defense

E. P. Wigner

Prepared Statement to the Committee on Foreign Relations, U.S. Senate,
Ninety-Seventh Congress, Second Session, March 16 and 31, 1982.
U.S. Government Printing Office, Washington 1982, pp. 21–23

It has become widely recognized that the Soviet Union has superiority over the United States in many important measures of military strength. Warsaw Pact forces in Europe outnumber NATO forces three to one in tanks, and almost two to one in manpower and aircraft. In strategic nuclear weapons, the Soviet Union surpasses the United States by factors of 2 to 1 in megatons and 3 to 2 in payload weight. These disparities have become widely recognized by most observers in the United States. We are rightly embarked on a multibillion dollar effort to correct them over the next several years.

But the greatest disparity in strength of the two countries is in the vulnerability of their civilian population to strategic attack. This disparity is greater than 10 to 1 in favor of the Soviet Union. If there were a full nuclear exchange in the near future after a few days' crisis, fatalities in the Soviet Union could be between 3 and 5 percent—less than their casualties in World War II. In the United States, fatalities could be 60 percent. The Soviet Union has been able to accomplish this dramatic reduction in the vulnerability of its population by a well-thought-out plan developed and implemented over the past two decades. Their plan encompasses evacuation of their urban population and construction of expedient fallout shelters for them in the surrounding host areas. They have constructed blast shelters for most of their critical workers who must keep military production going during an emergency. In addition, they have an unknown amount of blast shelters in some of their cities for up to possibly 50 percent of their population. They have developed expedient protection methods for their critical industries. They have established a strategic food reserve containing approximately a year's supply of grain. They have continuing training programs to educate all of their workers and school children on the nature of nuclear war and the means that can be taken to survive it.

The Soviets' objective, which they have stated repeatedly, is world domination. In the words of their anthem, "The Soviet international shall be the human race." Their actions in Eastern Europe, Afghanistan, Laos, Cuba, Angola, and Ethiopia should leave little doubt in anyone's mind about the determination behind their words.

Suppose one of their foreign adventures resulted in a confrontation with the West, for example, in Europe or the Persian Gulf. Suppose the crisis escalated. perhaps with conventional military clashes until the Soviets evacuated the cities. In what position would the President of the United States be in such a situation? How would he respond to a threat of a nuclear exchange? What pressures would be on him when 130 million Americans are facing immediate risk of annihilation? What leverage would he have over the Soviet Union, if he were able to threaten fewer of their population than they lost in World War II?

The Soviet Union does not want war, even one they know they can recover from. They want the fruits of victory without the war; a new Munich. The universal perception of their nuclear superiority and invulnerability cannot be other than a temptation to the Soviet Union to take longer risks of confrontation in pursuit of their goals, and this is dangerous. Confrontations can get out of hand and can escalate into a war that nobody wants.

What must we do?

We must proceed with the Federal Emergency Management Agency's crisis relocation planning (CPR) in order to develop a counterevacuation capability

that would give the American President a response to a Soviet evacuation other than "a choice between humiliation or holocaust." We must be able to reduce the vulnerability of the American people to a level comparable to that of the Soviet people. We must remove this temptation for nuclear blackmail. This can be done more quickly and at less cost than any of the proposed improvements in our strategic offensive systems. We should see significant improvements in the U.S. defense posture over 2 to 5 years at an annual cost of one-tenth of 1 percent of the Department of Defense budget, or approximately 1 percent of the cost of the proposed budget for enhanced strategic systems.

Then we must begin to build a strategic food reserve in host areas in conjunction with crisis relocation planning. This reserve will alleviate worries on the part of the host population about food supply in the event of an extended war. We must develop a program of incentives for incorporating shelter in new construction to reduce the dependence of our civil defense system on several days strategic warning.

And last but not least, we should develop a program of civil defense education of the population starting with high school students. Americans should be taught to protect themselves against the effects of nuclear weapons at least as well as the Soviet population. Education in the effects of nuclear weapons and defensive measures should promote informed political decisions. In democracies, it is the duty of government to keep people informed so they can make the right decisions.

It has been argued that educating the American people in the real effects of nuclear war and the means to survive it would make war more acceptable. Nothing could be further from the truth. My experience, and that of my coworkers, has been that the more we learn about nuclear war, the more determined we are to prevent it.

Our national policy must be to prevent nuclear war and simultaneously prevent the loss of American freedom through nuclear blackmail. This policy can only be accomplished by deterrence. We believe the ultimate deterrent to war against the United States by any tyrannical power is the prospect of the survival of the American nation and its example of freedom.

Two Remarks

Nuclear Blackmail and My Hope

E. P. Wigner

In: International Seminar on Nuclear War, Third Session
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I wish to make two remarks before turning to my main subject. Let we say first that most of the addresses we have heard impressed me greatly with their depth and generality. There was, nevertheless, a subject, the discussion of which I missed: nuclear blackmail. To mention one very undesirable example, one can imagine that the USSR puts its civil defense into effect, "disperses" the population of its cities and then threatens the United States' government that unless it is permitted to send regiments to Buffalo N.Y., to Austin TX etc., next day many millions of Americans will die as a result of a nuclear attack. How should the President of the United States respond to such a threat? Of course, this is only an example of a possible "nuclear blackmail" and I hope an unrealistic one but I feel the general problem of such a blackmail should be discussed – I hope it will be at our next meeting.

The second observation I wish to make is that even though the nuclear weapons' effectiveness is enormously greater than those of earlier non-nuclear weapons, the damage those did, the loss of life they caused, was already terrible. In the 30 Year War more than half of the German lives were lost. We must, therefore, strive not only for the elimination of nuclear wars, but of all wars. I present next an ideal which we may, and perhaps should, strive for, which would accomplish this purpose.

My Hope

We have heard several interesting discussions of what we can expect the future to bring mankind. I would like to present a picture of what I hope for.

I hope that we can persuade all governments to make it their prime purpose to increase the well being, even the happiness, of their people. I know that for a life-long ruler it is not easy to consider this his prime purpose. In the past most of those who expected to remain rulers wished to extend their power and area of domain. I hope this will not be so in the future; in fact even in the past, the successors of rulers with unlimited power, such as the later emperors of Rome, did not strive for an extension of their power as vigorously as the earlier ones, nor as did Hannibal, Napoleon or Hitler. I hope therefore that in the very near future, the main purpose of all governments will be to increase the well being of their people, their happiness and interest in life.

It is a nice hope that most of the competition between the governments will be directed toward providing the greatest satisfaction and the most interesting life for their people. But I believe it would be good if we had some more visible competition between the governments. Will there be one? Yes, if they adhere to the United Nations resolution, incidentally supported also by the USSR! "Everybody has the right to leave any country including the country of his birth". This would enable people to migrate to the country where they believe they will be happier – happier even after having lost many friends, the use of their native language, and the right of so many beautiful reminders of the past of their nation. But some people are willing to give all this up for what they hope will be a better life in another country. And we should not deprive them of this possibility. The freedom of the people to move to another country would also provide the rulers of the various countries with a worthwhile purpose: attraction of the immigration of people striving for more happiness.

Some people believe that it would be good if the whole Earth were under a single government. I doubt this wholeheartedly. I feel that man needs several competing governments among which he can choose, and if they compete the way I hope they will, this will lead to a better world, in fact a good world. And an interesting one – not an ant heap as a single government over all men would entail.

There is another reason I feel opposed to the unification of all nations. Our lives, our ideas, the conditions under which we live, have changed greatly since science became so powerful. But we cannot foresee the effects of all these changes, and not all changes have been for the good. Some are frightening, such as the drastic decrease of the size of *some* populations. But other dangerous changes may take place in other societies – we cannot foresee them and the government in question may not be able to foresee it. We need, therefore, several different types of governments so that all create the same dangers. And a variety of cultures and organizations will make life more interesting and beautiful.

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