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INDUSTRIAL SURVIVAL AND RECOVERY AFTER NUCLEAR ATTACK. A REPORT--ETC(U)
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INDUSTRIAL SURVIVAL AND RECOVERY AFTER NUCLEAR ATTACK

A REPORT TO THE JOINT COMMITTEE ON DEFENSE PRODUCTION U.S. CONGRESS

November 18, 1976

Prepared by:

The Boeing Aerospace Company
A Division of The Boeing Company
Seattle, Washington

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Congress of the United States

JOINT COMMITTEE ON DEFENSE PRODUCTION

(CREATED PURSUANT TO PUBLIC LAW 774, 81ST CONGRESS)

ROOM A-421 SENATE ANNEX III

WASHINGTON, D.C. 20510

October 8, 1976

Mr. Oliver Beaulieu, President
Boeing Aerospace Company
Box 3999
Seattle, Washington 98124

Dear Mr. Beaulieu:

As a conclusion to its year-long examination of the federal preparedness effort, the Joint Committee will be holding open hearings on November 17-19 to examine the condition of the defense industrial base. Because of your expertise in these important issues, I would like to cordially invite you to appear on November 18 to present your views. I believe that your membership on the Defense Science Board Task Force on Industrial Readiness Plans and Programs and your writing and speaking on Soviet industrial preparedness make you an especially well-qualified witness.

You may, of course, be accompanied by any persons who you believe might be helpful. The committee would particularly welcome your associate, Mr. T.K. Jones, who has provided quite useful insights to this committee in the past.

I have enclosed a copy of the committee's guidelines for witnesses. I would request that, in accordance with the guidelines, you provide the committee with 75 copies of your prepared statement 48 hours in advance of your appearance before the committee. You will also be asked to deliver a ten-minute summary of your prepared statement at the beginning of the session.

I hope to see you on November 18. If you have any questions, please call Bill Kincade of the Joint Committee staff at 202/224-2337.

Sincerely,

William Proxmire
Vice Chairman

INTRODUCTION

The United States and the Soviet Union both recognize and adhere to a policy of nuclear deterrence. The U.S. approach to deterrence, recently reaffirmed by Secretary of Defense Donald H. Rumsfeld, is to "have some minimum force which can survive even a well executed surprise attack in adequate numbers to strike back with devastating force at an enemy's economic and political assets."[1] This doctrine, which is the foundation of U.S. national security, is more commonly referred to as assured destruction. The U.S. sought in the Strategic Arms Limitations Talks (SALT) with the USSR to ensure continued viability and to gain mutual acceptance of the assured destruction doctrine. These efforts culminated in signing of a treaty limiting antiballistic missile (ABM) deployments to low levels, the premise being that such deployments undermined deterrence by protecting an aggressor's economic and political assets against retaliation.

Civil defenses have much the same effect on deterrence that an extensive ABM deployment would have, for civil defense undermines deterrence by protecting an aggressor's economic and political assets against retaliation. Paul H. Nitze recently noted that the Soviet Union has adopted a program of civil defense preparation and concluded that "the ability of U.S. nuclear power to destroy without question the bulk of Soviet industry and a large proportion of the Soviet population is by no means as clear as it once was, even if one assumes most of U.S. striking power to be available and directed to this end."[2]

Many Americans find it difficult to believe that civil defenses could provide effective protection against nuclear weapons. The whole idea is contrary to the widespread notion that nuclear war would be the end of all mankind and that the U.S. possesses a vast "overkill" capability. However, the national security of the United States depends not on what Americans believe but on what the Soviet leaders believe. Examination of Soviet literature reveals that they have no equivalent of the West's concept of assured destruction. On the contrary, the Soviet literature speaks of their capability to survive and recover from a nuclear war; and some spokesmen even hold out the possibility of victory from such a war.

The existence of even very effective civil defenses is not likely to alter the Soviet's present objective of avoiding war, particularly nuclear war. However, the Soviets view civil defense as a force complementing their growing offensive power. The Soviet civil defense chief, Colonel-General A. T. Altunin, wrote in 1974 of the relationship of civil defenses to the first-strike counterforce mission of the Soviet offensive forces:

> While the Armed Forces take as their objectives to prevent the use of destructive means against the rear of a country by the destruction of the attack weapons or the interception of the weapons on their way to their target, Civil Defense, by carrying out protective measures and the thorough preparation of the population seeks to achieve the maximum weakening of the destructive effects of modern weapons.[3]

Given the double advantage of offensive power, which, according to some estimates[4] constitutes a war-winning capability, and civil defenses to mitigate the consequences of what the Russians characterize as possible desperation moves by the United States, the Russians could become much more aggressive in future confrontations. Consider the situation that would be faced by a U.S. President if in some future confrontation the Soviets evacuated their population and executed the final actions to protect their industry. The consequences of further escalation would be much more disastrous to the United States than to the Soviet Union. Hence, the "balance of terror" would no longer be balanced; it would favor the Soviet Union. It would also create great pressures for the United States to make concessions to avoid war. For these reasons, the matter of civil defense is crucially important to the future security of the United States as well as to its political and economic future.

The purpose of this report is to address two questions regarding civil defenses:

1. Can Soviet industry be effectively protected by the methods described in Soviet literature?
2. Is it feasible to apply similar concepts to protect and ensure postwar recovery of U.S. industry?

FACTORS INFLUENCING INDUSTRIAL RECOVERY

After World War II, public attention was focused almost exclusively on the awesome destructive power of nuclear weapons. As a result, the industrial recovery of bombed cities such as Hiroshima went unnoticed. However, the fact that industry can and will recover from even nuclear devastation is evident from the published findings of the U.S. Strategic Bombing Survey of Hiroshima. The day after the explosion, bridges into downtown Hiroshima were open to traffic, and electric service was restored in some areas. On the second day, trains were again operating. By the third day, some streetcar lines resumed service. Within 9 days, telephone service was restored to the city center. In the outlying areas of the city, water, sewer, and gas services were never interrupted. When the U.S. survey team arrived 2 months after the explosion, the survivors were starting to erect dwellings on their original homesites.[5]

A number of studies done in the U.S. have examined the factors influencing industrial recovery of a nation following a nuclear attack. Taken collectively, the results indicate that survival of the work force is by far the most important factor in industrial recovery. Figure 1, which was derived from the results of several of these studies, compares the relative importance of the work force and of capital assets to recovery time. As can be seen, if one-half the work force were destroyed, recovery would take three times as long as it would take if half the capital assets were destroyed. The importance of the work force was dramatically demonstrated in Hiroshima, Japan. Within days of the attack, manual labor alone was able to reopen the bridge that was the target of the atomic bomb (Figure 2). The restoration of streetcar service in Hiroshima also resulted from a concentrated effort by the work force. They replaced trolley wires and realigned rails, as shown in Figure 3, and were the major contributors to the early restoration of services.

Second in importance to survival of the work force is survival of the capital assets of a country. In this regard, the machinery of production is more important to prompt recovery than the buildings. The main Messerschmitt plant at Augsburg was destroyed by over 500 tons of bombs. Thirty buildings and 70% of stored material were destroyed, but only one-third of the machine tools were damaged. Hence, production capacity was reduced by only 35%, and the plant was back in full production in little over 1 month.[6] It was also demonstrated in Hiroshima that industrial functions do not depend on survival of the buildings. Figure 4 shows a power converter station that was returned to operation with only a weather cover constructed of canvas, lumber, and ropes.

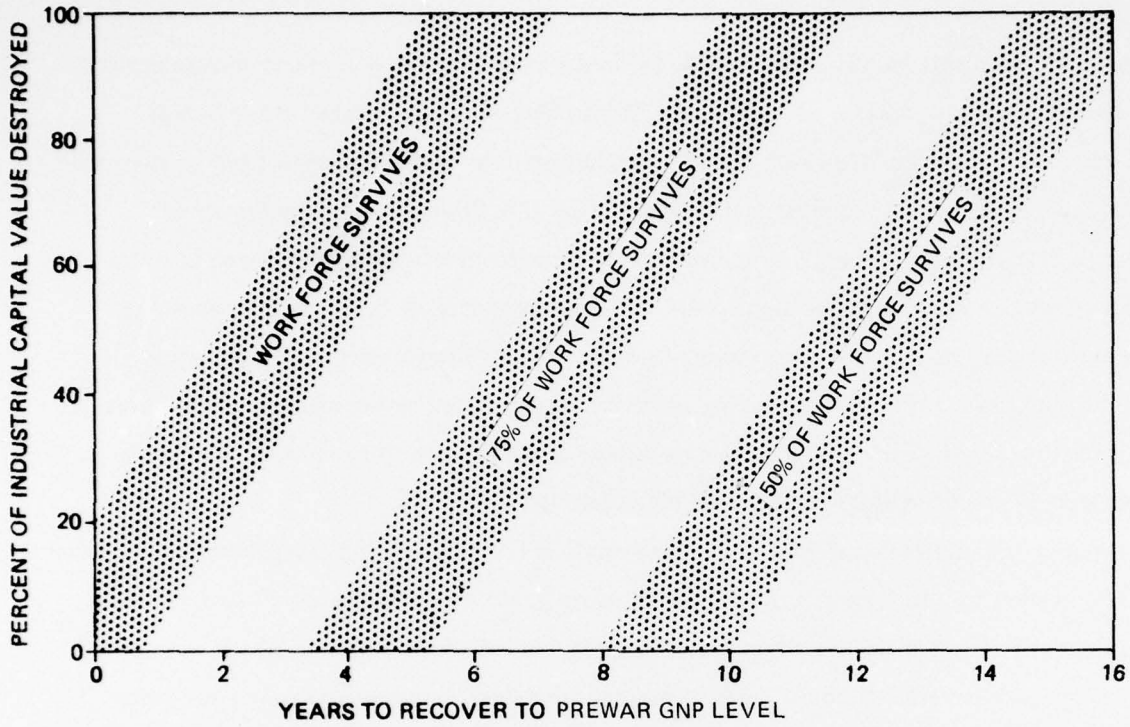


Figure 1. Postwar Recovery (1985 Time Period)

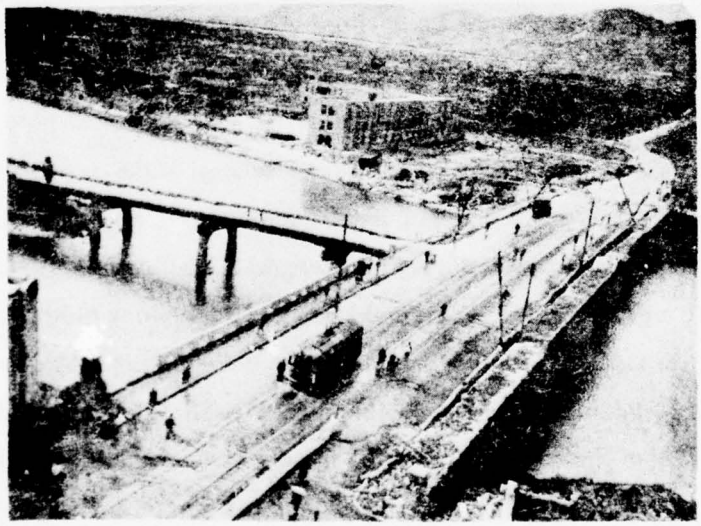


Figure 2. Intersection of Bridge 23 (Left) and Bridge 24 (Right). All Damage From Blast Effects. Bridge 23 (860 Feet to Gz, 2,170 Feet to Az). Bridge 24 (1,000 Feet to Gz, 2,230 Feet to Az).

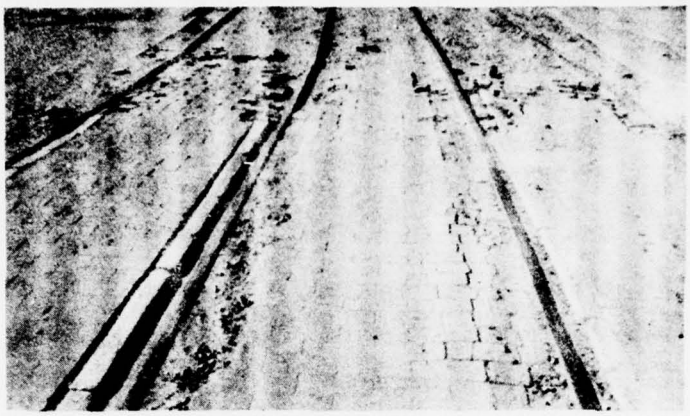


Figure 3. Bridge 24. West End of Bridge. Streetcar Rails Moved Laterally 15 Inches to the North When Blast Effects Shifted Bridge Deck (1,000 Feet to Gz, 2,230 Feet to Az).

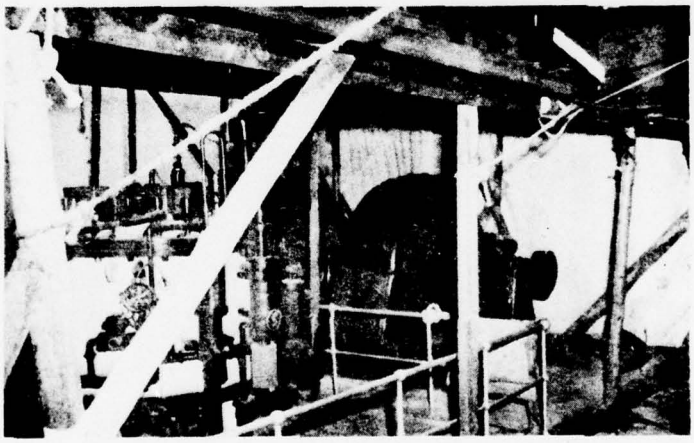


Figure 4. Building 35B. Rectifier and Rotary Converter in Operation Under Temporary Canvas Shelter.

The Russians have themselves demonstrated that industrial buildings are not essential to continued production. To protect their aviation industry from German bomber attacks, the Soviets in 1941 used railroad cars to relocate approximately 1,523 industrial enterprises, including 1,360 large war plants, to the Trans-Volga, Urals, Eastern Siberia, and to Kazakhstan and Central Asia. This relocation involved 85% of the entire aviation industry. At many sites, resumption of production began even before temporary facilities were constructed. Machines were set up on temporary platforms in the open, and work was accomplished in weather that reached -40 degrees. Within a year, production rates exceeded the highest rates that had been achieved prior to the relocation.[7]

PROTECTION OF THE INDUSTRIAL WORK FORCE

In the United States, public perceptions of nuclear war are oriented mainly toward population fatalities. Many Americans believe that the nuclear arsenal of the U.S. is sufficient to destroy the entire Soviet population several times over, a capability commonly referred to as "overkill." However, "overkill" is a myth rather than a real capability possessed by either the U.S. or the USSR. More important, Soviet authors point out the fallacy in the "overkill" argument, stating that such a theory is based on an "over-simplified, one-sided approach."*

In order for Americans to judge the true position of the U.S. in a future nuclear confrontation, it is first necessary to establish some perspective as to how damaging a U.S. nuclear retaliatory strike might be to Soviet targets. Briefly summarized, the U.S./USSR survival capabilities are as follows. Given a first strike by the USSR, the U.S. would have on the order of half of its nuclear arsenal (ICBMs, SLBMs, and bombers) surviving. If these weapons were programmed to achieve maximum destruction of industrial targets, the entire U.S. surviving inventory could destroy unprotected people in, at most, 3% of Soviet territory. If the people were protected by simple, foxhole-type shelters, the lethal area that could be imposed by the U.S. surviving arsenal would be reduced to one-third of 1% of the Soviet land mass.† People in the remaining 99-2/3% of the Soviet Union would survive. There would be no lingering lethal fallout.

If the U.S. were to program all its weapons to detonate at ground level, a lethal level of fallout might be spread over a wider area, but such an action would cut in half the lethality of the weapon against industrial targets. With favorable weather conditions, a lethal level of fallout could be spread over up to about 15% of Soviet territory. However, simple shelters can be constructed in a few hours to protect people against fallout until the radiation intensity decays to a nonlethal level. Figure 5 shows that within a week after a worst case U.S. retaliatory attack, the Russians could be out of their shelters for at least an 8-hour work day in 97% of Soviet territory.

The above figures clearly indicate that survival from a nuclear war is a matter of dispersal. If the Soviet population remained concentrated in a small area (the top 200 cities total about one-fourth of 1% of Soviet land area), their population losses would be heavy. Conversely, if the population is spread out and sheltered, losses will be reduced to a low level. Figure 6 illustrates this point. If the Soviet urban population remains in the cities, the Soviet Union would lose most of

*For a more complete discussion of the Soviet views on "overkill," see *The Role of Nuclear Forces in Current Soviet Strategy* by Leon Goure, Foy D. Kohler, and Mose L. Harvey, Center for Advanced International Studies, University of Miami, 1974, p. 60.

†The calculations from which these figures are extracted have been furnished to the Committee at a higher classification.

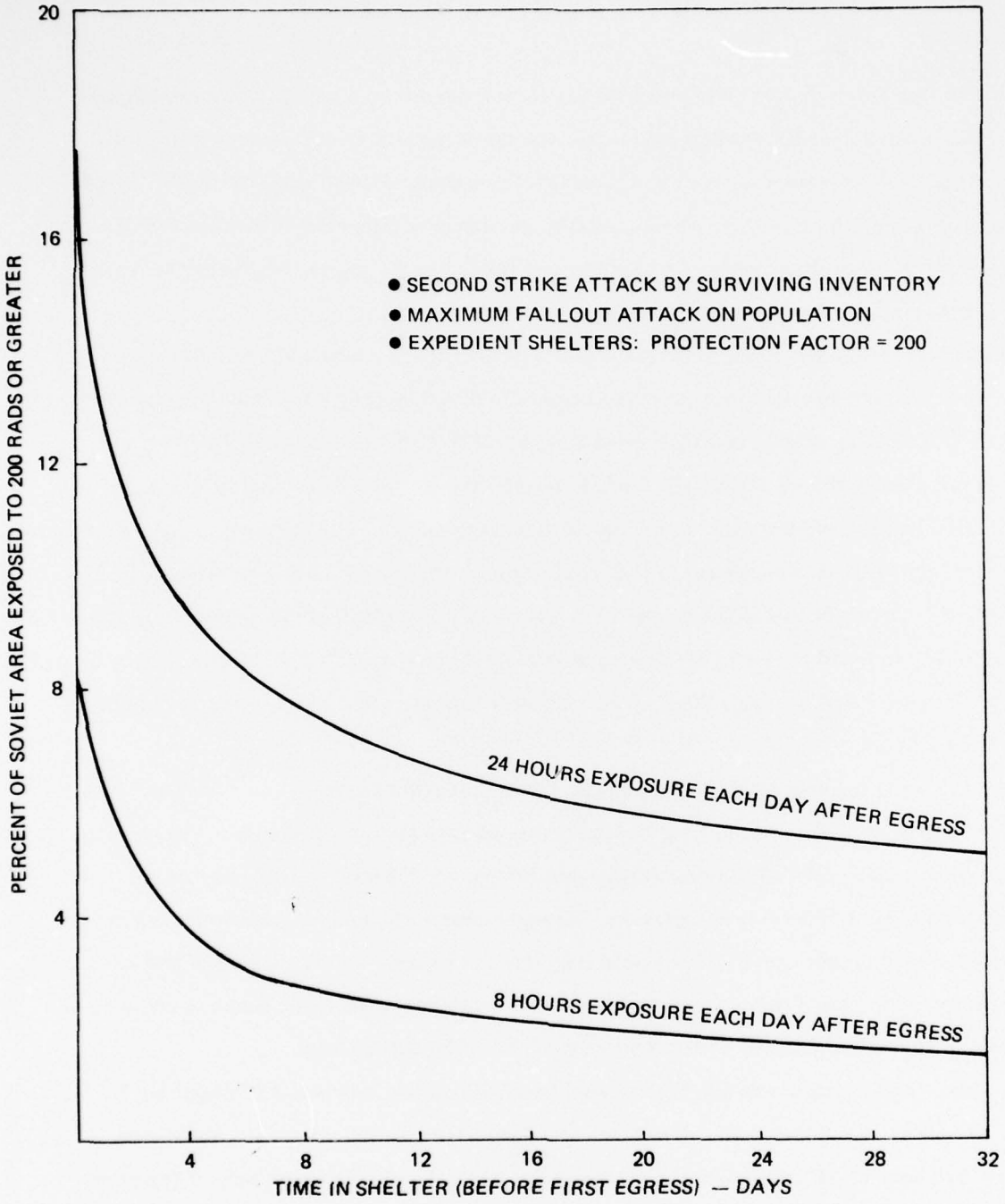


Figure 5. Worst Case Effects of U.S. Surviving Nuclear Arsenal

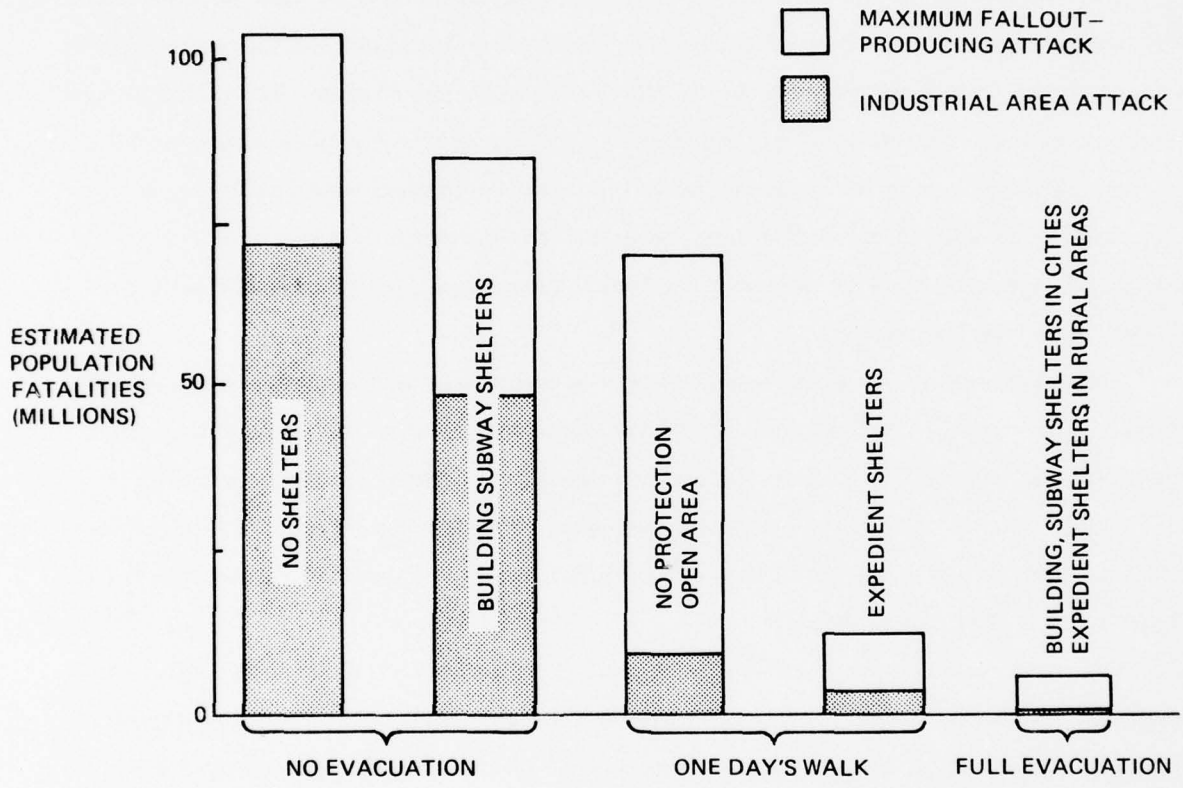


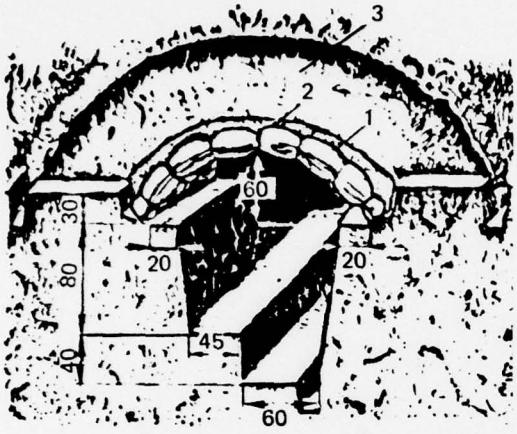
Figure 6. Soviet Population Fatalities (Surviving U.S. Strategic Forces)

its industrial work force. Even use of urban shelters would not help much against a U.S. attack designed to destroy population. However, using only minimal dispersal—such as could be obtained by ordering the population to walk for one day away from the cities—fatalities could be significantly reduced if simple shelters of the type shown in Soviet manuals (Figure 7) were constructed or if the U.S. followed a policy of retaliating against industrial targets. A full 3-day evacuation of the type called for in Soviet plans would reduce their fatalities to no more than 10 million people. This latter figure approximates that given by a Soviet civil defense text.[8]

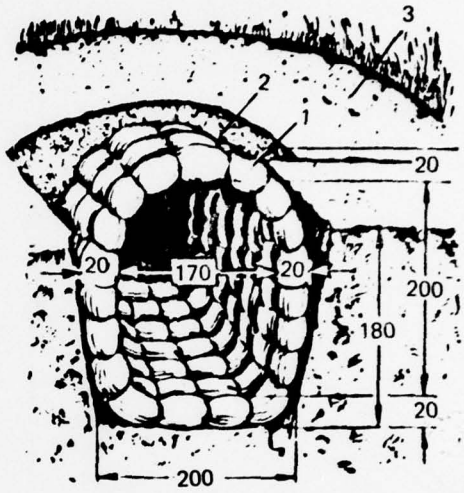
The conclusion is that the Soviets can, during the early stages of a crisis, take the steps necessary to ensure a very high level of survival for their work force. The most important prerequisite to such protection is first, planning, and second, the existence of a trained cadre. Soviet literature and textbooks provide extensive detail on their plans and preparations. These preparations, in addition to comprehensive planning for evacuation, include provisions to protect food supplies and manage crops and livestock, to ensure medical care, and to maintain the means of government and party control. A very comprehensive analysis of the Soviet preparations is published in *War Survival in Soviet Strategy* by Leon Goure.

The U.S. work force could be protected nearly as well as their Soviet counterparts if the U.S. initiated a basic civil defense program. The United States does, however, need to overcome some disadvantages; first, the U.S. has less territory over which to disperse its people; second, after attacking U.S. forces, the Soviets would have more weapons with which to attack the U.S. cities and evacuation areas (the amount of Soviet superiority is shown in Figure 8.) The net effect of these factors is illustrated in Figure 9.

The Soviets could cover the entire continental U.S. with a level of fallout so high that for at least a few days shelter would be required, while the U.S. could cover only 15% of Soviet territory with lethal fallout. More of the U.S. population would have to stay in the shelters for a longer period of time than their Soviet counterparts. After one week, Americans in 15% of the U.S. would still be unable to leave the shelters for an 8-hour work day—compared to about 3% for the Soviet Union. The higher level of radioactive contamination received by the U.S. would demand greater reliance on radiation monitoring, rescue activities, and on area decontamination work. (Soviet procedures for these activities are noted in their manuals and described in training exercise reports.) It should be noted that almost half of the potential radioactive contamination of the U.S. would result because the U.S. has at present largely abandoned its air defenses, and the Soviet Backfire bombers could penetrate unopposed to U.S. targets. Restoration of even rudimentary air defenses would eliminate most of the potential contamination of the U.S. by the Backfire force.



SHELTER IN CLAY GROUND WITH A COVERING OF CANE-REED ARCHED FASCINES: (1) FASCINES: (2) LAYER OF COMPACTED CLAY 3-5 cm THICK: (3) SOIL LAYER 70-80 cm THICK



SHELTER IN SANDY SOIL MADE OF ANNULAR BRUSHWOOD FASCINES: (1) FASCINES: (2) LAYER OF COMPACTED CLAY 3-5 cm THICK: (3) SOIL LAYER 70-80 cm THICK

Name of materials and designation	Shelter for 10 persons				Shelter for 20 persons		Shelter of hooped framework	
	Single row		Double row		Double row			
	Without covering of the sloping part	With covering of the sloping part	Without covering of the sloping part	With covering of the sloping part	Without covering of the sloping part	With covering of the sloping part	10 persons	20 persons
Cane reeds (brushwood), m^3	12	13	11	10	17	15	15	23
Poles, m^3	0.04	0.6	0.04	0.5	0.04	0.6		
1 mm wire, kg	4	4	3.5	3	5.5	4	7.5	13
Canvas, m^2	17	10	17	10	17	10	16	16
No. of persons in brigade	12	12	12	12	14	14	12	16
Preparation of basic components for cover, hours of labor	40	35	30	25	50	40	75	105
Building the shelter, hours of labor	80	85	75	80	110	105	95	150
General construction time, hours	11	11	9	9	12	11	15	16

Figure 7. Soviet Shelter Concepts

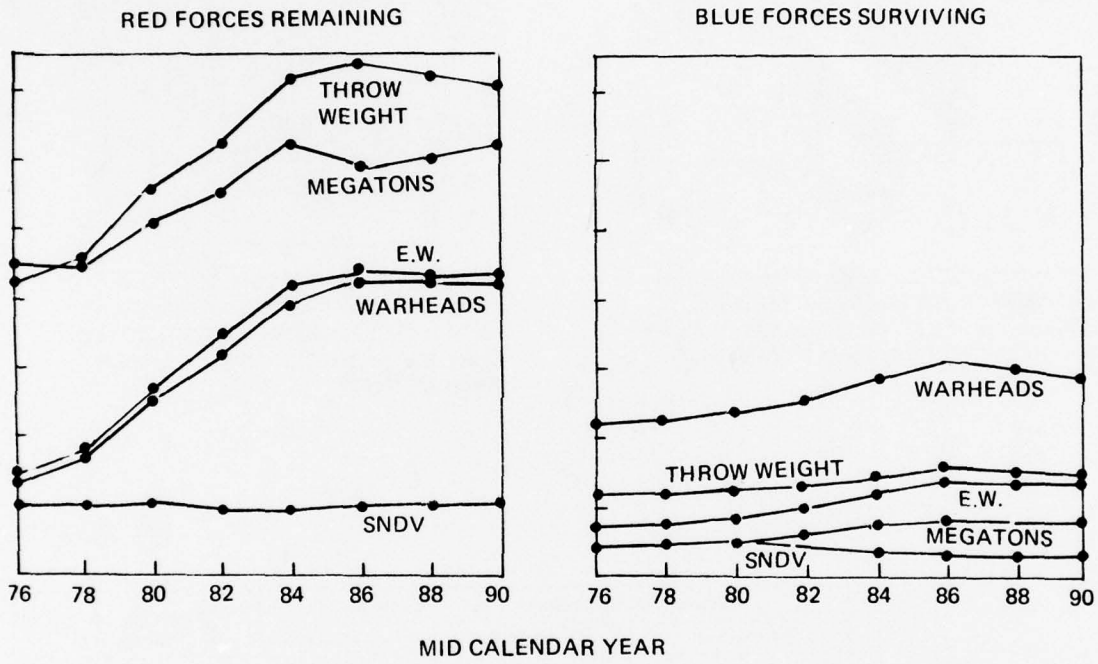


Figure 8. Capabilities After Soviet Union First Strike

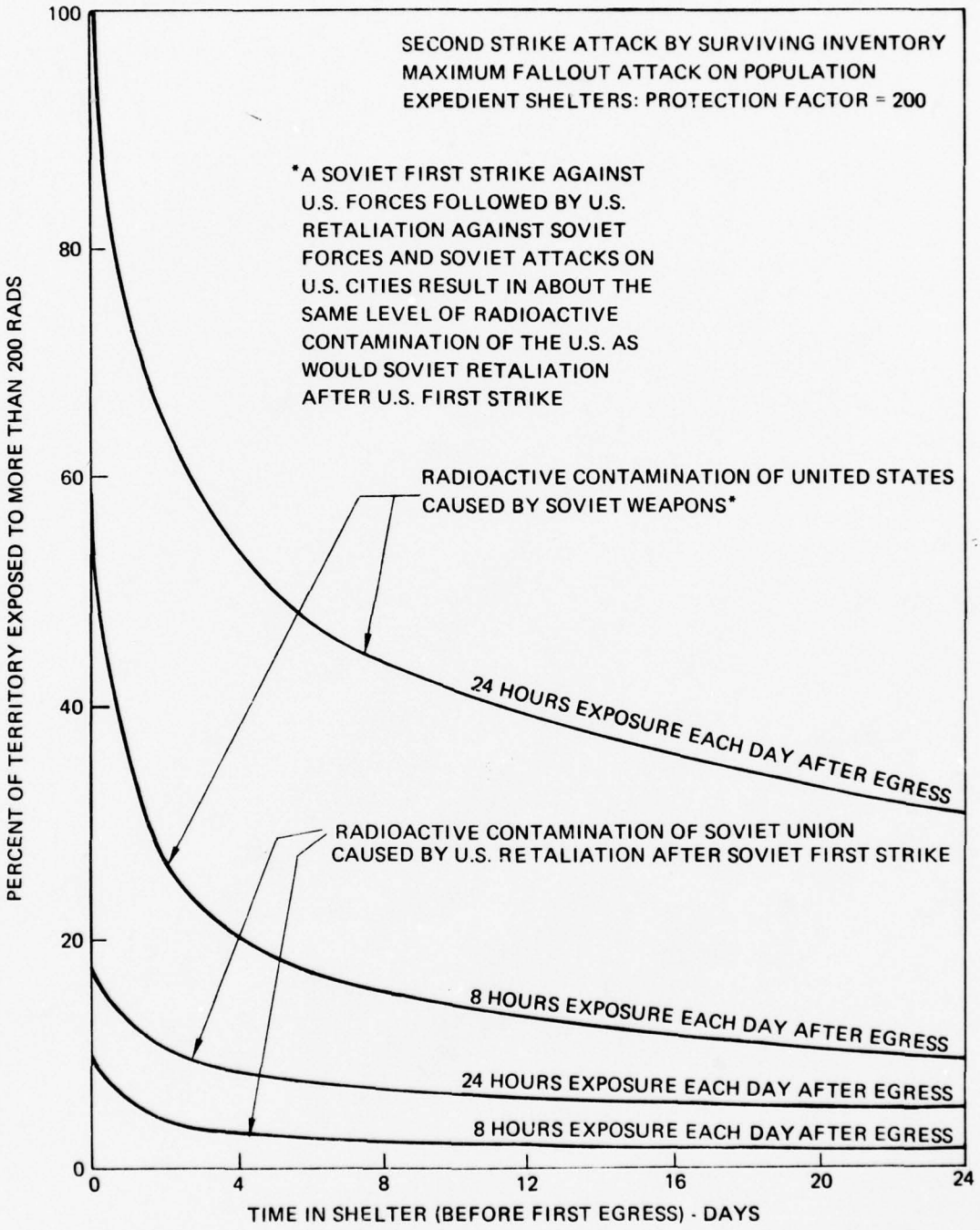


Figure 9. Worst Case Comparative Effects of Surviving Nuclear Arsenal

PROTECTION OF INDUSTRIAL CAPITAL ASSETS

The findings of the U.S. Strategic Bombing Survey gave strong indications to the world community that survival of a country's population and recovery of its economy was possible. The recommendations of this survey team were of even greater importance in establishing what measures were necessary to protect against the effects of nuclear warfare. The major recommendations are listed below:

1. Dispersal of critical industry into small communities. It was noted specifically that Hiroshima, from an industrial point of view, was not a good target for a nuclear weapon because of the remoteness of the industrial concentration from the center of the city.
2. Bomb-resistant construction, either underground for highly critical and compact industries or earthquake-resistant construction
3. Passive measures, including:

   Low building density

   Natural and man-made firebreaks

   Protection of fire departments, pumping stations, power systems, and communication centers

Although the U.S. chose to ignore the findings, the Soviets were attentive to such requirements and implemented a civil defense plan that incorporated the U.S. team's recommendations together with some valuable innovations of their own. Of the U.S. recommendations, dispersal is by far the most effective form of protection against nuclear weapons. The U.S. retaliatory arsenal, even if devoted entirely to industrial target destruction, could cover no more than 2% to 3% of the Soviet Union and no more than a few thousand aim points. Hence, industrial installations in the USSR will survive if they are dispersed over more area or more aim points that the U.S. can cover.

Since its implementation in 1932, the Soviet civil defense program has established effective procedures for industrial dispersal. These can be divided into four types. The first type is to disperse new industry away from the major cities. During the last decade, the Soviets have located more than three-fourths of their new industry in small and medium-sized towns. A second type of dispersal is to separate all new industrial sites by a distance adequate to ensure that a single U.S. warhead cannot destroy two adjacent factories. A third type of dispersal is accomplished by separating the individual factory buildings within a complex; this would reduce the effectiveness of smaller weapons; i.e., more than one weapon would be required to destroy a single factory. Figure 10 illustrates these types of dispersal as practiced by the Soviets. The two factories shown are

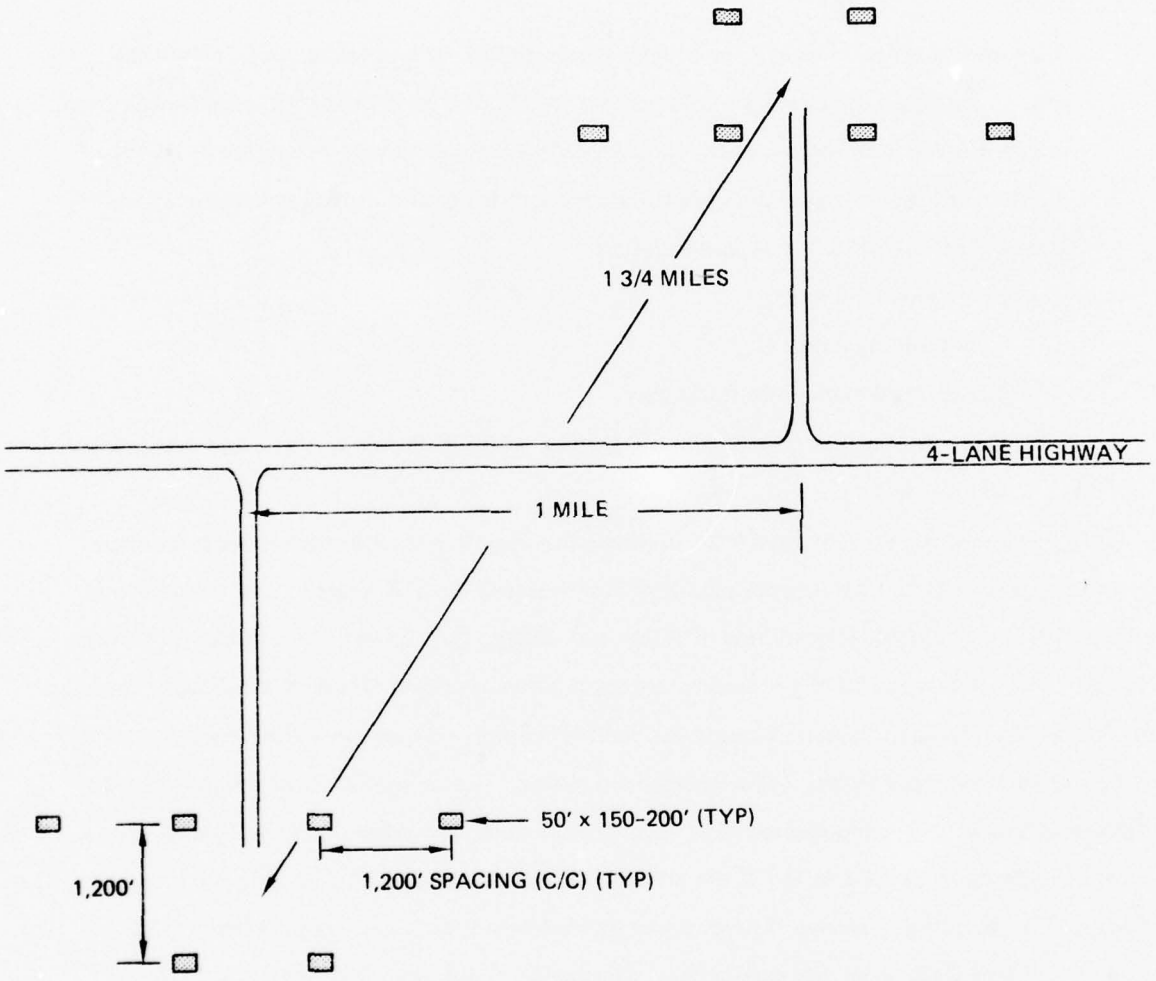


Figure 10. Soviet Industrial Dispersal

located many miles from the nearest large city and are separated by nearly 2 miles. Instead of using a single large building, the factory is comprised of several small buildings separated by nearly a quarter of a mile; the intervening space is typically plowed ground or greenbelts that form a natural firebreak. For comparison, Figure 11 shows to the same scale, a relatively new U.S. industrial complex near a small town. Two different companies share this complex, and the buildings of each company are large and close together. As can be seen, the U.S. industrial complex is more vulnerable to nuclear attack than the dispersed Soviet site. To destroy the Soviet complex would require eight times more megatonnage per square foot of the roof area than would be needed to destroy the U.S. complex.

A fourth type of dispersal is termed "crisis relocation" and involves establishment of relocation facilities for the more critical enterprises. Some of these facilities are fully equipped and maintained on a standby basis. Others are partially equipped and can be put into operation in a short time. During an emergency, equipment as well as the temporary structures in which to house it would be moved from the peacetime factory to the relocation facility. Reports indicate that during World War II, the Russians were able to move all equipment, stockpiles, and documents out of a factory in about 10 days.[9]

Another type of protection recommended by the U.S. Bombing Survey team was the construction of blast-resistant structures. Apparently the Soviets have also paid serious attention to this recommendation. In 1969, Marshal Chuikov, then chief of civil defense in the USSR, said that:

> There are tested techniques and measures to be used in industrial construction that can lessen the destruction and reduce the likelihood of secondary explosions and fires. Preliminary calculations show that they can lessen the effects of a nuclear attack by approximately 80 to 90 percent without great money and materiel expenditures.[10]

The extent to which the Soviets may have implemented such measures is not known; neither do we know of the specifics of the construction techniques referred to. However, even very small improvements in hardness and fire resistance, if employed in conjunction with wide separation of buildings, would substantially reduce the retaliatory effectiveness of the highly survivable U.S. SLBM force.

One of the major causes of loss of industrial capital assets in Hiroshima was fire. One way to prevent fire damage is to reduce the quantity of combustible materials in the area. The Hiroshima survey noted that the external structure and contents of a few of the buildings were generally noncombustible. These buildings suffered much less damage than neighboring structures. In the building shown in Figure 12, the wing facing the blast was burned, but suffered negligible

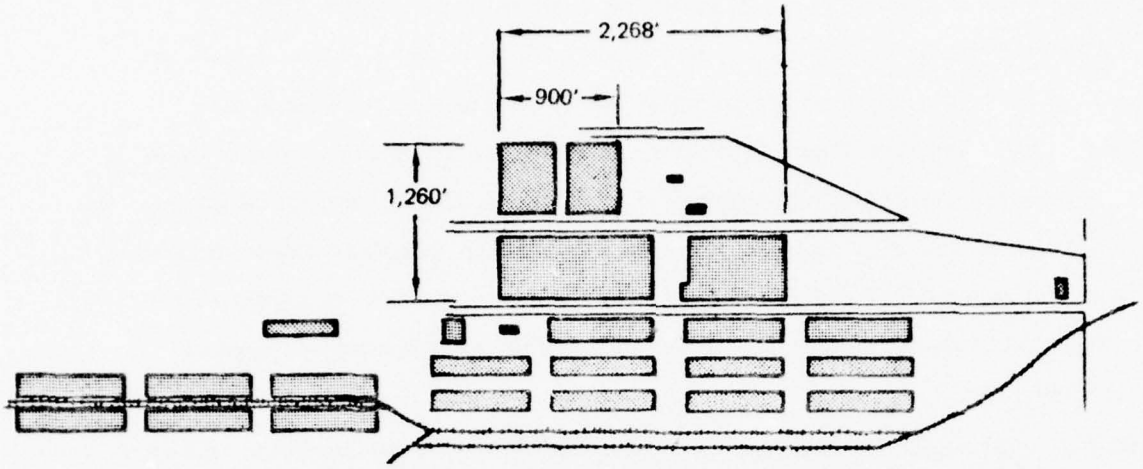


Figure 11. Auburn Complex

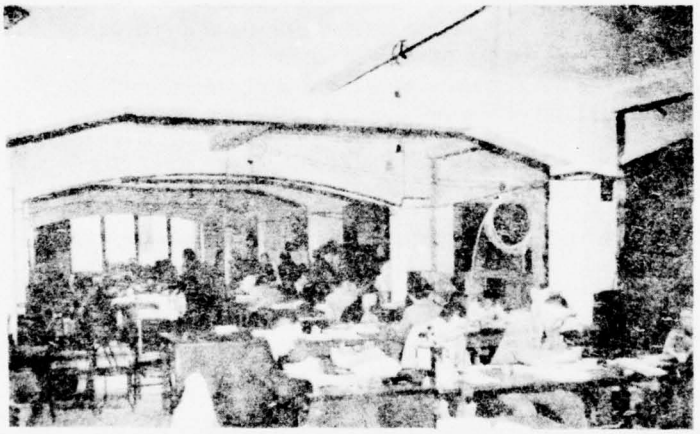


Figure 12. Building 65. Interior Third Story West Wing Showing Condition in Portion Not Burned Out. Note scarring of plaster on beams and ceiling by flying glass. Also note congestion and combustibility of contents.

structural damage. The adjacent wing was not burned and is shown back in operation soon after the blast. Much of the USSR's new industrial construction is highly fireproof; concrete and steel are used almost exclusively. Moreover, reports indicate that even existing factories are taking steps to reduce the combustible material in and around the plant facilities. The book coauthored by the director and civil defense chief of the First State Ball Bearing Plant in Moscow, A. A. Gromov, provides a classic example of the use of fire prevention techniques. Fire protection improvements extended to the fence line; a wooden fence was replaced with a masonry fence. Wooden cooling towers in the plant area were replaced, and artesian wells were constructed to ensure an uninterruptible supply of water for firefighting.

PROTECTION OF PRODUCTION MACHINERY

In Hiroshima, Japan, most of the damage to machinery was caused by fire rather than by blast or other nuclear effects. The second major cause of machine damage was due to debris from collapsing buildings striking the machines.

Figure 13 shows a burned out electrical generating station. This station could have survived in operational condition except for the fire that started from combustible material in front of the building. Figure 14 shows the interiors of small machine shops just outside the fire zone. The building in the lower photo suffered extensive structural damage. It has been braced with poles and "guy-wired" with a chain to keep it from falling over. Sheet metal covers have been placed over the machines to protect them from the rain. The machine shop shown in Figure 15 collapsed, but someone had crawled through the debris to apply a coat of protective grease to the machinery. All of these machine shops could have returned to nearly full operation within a few days or a couple of weeks.

The Soviet civil defense manuals provide for a number of possible ways to protect critical production machinery from nuclear damage. Protective means (illustrated in Figure 16) include structures, enclosures, hoods and housings, and canopies. Perhaps the simplest and most effective protective method described in Soviet literature is to cover vital equipment with sandbags or water. In *Civil Defense of an Industrial Installation*, A. A. Gromov described the actions taken to ensure continuity of utilities (electrical, gas, etc.). Other Soviet literature describing civil defense exercises in industrial plants also leave the impression that protective measures are taken prior to final evacuation of the work force. However, these descriptions are not sufficiently explicit to establish the practicality and effectiveness of protection measures for industrial machinery.

Figure 13a. Building 131A and B. Looking Northeast. Showing Destruction of Roofing. All Combustible Debris Burned. Note Burned-Over Area in Foreground From Which Fire Spread.

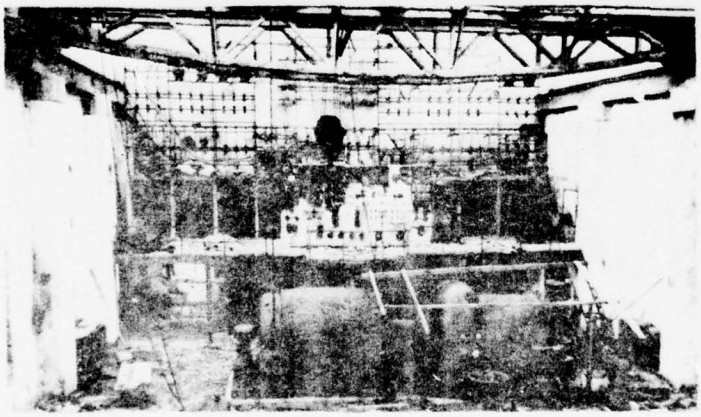
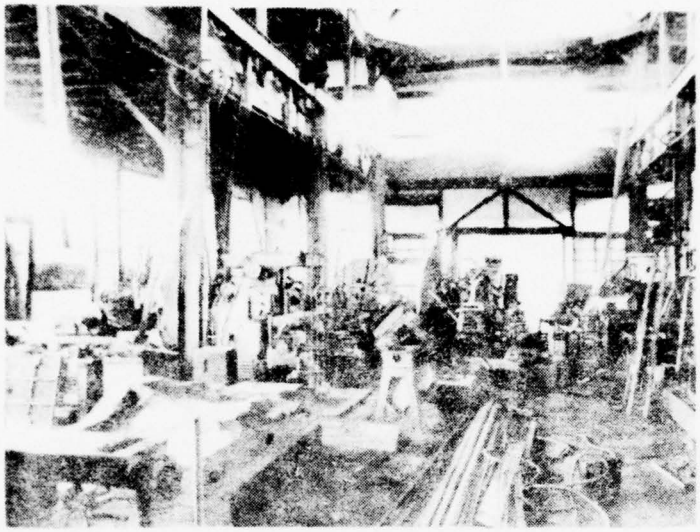


Figure 13b. Building 131A. Looking North Showing Turbo-Generator and Burned Out Electrical Panels at North End of Building



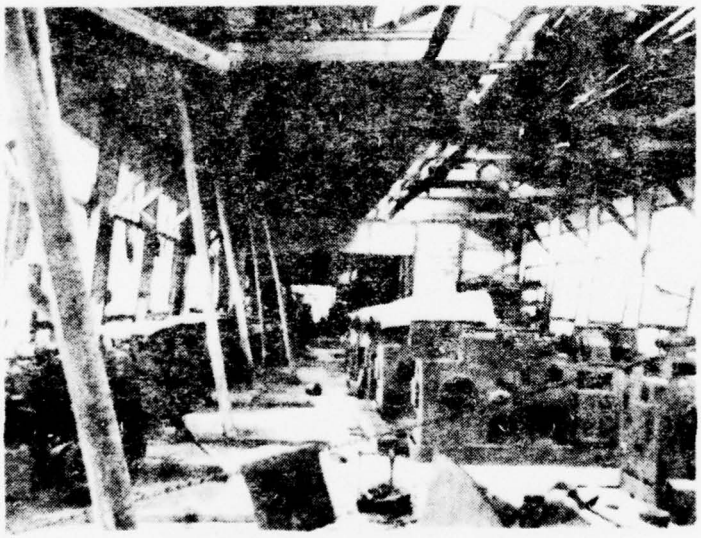


Figure 14. Interior of Small Machine Shops About 7,500 Feet South of Gz Showing Typical Combustible Construction and Arrangement of Machinery. Congestion is no Greater Than in Small American Shops.

Figure 15. Building G, 6,000 Feet South of Gz, Looking West. A Wood-Frame, Light-Engineering Shop Collapsed as a Unit by Blast. No Fire.

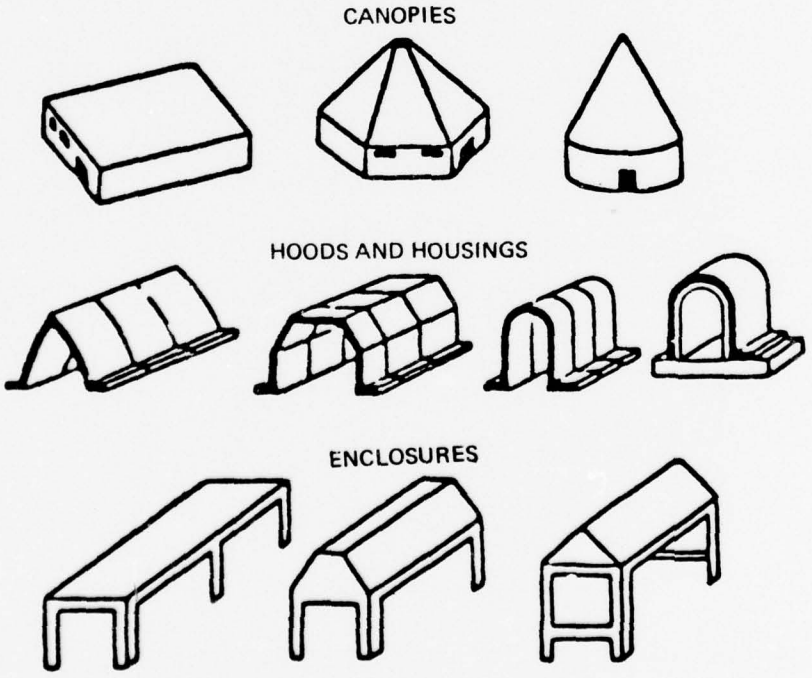


Figure 16. Protective Structures for Valuable Equipment

CIVIL DEFENSE PLANNING STUDY

In 1975, The Boeing Company initiated an internal civil defense planning study to estimate the effectiveness of the Soviet civil defense preparations and to determine the feasibility of applying such measures to U.S. industry. The approach used was to duplicate the planning and preparation processes being used in the Soviet Union. The study was assigned to Mr. John R. Potter, Boeing's facilities manager. Mr. Potter is, in effect, the U.S. counterpart of A. A. Gromov, the director and civil defense chief of the First State Ball Bearing Plant in Moscow.

Mr. Potter was given the same technical materials that were probably given to Gromov by the Soviet civil defense organization; these included manuals and various publications on planning for the civil defense of industrial facilities. Finally, Mr. Potter was given a copy of the book written by Gromov describing the specific protection measures he had instituted to protect his ball bearing plant. Mr. Potter was asked to study the Soviet literature and follow its step-by-step instructions to the extent of preparing a plan showing in specific detail how the Soviet protection concepts would be applied to the Boeing industrial facilities. The principal steps called for and accomplished in the planning study were as follows:

1. Determine which machines are critical to continued production.
2. Determine the strengths and weaknesses of each critical machine and develop methods to protect it.
3. Determine cost, time, and technical feasibility of implementing expedient protection for postattack recovery.
4. Determine the capability of the surrounding region to assist in recovery, assuming the surrounding region is also attacked.

The study began with a review of various weapons effects studies and Soviet civil defense literature. A representative Boeing industrial facility was then selected for evaluation, and studies were conducted to determine how to ensure the survivability of the equipment in that facility. Finally, an analysis was conducted to evaluate the survivability of industrial capabilities in an urbanized industrial region.

The Boeing Company's manufacturing facility in Auburn, Washington, was selected for analysis. Aside from its ready accessibility to the Boeing study team, the Auburn facility (see Figure 17) appears to be a good choice for several reasons:

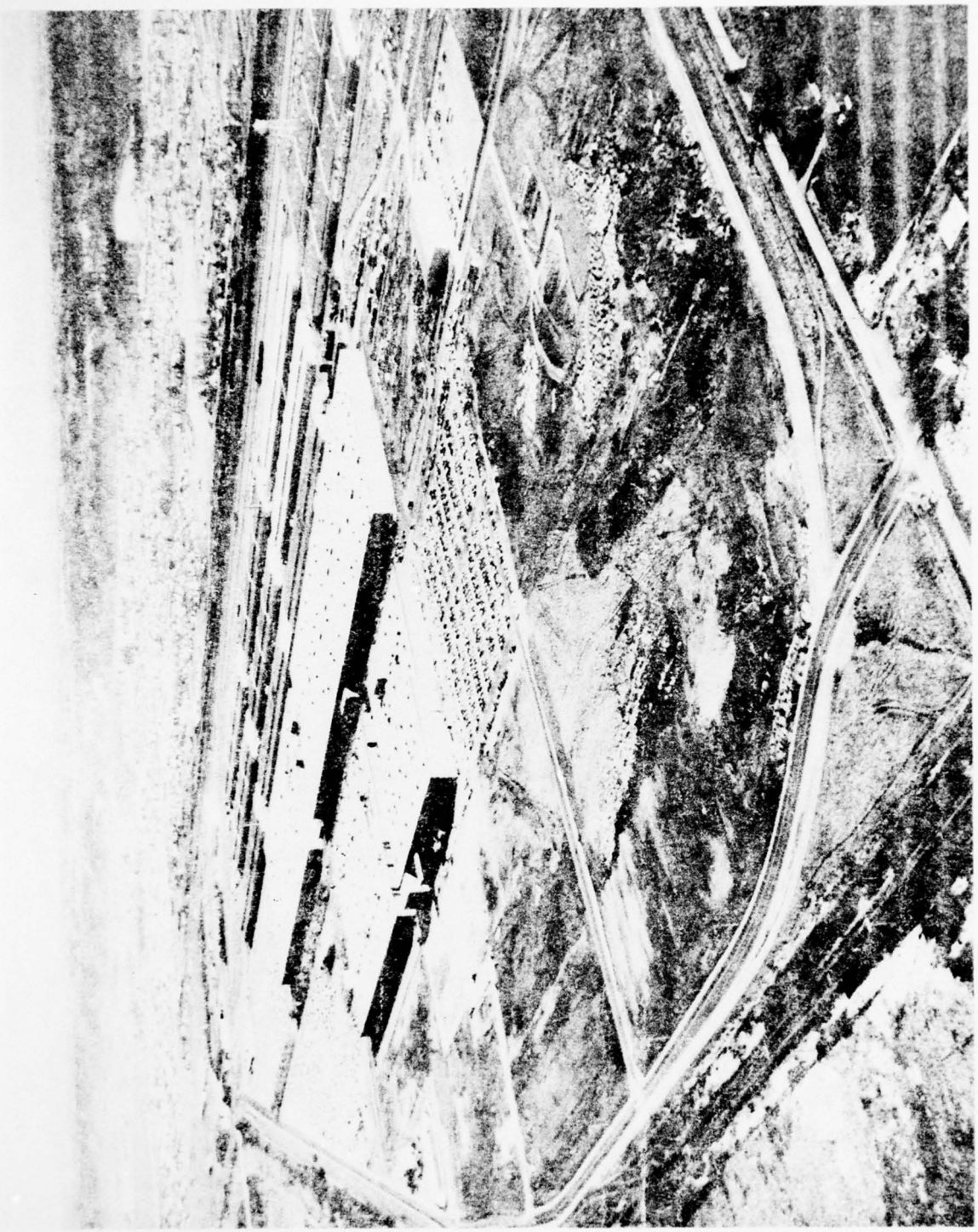


Figure 17. Aerial View of Boeing's Auburn Facility

1. It is a high-technology facility.
2. It is the basic machine shop on which Boeing aircraft production depends. (Most other Boeing facilities assemble high-tolerance parts machined at Auburn. Recovery of these assembly plants would be a less difficult task since few high-tolerance machines are involved).
3. Auburn machines are large, varied, and complex, giving a good cross-section of machines throughout industry. (Auburn is one of the largest machine shops in the world.)

It was assumed that if protective measures work for Auburn, they should work for other industries employing similar machinery.

The types of machines examined in the study were selected because they are large, expensive, crucial to aircraft production, difficult to replace, and generally difficult to repair.

1. Five-axis milling machines (Figure 18)
2. Spar mills (Figure 19)
3. Skin mills (Figure 20)
4. Autoclaves (Figure 21). These are used to provide a controlled heat/temperature environment for curing of structural adhesives.
5. Heat treat facility (Figure 22)
6. Process tank lines (Figure 23). These are used for such functions as cleaning and corrosion-proofing large parts.

Several different types of protective measures were considered in the course of the study. The investigation first centered on canopies; i.e., relatively light protective structures that could be moved over the machines prior to evacuation of the work force. In general, typical industrial buildings suffer significant damage at about 2 to 5 psi and complete destruction at about 10 psi. Canopy-type structures could provide some protection from the debris of a collapsing building as well as from the free-field nuclear blast environments. An unprotected industrial machine, although it might survive greater overpressures in an open field, would suffer major damage if the building collapsed on top of it. It was considered that the use of canopies might also work well for the newer Soviet factories since the buildings are separated by a greater distance than in the U.S. and most of the U.S. retaliatory weapons are much smaller than the Soviet weapons. However, the 10-psi protection limit afforded by the steel canopies was considered inadequate to protect either the U.S. facilities or the older Soviet facilities.

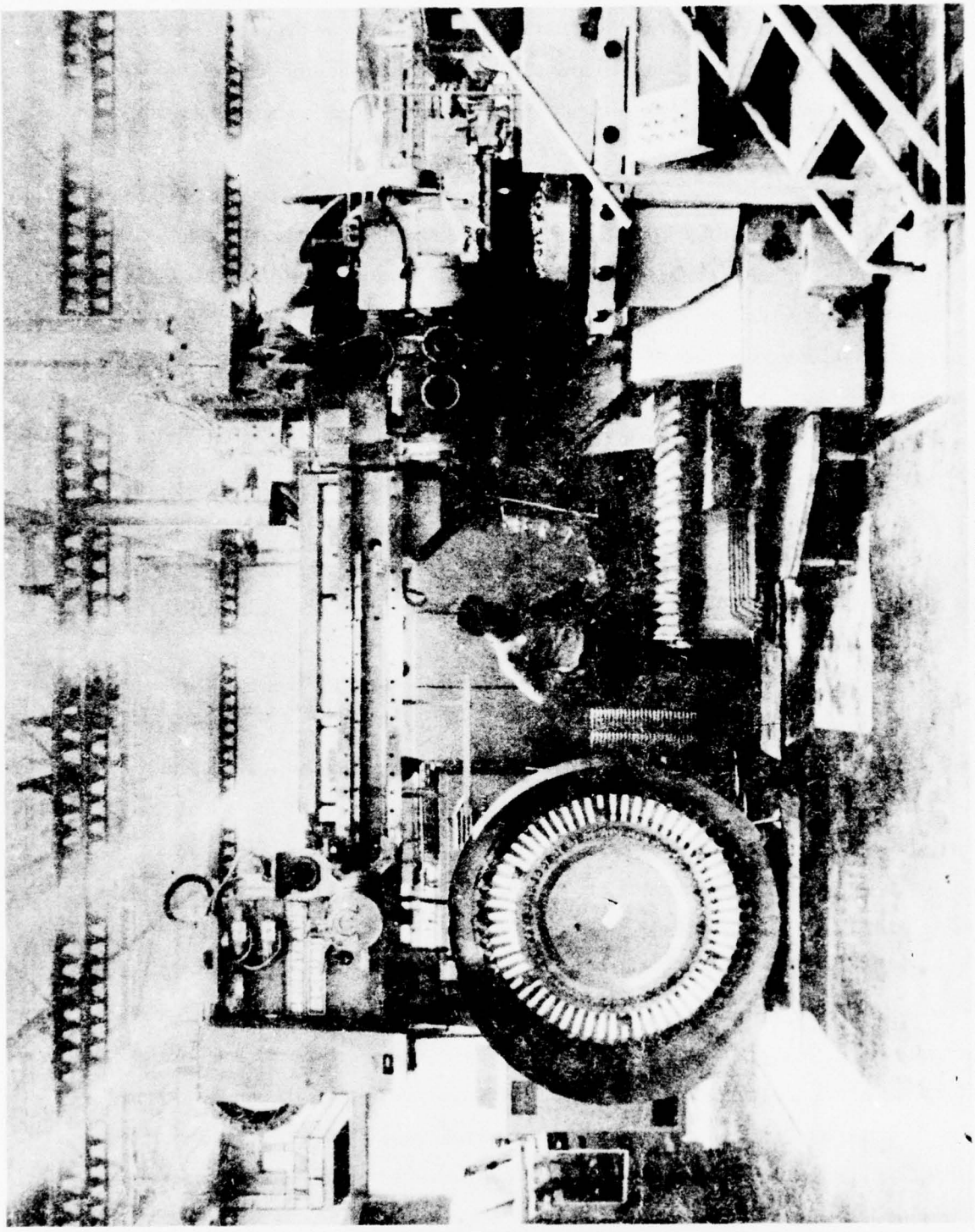


Figure 18. Five-Axis Milling Machine

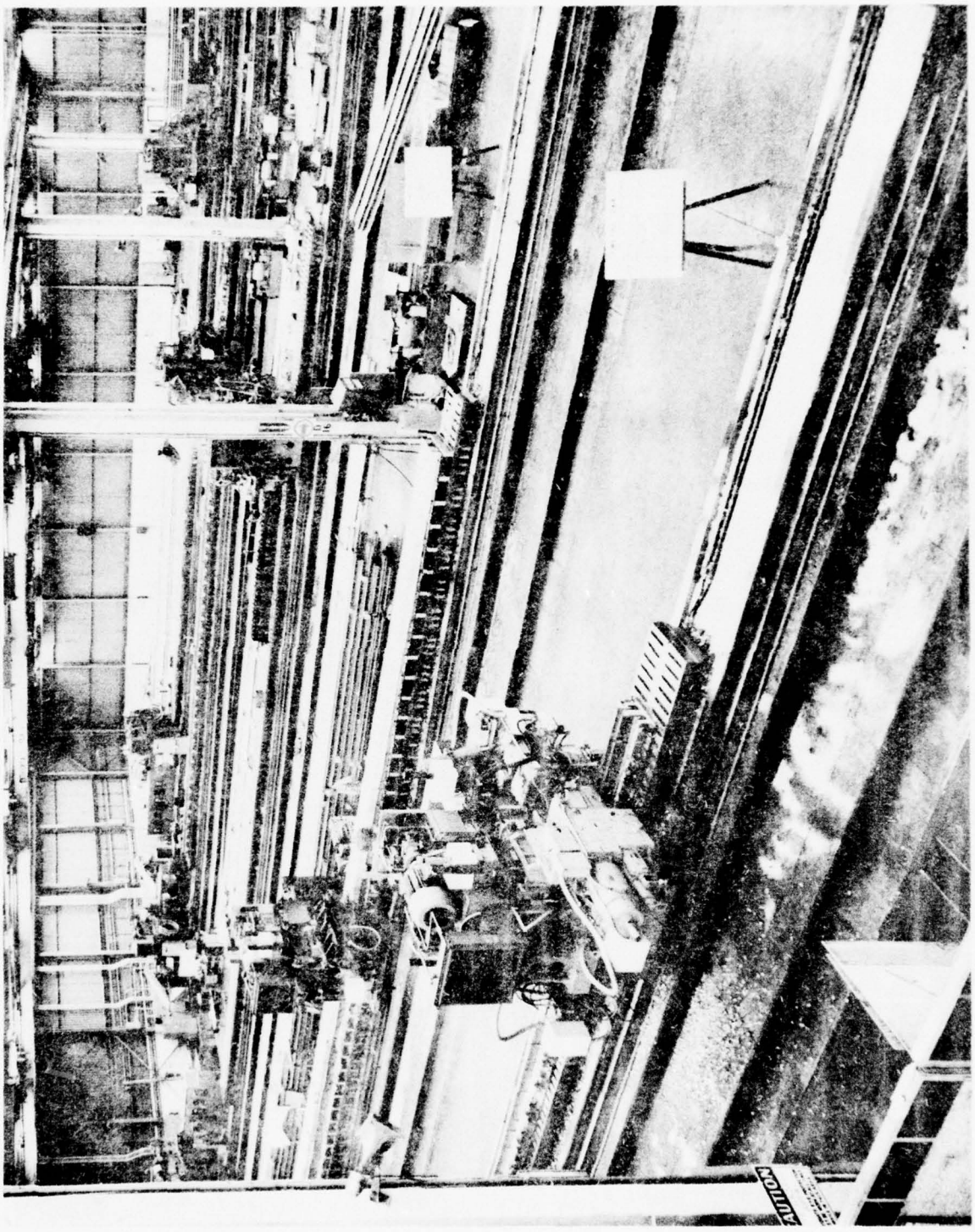


Figure 19. Spar Mills

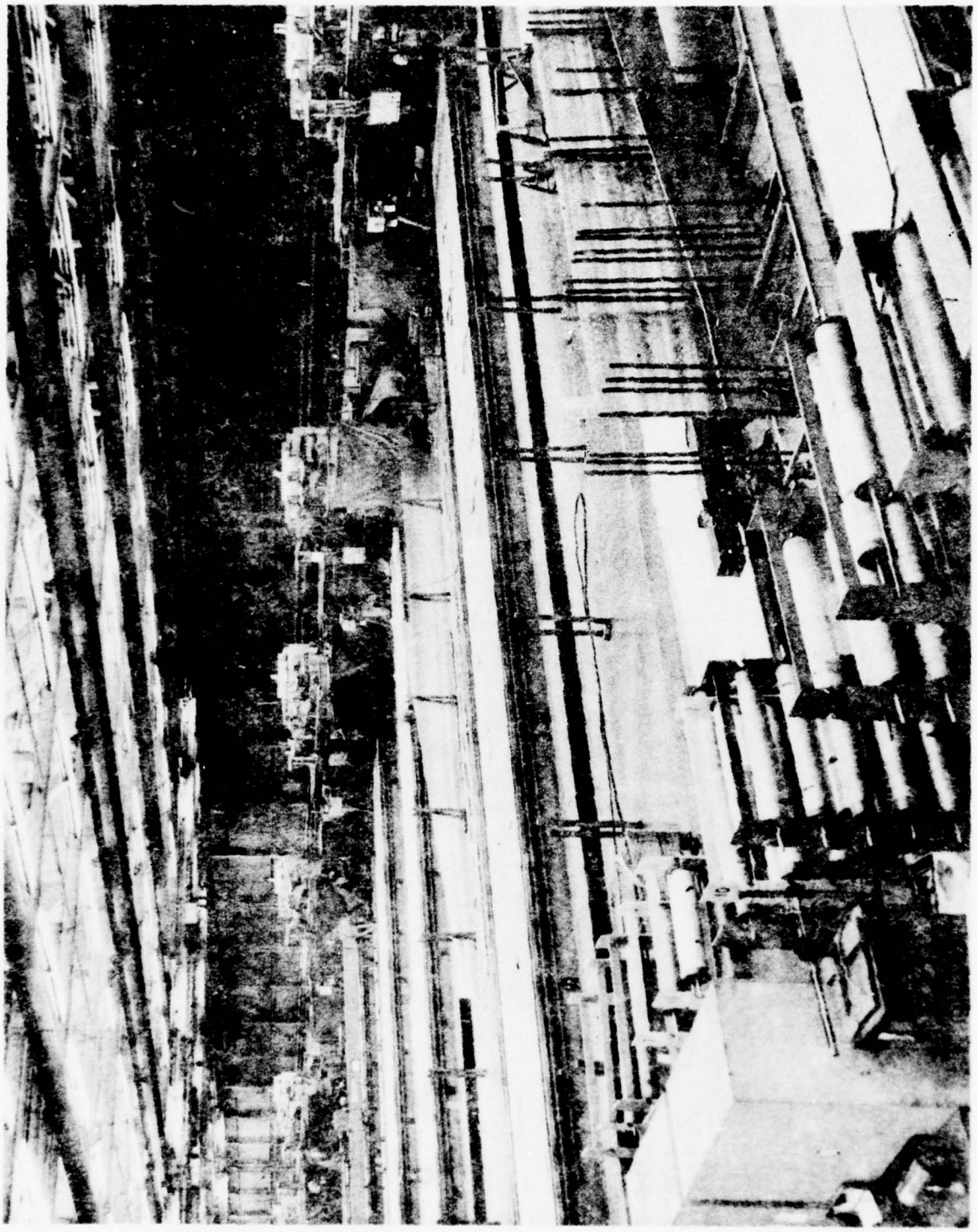


Figure 20. Skin Mills

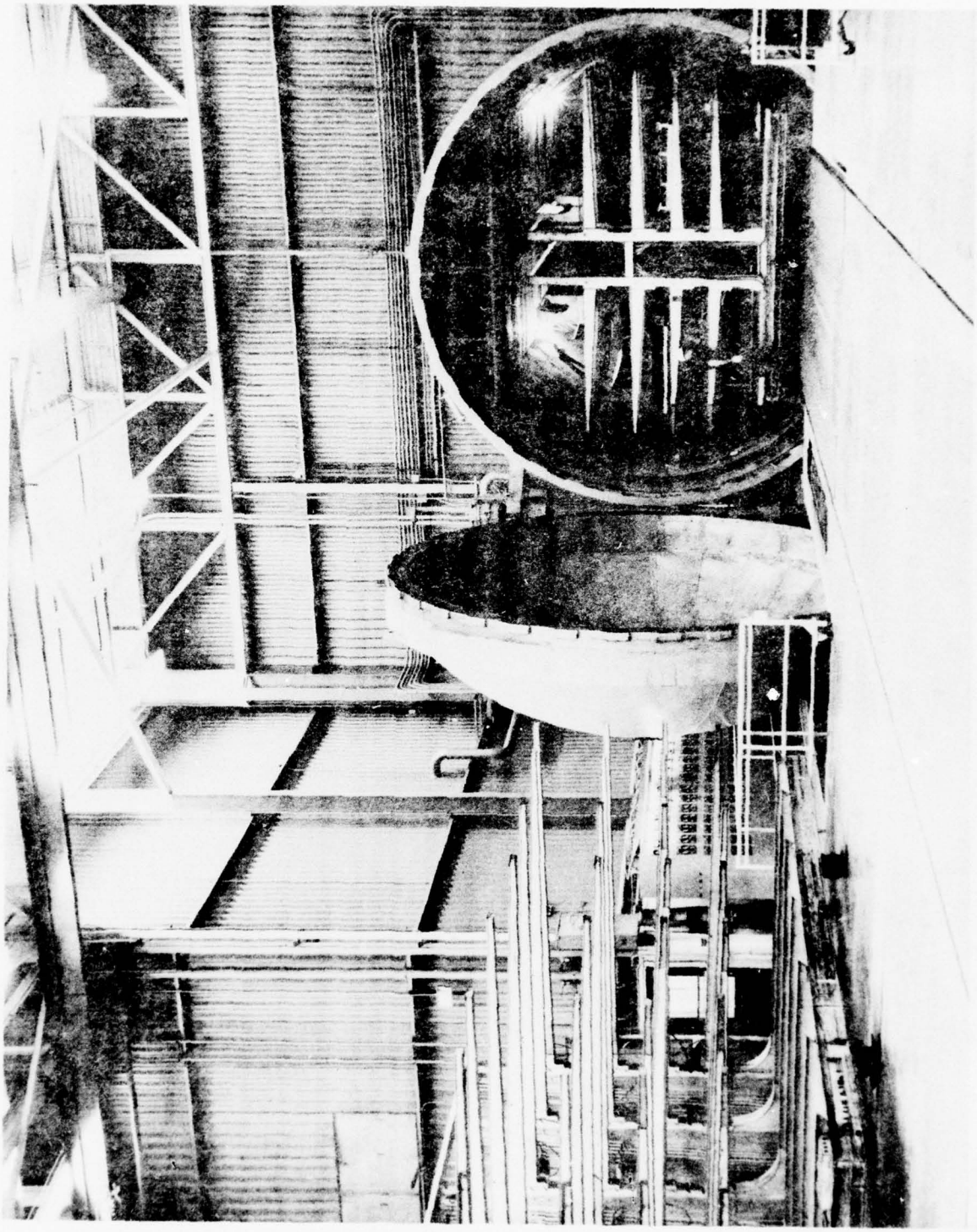


Figure 21. Autoclave

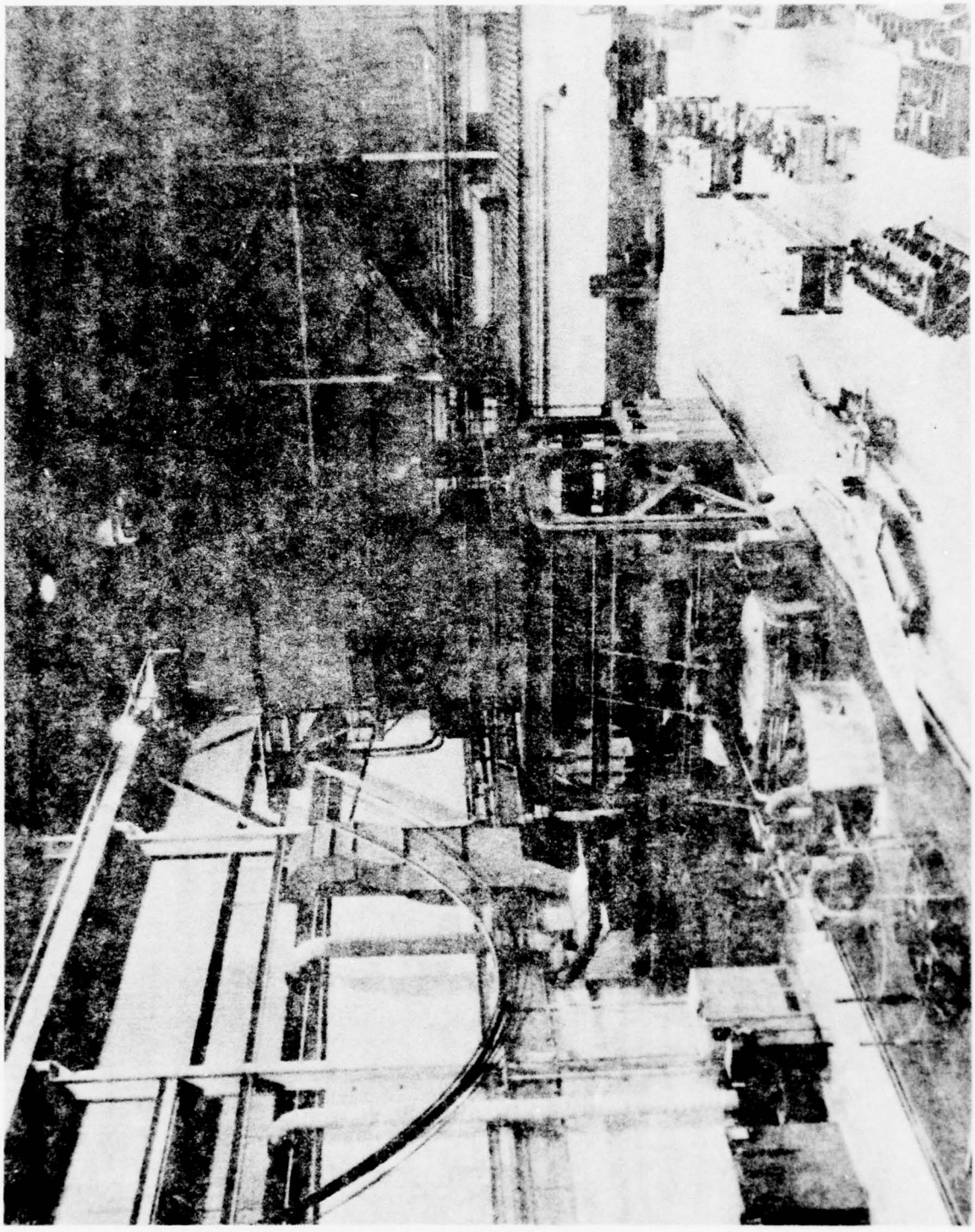


Figure 22. Heat-Treat Furnace

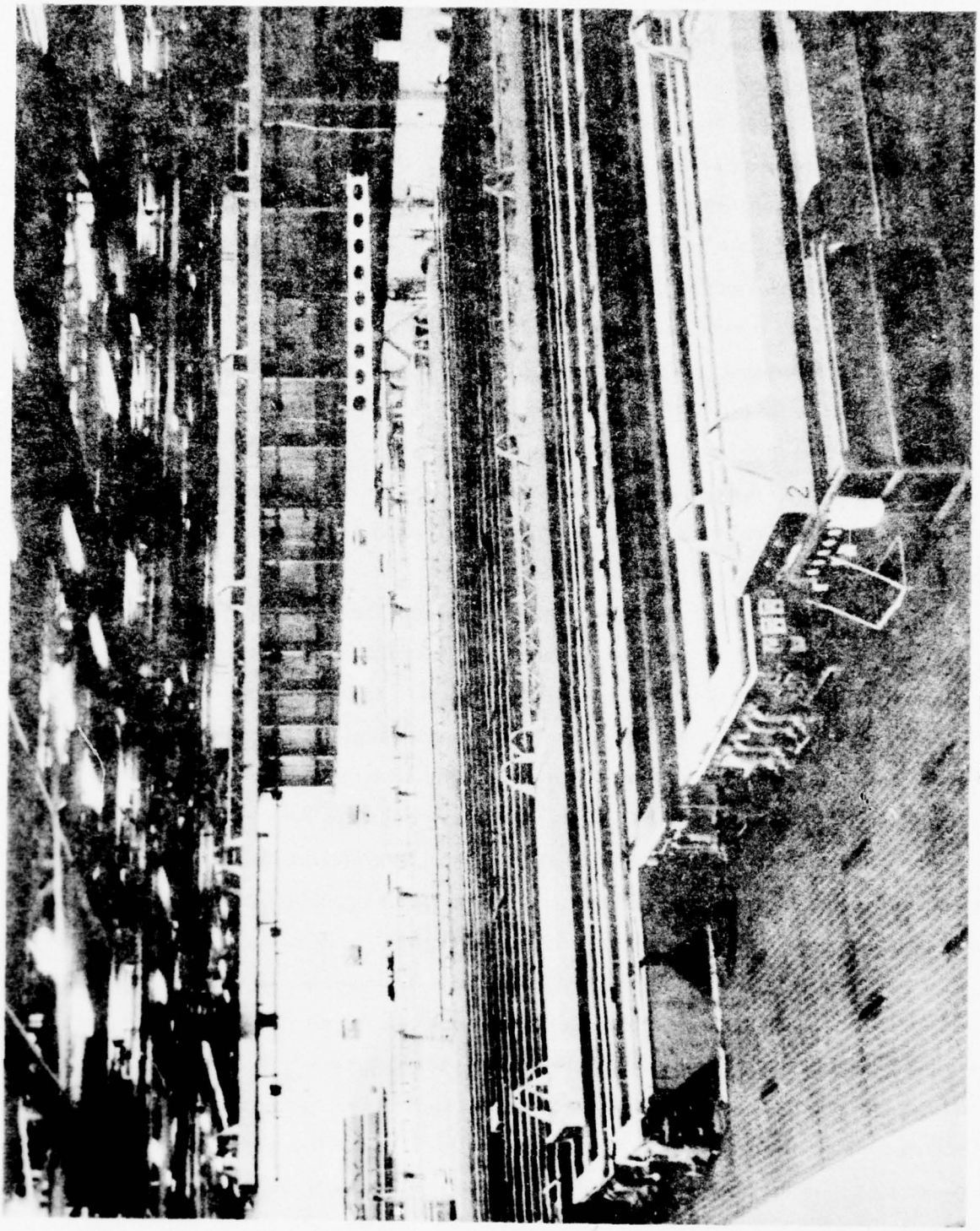


Figure 23. Process Tank Line

As overpressure levels increase above 10 psi, the size (and cost) of protective arches or canopies increases. In addition to resisting vertical loads from blast and from falling roof structure, the protective structure must resist side loads from the blast wave overpressure and dynamic pressure. Some method of tie-downs or massive foundations thus are necessary to resist the sideward translation and overturning forces. As design work progressed on several potential candidate protective structures, it became apparent that the overturning loads were predominant and required prohibitively massive tie-downs and foundations at overpressures of 20 to 30 psi. Forty psi was about the technical limit at which foundations and tie-downs were adequate to resist overturning loads. At this overpressure level, the size and mass of the protective structures made them prohibitively expensive and cumbersome. In addition, permanently in-place structures would require extensive modification to the original factory layouts and even then would interfere with work flow. The study team concluded that the use of canopies was unacceptable from the standpoint of cost, interference with machine power and chip removal systems, and productivity impact. The expense of implementing this scheme in an existing plant would be enormous. It would probably be unacceptable even in a new plant designed for hardness.

At this point, the study team began to "think Russian." The cheapest protective method shown in the Soviet literature is to pack the machinery in sandbags or earth (Figure 24). This, in addition to protecting against structural debris, would protect against blast pressures up to 80 psi. Moreover, unlike the canopies, the soil cover would protect against fire. The disadvantage of this method is that the equipment is out of operation until the soil is removed and is subject to corrosion unless care is taken in greasing or painting all surfaces that might corrode.

Preliminary examination of typical industrial areas indicated that the level of protection obtainable from earth cover (40 psi minimum, 80 psi maximum) would be generally adequate to protect machinery in all but high-density industrial areas. However, to ensure survival of unique machinery such as skin mills, the 40-psi to 80-psi protection level would not be adequate if the machinery was located in a single building such as is the case at the Boeing Auburn facility. In theory, such a problem could be solved by distributing the machines among the several Boeing plants in the metropolitan area. Such distribution would provide adequate protection against low-yield weapons. The increase in production costs resulting from such a move, however, would be intolerable in the high competitive environment of the aerospace industry. Alternatively, higher levels of hardness could be used to protect nondispersed facilities (U.S. and older Russian factories) against high-yield (1-megaton) weapons. Having considered these factors, the study team began to search for protective methods that would provide higher levels of protection.

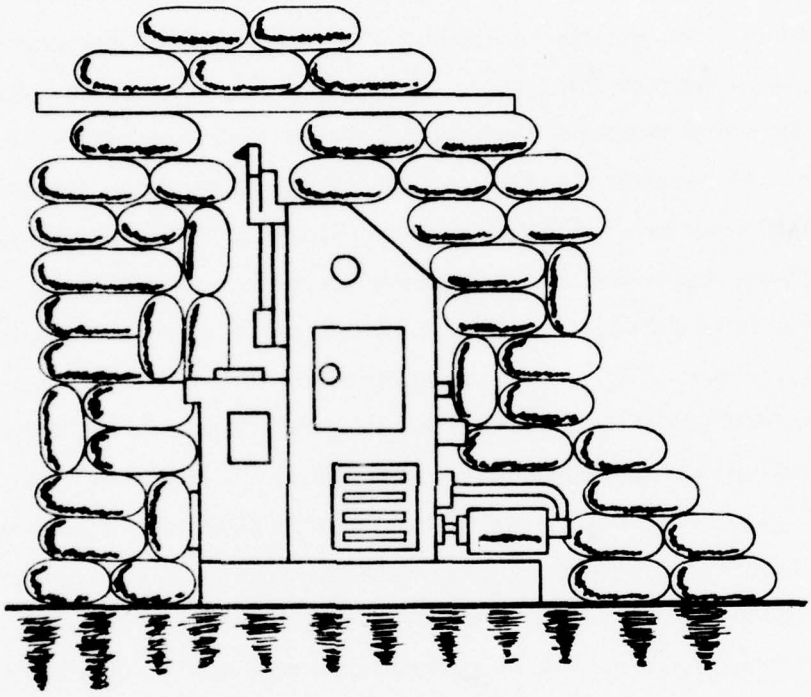


Figure 24. Рис. 2. Вариант консервации

Расход материалов: мешки — 180; брус 60×200 — 20 пог. м; пленка полиэтиленовая — 25 м².

Затрата рабочей силы: насыпка мешков песком, подноска, укладка — 58 чел/час; бригадой в 8 человек при 10-часовой смене работа выполняется за 5,3 часа

One of the factors that limits the protective capability of the earth cover method is the soil motion that would be induced by a nuclear blast. At about 80-psi air overpressure, shock from the soil motion is sufficient to damage even massive machines. To prevent ground shock damage at higher overpressures, some method of shock isolation or shock mitigation is required. Of the several methods investigated, the cheapest and easiest way of protecting a machine was to completely surround it with a layer of crushable material such as foamed plastic or the metal chips from machining operations. (This protection method is exactly analogous to packing sensitive instruments in plastic foam for shipment.) In practice, during construction or relocation of machines, the foundation of each individual machine would be supported on a crushable pad such as styrene or polyurethane foam. (In the event of a crisis, machines that had not previously been shored up with crushable material would have to be jacked up and supported on wooden cribbing.) Prior to an attack, each machine would be covered with crushable material such as plastic foam, balsa wood, or metal chips. Since metal chips are a byproduct of normal machining operations, there would be no supply problem; Figure 25 illustrates the quantities of such chips produced in a couple of hours by one of the large skin mills at the Auburn facility. The crushable material would then be covered by a layer of soil or sandbags to protect the machine from fire, air blast, and debris. Figure 26 illustrates the application of this protective method to a five-axis milling machine; this protective treatment is also suitable for the spar mills. The autoclaves are somewhat easier to protect as they can be strengthened by internal pressurization and hence would not need a cushion of chips.

A few machines do not lend themselves to the hardening techniques described above. Thin-walled vessels such as the process line tanks would be crushed, and wide unsupported plates such as the skin mill beds could collapse. For these devices, some method is necessary that would permit equalization of the explosive pressures on all sides of the structural elements. To provide this protection, the study team used a technique extracted from the Russian literature whereby the machines are covered with grease to prevent corrosion and then submerged or flooded in water. Using this method, sandbags supported by cribbing could be placed immediately above the surface of the water to protect the machine from debris and limit displacement of the water by the blast wave. The application of this protection technique to the process tank line and to the skin mill is shown in Figures 27 and 28.

The vertical heat treat furnace required yet a different type of protection approach. This furnace is very large and relatively fragile. The furnace itself could be protected by either turning it on its side, packing it with sand, and then surrounding it with sandbags or earth, or by moving it

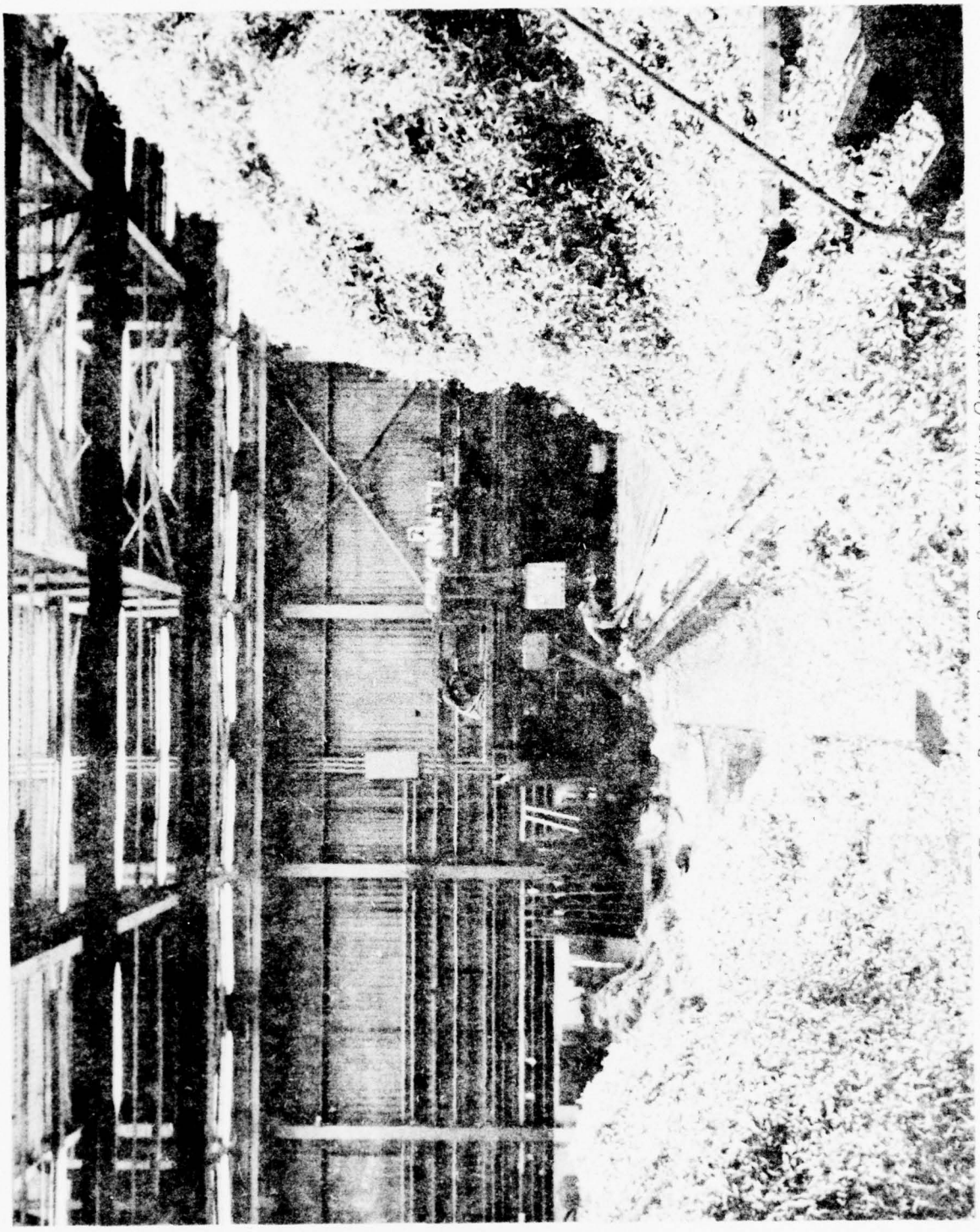


Figure 25. Chips Produced as a Byproduct of Milling Operations

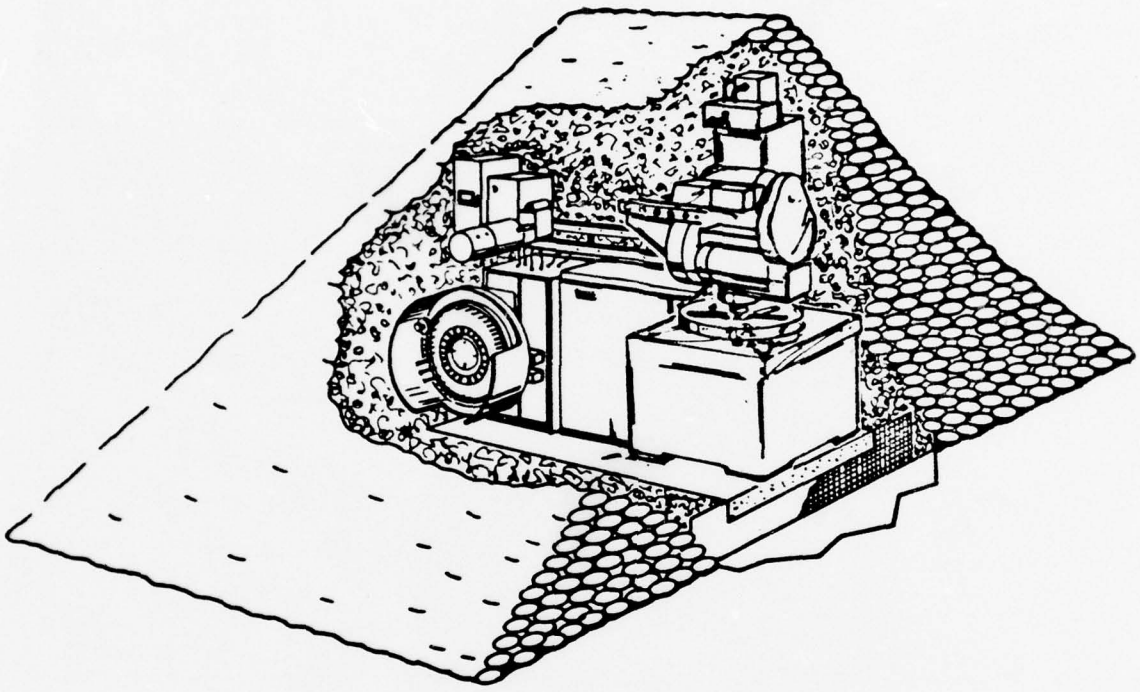


Figure 26. Hardened Five-Axis Mill

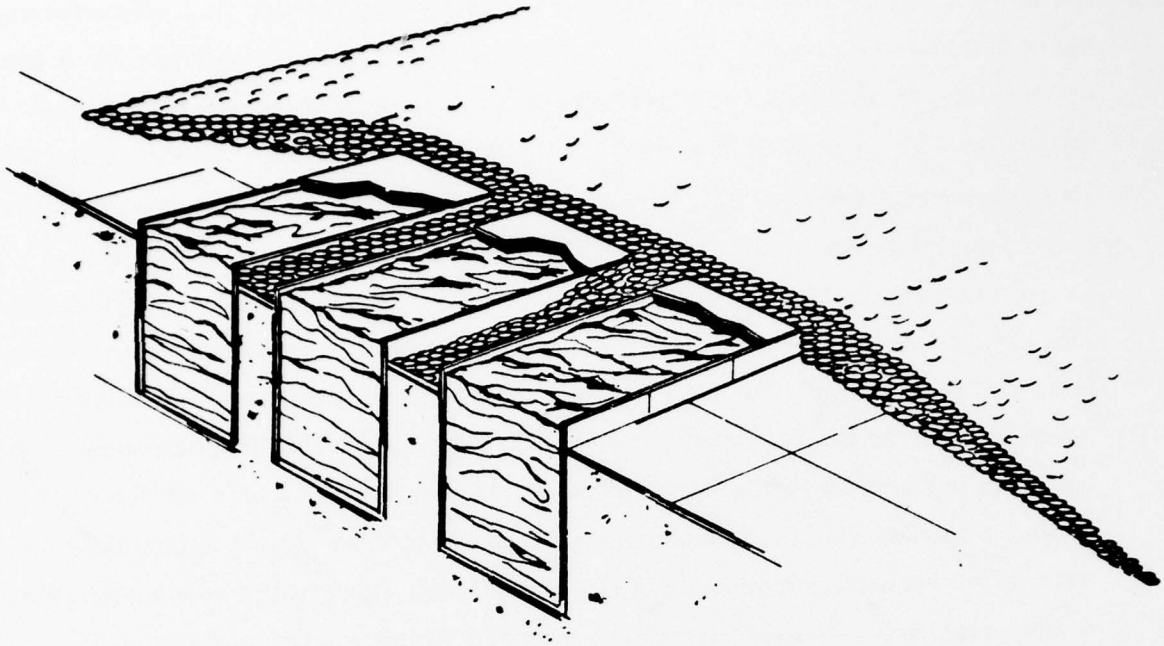


Figure 27. Hardened Tank Line

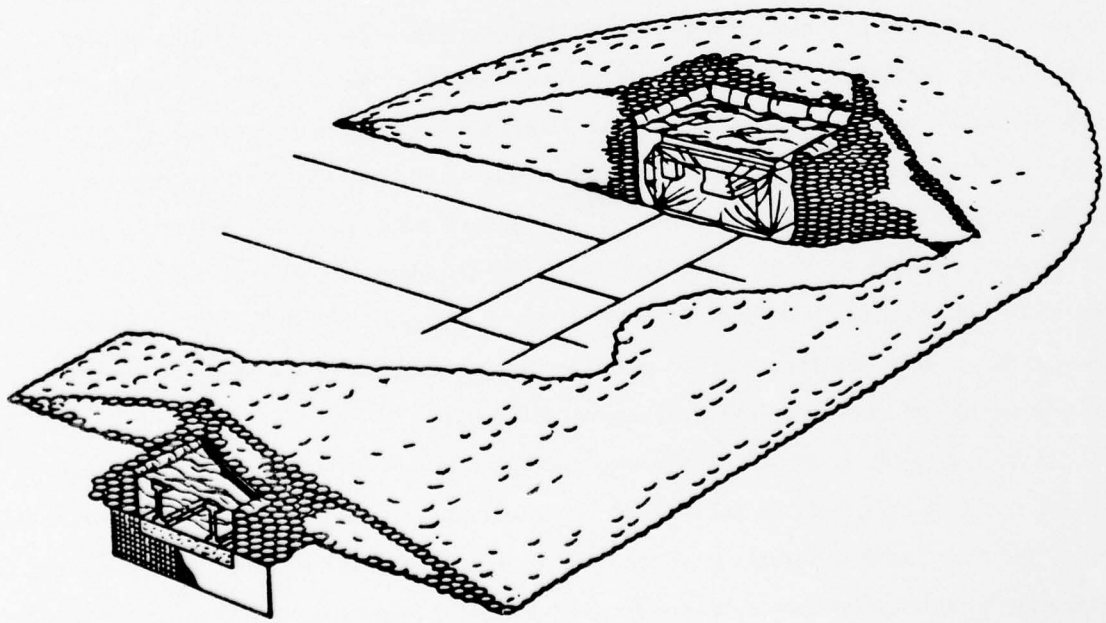


Figure 28. Hardened Skin Mill

into a pit and packing it with sand. The quench tanks would be filled with water after being emptied of their corrosive contents. Application of this technique is illustrated in Figure 29. In practice, the collocation of machines in the shop would permit merging of the earth mounds from adjacent machines. This results in an essentially flat soil surface throughout the factory area and greatly reduces the amount of soil per machine that must be moved. Preliminary estimates indicated that the machines could be protected against 200- to 300-psi blasts by the means described.

The next step in the study involved a test program to confirm the validity of the protective methods considered. The technical principle involved in the proposed methods of protection is known as "earth arching." The metal chips used to pack the machines also serve to support the lower surface of the soil layer covering the machinery. If the soil layer is properly supported from below, the soil itself will form a natural bridge that will carry the blast loads across the cavity in which the machine is located, thus preventing the blast forces from reaching the machine itself. The principles of earth arching are well understood in highway construction and tunnel building technologies, where culverts and tunnel liners are not of themselves structurally adequate to carry the full weight of the earth above the tunnel itself.

Static Tests

A series of static tests was initiated to test machine survivability concepts. These were designed to provide information at an absolute minimum cost. Simple static tests were first conducted to determine whether or not chips were adequate to support earth arching and also provide the "rattle space" needed to protect against ground shock. In the most convincing of these tests, a shoebox was surrounded by several inches of chips, covered with soil, and subjected to static overpressure by driving a pickup truck wheel onto the mound of soil. The static overpressure at the surface was about 30 psi. After the test, the shoebox was somewhat dished in on top but not flattened. A second test involved only chips and soil (Figure 30). A glass plate was set up against the chips to permit observation of soil motion and crushing of the chips. These tests clearly established that the chips would support soil arching.

The next test in the static test series was conducted using a full-scale precision grinding machine. The purposes of this test were to (1) provide a larger scale static load test, (2) determine the effect of soil settling during a prolonged period of burial, and (3) determine whether or not corrosion would be a problem during prolonged burial in an area exposed to weather. This latter

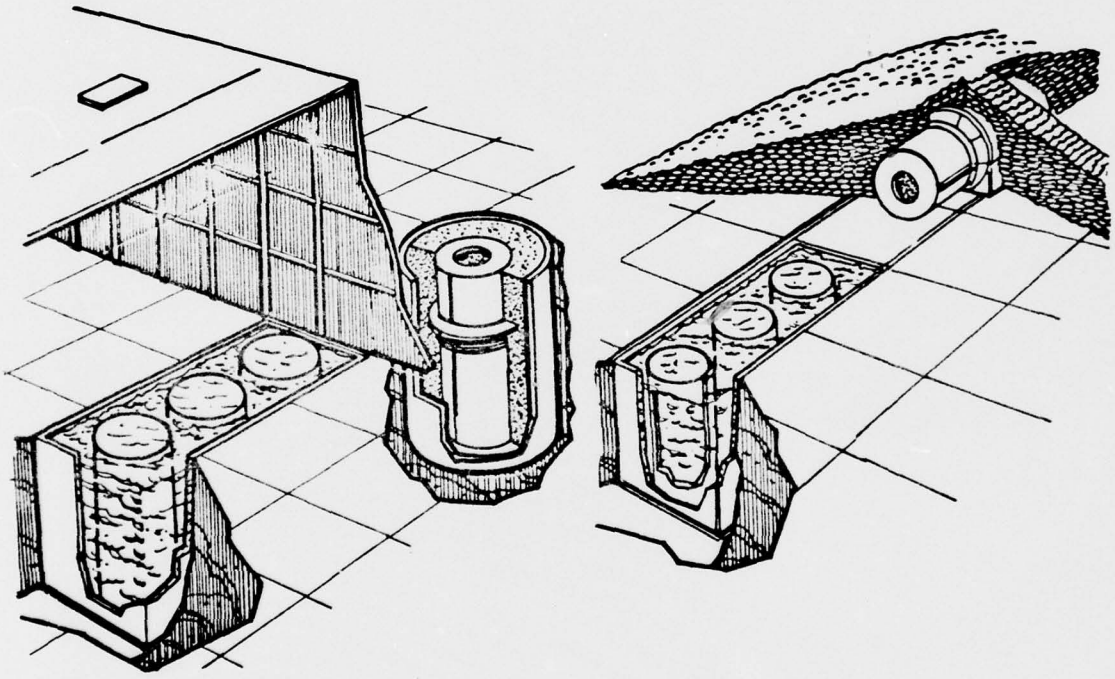


Figure 29. Hardened Heat Treat Facility

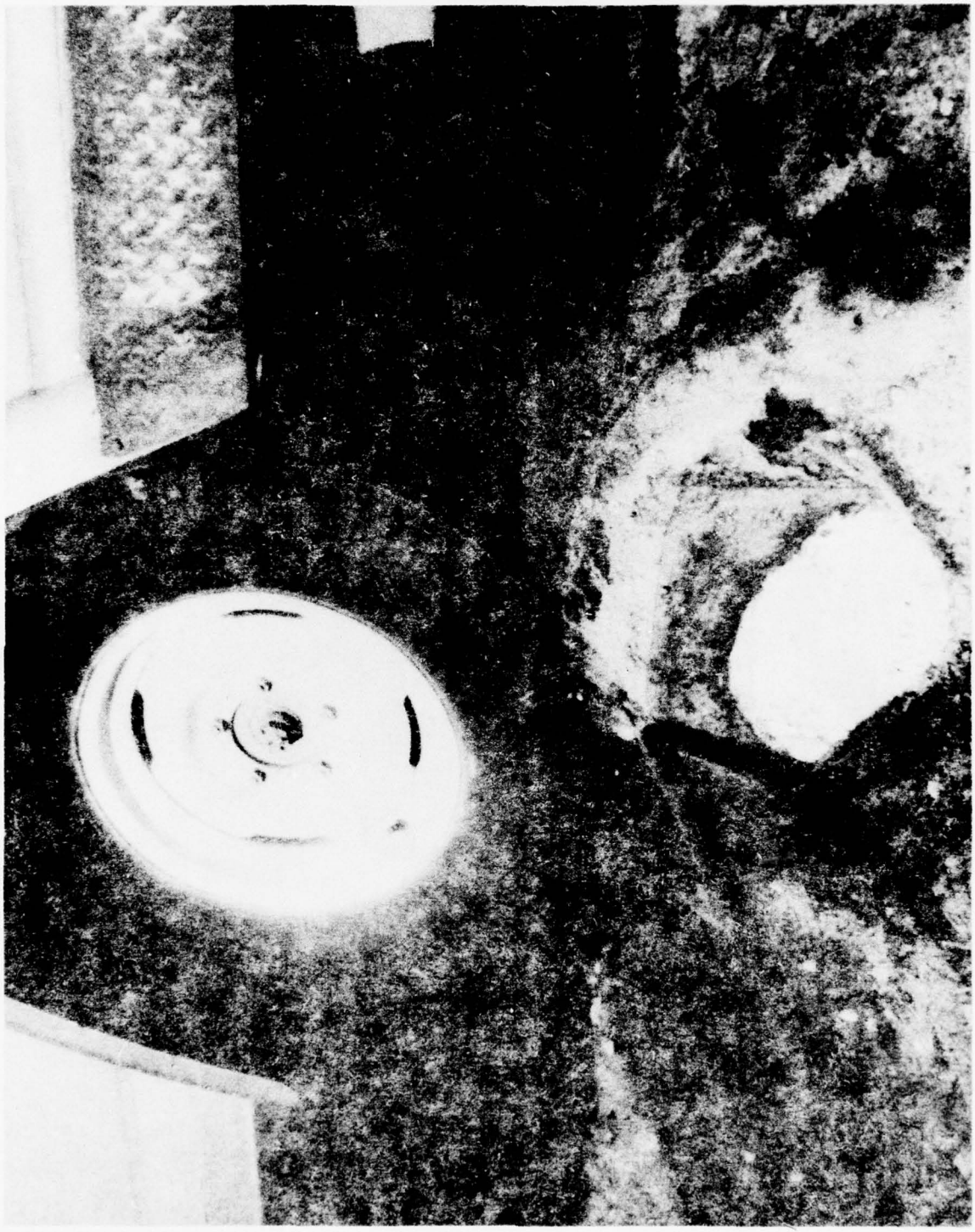


Figure 30. Static Test of Earth Arching Principle

point is important because buildings and roof cover would probably be destroyed in a nuclear attack. The test involved placing the grinder wrapped with plastic on a crushable styrene base (Figure 31), and then surrounding it with bags of metal chips (Figure 32). Several very simple types of gauges were used to record the motion of the chips and the covering soil (Figure 33). The area above and around the machine was then covered with soil. Mr. Jack Potter, the facilities manager, personally conducted the static load test (Figure 34). The machine was left in the buried condition for approximately 6 weeks; in this interval, a rainfall of about 3 inches was recorded. During excavation of the machine, the soil motion gauges were checked (Figure 35). The protective chips compressed less than 5%, an amount that would cause no damage even to fragile items. Afterwards, the grinder was moved back into the shop and functionally tested (Figure 36). The machine sustained only slight, easily repairable damage, much of which was probably due to handling during the burial and excavation processes. Also, there was a very slight layer of surface corrosion that could probably have been prevented by the use of an antirust coating prior to burial.

Five-Ton Test

The next step in the test program was to investigate whether or not the earth arching technique would withstand the dynamics of a high explosive blast. The Defense Nuclear Agency had scheduled a test involving detonation of 5 tons of TNT at Holloman Air Force Base on August 25, 1976, as part of a scale-model B-1 bomber test. Boeing was allowed to emplace test specimens in the vicinity of the explosive. Test components, together with very simple crush gauges, were emplaced at levels where they would receive 20-, 40-, 80-, 200-, and 300-psi blast pressures. Because of the relatively small yield of the explosion, small components such as electromechanical calculators, chain hoists, and vacuum pumps of the types shown in Figures 37, 38, and 39 were used. Gallon-size cans were included to represent processing tanks. The results are summarized in Table 1. The chain hoists and the vacuum pumps were completely undamaged. At the 200-psi level, the tanks were bent, but the bending was sufficiently light that they could have been repaired and returned to service. The electromechanical adding machines were the most complicated and fragile mechanisms tested. There was no damage visible to any of these machines at the lower overpressure levels. At 200 psi and 300 psi, the movable parts appeared to be slightly loosened, but the machine operated correctly during checkout. A test report giving further details on the test specimens, emplacement, gauge readings, and other results is in preparation. When completed, it will be available upon request from The Boeing Company.

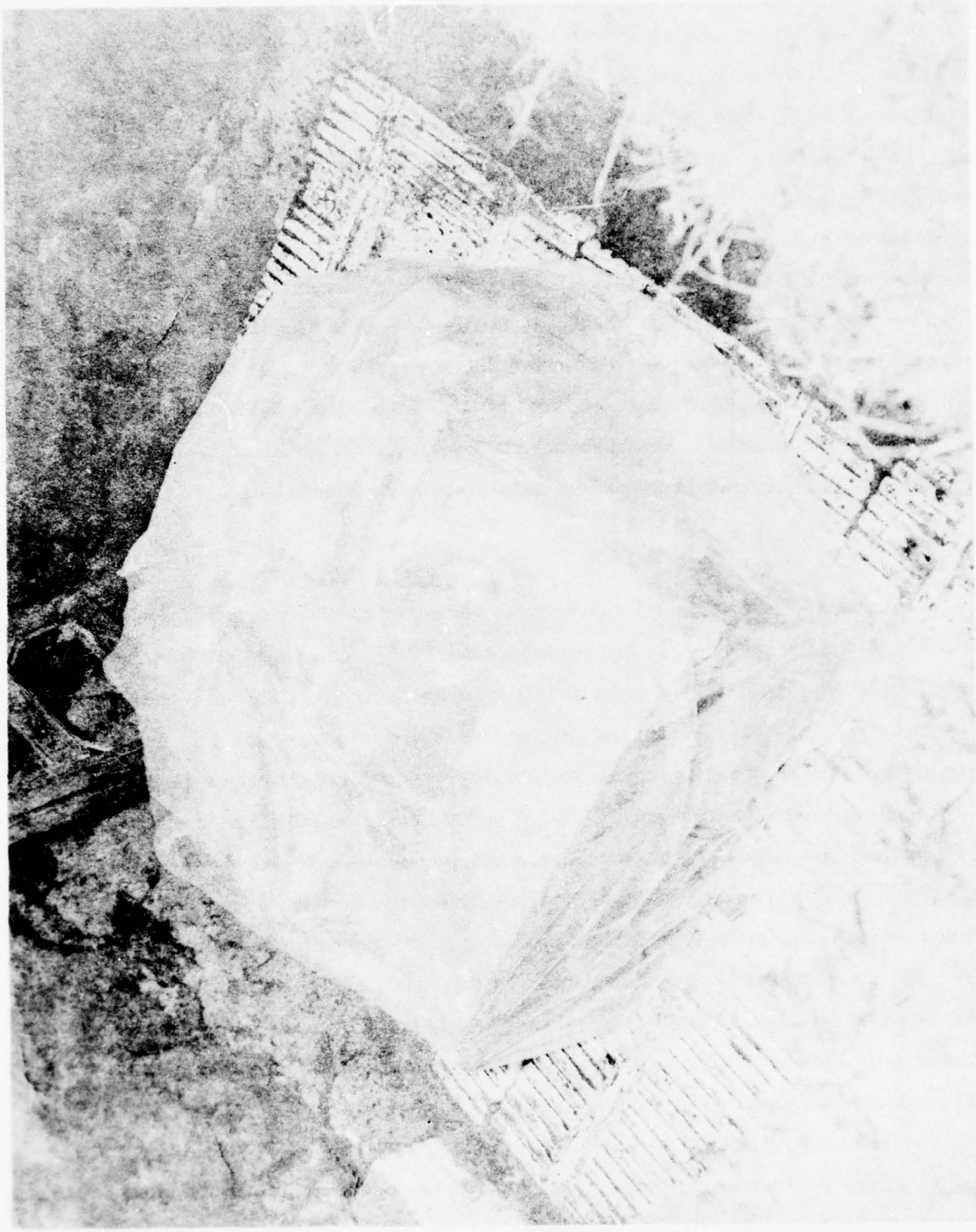


Figure 31. Burial Test (Machine Is Wrapped in Plastic and Placed on Styrofoam Blocks)

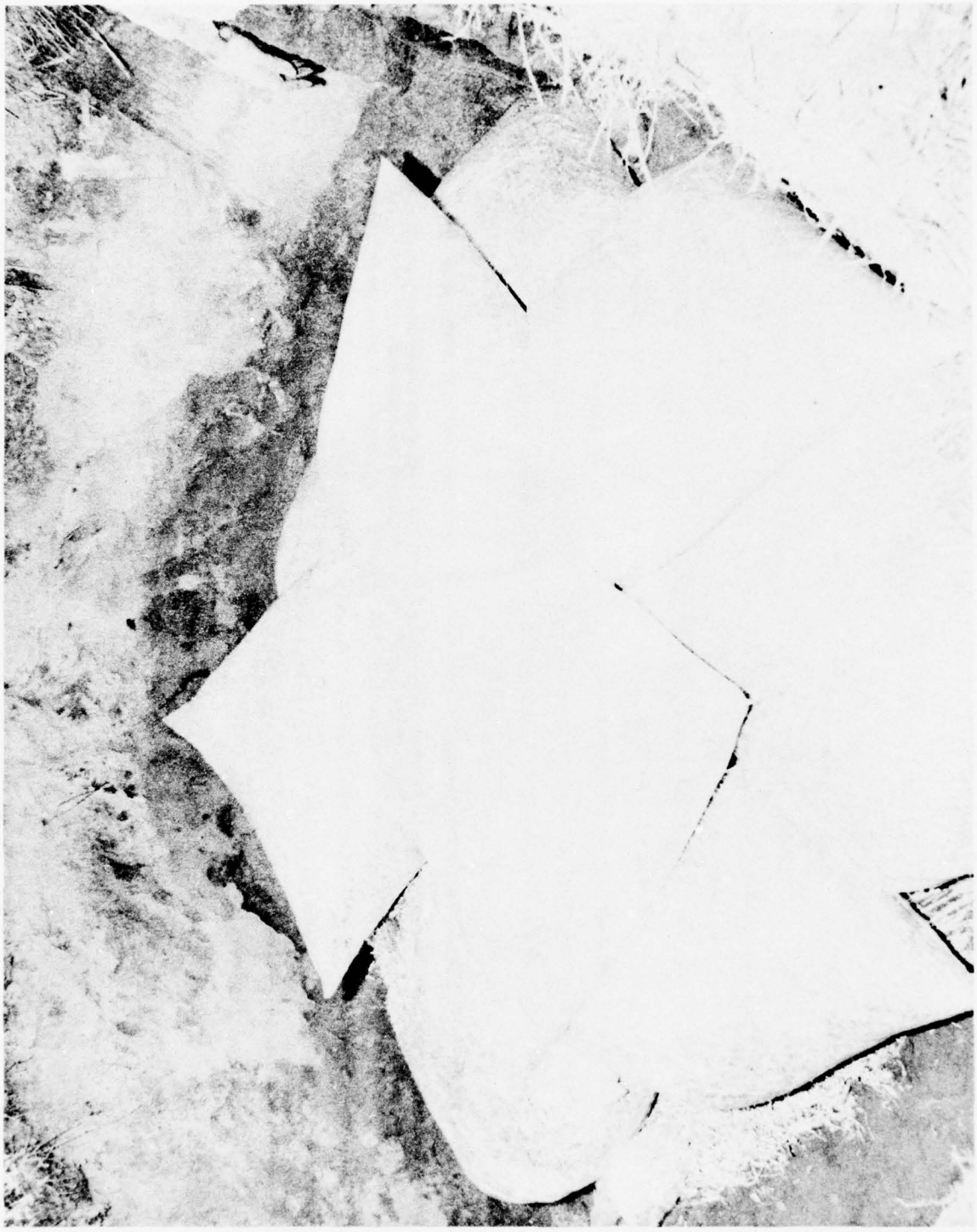


Figure 32. Machine Packed in Bags of Metal Chips

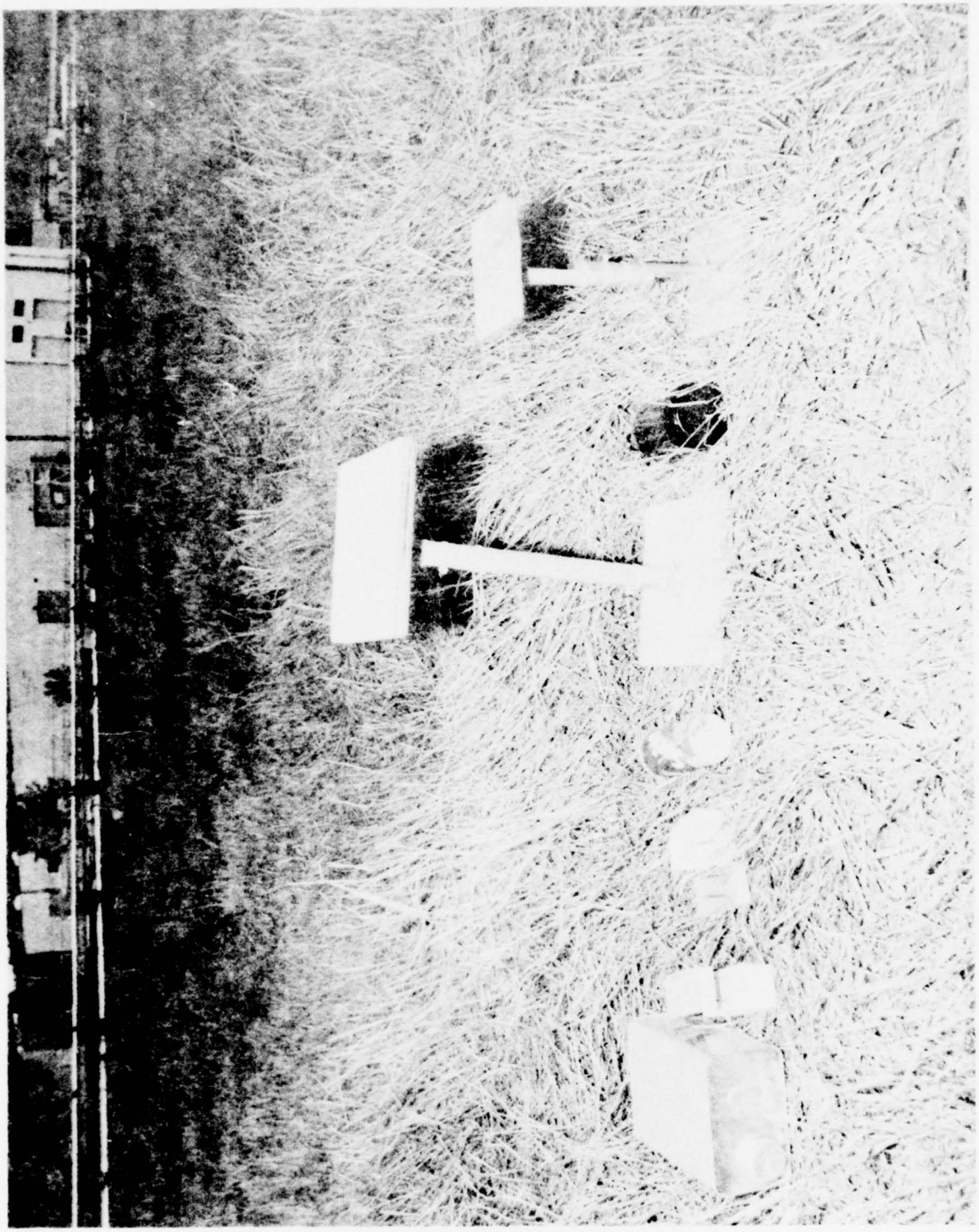


Figure 33. Gauges Used To Record Soil Settling During Burial Test

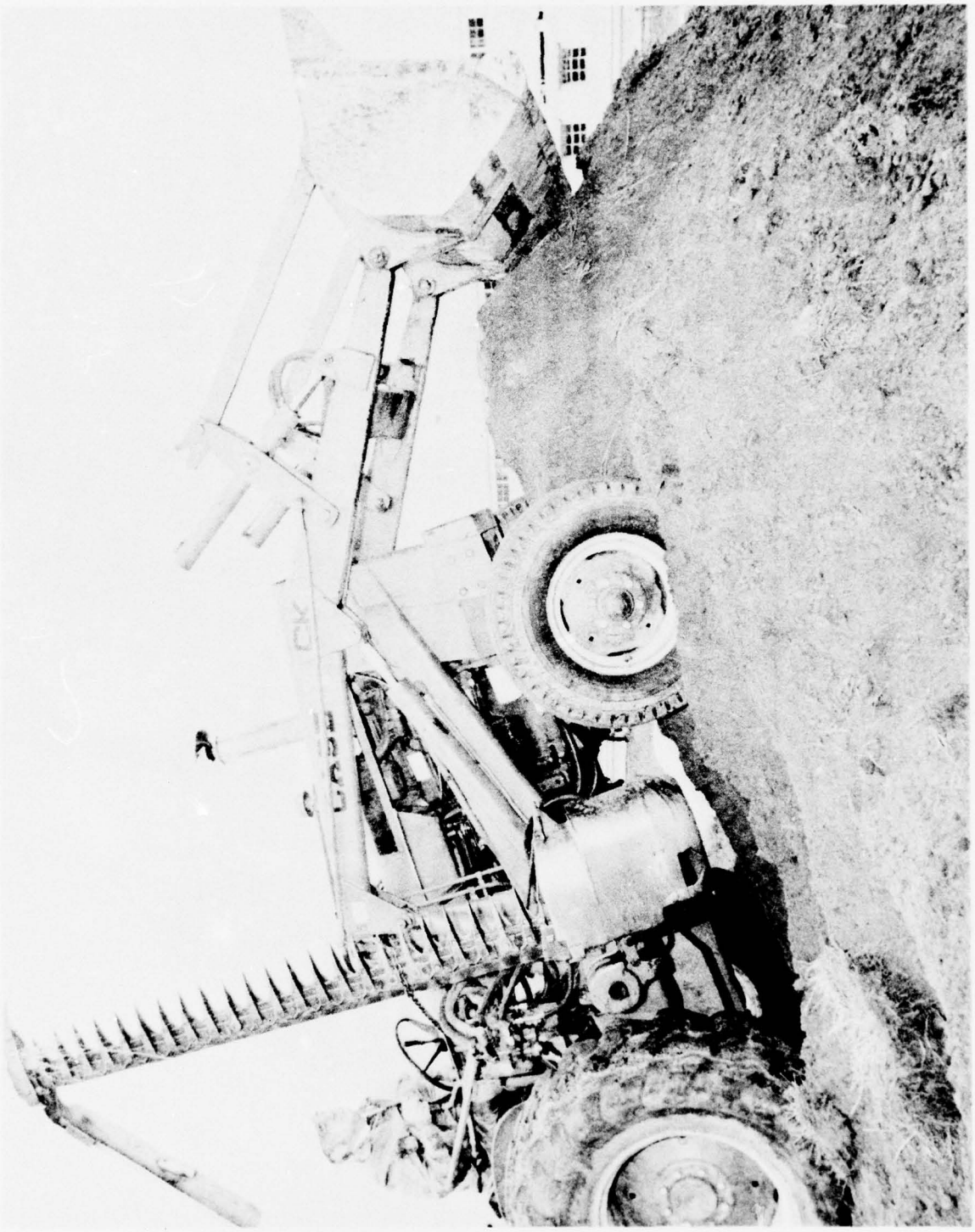


Figure 34. Static Load Being Applied to Buried Machine

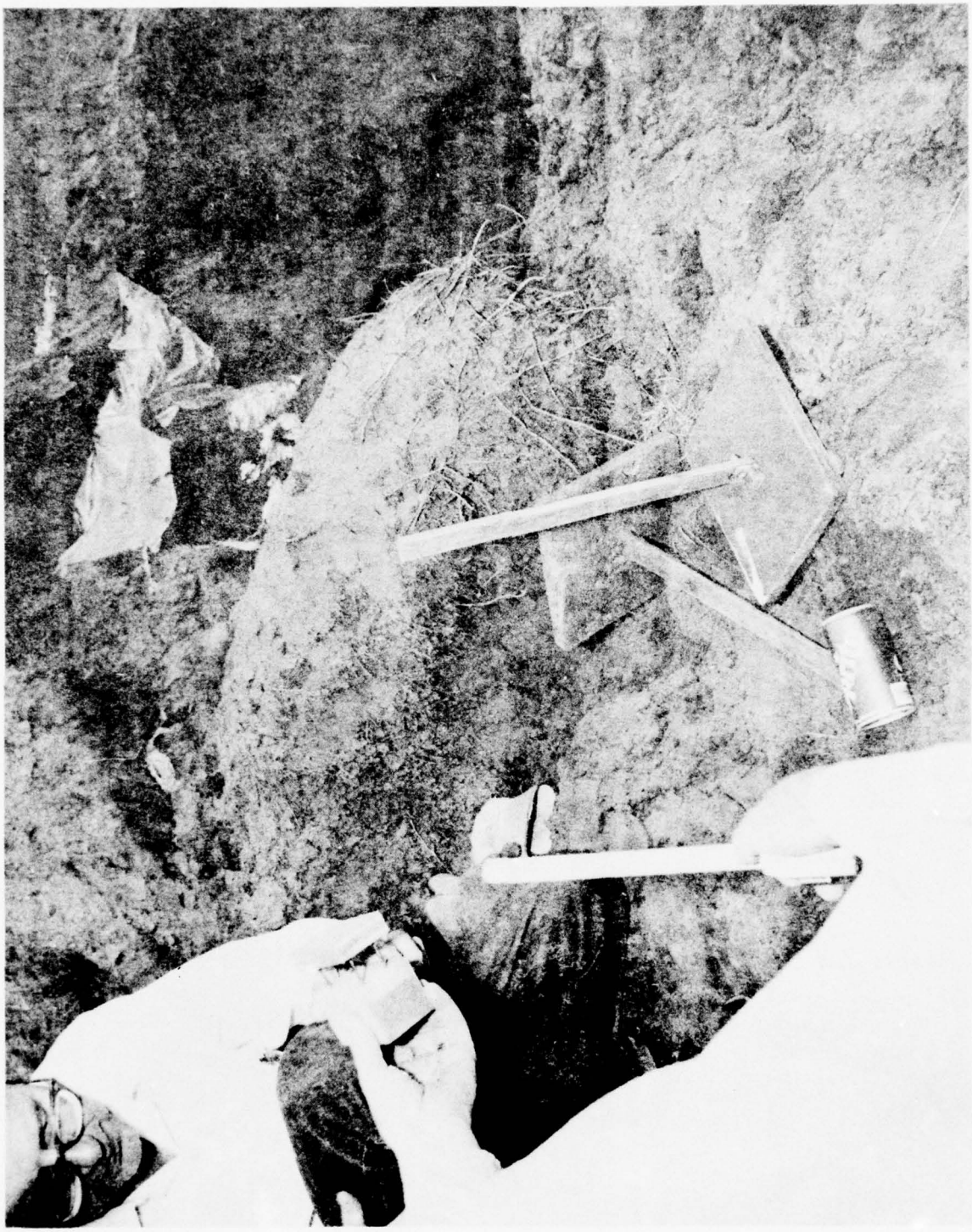


Figure 35. Excavation (Measuring the Soil Movement Gauges)

Figure 36. Functional Test of Machine After Burial Test

Figure 37. *Electromechanical Calculator After 5-Ton High-Explosive Test (Calculator Survived in Area Exposed to 300-psi Blast Pressure)*

Figure 38. Chain Hoist Before 5-Ton High-Explosive Test (200-psi Level)

Figure 39. Vacuum Pump After 5-Ton High-Explosive Test (200-psi Level)

Table 1. Five-Ton Test Results

	300	200	80	40	20
Chain hoists	←	Undamaged	→	#	#
Pumps	#	←	Undamaged	→	#
Adding machines	← Operable	→	←	Undamaged	→
Tanks	#	** Repairable	←	Undamaged	→

\# Not tested

* Movable parts were loosened but machine operated correctly during postshot checkout.

** Tank walls slightly dented

Five-Hundred-Ton Test

The final test conducted by Boeing was at the invitation of the Defense Nuclear Agency. They had scheduled a test equivalent to more than 500 tons of TNT for October 6, 1976. Because of their interest in, and potential importance of, industrial hardening measures, they asked Boeing to participate on a contract basis (Contract DNA-001-76-C-0350). Since no failures occurred to specimens during the 5-ton tests at Holloman at overpressures of up to 300 psi, the DNA requested that specimens be included in the large-scale test at the 600-psi level.

The first set of test specimens included four large machines—a drill grinder located at 200 psi (similar to the machine buried in the static test at Auburn, Washington); an electrolytic chip breaker grinder at 80 psi; a power supply device at 40 psi (the grinder and its power supply are shown in Figure 40); and a minibike at 600 psi. The bike, in addition to being a functional component, was available locally in time to meet the schedule and represented several different types of structure, including hollow tanks, tubular structure, and the relatively damage-resistant castings of the motor.

The second set of test specimens was comprised of aluminum pipes. These were tested at the 600-psi overpressure level to permit analytical correlation of observed damage with predicted failure mechanisms. The third set was made up of portable electric hoists. These were included to represent very rugged machinery. Small electric pumps and varidrive units were included in the fourth set of specimens to represent medium-hard machines. The fifth set was made up of the electromechanical calculators and adding machines. These represented soft, relatively fragile machinery. The sixth and last set of the test specimens included waterfilled electronic cabinet racks. These represented tanks such as those found in chemical processing lines.

The test specimens were placed on styrene blocks to permit protection against ground shock and then packed in chips and covered with soil. Most of the test specimens were placed so that the depth of soil above the protective chips would ensure reliable earth arching. The soil cover calculations were based on the assumption that the angle of failure of the soil under dynamic blast loading would be the same as the angle of failure previously demonstrated under static load conditions. To learn more about the minimum effective depth of cover for soil arching, several of the mechanical calculators buried at the 200-psi location were placed in 1-foot increments of depth from 5 feet to only 1 foot to ensure that some specimens would be damaged because of insufficient soil cover.

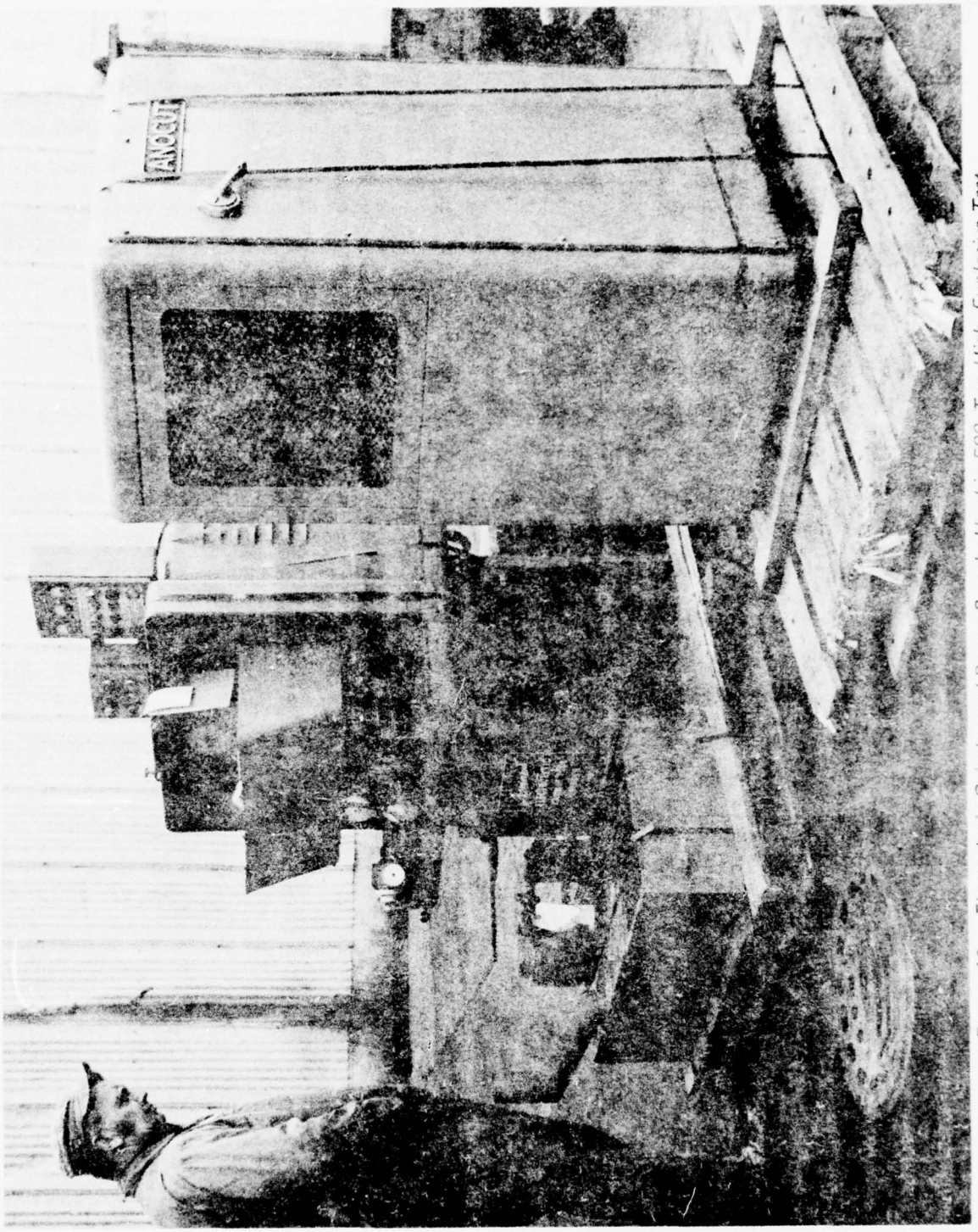


Figure 40. Electrolytic Grinder and Power Supply Used in 500-Ton High-Explosive Test

The principal results of the test were as follows. The large grinder located at the 200-psi level incurred only a slight dent on the operator's adjustable light. All of the working parts appeared to be undamaged. The grinder at the 80-psi location suffered some damage to sheet metal collars and guards. There was no visual damage to any working parts. Similarly, the power supply located at the 40-psi point suffered only sheet metal damage with no apparent damage to any working parts. The minibike withstood 600 psi. It was so close to the 200-foot-diameter crater that it was subjected to 1-1/2-foot soil heave. The only damage was that the front fender was bent sideways about 5 degrees and the handlebars and fork were misaligned (Figure 41). The minibike started after perhaps 5 minutes of cranking and was driven away.

Figure 42 shows aluminum tubing located immediately adjacent to the minibike. This area also received 600 psi of blast pressure. Because the depth of soil cover was not sufficient to provide earth arching, the tubing was totally destroyed by the blast pressures. Similarly, one of the calculators at the 600-psi location (Figure 43) was severely damaged because, again, insufficient earth cover had been placed over the metal chips. The importance of the metal chips is shown by the two calculators in Figure 44. The calculator on the left, surrounded by an adequate layer of chips, was undamaged. The calculator on the right, which was covered only with earth, was crushed by the blast pressures that forced the earth downward into the machine case. Figure 45 shows the tanks after the explosion. Some of the tanks were slightly bent but still serviceable. The main difficulty experienced with the tanks in the test was that the water tended to leak out, thus exposing the tanks to a greater amount of damage than would otherwise occur. A detailed report on the test setup, gauging, and data derived from this test is being prepared for the Defense Nuclear Agency.

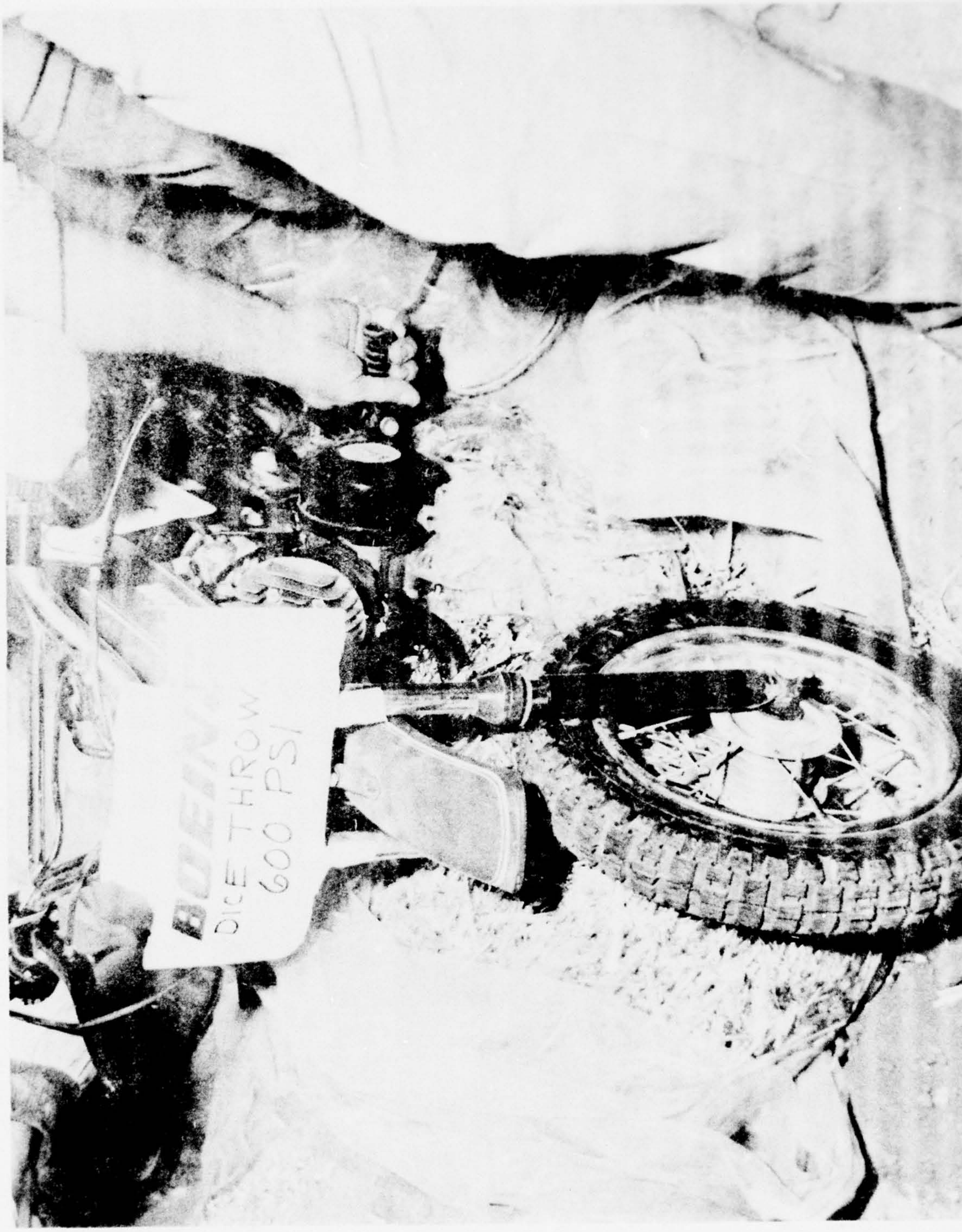


Figure 41. Minibike Being Removed From Test Location After 500-Ton High-Explosive Blast.
Test specimen was in an area subject to over 600-psi blast pressure and 1-1/2-foot soil heave. Note misaligned front fender.

Figure 42. Tubing From 600-psi Location. Because of insufficient earth cover, the tubing was crushed by blast forces.

Figure 43. Calculator From 600-psi Location. Damage resulted from insufficient earth cover.

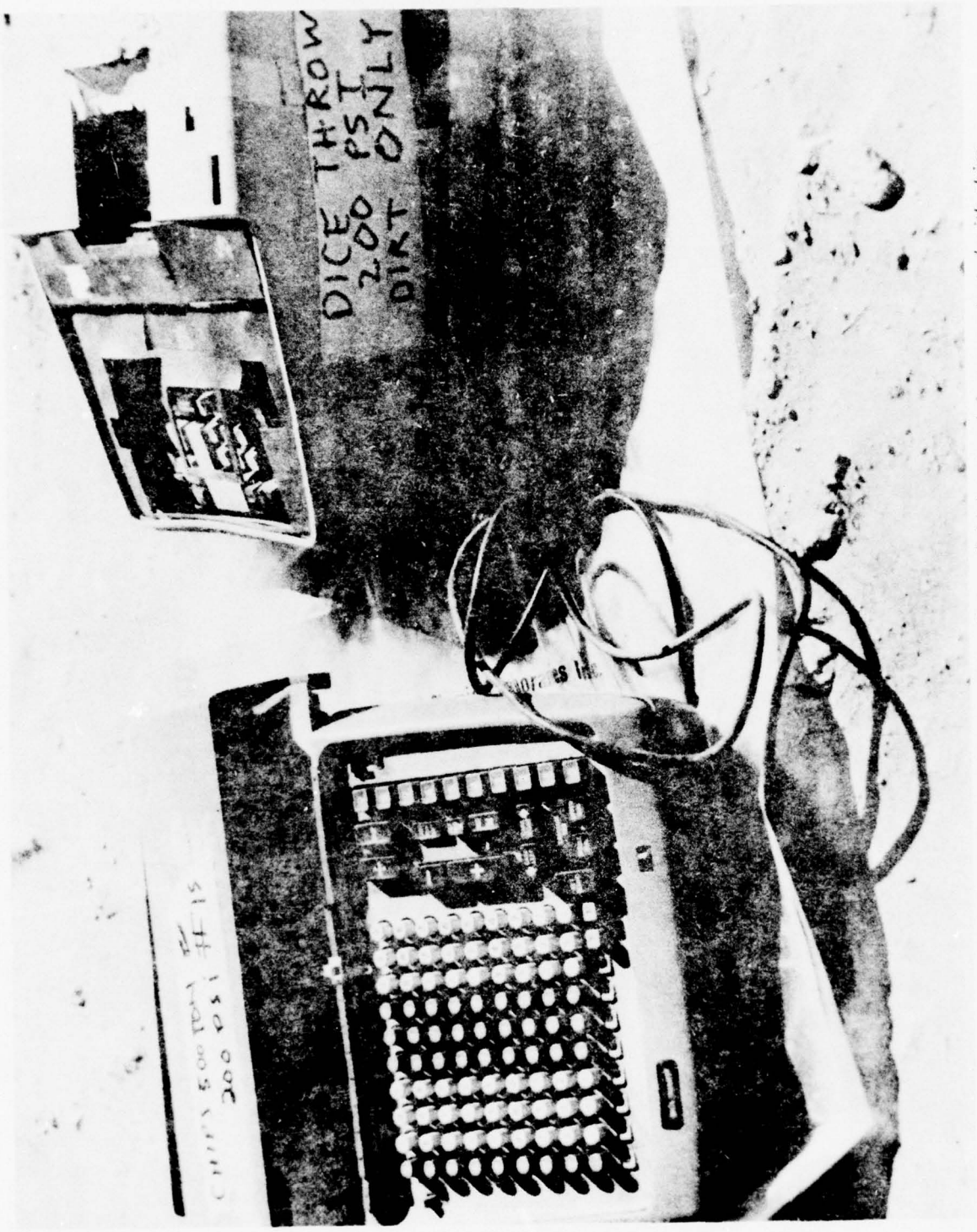


Figure 44. Protective Effects of Using Metal Chips. Calculator on left was protected with chips, calculator on right was not.

Figure 45. Tanks After 500-Ton Blast

Protection of the Seattle-Tacoma-Everett Area

To obtain an accurate appraisal of the effectiveness of industrial protection measures, it was necessary to consider how these measures would be applied to a large metropolitan area. A major nuclear conflict would, in addition to damaging industries that were directly targeted, cause damage to some supporting industries, services, and utilities. The damage to these secondary industries would further delay recovery time. Also, although the U.S. has had no plan to disperse its industry for civil defense reasons, the "urban sprawl" phenomenon has resulted in a degree of dispersal that could improve U.S. industrial prospects.

The Seattle-Tacoma-Everett metropolitan area was used as a model for this portion of the study because it permitted consideration of detail information not obtainable from Soviet industrial areas. The number of weapons that would probably be targeted against this area was based on the relationship of the gross product of this industrial area to the total gross national product. Primary targets for this number of allocated weapons were selected based on size and apparent output of each industry and also to ensure that several critical sectors of the local economy would be damaged. The location of the primary targets in the central section of this area is shown in Figure 46. For perspective, the large circles show the area of destruction that would be caused by the relatively large weapons (≈ 1 megaton) of the Soviet arsenal, assuming no protective measures were applied. The small circles show the area of destruction of U.S. sea-based weapons, assuming the minimum protection of simple earth cover (40 psi).

The location of supporting industry is shown in Figure 47. The separation of this industry from the primary target areas is important since, for example, the "small" machine shops distributed through the metropolitan area comprise about two-thirds of the total machining capacity. The effect of protective measures in improving the survivability of the basic industrial functions is illustrated by Figures 48 and 49. Two warhead sizes are shown: Figure 48 assumes a relatively low-yield warhead that is representative of those which are most numerous in the U.S. retaliatory forces; Figure 49 assumes a higher yield warhead such as would be found in the Soviet inventory. A very high level of protection against the low-yield warheads is provided by the most simple protective measures; the 20- to 40-psi hardness needed is easily provided by a light covering of earth. Against the high-yield warheads, the minimum protection is significantly less effective but still improves survivability by a very important margin. Hardness levels of 60 psi to 150 psi, which could be obtained by packing in crushable material, would be needed to obtain a high level of survival against the high-yield weapons. For perspective, it is noted that present levels of production in most of the area's industry could be obtained by splitting the work force into three shifts

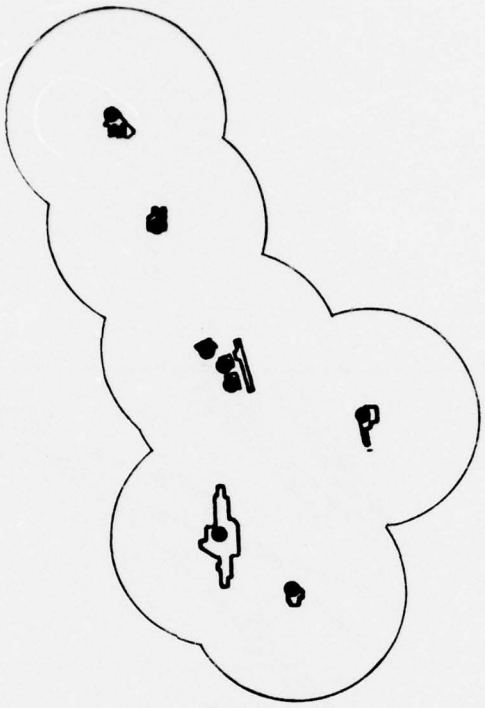


Figure 46. Seattle-Tacoma-Everett Primary Target Areas

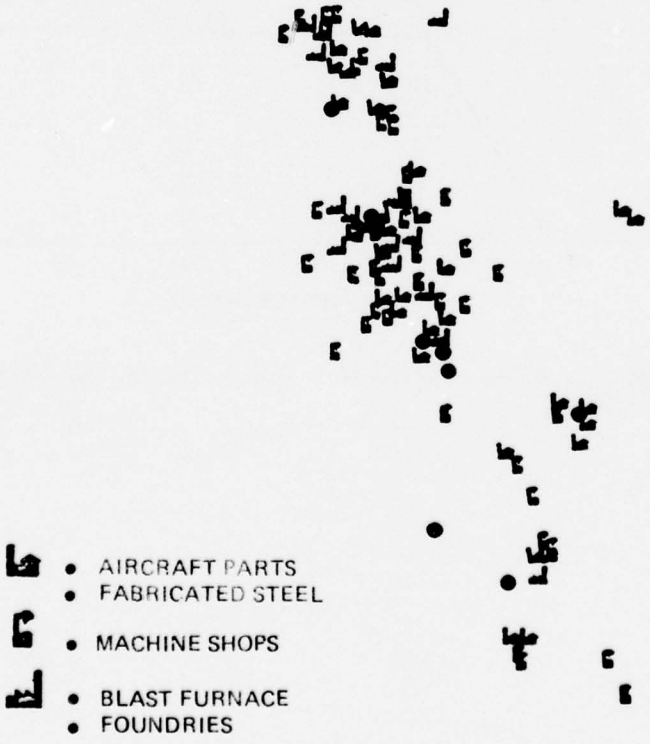


Figure 47. Supporting Industry

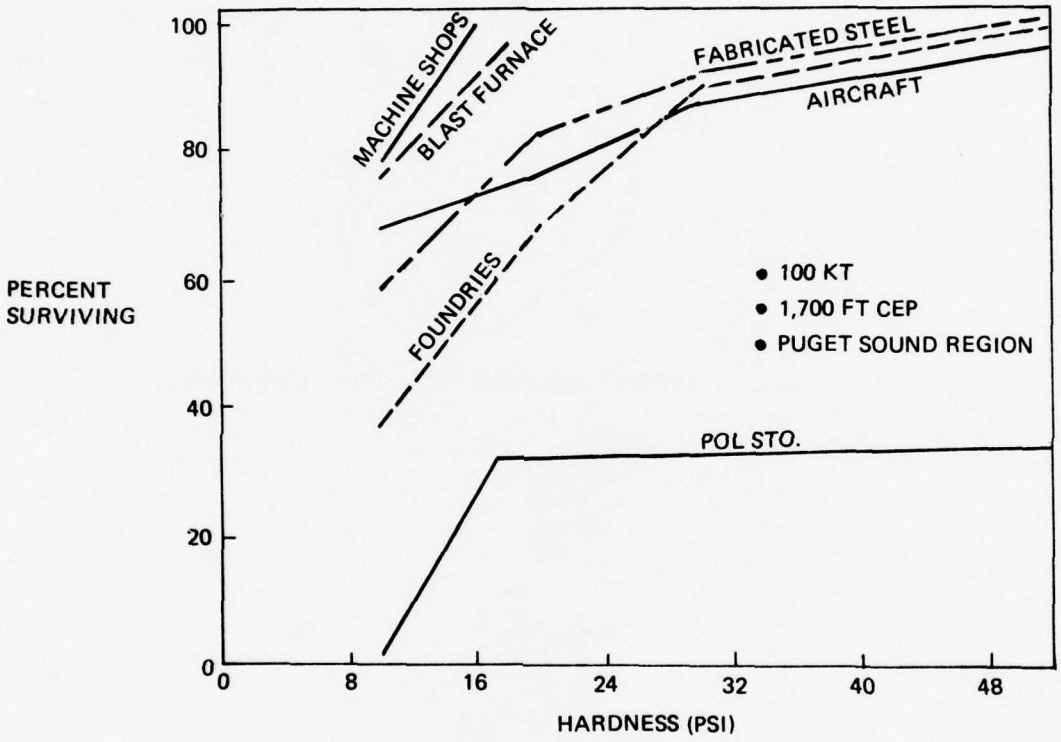


Figure 48. Effect of Hardness in Reducing Industrial Damage (Seattle-Tacoma-Everett Area) (100-Kiloton Blast)

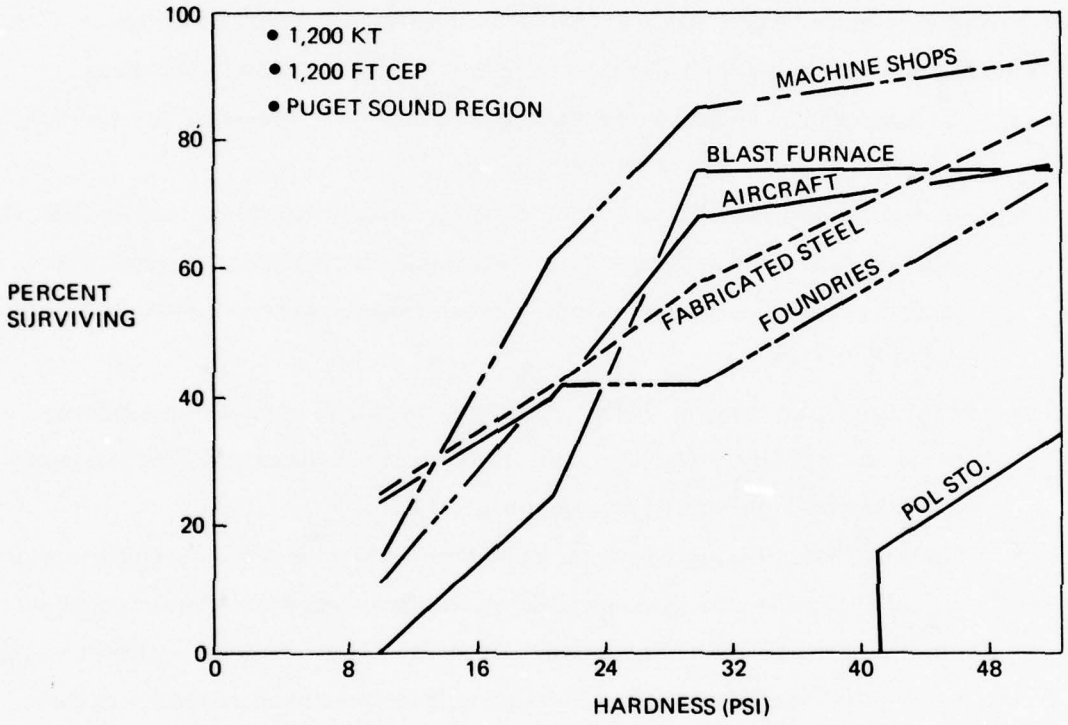


Figure 49. Effect of Hardness in Reducing Industrial Damage (Seattle-Tacoma-Everett Area) (1,200-Kiloton Blast)

per day; this assumes that 30% of the machinery is operable. In order for this level of recovery to occur, however, it is necessary to protect petroleum, oil, and lubricant (POL) supplies. All POL facilities in the metropolitan area studied are collocated with primary target areas. Further dispersal or hardened underground storage would be required to ensure survival of POL stocks.

The study also examined the question of whether some sector of the economy represents an "Achilles heel" which, if destroyed, would prolong recovery for many years. Electrical power was investigated as a possible weak link because of the availability of low-cost hydroelectric power in this particular area and the resulting dependence on electrical energy. It was found that the distribution of capacity among the 2,700 generating plants in the U.S. is not dissimilar from that within the State of Washington (Figure 50); about half of the plants produce 90% of the power. There are several reasons why it is not feasible for an adversary to target electrical powerplants:

1. To target all U.S. powerplants would require a major expenditure of Soviet warheads and would leave 20% to 30% of the capacity intact.
2. It would be impossible to prevent the surviving capacity from being used by those industries critical to rapid recovery efforts. (Attempting to isolate key economic regions would mean attacking the major substations in the distribution network—about 24,000 aim points in the U.S.)
3. Emergency power systems appear adequate to operate all or most of the industry initially needed for recovery, even if all commercial sources were destroyed. The emergency power sources in the Seattle area are listed in Table 2.
4. Given survival of the machinery needed to repair powerplants and the emergency power required to operate that machinery, the primary production facilities can be rebuilt early in the recovery program. This recovery capability was demonstrated in North Vietnam, where powerplants destroyed by bombing were returned to operation in less than a year.

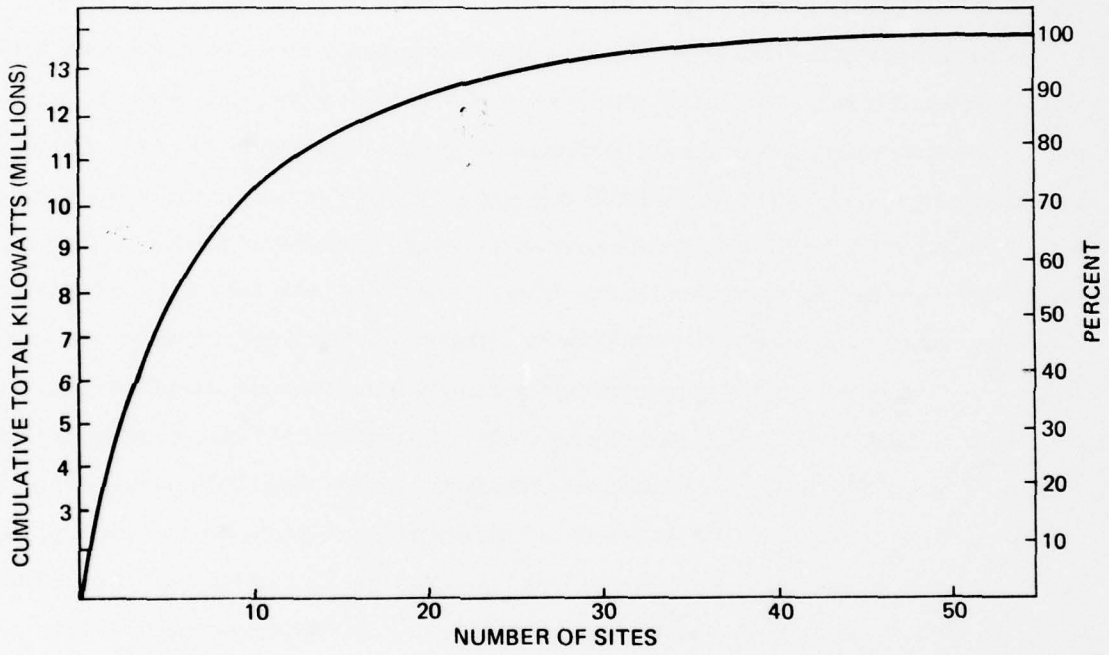


Figure 50. Electrical Power Generation Capacity for Washington State (1974)

Table 2. Electrical Power System Emergency Power in Seattle Area

Private emergency generators	44 identified	29,285 kW
Diesel electric ferries	16	58,400 kW (600 volt DC)
Diesel electric locomotives	130 (typically)	93,500 kW (600 volt DC)
Mothballed ships	15 (typically)	75,000 kW
	205	265,185 kW

Recovery Time Considerations

A number of studies done in the U.S. have addressed various aspects of recovery from nuclear war. However, it appears that all such studies pertaining to industry have focused on the time needed to restore things to their prewar conditions and prewar production priorities and further have assumed no protection of the industrial components essential to recovery. For an industry such as Boeing, the criterion of full restoration would imply a capability to produce airframes at prewar manhours and costs per pound and to achieve present payload/gross weight performance while maintaining the guarantee of a 60,000-hour airframe life. This degree of restoration would require the capability to produce prewar designs using prewar materials and production processes.

Without protection of machinery, Boeing could achieve full restoration only after restoration of the machine tool industry. Hence, recovery time would be very long. With the maximum obtainable protection of machinery *plus* distribution of unique machines among Boeing's metropolitan area facilities (e.g., skin mills, which are not found in supporting machine shops), full restoration of production processes is estimated to be achievable in 12 to 18 months, but the maximum production capacity would be reduced by about half.

The criterion of full restoration examined above is not considered to be a realistic approach to recovery. The German, Japanese, and Russian experience during World War II is a more appropriate guideline for U.S. postwar recovery. Their approach was to substitute materials and processes where needed and substitute labor for destroyed capital equipment. The difference between full restoration and the substitution concept can be illustrated by an example from a study of postwar restoration of refineries. The item pacing the "full restoration" schedule was the availability of process instrumentation essential to prewar efficiency (gallons of gasoline per barrel of crude) and production cost per gallon. However, after widespread bombing, there would be massive unemployment and extreme shortages of gasoline. The forces of supply and demand would tend to reduce

labor cost per hour and increase gasoline prices. Hence, it would be feasible to substitute people for the process instrumentation, thus allowing refining to start earlier on a more labor-intensive basis. The same technique could be used in the Seattle-Tacoma-Everett metropolitan area. If aircraft production is needed, parts could be redesigned so that they could be built on the surviving machines. Corrosion proofing could be done with paint brushes if processing tanks did not survive. Strong backs or primitive lifting methods could be used until overhead cranes were restored. Using this approach, some production operations could start within 4 to 12 weeks (depending on the absence or presence of heavy fallout) and reach half of present maximum capacity within about a year.

Planning Factors for a U.S. Industrial Civil Defense Program

A number of factors that should be considered in any U.S. plans for industrial survival can be extracted from the results of the Boeing study. These planning considerations are outlined below.

1. **Dispersal**

   Separation of industrial plants and industrial buildings is the most effective form of protection against nuclear weapons. The pattern of urban development that has occurred in the U.S. has provided substantial dispersal of existing industry. However, current zoning codes and practices tend to group industrial installations into "industrial parks" that can be efficiently destroyed by nuclear attack. Moreover, these same zoning practices and related tax measures tend to raise the cost to industry of acquiring large parcels of industrial land, thereby discouraging the separation of industrial buildings. The dispersal of unique machines (e.g., skin mills) among several plant locations or at least separate buildings would increase production costs and hence could not be done in a highly competitive environment without some form of industrywide regulation.

2. **Damage-Resistant Construction**

   Damage-resistant building construction techniques would make sense only if done in conjunction with dispersal. However, the U.S. has not developed the technology to design such buildings. The Defense Civil Preparedness Agency has done some design research and model tests, but further research would be needed. Damage-resistant construction, although it may be no more costly than earthquake-resistant designs, is still not free. Hence, such a requirement could be imposed only through building codes.

3. **Protection of Critical Machinery**

   The measures necessary to protect critical machinery could be implemented by U.S.

industries within a few days following warning of a Soviet evacuation if each company had an emergency action plan that could be immediately put into effect. To develop the basic methods of protection for the Boeing facilities required several months of study. Although these methods could be used by other aerospace manufacturers, each industry has some unique problems that would require special protection measures. Studies similar to the Boeing study should be conducted for the different industries (e.g., steel) prior to developing specific plans for individual companies. If such industry studies were available, a company could develop specific plans for its own facilities within 2 to 4 weeks. After a plan had been developed, the advance procurement and storage of corrosion preventatives, sheet plastic, and other supplies needed for protection would significantly reduce the time needed to execute the protection plan. Table 3 gives a preliminary estimate of the costs to Boeing of such preparation and the approximate costs of comparable nationwide preparations.

Table 3. Cost and Time for Industrial Protection Planning and Advance Preparation

	Boeing cost	U.S. cost
Industry studies (10 basic industries) plus individual company plans	$ 0.250M	$ 20-40M
Preparation for 40- to 80-psi protection	$ 0.1-0.15M	$ 200-300M
Preparation for 200- to 300-psi protection	$ 1.2-1.5M	$ 2,500-3,000M

In the event of a crisis, a major consideration is how to keep the work force in place long enough to protect the industrial machinery. The Russian approach appears to rely on a combination of patriotism, discipline (probably enforced), and blast shelters near the factories to protect the workers should war begin prior to completion of industrial protection measures. As a minimum, the U.S. would probably need comparable sheltering for part of its work force.

4. **Restoration and Resiliency**

The size of the Soviet arsenal would impose a major requirement for decontamination of radioactive areas. Techniques for decontamination were worked out during the U.S. nuclear testing program. Soviet reports of civil defense exercises describe a variety of rela-

tively practical decontamination procedures. The effectivity of these procedures, however, is dependent on trained decontamination teams and the availability of radiation-monitoring equipment.

The high degree of automation in U.S. industry is a major drawback to recovery since automation has displaced many of the basic skills. Restoration of basic metalworking and analogous skills would be a prerequisite to rapid recovery.

The Soviet economy has substantial resiliency because of the relatively large amounts of raw materials and in-process goods present in the factories and the finished products in the distribution system. Because of inventory taxes and capital costs, the U.S. lacks this advantage and its economy, therefore, would be much more susceptible to disruption by even relatively light attacks.

5. ***Management***

Planning at the national level would be essential to industrial recovery. Such planning would necessarily include provisions for protection of industry as well as procedures and priorities for postwar recovery. National planning should also provide for the communications and personnel who are necessary to assess damage and direct recovery efforts needed to ensure the best application of surviving assets to national needs. The management of a U.S. industrial survival program should be structured so that industrial plans will complement other programs for the defense and security of the United States.

CONCLUSIONS AND RECOMMENDATIONS

The conclusions derived from The Boeing Company's analysis of the Soviet plans for civil defense and its industrial civil defense planning study are of significant concern to every American. First, the USSR has a civil defense program that can effectively protect their industry and facilitate its rapid recovery should a nuclear war occur. Second, the Soviets can protect their work force by means of evacuation and construction of expedient shelters during the initial stages of a crisis. Although the level of work force survival is influenced by a number of variable factors, the most important of these variables can be controlled by the Soviets rather than by the United States. Third, the Soviets can protect their industrial machinery. This is a critical factor in postattack recovery. Tests show that even large machines, if properly protected, could survive if they were a few hundred feet from a 40-kiloton nuclear blast or 2,000 feet from a 1-megaton blast. More important, if the observed examples of industrial facility dispersal and separation become the pattern for a significant portion of the Soviet Union's future capital expansion, their industry would require little or no preattack hardening to survive and recover rapidly from a nuclear war.

There is increasing evidence that the Soviet Union has mounted a large-scale and well-integrated effort to implement the provisions of its civil defense plan. There are areas of known deficiency in their implementation and other areas where the extent of implementation is largely unknown to the U.S. However, these deficiencies and unknowns are not likely to significantly degrade the effectiveness of the Soviet program. Instead, their effect is to extend the time required to transition from their present posture to a fully evacuated and protected posture. If all advance preparations called for in Soviet plans were complete, they could transition into a war-ready posture in 3 to 4 days. If advance preparations are incomplete, it could take a week for complete dispersal and evacuation of their population and up to several weeks to achieve full protection of their industrial machinery. These times are substantially less than would be required for the U.S. to respond from its present state of preparedness.

The Soviet civil defense preparations substantially undermine the deterrence concept that has been the cornerstone of U.S. national security. Although the U.S. sought through the ABM Treaty to ensure the future viability of mutual deterrence, the Soviet civil defense preparations (which appear to have been accelerated in mid-1972) have circumvented the intent of this treaty. The increasing power of the Soviet strategic offensive forces in combination with the strength of their civil defense program completes the destabilization of the strategic relationship between the two nations.

Some critics argue that the Soviet evacuation and industrial protection plans are not viable because, if an evacuation was started, the U.S. could attack the evacuees before they could be fully dispersed. Such an argument is contrary to the U.S. objective of deterrence. It would be illogical for the United States to be in a position in which, to preserve the viability of its doctrine to deter war, its only recourse would be to preemptively attack the Soviet Union and accept the subsequent destruction of the United States.

The growing Soviet defensive and offensive superiority will most likely result not in nuclear war, but rather force the U.S. to make costly concessions to avoid nuclear war. In a future confrontation, should the Soviets execute their civil defense plans, the consequences to the U.S. of escalation to nuclear war would be disastrous, while the consequences might be tolerable to the Soviet Union. It is believed that the USSR could recover within no more than 2 to 4 years whereas the U.S. could not recover in less than 12 years. In such a condition, the so-called "balance of terror" would no longer be balanced.

Present Soviet civil defense capabilities require that the United States make some important policy decisions. One course of action would be to adhere to our present doctrine and try to make nuclear war as unthinkable for the Soviet Union as it now is for the United States. Another course would be to try to make nuclear war as survivable for the United States as it now is for the Soviet Union. There may be some middle ground between these two options.

Following the first course would imply an attempt by the U.S. to overpower the Soviet civil defenses. This would require a massive increase in the U.S. nuclear arsenal, or possibly a search for some new terror weapon that if used would really destroy all mankind. The second course would involve increased emphasis on defenses for the United States; probably some combination of air and civil defenses. Such defenses presumably would make nuclear war more thinkable for the U.S. and hence would be objectionable to some. However, unless we can be assured that nuclear war is unthinkable for the Soviet Union, it must be made survivable for the U.S.

There is no technical or economic reason why the U.S. cannot have effective civil defense capabilities. It is recommended that the Congress give consideration to protecting Americans and the industrial capabilities of the nation.

It is not possible that U.S. civil defense preparations could by themselves entirely remove the destabilizing impact of the Soviet civil defense preparations. Such U.S. preparations could,

however, negate certain destabilizing capabilities that result from the new Soviet weapons now being deployed. Of equal importance, such preparations could balance an instability that is now, in the words of a Library of Congress report, a one-sided "buttress [for] the Kremlin's bargaining power in times of intense international crisis. . .".[11] Of even greater importance, it is believed that a civil defense program will permit the United States to maintain its security for less cost and with less nuclear weaponry than would otherwise be required.

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APPENDIX

CIVIL DEFENSE AND THE STRATEGIC BALANCE

Civil defense is not of itself a threatening capability. Both Sweden and Switzerland have extensive and well-prepared civil defense programs. These programs do not threaten either the U.S. or the USSR because neither Sweden nor Switzerland possesses the offensive weaponry to seriously damage either of the two major powers. For this same reason, the Soviet civil defense preparations, although they date from before World War II, did not in earlier years threaten the United States.

However, in 1972 when the SALT I agreements were signed, it was publicly stated that the United States no longer had nuclear superiority; the forces of the two sides were at approximate parity. Since then, the Soviets have initiated concurrent deployment of four new ICBM models, creating serious concerns in the U.S. as to the trends in the strategic balance.

Paul H. Nitze has suggested that there are three different ways in which the strategic balance can be measured:

1. That which each side has *before* a strike
2. That *surviving* to the United States after an initial counterforce strike by the Soviet side
3. That remaining to each side *after an exchange* in which the Soviet side attacks U.S. forces and the U.S. responds by reducing the Soviet side's reserve forces to the greatest useful extent

These three types of measurement are illustrated by the figures that follow.

The nuclear balance that each side has in inventory is shown in Figure A-1. The data are presented to eliminate most of the numbers and show not just where the United States stands today, but where the U.S. has been and what prospects the future holds. The data show who is ahead or behind in the principal dimensions of military power: throw weight, equivalent megatonnage, number of warheads, and number of missiles and bombers. The combined effect of the U.S. lead in accuracy and the Soviet advantage in warhead size is illustrated in the "2,000-psi index," a measure of the capability to destroy targets of that hardness. The trends indicate continuing equality in delivery vehicles (missiles and bombers) and in the capability to destroy hard targets. The Soviet Union is ahead in throw weight, equivalent megatons, and total mega-

tonnage, which are, in effect, different measures of the same thing—deliverable weight. The U.S. leads in number of warheads. If it is assumed that the Soviet lead in deliverable weight (throw weight, etc.) is counterbalanced by the U.S. lead in number of warheads, it is perhaps reasonable to conclude that the U.S.-Soviet strategic nuclear forces are "roughly equivalent."

The balance of forces that would exist immediately after a Soviet first strike against U.S. strategic forces is shown in Figure A-2. The Soviets would hold a significant margin of superiority over the United States in every index of capability. The Soviets would hold a 3-to-1 superiority in equivalent warheads, which is the most meaningful measure of relative power. The theory of deterrence is predicated on a number of factors: first, the threat that the United States would retaliate, even in the face of the vastly superior Soviet forces; and second, that the surviving U.S. forces could devastate the Soviet economic and political assets. Soviet military strength combined with their civil defenses would deter the U.S. from use of its deterrent force and, if the U.S. did retaliate, would reduce substantially the damage that could be inflicted.

The U.S., instead of retaliating against Soviet economic and political assets could attack the Soviet reserve forces (those not used in the Soviet first strike). This would reduce slightly the Soviet advantage but, as shown in Figure A-3, the Soviets would still retain superiority in all indices of capability except numbers of warheads. Moreover, this last remaining U.S. advantage will disappear within the next 2 or 3 years. Viewed from this perspective, the "roughly equivalent" forces of the United States are seriously defeatable, a condition which, because of Soviet civil defense capabilities, should be of serious concern.

The data shown in the figures in this appendix and in the study report are based on the United States' current plans for strategic forces (which include both the Trident submarine and the B-1 bomber) and the forces that the Soviet Union is believed most likely to deploy. The future force projections *assume that a SALT II agreement had been imposed in 1976,* establishing the limits outlined at Vladivostok in November 1970. The forces and assumptions used in the analysis cannot be spelled out here because security considerations necessarily restrict some of the underlying data.

The descriptions of the indices of capability used in the preceding figures is as follows:

Megatons—The aggregate total megatons of all warheads carried by missiles and bombers

Equivalent megatons—Same as megatons except scaled to the damage-causing capability of an equivalent number of 1-megaton warheads

Throw weight—The aggregate total of missile and bomber warhead delivery capabilities

Equivalent warheads—Based on number, size, and accuracy of warheads and considering the characteristics of targets against which the warheads would probably be used. (This is the most sophisticated and comprehensive of the indices illustrated.)

Countermilitary potential (CMP)—The capability to destroy hardened targets

Number of warheads—The total number of missile and bomber warheads; it does not account for size or accuracy.

Delivery vehicles—The total number of ICBMs, SLBMs, and bombers having intercontinental range

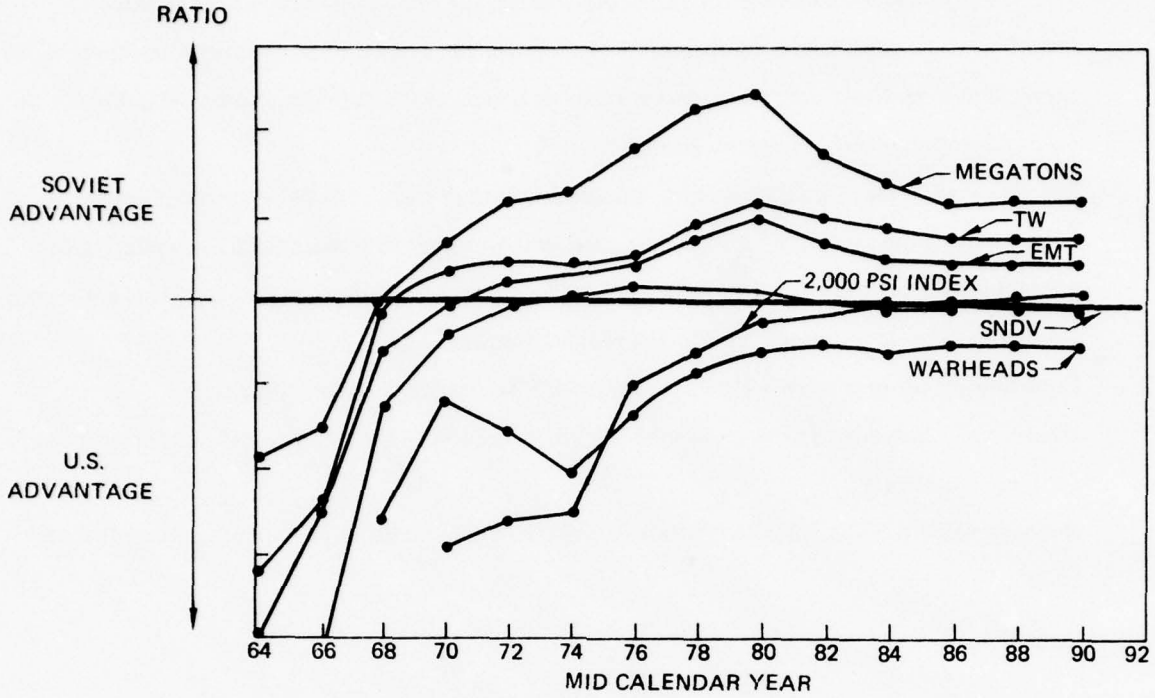

Figure A-1. Balance of Deployed Forces (Static or Pre-Attack Levels)

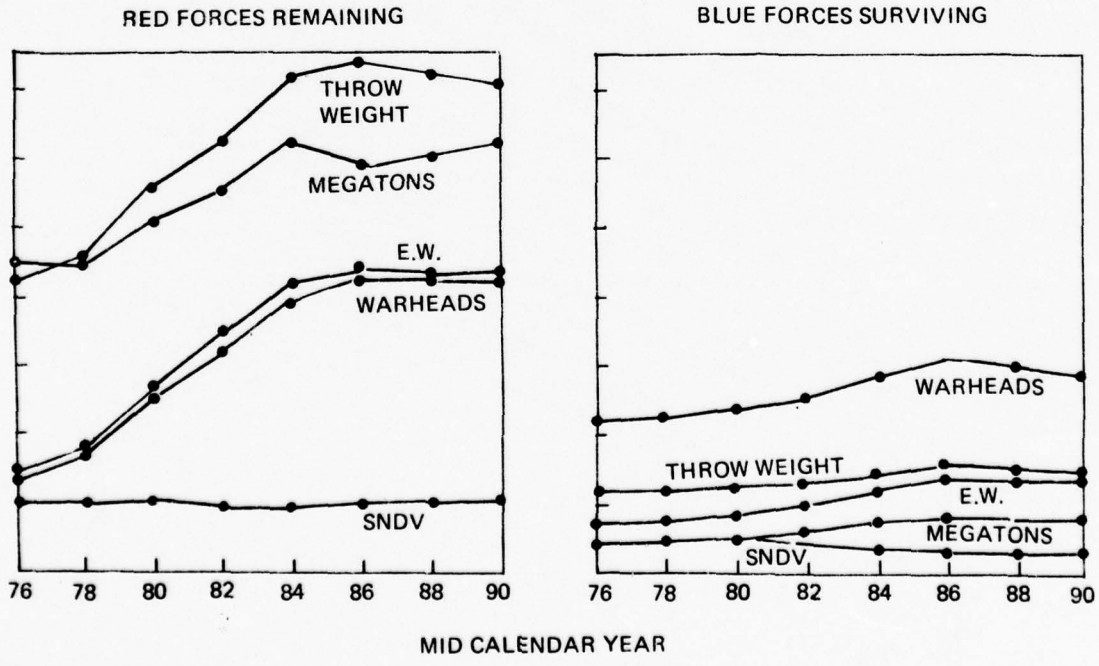

Figure A-2. Capabilities After S.U. First Strike

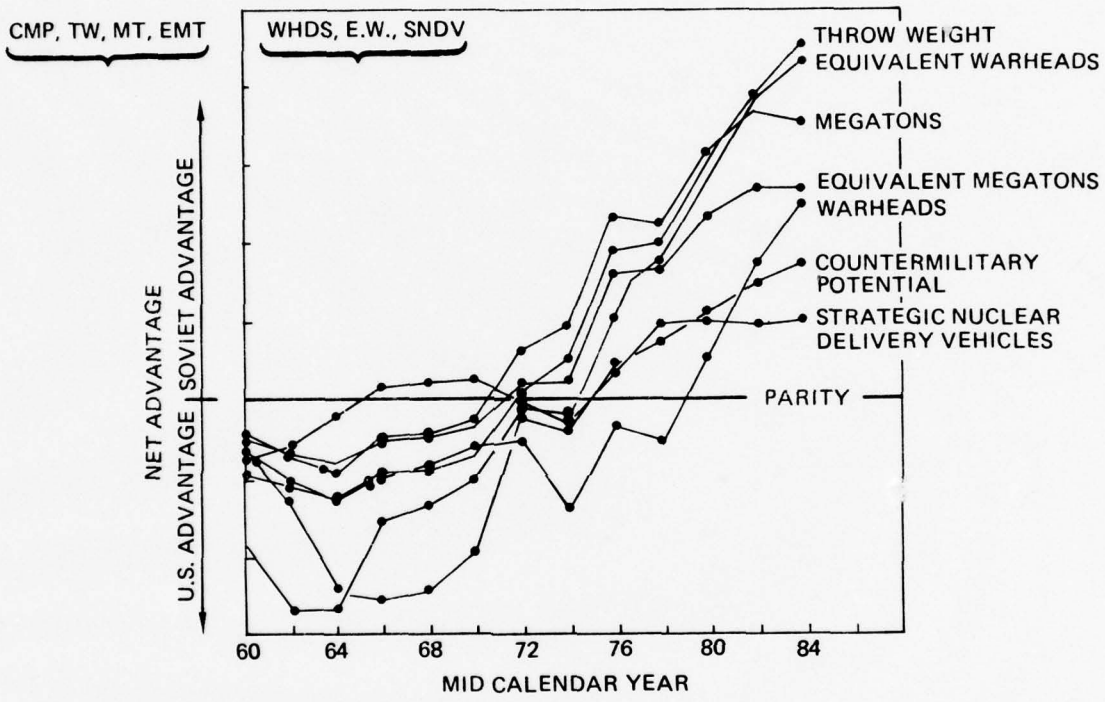

Figure A-3. Comparison of Alternative Indices of Capability (After a Counter Force Exchange)

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A Division of The Boeing Company

January 7, 1977

Mr. William H. Kincade
Joint Committee on Defense Production
U.S. Congress
Washington, D.C. 20515

Dear Bill:

Enclosed are the answers to the follow-up questions transmitted by your letter of December 3, 1976. These questions focus on a number of issues of critical importance to the United States and, in my view, represent a highly constructive approach to these issues. Hence, in developing answers to these questions, we have wherever possible adhered to factual-analytical methods rather than submitting unsubstantiable opinions. In those areas where opinions and value judgements were unavoidable, they have been identified as such.

I hope that the resulting answers will be helpful to you and to the committee.

Sincerely yours,

T. K. Jones

Thomas K. Jones

Enclosure

BOEING

APPENDIX

CIVIL DEFENSE AND THE STRATEGIC BALANCE

Question 1.

On what calculations do you base your estimate that 98% of the Soviet population would survive a massive countervalue attack with the entire U.S. arsenal of 8,500 or more nuclear warheads? (pp.62-63)

Answer

First, our estimate is based not on the "entire U.S. arsenal" but on the weapons that the U.S. could optimistically expect to survive a Soviet first strike. The reason is that a stated purpose of the Soviet civil defenses is to complement the first-strike counterforce capability of the Soviet offensive forces. This policy was stated in 1974 by Colonel-General Altunin, Chief of Soviet civil defense, in *Luidi i Dela Grazhdanskoi Oborony*:

> While the Armed Forces take as their objective to prevent the use of destructive means against the rear of the country by the destruction of the attack weapons or the interception of the weapons on the way to the target, Civil Defense, by carrying out protective measures and through preparation of the population, seeks to achieve the maximum weakening of the destructive effects of modern weapons.

The Soviet forces used in the estimate are those projected by the U.S. Government as most likely to be deployed by 1985, assuming SALT II limit. Projected estimates of U.S. forces, similarly limited by SALT, assumed deployment of both the B-1 and Trident systems.

Since a Soviet evaluation of their cities would give several days warning, U.S. forces were assumed to be in a highly survivable posture. All ballistic missile submarines not in drydock or major overhaul would be at sea and were assumed totally survivable. Bombers would be distributed to dispersal bases, and it was assumed that all U.S. warning systems would remain intact. Tanker aircraft essential to bomber penetration were arbitrarily assumed to survive. The attack on U.S. ICBMs was assumed to be limited to no more than one warhead per silo. Hence, a large fraction of the U.S. ICBMs would survive.

The Soviet Union was assumed to have *no* antiballistic missile (ABM) defenses. Soviet air defenses were assumed to have been suppressed even though no U.S. warheads were assumed to be used for this purpose. All U.S. warheads (on SLBMs, bombers, and ICBMs) were assumed to be expended in a retaliatory strike on Soviet urban/industrial areas or on evacuation areas. (This latter assumption is particularly naive since it would leave the United States totally disarmed and leave Soviet military assets largely untouched.) As can be seen from the foregoing, the analytical

assumptions were, from the U.S. perspective, highly optimistic and represent what the Soviets would probably view as a worst case.

The estimate that 98% of the Soviet population would survive was one of several estimates considering conditions ranging from no evacuation—no protection to full evacuation and expedient protection and involving two basic types of U.S. retaliatory strikes. Figure 6 of the study report shows these estimates. The 98% figure corresponds to full evacuation and expedient sheltering of the evacuees. The U.S. retaliatory strike was designed to produce maximum destruction of industrial targets. (A fallout-producing attack on the evacuation areas would result in a 96%-97% survival level at the expense of substantially reducing industrial damage and speeding up Soviet economic recovery.) The basic assumption regarding evacuation was that the Soviets would do what their plans specify and their known preparations permit. Data sources include:

a. Soviet manuals and textbooks.

b. Reports from Soviet open literature describing training and preparation in areas such as transportation, firefighting, radiation monitoring, rescue, medical services, protection of food supplies, etc.

c. Classified evidence of Soviet civil defense preparations.

Calculations were modeled to be consistent with the data from these sources. Several of the more significant assumptions are:

a. Some essential personnel, including on-shift workers, are left in the cities. It was assumed that the Soviets would not leave more people than the factory area and residential shelters would accommodate.

b. Radiation protection factor of the Soviet expedient shelters was degraded to 200 (from a calculated value of 1,000) to compensate for operational factors such as ventilation.

c. For further conservatism, all persons receiving a radiation dose of more than 200 rads were counted as fatalities. (Most analyses are based on 450 rads, which produces about 50% fatalities.)

Question 1.a.

How much warning (in days or hours) of the hypothetical U.S. attack would the Soviet Union require in order to assure the survival of 98% of its population?

Answer

Soviet literature calls for a 3-day period for evacuation (a somewhat longer time is needed for crisis relocation of selected factories.) I regard 3 days as a minimum feasible time; flaws in planning and execution and the possibility of adverse weather could lengthen evacuation time to as long as a

week. However, as the initiator of the hostilities, the Soviets could take whatever time is necessary to transition to a fully war-ready posture. Hence, the possibility of delays would have no adverse effect on their survivability.

Question 1.b.

Precisely what measures would the Soviet Union employ to assure so large a portion of its population would survive?

Answer

The most important element of the Soviet preparations is to evacuate the urban residents to the collective farms and outlying villages. The purpose of this measure is to disperse the population over an area many times larger than the total area that could be destroyed by the portion of the U.S. arsenal that would survive a first strike by the Soviet forces.

Evacuation is supplemented by several measures of secondary importance. One such measure is construction by the evacuees of expedient shelters. Such shelters would be necessary only if the U.S. were to sacrifice half the effectiveness of its arsenal against industrial targets in favor of a fallout-producing attack. Substantial preparations have been made to protect food supplies, and the people are trained in the measures needed to protect livestock and food crops. Also, there is evidence of much training, including practical exercises for the civil defense troops and 20 hours of classroom indoctrination for the general population.

Soviet literature also cites provisions for medical aid and training of medical service cadres. Extensive training exercises are reported for radiation survey and rescue teams since these operations require a fair degree of proficiency. However, in our analysis, we gave the Soviets no credit for the survival benefits of either the medical or the rescue capabilities. The Soviets have also provided extensively for preservation of their leaders and for the communications essential for preservation of government control. The party workers' function would continue to ensure continued control at the local level.

A definitive description of Soviet plans can be found in a translation of the Soviet 1969 manual (ORNL-tr-2306, National Technical Information Service, Springfield, Virginia) and the 1970 manual (Stock no. 008-070-00382-1, Superintendent of Documents, Government Printing Office, Washington, D.C.). The training, planning, exercises, and other preparations being made to implement the Russian plan are cited extensively in Soviet open literature, and many of the preparations have been confirmed by knowledgeable observers touring the Soviet Union.

Question 1.c.

What alternatives does the U.S. possess to blunt the effectiveness of these measures?

Answer

The United States does not possess military capabilities which, if prudently used, could blunt the effectiveness of the Soviet civil defense measures. Moreover, the U.S. has no plans which would provide such capabilities in the future. Even worse, the U.S. cannot counterbalance the Soviet measures. The present lack of civil defense planning, preparation, and training in the U.S. is such that the American population could not transition to a significantly more survivable posture within the 3-7 days required for a Soviet evacuation.

Question 1.d.

Do your estimates of the Soviet survivors include casualties resulting from blast effects, radioactive fallout, and secondary or tertiary effects such as lack of medical care, lack of food, or lack of other essential commodities and services?

Answer

Our estimates of Soviet survivors include all casualties from prompt effects of blast, thermal, and radiation plus the long-term (lifetime) effects of radioactive fallout. We used two sources of nuclear weapons effects data: *Physical Vulnerability Handbook—Nuclear Weapons*, AP-550-1-2-69-INT, Defense Intelligence Agency, September 1972, and *The Effects of Nuclear Weapons* by Samuel Glasstone, U.S. Atomic Energy Commission, February 1964.

It should be noted that Soviet data on radiation and biological recovery would indicate a *higher* level of survival than is shown by our analysis.

The analysis assumed a complete absence of medical care. All persons receiving a radiation dose high enough that they would require medical care (200 rads) were counted as fatalities. Moreover, the "radio-protective pills" referred to in Soviet literature were arbitrarily assumed to provide no protection.

We know of no evidence or other basis to assume that there would be insufficient food—either near or long-term—to keep the Soviet population alive and working. Moreover, the relocation of the population into the food-producing areas would mitigate what otherwise might be a difficult problem of food distribution.

About half of the housing spaces in the Soviet Union could realistically be expected to survive an all-out nuclear war. If the observed examples of industrial dispersal (which includes dispersed housing) become the pattern for future development, the Soviets by 1985 could expect about three-quarters of their housing to survive in a habitable condition. We believe that these levels of

housing are adequate to avoid fatalities; housing probably would not even be a factor pacing recovery. We know of no other commodities or services the lack of which would increase fatalities above the level of our estimates.

Question 1.e.

Are the means by which the Soviet Union could protect 98% of its population currently in being or are they under development?

Answer

It is believed that the means by which the Soviet Union could protect 98% of its population are available today in the Soviet Union. It is important to note that the analysis on which the 98% survival estimate is based is highly conservative. The only capabilities with which the Soviets were credited in the analysis were use of urban shelters, known to exist, by the essential workers remaining in the cities, evacuation, construction of expedient shelters by the evacuees, and protection of food supplies. The only additional "in-being" essentials to support such capability are planning and education. Current evidence is that the Soviets are now concentrating on identifying and correcting weaknesses in their detail plans and on increasing the "realism" of their training—all of which would indicate that the initial plans and training are either complete or well along.

The Soviets are continuing to develop their protective means. Shortcomings that could lengthen the time required for evacuation are apparently being eliminated. Amenities are being provided that would reduce the privations of an evacuation and could improve survival to a level higher than our estimate. The extensive program to construct hardened shelters within the cities will make it more feasible to keep important industry going during an evacuation. Also, the means of government are becoming better protected through construction of an extensive system of command bunkers and survivable communications.

The effect of this continuing development will be to allow easier and quicker evacuation. The Soviet's stated requirement of a 3-day evacuation capability will become more realizable.

Question 1.f.

How large a proportion of its population could the Soviet Union protect if the U.S. attack came today? What is the basis of this estimate?

Answer

The Soviets today could probably protect more than 98% of their population. The 98% estimate was based on U.S. forces that will not exist until 1984 and assumes that the B-1 and Trident will be built. Figure 8 of the study report shows that if a Soviet attack came today, the U.S.

surviving number of equivalent weapons (EW) would be only about half of the number that would survive in an attack against U.S. forces in 1984.

Question 1.g.

At what time do you project the Soviet Union will have the capacity to protect 98% of its population? On what do you base this projection?

Answer

Refer to answers provided for questions 1.e. and 1.f., above.

Question 1.h.

To what do you attribute the prevailing U.S. policy view that the United States possesses the capacity to destroy significant numbers of Soviet citizens and a significant portion of the Soviet economy, a capacity which acts as a deterrent against a Soviet attack? Is this view erroneous? Why or why not?

Answer

The policy view set forth in the *Annual Defense Department Report, FY 1977* is that the U.S. deterrent is based on a capability to retaliate with devastating force against an enemy's economic and political assets. Population is not mentioned as an element of deterrent strength. We do not know of any officially stated view that the United States currently has the capacity to destroy a significant portion (25% or more) of the Soviet population. We are aware of unofficial *opinions* claiming that the Soviet Union would suffer high levels of fatalities but we have yet to see an *analysis* that supports such claims without relying on the assumption that not even the most rudimentary evacuation will occur.

There are analyses which conclude that the U.S. has the capability to destroy "a high percentage of the industrial targets" in the Soviet Union. However "the industrial targets" referred to in these analyses is a limited list of targets which comprises only a small fraction of Soviet industrial capacity. Our analysis accounts for the following factors which we believe are essential to an accurate appraisal of retaliatory capability against Soviet economic assets:

a. All of Soviet industry
b. The actual size of each factory (some analyses treat industrial targets as points, rather than areas)
c. The projected capital growth of Soviet industry
d. The effect of hardening machinery—using techniques described in reports of Soviet training exercises and shown by our tests to be practical and effective
e. The effect of observed examples of industrial dispersal

Question 1.i.

Can you explain why U.S. officials continue to express confidence in our deterrent forces, if they are no longer capable of destroying over 2% of the Soviet population, instead of the 25% or so once thought to be adequate to make an effective deterrent?

Answer

Many knowledgeable U.S. officials no longer express confidence in the effectiveness of our deterrent. Rather, some official statements have recently expressed extremely serious concerns.

The *Annual Defense Department Report, FY 1977*, a document remarkably candid for an election year, states that ". . .confidence in the future adequacy of our force structure is gradually declining" (p. iv), notes that in civil defense ". . .an asymmetry has developed over the years that bears directly on our strategic relationship with the Soviets and on the credibility of our deterrent posture" (p. 57), and implies that if the Soviet Union were to attack the U.S. strategic forces the U.S. would not necessarily retaliate (pages 12, 13, and 46). The specific reasoning behind this latter point is as follows:

> The Soviets are gaining the capability in an initial counterforce attack to withhold a large percentage of their forces with which they could retaliate in kind. If we struck their cities, they would have strong incentives to do the same. In these circumstances, whatever the other objections to such a U.S. strategy, *it would represent a response of uncertain* credibility to anything but the most barbaric kind of attack and, as a consequence, cannot serve this country or its allies well as a deterrent. (p. 47)

The results of our force balance studies, shown in the appendix to the study report, are fully consistent with these observations.

Former Secretary of Defense James R. Schlesinger in February 1976 wrote, "The underlying reality is that at no point since the 1930s has the Western world faced so formidable a threat to its survival. As then, the military balance is deteriorating, but the trend in large measures goes unnoticed. . ."

Air Force Chief of Staff, General David C. Jones, in an address on September 21, 1976, made the following statement:

> My report to you this year must begin with a warning I will express in stark terms: I believe the momentum and the direction of growth in Soviet power represent the greatest potential threat to our survival as a nation since the Civil War. I don't imply an imminent danger of attack, for I consider that highly unlikely and, in any event, unnecessary if the Soviets can achieve their aims through indirection. . .
>
> The most visible element is the inexorable buildup of the most potent strategic arsenal in history, exceeding ours in sheer destructive power by a factor of two to one. Compounding the hazards of such a margin is the greater vulnerability of our highly concentrated population and industrial centers, compared to the more dispersed pattern in the USSR. . .

General Jones went on to cite ". . .the wide gulf between Soviet civil defense preparations and our own" and to note the beliefs and calculations of U.S. experts regarding the effectiveness of the Soviet preparations.

General Russell E. Dougherty, Commander in Chief of the Strategic Air Command, on December 13, 1976, stated, "We live in a very real and sometimes frightening world. . .a world in which for the first time in the history of our nation, a potentially inimical nation possesses the power to attack this nation directly—and possibly fatally."

Similar concerns have been voiced within the U.S. Congress. In a report prepared at the request of Senator Culver, the Library of Congress Congressional Research Service stated, "The present balance between U.S. and Soviet strategic offensive forces would be degraded dramatically by pre- and post-launch attrition at the onset of a general nuclear war" and "U.S. strategic defense problems are perhaps even greater." The report further noted the Soviet emphasis on strong air and civil defenses and stated that ". . .even partial defenses could buttress the Kremlin's bargaining power in times of intense international crisis, by undercutting our second-strike Assured Destruction Threat." (From "U.S./Soviet Military Balance," January 1976, p. 28)

Senator Howard Baker, in a June 24, 1975, speech before the Senate, stated, ". . .the U.S. concept of assured destruction, though much propounded, has been undermined by the civil defense measures of the USSR. . ."

On November 11, 1975, this concern was again brought before the Senate. Senator Peter Dominici stated that ". . .the Soviet Union has found another way to undermine the strength of the U.S. deterrent force—by implementing a meticulously planned comprehensive civil defense program." The Senator concluded that such preparations have "effectively circumvented the protection which we sought to achieve from the ABM Treaty."

In summary, we submit that knowledgeable and responsible officials are expressing not confidence but serious concern about the adequacy of U.S. deterrent capability. Our analysis results are consistent with and confirm the factual basis for these concerns.

Question 1.j.

At what point, and for what reasons, did the United States lose its capacity to destroy a significant portion of the Soviet population and its economic infrastructure?

Answer

It appears that the Soviets have for some years had a capability to evacuate their people prior to a nuclear conflict. However, the program was upgraded in 1972 to provide increased classroom

training and more realistic exercises. Also, there are many reports of inspections and reviews to identify and correct weaknesses in plans, preparations, and readiness. Although these recent preparations may not have had a determinable effect on U.S. capacity to destroy a significant portion of the Soviet population, they probably have improved Soviet confidence in the effectiveness of these preparations and reduced the length of time that would be required to transition from a peacetime posture to a fully war-ready posture.

It is more difficult to assess the Soviet Union's readiness to protect its industry because implementation of the necessary preparatory measures is not easily detectable. If plans have been prepared for most factories, if the training exercises reported have been sufficiently widespread to provide a cadre equal to perhaps 5% of the work force, and if materials (plastic, grease, etc.) are available, Soviet industry could transition to a well protected posture within a 3-day period. If no plans have been prepared and the training exercises have been limited to those reported in the Soviet literature, it would take from 4 to 6 weeks of concerted national effort to transition to a protected posture. Hence, the issue is not whether they can protect their industry but how long it would take to transition to a protected posture.

If the observed examples of Soviet industrial dispersal become the pattern for a significant (i.e., 1/3 to 2/3) portion of Soviet capital growth, the transition to a protected posture will become easier and less dependent upon pre-attack hardening measures.

Question 1.k.

What specifically are the deficiencies in U.S. strategic forces that account for this erosion of its deterrent capacity?

Answer

The U.S. strategic forces were designed to retaliate against concentrated and unprotected targets. Hence, these forces do not have the number, yield, and accuracy of warheads that would be required to effectively destroy the highly dispersed and somewhat hardened target complex that is presented by the Soviet civil defense measures. Moreover, based on our analysis results, it is my judgment that to preserve the U.S. present concept of deterrence by attempting to overpower the Soviet civil defenses would require an unrealistic and imprudent increase in the size of the U.S. nuclear arsenal. It is my recommendation that we search for an alternative, less objectionable concept to deter the Soviet Union.

Question 1.l.

Would your estimates of the surviving percentage of the Soviet population change if the Soviets had no warning of a U.S. nuclear attack?

Answer

Yes. As shown in Figure 6 of the study report, if the Soviets did not evacuate or shelter their population, their losses could range from 70 to 105 million people. A sheltered but unevacuated population could suffer from 50 to 85 million fatalities.

Question 1.m.

If the Soviets evacuated their cities and used expedient measures to harden critical industries prior to an attack on the United States, wouldn't the visibility of these measures permit the United States to take countermeasures, such as a pre-emptive attack, a redeployment of U.S. strategic forces, or a retargeting of U.S. warheads to offset evacuation and industrial hardening?

Answer

Soviet actions to evacuate their population would be highly visible and would allow the United States 3 or more days to implement countermeasures. However, our analysis has already accounted for all of the measures which, in my opinion, the U.S. could prudently or productively take. Specifically, all U.S. ballistic missile submarines not in drydock or major overhaul would be put to sea, all bombers and tankers would be relocated to dispersal bases, and it was *assumed* that all U.S. warheads would be retargeted to offset Soviet industrial hardening. This latter assumption is particularly optimistic since it was assumed that the U.S. would know precisely which factories had been hardened and to what level of hardness.

We did calculate the effect of retargeting U.S. warheads to offset evacuation. As shown in Figure 6 of the study report, this would reduce Soviet population survivors to 96% to 97%. However, because lethal area against industry is approximately halved by this tactic and most of the warheads would be targeted in non-industrial areas, the net effect would be to shorten rather than to lenghen Soviet recovery time.

We did not consider a preemptive attack on the Soviet Union to be a course of action which the U.S. could prudently pursue because the Russian retaliation would destroy on the order of 130 million Americans and 50% to 80% of U.S. industrial capacity. More importantly, a deterrence concept that for its viability depends on a U.S. preemptive attack of the Soviet Union would be inconsistent with the objectives of deterrence.

Question 2.

In view of the fact that Soviet civil defense manuals themselves claim only that the recommended measures would protect 93-95% of the urban population in the event of a nuclear attack, on what do you base your projection that 98% of the Soviet population would survive such an attack?

Answer

The Soviet manual's claim that their civil defense measures would protect 92% to 95% of the *urban* population equates to 96% to 98% of the *total* population. The higher figure is consistent with our estimate that 98% of the *total* population will survive. Should the U.S. attempt to produce fallout instead of mounting an effective attack against industrial targets, on the order of 96% to 97% of the *total* Soviet population would survive (Fig. 6 of the study report). We consider that this figure corresponds to the lower of the Soviet figures.

Question 3.

According to recent population estimates, about 9% or 22,845,000 of the total Soviet population of 258,528,172 is concentrated in eleven urban areas (Moscow, Leningrad, Kiev, Tashkent, Kharkov, Gorky, Novosibirsk, Kuibyshev, Sverdlovsk, Minsk, and Odessa.) In a nuclear confrontation the U.S. could retarget its ample and invulnerable submarine-launched ballistic missiles (SLBMs) so as to provide for the warhead saturation of these eleven major urban areas, including the surrounding territory where "expedient evacuation" refugees would be hosted, using only half, or 2,500, of the five thousand SLBM re-entry vehicles currently available.

a. In your opinion, would this retargeting, in the absence of additional ABM defenses, be adequate to destroy over 5% of the total Soviet population? Would it be adequate to cripple industrial production in these eleven centers for a significant period of time? If no, why not? If so, why would this not act as an effective deterrent?

Answer

Since the answer to this question can be established by analysis rather than opinion, the following is provided. The estimate is based on the assumption that the size of the evacuation area would be limited to an average of 67 miles from the eleven cities named in the question. The total population at risk would be the 23 million noted in the question plus the approximately 6 million rural residents of the evacuation area—a total of 29 million people, who in an evacuated posture, would be distributed at an average density of 190 persons per square miles.

Against the most simple shelter described in the Soviet manuals (Fig. 7 of the study report), the warhead specified in the question has a lethal radius of 4,700 feet or a lethal area of 2.5 square miles. This lethal area is based on the worst of the nuclear effects of blast, prompt radiation, and fallout. Each weapon could then destroy 2.5 times 190 persons or 475 persons. The 2,500 weapons noted in the question could destroy a total of 1,187,500 persons. If the Soviets increased the evacuation distance, the number of fatalities would be reduced. It should be noted that this attack would leave the industrial areas of these cities virtually undamaged.

If the specified warheads, instead of being expended against the vacuation areas, were used against the industrial plants in these cities, the results would be as follows, assuming that all industrial machinery would be hardened to only 40 psi, the minimum protection obtainable with only an earth cover (no crushable material): By targeting each factory individually, we could destroy machinery equal to about 50% of the total productive capacity of the eleven cities. With continuation of Soviet capital expansion, this damage level will decrease, particularly if the dispersal pattern shown in Figure 10 of the study report becomes the model for a significant share of the future industrial expansion around these cities. Also, a higher level of hardening demonstrated in our test program (using crushable material), if applied to the larger factories, would significantly reduce the damage levels.

In addition to the industrial damage, this attack would destroy on the order of 349,000 workers, *if* the entire on-shift work force was caught in the factory-area shelters.

In summary, the warheads specified are totally incapable of causing the damage implied by the question. It is probable that some industrial production in these cities could be restarted within a few weeks and, even with no outside assistance, these cities could recover to prewar levels within 2 to 4 years. Moreover, these top eleven cities contain only about 20% of Soviet industrial production (based on the percent of urban population they contain). The attack specified in the question would, then, damage only about 10% of Soviet production, which they could compensate for merely by adding work shifts to factories in other areas of the country.

Question 4.

Your estimate of only 2% Soviet fatalities after a devastating U.S. attack amounts to some 5,170,560 Soviet lives. Assuming that fatalities from such a U.S. attack reached 7% of the total Soviet population, the figure represents 18,096,960 Soviet lives. Do you consider that the Soviet leadership would find the loss of five to eighteen million lives an "acceptable" risk to run in order to bluff or coerce the United States? If so, what evidence do you have to support this interpretation of Soviet thinking? For what kinds of political, economic or territorial benefits do you believe the Soviet leadership would be willing to risk the loss of five to eighteen million lives and the loss of considerable industrial capability?

Answer

The 7% figure cited in this question presumably is derived from the 93% figure cited in question 2. That percentage (which the Soviets state to be 92%) refers to the urban, not the total, population. Eight percent of the urban population works out to about 11 million fatalities rather than the 18 million mentioned in the question.

This question is of crucial importance since it focuses on the realities of what has happened to U.S. deterrent strength. The deterrence definition originally postulated by U.S. officials was based on a capability to destroy in a retaliatory strike two-thirds of the Soviet industrial capability with collateral destruction of one-fourth and perhaps as much as one-half of the Soviet population. Such heavy losses were assumed to be intolerable; i.e., would destroy the Soviet Union as a viable power and probably reduce its society to purely agrarian culture. It was considered that this concept would provide a high level of security since no rational leader would run a finite risk of destroying his country.

The presently estimated losses (ranging from 5 to 11 million) are clearly a tolerable level. The Russians have tolerated far greater losses before, once by their own choice for a political purpose. Since the potential loss has been reduced to a tolerable level, the issue now becomes the magnitude of the risk that such loss might occur and whether or not the Soviet leadership would be willing to accept that magnitude of risk for some projected gain.

The magnitude of the risk to the Soviets is equal to the probability that the U.S. would attack or retaliate against the Soviet population in spite of the fact that, following such U.S. attack or retaliation, the Soviets would then inflict intolerable losses on the United States (107 million fatalities according to a Government study in 1975, plus 50% to 80% industrial destruction by our estimates). Hence, based on the principles of America's own concept of deterrence, the magnitude of the risk to the Soviets is quite low. The main element of this risk arises from the possibility that *the United States leaders* may act in an irrational manner.

I firmly believe that the present Soviet leadership would have no qualms in risking the loss of 20 million or so of its population. The Soviet state and indeed its predecessor the Tsarist state have long conducted foreign policies dedicated primarily for the enhancement of the state, with the population usually paying a heavy price for these expansionist endeavors. The Soviet leadership can and historically has made comparable sacrifices of population in order to achieve political, economic or territorial benefits. General Secretary Brezhnev made his career under Stalin. By the time of Stalin's death, Brazhnev was already on the fringes of the Politburo.

In order to achieve agricultural collectivization, the Soviet state sacrificed 10 million of its inhabitants (out of a much smaller population base) in the early thirties. Under the same leadership team while Brazhnev was gaining experience and successfully moving up through the ranks, the Soviet state lost over 20 million casualties in the period of 1940-45. Many of these losses were directly due to a desire to acquire territory as in the case of the assault on Finland and in the broad

frontal assaults to occupy the territory of Hungary, Czechoslovakia, and the other nations of Eastern Europe. Many lives lost in these secondary theatres of war could have been saved if the effort was concentrated against the Nazi's homeland alone and quite possibly the war would have ended sooner.

The era of detente does not appear to have changed either the Soviet leaderships, fundamental objectives, their acceptance of war as a tool of policy, or their willingness to accept losses in pursuit of their purposes. Leonid I. Brezhnev in a December 21, 1972, speech said, "The Communist Party of the Soviet Union always held and now holds that the class struggle between the two systems—the capitalist and socialist—will continue. It cannot be otherwise, because the world outlook and class aims of socialism and capitalism are opposed and irreconciable."

On July 4, 1972, shortly after the Moscow Summit meeting, *Pravda* reported Premier Kosygin's statement that peaceful coexistence ". . .in no case means the rejection of the right of the peoples, arms in hand, to oppose aggression or to strive for liberation from foreign oppression." The government-controlled press has been more explicit. *Izvestiia* on September 11, 1973, stated, ". . .we must not ban civil or national liberation wars—uprisings—revolutionary mass movements aimed at changing the political and social status quo." The Soviet Party military journal, *Communist of the Armed Forces*, in November 1975 contained the following statement:

> The attempt of certain bourgeois ideologists to prove that nuclear missile weapons leave war outside the framework of policy and that nuclear war moves beyond the control of policy, ceases to be an instrument of policy and does not constitute its continuation is theoretically incorrect and politically reactionary.

Soviet authors almost universally agree that should a war occur, "losses may be extremely high in this decisive clash between opposing forces."

It is my belief that these views of Soviet leaders convey a clear intention to continue "liberating" various parts of the world—and pursuing a course of action that may prove detrimental to U.S. security or to the continued supply of resources essential to the U.S. economy. Should this adventurism lead to war, the U.S. would be removed as an impediment to further and more lucrative "liberations." A more fundamental consideration, however, is that the security and survival of the United States should be based on in-being capabilities adequate to counter the capabilities of the Soviet Union rather than on a hope that the Soviet leaders will not do what they say they will do.

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Question 4.a.

Do your estimates of Soviet fatalities include only immediate deaths from blast, thermal or radioactive effects or do they include subsequent deaths from secondary causes as well?

Answer

See the answer to question 1.d.

Question 5.

Do your calculations concerning the Soviet "war recovery capability" address any of the social, political or psychological effects of nuclear weapons attacks? If so, how have these factors been taken into account?

Answer

Out calculations on Soviet "war recovery capability" have considered the social, political, and psychological effects of nuclear weapon attacks. This has been done primarily by considering their effect on the classical manner in which mankind recovers from catastrophic events. Basically, this recovery is divided into three periods: *survival*, in which efforts focus on the fundamental necessities of life such as food, clothing, and shelter; *reconstitution*, in which the organization of the division of labor needed for industrial societies is reestablished; and *recovery*, in which the excess production of an industrial society is used to restore damaged assets. The social, political, and psychological effects are predominant in the survival and reconstitution phases. We note here a large asymmetry favoring the Soviets. First and foremost, through the very long-term training and preparations of their civil defense program, they have psychologically prepared their people to survive a nuclear war. Moreover, not only have the Soviets psychologically conditioned their people to survive, but they have provided them with survival training and emergency food stores to sustain them until agricultural production is resumed.

The Soviets have also made careful preparations to insure that societal reconstitution does not change the nature or leadership of the Soviet Union. Their massive program of hardened, dispersed, and redundant command posts; communication facilities; blast and fallout shelters for their leadership (down to the 3rd and 4th echelons of government), and Civil Defense, KGB, and Army troops insure that the reconstitution phase will take place both rapidly and in conformance with Soviet Communist Party goals. These factors—which shorten both the survival and reconstitution phases of Soviet recovery—have been accounted for, to the best of our judgment, in our estimates of recovery time.

The estimate that the U.S. would recover in 10 to 12 years is, by comparison, highly optimistic. Several factors could materially lengthen U.S. recovery time. First, Americans are conditioned to believe that everyone will die in a nuclear war. Such conditioning can only cause more Americans to die should a war occur. Second, while U.S. population losses would be about 50%, the losses in the industrial work force would be much higher, a fact which would significantly prolong recovery. A third factor is that at the end of a war, the Soviet Union would have overwhelming strategic nuclear superiority. Through continued coercion or denial of imported resources, the Soviets could direct or limit U.S. recovery. They could also use this strength to force other industrialized nations to assist them, thereby reducing Soviet recovery time below that which we have estimated.

Question 6.

Do you believe that a Soviet attempt to conduct nuclear coercion or "blackmail" which led to the deaths of five million or more Soviet citizens and the extensive destruction of property would have any effect on the composition of the Soviet leadership? If so, what effect? If not, why not?

Answer

"Winning" versus "losing" has historically had more effect on the Soviet leadership than has the cost of an undertaking. Changes in the Soviet leadership would be likely only if the Soviet Union was forced to back down or failed to achieve their sought-after objective in a confrontation with the United States. Consider the situation that would exist if a confrontation did escalate to a level where the Soviets had lost 5 million of their people. For these Soviet losses to have occurred, the U.S. would have had to expend all or most of its surviving arsenal. The Soviet Union, even after having destroyed the U.S. cities, would still retain a very large strategic nuclear reserve force. Hence, there would be no way that the U.S. could prevent the Soviet Union from achieving its originally sought-after objectives. More importantly, the Soviet citizens would almost certainly be told that it was the "imperialist aggressors" who had attacked the Soviet Union and that the regime, through "vigorous action of its armed forces and civil defense of the people" had "defeated the aggressor" and ensured the survival of the Soviet state.

It is instructive to also consider the corollary question: Would the refusal of a U.S. leader to give in to Soviet demands that led to 107 million American deaths and destruction of most of U.S. industry have an effect on the composition of the U.S. leadership? I believe that it would. Hence, in such a confrontation the leaders of the two countries would face pressures that would be unequal and that would favor U.S. submittal to Soviet demands.

Question 7.

Do you believe that loss of life of this magnitude would have any effect on the stability of the Soviet regime? If so, what effect? If not, why?

Answer

Losses of such magnitude probably would have appreciable but not critical impact on the stability of the Soviet regime. There could well occur localized, temporary breakdowns of stability, but such aberrations would be eradicated before they became a threat to the state. A number of factors indicate that the Soviets will in fact maintain stability. First of all, the Russian state, both in its Tsarist and Soviet manifestations, has a long history in maintaining strong controls over its population. As a result the Soviet population is not inclined to reject direction from above. Secondly, the Soviets continue vigorous efforts even today to ensure that no significant possible center of organized dissent can exist within the body politic. Thus, in time of crisis, there will be no existing hostile organizations capable of taking advantage of a temporary breakdown of stability. Third, the Soviets recognize the potential for such instability and have made a concentrated effort to prevent such a possibility. Elements of this effort include a broad scale indoctrinization of the general population, close integration of the civil defense and strategic military programs, and a concentration on the development and construction of redundant command and control systems.

Perhaps more importantly, the Communist Party workers and the civil defense forces collaborate closely at the local level, creating the impression of the CPSU as the protector of the people. By contrast, in the United States there probably would be serious doubts regarding the stability of a government that had failed to protect its people.

Question 8.

Do your calculations include any estimate of the probable effectiveness of Soviet civil and industrial defense measures? If so, what statistical techniques were used to establish this level of probability?

Answer

Our calculations have included estimates of the probable effectiveness of Soviet civil and industrial defense measures. The statistical techniques used in our analysis are the same as those which have for many years been used by the Government to assess the survivability and retaliatory effectiveness of the U.S. strategic forces.

The damage resistance of Soviet factory-area shelters was estimated using the same techniques used to estimate the hardness of Soviet military structures (e.g., command and storage bunkers, aircraft shelters, and missile silos). Damage resistance of the Soviet expedient shelters was based on

the results of tests in the U.S. of shelters constructed according to the Soviet designs. Damage resistance of protected machinery was based on the static and high-explosive tests outlined in the study report. We used the same test and analysis methods and the same expert personnel that are used to establish the survivability of U.S. military systems.

The damage-producing capabilities of U.S. retaliatory weapons was calculated using the formulas of the "Physical Vulnerability Handbook—Nuclear Weapons" (Defense Intelligence Agency AP-550-1-2-69-INT, June 1969), for kill probabilities of nuclear weapons. These formulas account for all effects of the nuclear weapons, the size and damage resistance of the target, and weapon accuracy. Reliability and penetration capability were also taken into account. These formulas were derived from weapons test programs conducted by the United States Government and are the standards on which retaliatory effectiveness computations have always been based.

Question 9.

Do your calculations include any estimate of the statistical probability that the Soviet Union intends to wage an offensive nuclear war?

Answer

We know of no credible method of estimating the statistical probability of an intention. Moreover, the security of the United States should not be based on a hoped-for absence of Soviet hostile intentions since such intentions could develop quickly. The United States should have the capabilities necessary to reliably deter Soviet aggression or to defend itself against the military forces possessed by the Soviet Union.

Question 10.

Inasmuch as the Soviet Union is potentially threatened with military attack from China and with rebellion among its Eastern European client states—situations in no way faced by the United States—is it not likely that their industrial and civilian defense measures are driven more by these considerations and less by the idea of threatening and coercing the United States?

Answer

It is not realistic to assume that the Soviet Union is threatened with a military attack from China. Military analysts generally agree that the large standing army of the PRC is neither postured nor equipped for power projection any significant distance beyond the Chinese borders. These analysts also agree that the small PRC force of nuclear missiles is maintained in a defensive posture to enhance its survivability. This posture does not allow them to undertake an offensive strike without considerable preparations. These preparations, if started, would undoubtedly be detected by the Soviets and might well cause a Soviet preemptive counterforce strike. The PRC bomber force is

ill-equipped to challenge Soviet air defenses and highly vulnerable to the Soviet fighters stationed in areas near the PRC border. In addition, its projection range is severely limited.

The Soviet problem with respect to the PRC is essentially one of containment; i.e., border disputes and potential creeping encroachment of settlers of PRC ethnic origins. They have reacted to this problem by stationing large numbers of regular army troops, KGB border guards, air defenses, and fighter aircraft along the Chinese border. Given the PRC's present lack ot mechanization, roads, logistic support, or industrial base to conduct an effective offensive into the Soviet Union, the Soviet troops presently stationed along the PRC border are deemed more than adequate to contain any PRC expansionist thrusts. Further, given the present marked asymmetry in nuclear arsenals as well as the Soviet air defenses, it is inconceivable that the PRC would initiate nuclear war with the Soviet Union.

With reference to the Eastern European states, the inference that the Soviet Union is faced with rebellion of its client states appears to be unfounded. While it is true there is dissension in these states, it is also true that the population is very well controlled by a combination of Soviet and indigenous troops. The Soviets must have a much higher confidence in their ability to control these states than Americans are willing to admit. If they did not, one would have to seriously question why the Soviets have embarked on such an extensive program of civil defense shelters and other protective measures in these client states. Further, a scenario in which the U.S. and USSR have experienced an exchange of nuclear weapons will undoubtedly include attacks on Soviet and probably indigenous military facilities and forces in these client states. Thus, their populations will have been placed at some degree of risk by U.S. weapons. It is difficult to believe they will then rise up in rebellion against the Soviet Union (which will still retain a sizable arsenal of nuclear weapons) if faced with no hope of support from the United States. In any event, it is apparent that the Soviet troops stationed there would be more than adequate to quickly crush any uprisings. One facet of this control, frequently overlooked, is the complete dominance by the Soviets of the command, control, and communications mechanisms of the indigenous forces. Any attempt to use these forces against the Soviets must, of necessity, be spontaneous, individual unit efforts since the means to coordinate them remains firmly in the control of the Soviets.

From the above, we cannot in any way conclude that the Soviet industrial and civilian defense measures are driven more by considerations of China and Eastern Europe than by competition with the United States. While it is certain that the Soviets view civil defense measures as protecting against both the U.S. and PRC, the primary thrust clearly must be against the U.S. It is illogical to

infer that the Soviet preparations are driven by threat of rebellion from client states that possess no nuclear weapons, especially when the USSR expends considerable resources building civil defenses for the people and industries of the client states.

Question 11.

In view of these gross strategic disparities between the U.S. and the U.S.S.R., is it not true that the Soviet Union has a lower tolerance for nuclear destruction than the United States, because it is subject to uncertainties on its borders from which we are free?

Answer

In my opinion, the Sino-Soviet border disputes and the occasional dissension within the Eastern European client states do not constitute a "gross strategic disparity." Rather, the Soviet Union appears to be more than adequately prepared to cope with any potential problems on its borders. Even after an all-out nuclear war with the United States, the Soviet Union would have remaining a strategic reserve force more than adequate to deal with China, Europe, and whatever might be left of the United States. (See Figure A-3 of the study report.) In addition, the Soviet non-central systems (medium bombers, cruise missiles, and medium-intermediate range ballistic missiles) would survive in numbers sufficient to provide a second, fully independent capability against China and Europe. Moreover, Soviet conventional forces, together with the materiel and logistics to fight a war, would provide a third independent and adequate capability.

It is also, in my opinion, the United States that has the lower tolerance to nuclear destruction. The Soviet population, notwithstanding desires for personal freedom, is well disciplined and firmly controlled by a regime that continues to be effective in suppressing dissent. Since essentially all of the information they would receive in the event of a nuclear war would be from the Soviet government, the events will be described in a manner which can only cause the Soviet people to blame the United States for the destruction. As was the case with the American people following the attack on Pearl Harbor, their population will undoubtedly be made more cohesive against a common enemy who has "without provocation wreaked this horrible disaster on the peaceloving Soviet people."

By contrast, many people in the U.S. are prone to express their dissent by rioting and violence. When one considers that in 1968 the United States had to deploy almost a full division of troops to its capitol city in order to quell widespread rioting, looting, and arson, it is apparent that nationally our population is totally unprepared to deal with the consequences of nuclear war. Further, we must consider the fact that people have been deceived into believing that a nuclear war is the end of the world and that if such a war occurs they will all die. These facts emphasize the disquieting

realization of how totally ill-prepared our nation is to deal with such an event. On the other hand, the Soviets have—through years of psychological conditioning, practical training, and physical civil defense preparations—provided their people with the basic mental attitudes and tools to cope with such a catastrophe.

Question 12.

If, as you say in your testimony (p. 1-80), the Soviet Union wants to avoid nuclear war and would not initiate it except as a last resort, why do you believe that they would run the risk of provoking one by attempting nuclear extortion?

Answer

The Soviet Union views war ". . .as a continuation of policy by military means." They hope and plan on obtaining their political goals without the use of war. However, ". . .the Communist Party of the Soviet Union always held and now holds that the class struggle between the two systems—the capitalist and socialist—will continue. It cannot be otherwise, because the world outlook and class aims of socialism and capitalism are opposed and irreconcilable."

In general, Soviet leaders recognize that the role of the USSR as a military superpower provides the base for a dynamic Soviet foreign policy. They believe that the changes in the U.S./Soviet military balance have led to political changes and given rise to new opportunities for the Soviet Union to shift the "correlation of forces" still further in its favor. The ultimate Soviet objective, as Brezhnev has indicated, is to achieve a power posture such that ". . .no question of any importance in the world can be solved without our [i.e., Soviet] participation, without taking into account our economic and military might." Thus the Soviets seek a power balance in which they would deal with the U.S. and the rest of the world from a position of superior strength.

The preceding discussion clearly shows that while the Soviets seriously want to avoid a nuclear war, they do not intend to abandon their quest for changing the world social order. They perceive, and in my opinion quite correctly, that the risk of nuclear war is quite low as long as they have a position of superior offensive strength coupled with the ability to limit damage to themselves. The United States, in contrast, remains fully exposed to intolerable damage.

One can also ask why the United States—a charter member of the United Nations, an organization charged with keeping peace in the world—risked nuclear war during the Cuban missile confrontation with the Soviets in 1962. The answers for both the 1962 confrontation by the U.S. and potential Soviet threat are the same. The nation with the superior power, while recognizing that some risk exists, is nevertheless willing to take that risk in order to achieve a vital political objective;

i.e., as long as offensive attacks are not initiated, the nation with the superior force is taking only an extremely small risk that his opponent, rather than yield a single political advantage, will commit national suicide and initiate or provoke a nuclear war.

Question 13.

The evidence cited in your statement and study taken from Soviet strategic and civil defense literature suggests only that the Soviet Union be taking measures to protect population and industry in the event of a nuclear war, not that it is planning to wage nuclear war. What is there to substantiate your inference that these defensive capabilities portend an *intention* to wage nuclear war or to attempt nuclear coercion?

Answer

I did not infer that the Soviets *intend* to wage nuclear war. In fact, such an inference would be contrary to the published statements of the Soviet leaders. These same leaders, however, have stated that they intend to pursue "wars of liberation;" to continue their unrelenting struggle against the West; and that war, including nuclear war, is an extension of policy. They have cautioned their people that in the process of this struggle nuclear war could occur as a final desperate move by the West to regain its former power and that the Soviet Union must be prepared to survive, recover, and emerge victorious from such a war. These factors, taken together with the considerations discussed in the answer to the previous question, indicate that the Soviet Union intends to continue using its power to get its way in the world.

Moreover, the timing of the Soviet civil defense preparations creates an inference of its own. The acceleration of Soviet civil defense preparations did not occur when the U.S. had nuclear superiority and was threatening the Soviets with "massive retaliation." Instead, the program was accelerated in the early 1970s, in the era of detente, when the trends (see Figures A-2 and A-3 of the study report) showed that a nuclear war-winning capability was within the Soviet grasp.

Question 14.

Even if the Soviet Union were willing to risk an avoidable nuclear war and even if they believed their civil and industrial defenses gave credibility to their threats, what reasons do you believe they have for expecting the United States to back down in a confrontation?

Answer

For the past several years, Soviet spokesmen have pointed out that the "correlation of forces," a term which includes military, economic, and political power, has been shifting in favor of the Soviet Union and that for this reason the U.S. is already being forced to back down. For example, the Soviets asserted that the SALT I agreements represented a change in U.S. policies that was forced on the U.S. by Soviet power:

> The strategic course of U.S. policy is now changing before our very eyes from "pax Americana" – the Americanized formula of world domination – to a definite form of necessity for peaceful coexistence. But, we must clearly understand that this change is a forced one and that it is precisely the power – the social, economic and, ultimately, military power of the Soviet Union and the socialist countries – that is compelling American ruling circles to engage in an agonizing reappraisal of values. ("A Triumph of Realism," Komsomelskaia Pravda, June 4, 1972)

This belief was further amplified in an editorial in the May 1973 *Kommunist*:

> . . .[imperialism] is compelled to adjust to the new condition wherein the correlation of forces in the world arena has changed in favor of peace, progress and socialism. A considerable role in the strategy of the imperialist powers is also played by the realization that a nuclear war would be suicidal for capitalism.

One fulfillment of this view was the October 1973 Middle East war, where a Soviet threat to intervene caused the United States to restrict deliveries to Israel, thereby bringing about the release of the encircled Egyptian army.

Marshal Grechko's view of the matter was that:

> It was precisely the change in the correlation of forces in favor of socialism and the process of the relaxation of tension taking place on this basis which prevent the dangerous eruption of the war in the Near East from assuming dimensions threatening universal peace.

In Angola, the United States backed down with minimum protest and no effective counteractions. The Soviet leaders could logically view these events as an emerging tendency of the United States to back down in confrontations. Once such a pattern of concessions is established, it is increasingly difficult to halt the process.

As the correlation of forces shifts further in favor of the Soviet Union, it is not unrealistic to believe that the United States would be willing to back down in confrontations even more important than Angola and the Middle East. By 1978, the Soviet Union will have gained a "war-winning" capability comparable to that which the United States held in 1962 during the Cuban missile crisis. (See Figure A-3 of the study report.) The Soviets believe we have rational leadership and that the U.S. leadership, when placed at a major disadvantage, as the Soviets themselves were in 1962, can be forced to acquiesce to Soviets' demands in future confrontations.

Question 15.

The scenario for nuclear coercion suggested in your testimony requires that the Soviet Union have a high confidence that the United States would not engage in nuclear war, if its vital interests were threatened. What information do you have that the Soviet leaders have this high confidence or what factors would entitle them to this high confidence?

Answer

We cannot identify an interest of the United States so vital that it would be worth "defending" at the expense of a 100-million-plus American lives, destruction of most of American's industrial capability, and a postwar military balance such that America's future could be dominated by the Soviet Union. It is ironic that because of American adherence to our own concept of deterrence the Soviet leaders can have high confidence that the U.S. would not engage in nuclear war, even to protect a "vital interest." Indeed, the Soviet leaders' confidence should be further reinforced by the realistic and candid statements of the *Annual Defense Department Report* (FY 1977), which implies that even if the Soviet Union attacked the U.S. strategic forces the U.S. might not necessarily respond since in such an attack the Soviets could ". . .withhold a large percentage of their forces with which they could retaliate in kind" (p. 47).

Question 16.

At different points in your testimony, you say that extensive civil defense measures are "destabilizing" to the strategic balance and that the United States needs to undertake such measures in order to regain the stability of the strategic balance. Are civil and industrial defenses intrinsically "stabilizing" or "destabilizing?" Historically, has not the adoption of "destabilizing" measures in order to achieve stability led, instead, to new rounds of instability?

Answer

In the study report and my testimony, the discussion of strategic stability was in consonance with the definition outlined in the *Annual Defense Department Report* (FY 1977) (p. 45); i.e., a ". . .situation in which neither side will see any advantage in initiating the use of strategic forces." Moreover, both the prepared testimony and the study report noted specifically that the U.S./USSR strategic relationship had not been destabilized by Soviet civil defenses alone but by the combined effect of these civil defenses and increasing Soviet offensive power.

In more specific terms, the present instability is caused by:

a. The growing capability of the Soviet Union to improve their military advantage by attacking the U.S. strategic forces. The deployed forces of the two sides are roughly equivalent (Fig. A-1 of the study report). By attacking the U.S. forces, the Soviet Union would gain the position of military superiority shown in Figure A-2 or, if the U.S. sought to redress the imbalance, the superiority shown in Figure A-3.

b. The Soviet Union following an attack on U.S. strategic forces would still retain a very large portion of their original strategic force (See Fig. A-2 of the study report), a factor which the DOD report notes could deter the United States from using its deterrent force in response.

c. In the event that the U.S. did respond to a Soviet attack, the Soviet civil defenses can limit the damage to a level that the Soviets know can be tolerated.

d. Since Soviet civil defenses will allow the USSR to recover from a nuclear war much faster than the United States, and since the USSR would retain military superiority at the end of a nuclear war, the Soviet Union could continue to dominate or at least substantially influence the United States in the postwar period. Thus the Soviets could be reasonably certain that the U.S. would no longer stand between the Soviet Union and its global objectives.

The issue then is not whether civil defenses are intrinsically stabilizing or destabilizing. The issue is that the strategic relationship between the U.S. and the Soviet Union *is now unstable*. U.S. civil defense preparations by themselves could not entirely remove the instability caused by the several factors outlined above. Such preparations could, however, make nuclear war less attractive for the Soviet Union and more survivable for the United States.

Question 17.

If, as you say on pages 1 and 73 of your statement, non-military (civil and industrial) defense undermines nuclear deterrence, just like an ABM system by provoking destabilizing fears of a first strike, why should the United States incur this increased risk by going beyond its present limited program of fall-out shelters?

Answer

It would not necessarily be correct to say that civil and industrial defense undermines nuclear deterrence by provoking destabilizing fears of a first strike. The statement said that "civil defense undermines deterrence by protecting an aggressor's economic and political assets against retaliation." Hence U.S. civil defense preparations would not increase any risks to the United States. In fact, since for the reasons noted in the answer to the previous question, the U.S. deterrent concept *has been undermined* and the strategic relationship *is now unstable*, the U.S. now faces a finite risk that a nuclear war might occur and a relatively large risk that nuclear blackmail or coercion could be applied. U.S. civil defense preparations could reduce both the magnitude and the potential consequences of this risk.

Question 18.

In view of the universal tendency of population and industrial capacity to become concentrated in relatively small areas, why do you relate the destruction potential of U.S. strategic forces to the entire geographic expanse of 8.65 million square miles of Soviet territory (pp. 1-53, 54 of testimony), the overwhelming proportion of which contains no worthwhile population or industrial targets?

Answer

The effect of the Soviet civil defense preparations is to reverse "the universal tendency of population and industrial capacity to become concentrated in relatively small areas." For population, this reversal is obtained through evacuation and over the longer term will be facilitated through colocation of new housing units with the dispersed industry. For industry, this reversal is being obtained through the dispersal mechanism shown in Figure 10 of the study report.

Because the thrust of the Soviet civil defenses is to disperse potential targets over very large areas, noting the areas which can be covered by the U.S. arsenal provides a useful perspective, particularly since many Americans have long been conditioned to accept the myth of "overkill." Further information on this matter is included in the answer to question 19.

Question 19.

Does your data indicate what proportion of Soviet territory is occupied by the majority of its population or the majority of its industrial capacity and, if so will you make those figures available to the committee?

Answer

The Soviet urban population (about half of the national total) is in normal day-to-day living concentrated in a small fraction of one percent of the Soviet land mass. It is for this reason that U.S. weapons could exact heavy destruction if the population is not evacuated (see Figure 6 of the study report). If evacuated to the collective farms and outlying villages, the urban population would be distributed over about 27% of the Soviet land area. If the evacuees are further distributed into nonagricultural areas surrounding the cities, the urban population could be spread over as much as 48% of the Soviet Union.

The industrial dispersal illustrated in Figure 10 of the study report includes housing for the work force. Hence, in the future, an increasing share of the "urban" population will in normal day-to-day living be dispersed over an area that could grow to as much as one-fourth of the Soviet Union.

Since the locations of factories can be precisely defined, industrial targeting is based on the actual factory-by-factory layout of the Soviet industrial complex. Hence, we have not aggregated the total area covered by Soviet industry.

Question 20.

Since the large relative U.S. advantage in re-entry vehicles (over 8,500 to less than 3,500) permits the United States to target more aim-points or to place more warheads on fewer aim-points (thus neutralizing hardened sites), why do you assume that the Soviet Union would find a nuclear attack "tolerable," while for the United States it would be disastrous? Given the imbalances in

offensive and defensive capabilities, it would appear to be equally disastrous for both. What assumptions and calculations are required for you to arrive at the conclusion that nuclear attacks would be benign for the U.S.S.R. and catastrophic for the U.S.?

Answer

It would be incorrect to infer that the United States has a large advantage in offensive capabilities. Figure A-1 of the study report shows that "numbers of warheads" is the only measure of military power in which the United States will continue to hold an advantage; the Soviets will be at parity or superiority in the other measures. Moreover, counting the numbers of warheads that each side has is a poor way to measure military strength since it does not account for the size or accuracy of the warheads nor the survivability and penetration capability of the delivery systems.

The portion of my testimony to which this question refers states that ". . .should the Soviet execute its civil defense plans, the consequence of further escalation would be disastrous to the United States. It might well be tolerable to the Soviets." An example of such "further escalation" would be a Soviet attack on U.S. strategic forces, the outcome of which is shown in Figure A-2 of the study report. If such an incident were to occur in 1980, the U.S. and USSR would end up with an approximately equal number of warheads while the Soviets would have a 4 to 1 advantage in throw weight, a 10 to 1 advantage in megatons, and a 2 to 1 advantage in the number of missiles and bombers. In equivalent warheads, a comprehensive measure of actual capability to destroy targets, the Soviets would have a 3 to 1 advantage. Hence, one consequence of "further escalation" would be to give the Soviets a clear superiority in offensive power. (Even if the U.S. attacked first, the Soviets would still have superiority in equivalent warheads.)

The Soviet civil defenses have the effect of magnifying this superiority in offensive power. Table A illustrates the effect of hardening on the numbers of U.S. warheads required to destroy industrial machinery. Depending on the size of the factory area, hardening could have the same effect as a 22-fold to a 43-fold *decrease* in the number of U.S. SLBM current warheads. Even the bomber laydown weapons, whose effectiveness is less sensitive to hardening than that of other U.S. warheads, would be subject to a 3- to 9-fold decrease. Dispersion of smaller industry as illustrated in Figure 10 of the study report, has the effect of an 8-fold reduction in numbers of U.S. SLBM warheads even if the machinery is not hardened.

In sum, the Soviet Union may well find such escalation tolerable *if it executes the civil defense plans which it has published and is prepared to implement*. The assumptions and calculations of potential damage to the USSR have been described in the answers to questions 1, 1a, 1b, 1d, 1l, 1m, and 8. We assume that the question does not imply that there is disagreement over our statement that nuclear war would be disastrous to the United States.

TABLE A

EFFECT OF INDUSTRIAL HARDENING ON WARHEAD REQUIREMENTS
(NUMBER OF WARHEADS REQUIRED TO DESTROY 90% OF MACHINERY)

	TARGET SIZE					
	MEDIUM AREA			LARGE AREA		
TARGET HARDNESS / WEAPON TYPE	SOFT	*MINIMAL HARDENING	**EXTENSIVE HARDENING	SOFT	*MINIMAL HARDENING	**EXTENSIVE HARDENING
SLBM, CURRENT	1	5	22	2	17	87
SLBM, PROJECTED	1	3	13	2	10	48
BOMBER STAND-OFF WEAPONS	1	1	8	2	4	27
BOMBER LAY-DOWN WEAPONS	1	1	3	1	1	9
MINUTEMAN III	1	1	9	2	4	30

*MINIMAL HARDENING CONSISTS OF EARTH COVERING ONLY.

**EXTENSIVE HARDENING CONSISTS OF SURROUNDING MACHINE WITH CRUSHABLE MATERIAL AND COVERING WITH EARTH OF SUFFICIENT DEPTH TO PROVIDE EARTH ARCHING.

Question 21.

Since sufficient economic or industrial capacity would survive a limited nuclear attack in any case, it would appear that your conclusions derive from a large-scale nuclear attack. Is that correct? If this attack or exchange were spread over several days, would it be possible for the U.S. to determine where surviving Soviet industry and population were located and target these areas, since as you say, our methods of verifying these facts are extremely good?

Answer

Our conclusions *are* based on a large-scale nuclear attack. In my testimony, however, I indicated only that the U.S. would know if the Soviets actually initiated an evacuation of their cities. Following a Soviet attack on U.S. forces and a first portion of a U.S. retaliation against Soviet economic and political assets, it would be highly unlikely that the United States would have remaining the means to determine the location of Soviet surviving industrial facilities or population.

Question 22.

Why do you conclude that the Soviets would have a bargaining advantage over the U.S. if it requires them two to four years to recover from a U.S. nuclear attack? Would not your projected industrial recovery periods (2-4 years for the U.S.S.R., 12 years for the U.S.) make any bargaining power rather academic?

Answer

Let us examine the specifics of the bargaining position that would exist in a future confrontation in which the Soviets had executed their civil defense measures. If the confrontation escalated into full-scale nuclear war:

a. The United States would lose over 100 million of its citizens, compared to 5 to 10 million Russians.

b. Half to three-quarters of U.S. industrial capacity would be destroyed, compared to 10% to 30% of Soviet industrial capacity.

c. The present "rough equivalence" in strategic forces would be gone—the Russions would have superior strength and hence could dominate or strongly influence U.S. actions for the forseeable future, particularly since the USSR would recover its industrial capacity much sooner than would the United States.

d. The Soviet people have been conditioned to believe that they can survive and perhaps even win a nuclear war. Americans have been conditioned to believe that we would all die in such a war.

While "industrial recovery time" may appear to be rather academic, the above specifics, which would enter into the bargaining position in a serious confrontation, are anything but academic. In my judgment, the above specifics represent a bargaining situation for the United States that is worse than the situation faced by the Soviet leaders during the Cuban missile crisis of 1962.

Question 23.

In view of the historical problems of Soviet economic development (low productivity, misallocation of capital, technological constraints, etc.), is the relatively shorter recovery period you postulate for Soviet industry attributable solely to their industrial defense techniques?

Answer

As we indicated on page 3 of the study report, "survival of the work force is by far the most important factor in industrial recovery." Hence, the relatively rapid Soviet industrial recovery is attributable first to their measures to protect the skilled workers and, second, to their industrial defense techniques.

It is also important to understand that in spite of the problems of Soviet economic development cited in the question the Soviet Union outproduces the United States in several areas including steel, 1.3 to 1; cement, 1.6 to 1; coal, 1.2 to 1; and petroleum, 1.2 to 1; and Soviet machine tool production equals that of the U.S. In fact, the conditions which Americans regard as inefficiencies in the Soviet economic system give the Soviets more resiliency and hence a better prospect of recovery. Soviet factories appear to American observers to be glutted with people, a condition which insures availability of the work force needed for the labor-intensive steps of recovery. Soviet machine tools are less automated and hence easier to protect and restore. The U.S. laborer has lost many of the basic skills that would be needed for recovery—we employ "machine operators," the Russians employ "machinists." The general lack of communications between enterprises and uncertain delivery of repair parts has forced Soviet factories to become highly self-sufficient in machine tool repair and to keep machinery far in excess of their normal needs. In addition, because of supply difficulties, Soviet managers tend to keep large stocks of raw materials and finished product. While all of these factors attest to the day-to-day inefficiency of Soviet industry, they are marked advantages in recovery from nuclear war.

Question 24.

What evidence is available to indicate that the Soviet industrial defense measures have been implemented throughout the U.S.S.R. and are not merely "pilot" or "demonstration" programs at a few facilities?

Answer

Soviet civil defense literature and commentary by Soviet civil defense spokesmen over the past several years indicate this is not the case. Soviet newspapers and journals, especially the civil defense monthly, VOY ZNAN (circulation in excess of 300,000), refer to industrial defense measures underway at a broad variety of industry installations. Books such as *Civil Defense of an Industrial Installation* (2 editions totalling 500,000 copies) indicate nationwide programs. The book referenced appears to be a primer for the conduct of civil defense operations at industrial enterprises throughout the country. Training of special civil defense functions in all industrial facilities nationwide is a regular program. Civil defense staffs exist in all government jurisdictions in the USSR. The civil defense staffs for the 15 republics comprising the USSR are in all cases headed by active-duty general officers, varying from one to three star rank, who devote 100% of their efforts to making the program effective. The entire program is headed by a Deputy Minister of Defense, whose sole responsibility to make the program effective. Far from being a token effort, all the evidence indicates that the various aspects of industrial defense; i.e., training of special civil defense functions, shielding, etc., are being carried out on a broad national scale.

It is of course true that some of the Soviet industrial defense measures are not amenable to cross-checking by more than one method since the preparations associated with these particular measures tend to be unobtrusive or could be normally concealed. However, those measures that are readily observable have been found to be surprisingly widespread. It would not be logical for Americans to assume that the Soviets had implemented only those measures which could be observed by the U.S. and had failed to implement the remainder of their program, particularly since the more observable measures tend to be more costly than the others.

Question 25.

Do your conclusions about Soviet advantages in industrial defense (less damage, shorter recovery) assume that what is known from Soviet publications is universally practiced throughout Soviet industry? If not, what proportion or what segments of Soviet industry would have to be protected by these measures for your projections to be valid?

Answer

Our conclusions about Soviet industrial defense have been based on the fact that the program is national in scope. We have not assumed that everything that is listed or known from Soviet publications could or would be universally practiced throughout Soviet industry. Industrial protection techniques will vary considerably between industry types. Take a steel mill for example. While it may not be very feasible to harden a blast furnace, it would be relatively easy to stockpile and

protect the basic materials to rebuild it (steel and firebrick). On the other hand, the long-lead controlling item in restoring steel production would be the rolling mills. Several Soviet examples have been noted where a single steel mill has two separate rolling plants separated by distances of several miles. These mills, which are inherently hard and very tough, are well suited for protection by the methods selected for machine tools in our Auburn facility.

Moreover, we did not assume that all Soviet industrial machinery would be hardened to a uniformly high level. We assumed that only a selected 5% of machinery would be hardened to about 300 psi, 10% to about 200 psi, 50% to about 60 psi, and 35% would not be hardened. The results of this rather practical and achievable degree of hardening are sufficient to support our conclusions on Soviet industrial recovery.

Question 26.

In view of the current paucity of intelligence data on Soviet civil and industrial preparedness measures and in view of what you call the "unknowns" in the Soviet program, what is the foundation of the high rating you assign to the effectiveness of Soviet civil and industrial protection?

Answer

In the study report prepared for the committee, we stated on page 73 that ". . .these deficiencies and unknowns are not likely to significantly degrade the effectiveness of the Soviet program. Instead, their effect is to extend the time required to transition from their present posture to a fully evacuated and protected posture." Moreover, in our analysis we tended to treat the unknowns which could impact effectiveness in a "worst case" manner. For example, because the extent of medical support preparations is unknown, we assumed that medical services were nonexistent and counted as fatalities all persons that would require medical attention.

We do not concur with the inference that there is a paucity of intelligence data, particularly when the data obtainable from open sources is considered. While it is true that there are gaps in the data, we have determined through use of various analytical and modeling techniques and tests that few of the gaps have significant influence on the estimated effectiveness of the Soviet civil defense measures. If anything, the Soviet program could well be more effective than is indicated by our estimates.

Question 27.

Does your estimate of the costs of protecting U.S. industry against nuclear attack address (1) all industry, (2) all defense industry, (3) essential civilian industry, (4) essential defense industry, or (5) essential civilian and defense industry?

Answer

The preliminary cost estimates shown in Table 3 of the study report refer to the protection of essential capital equipment in the entire U.S. civilian and defense manufacturing industry. These estimates are based upon a detailed examination of the preparations and stockpiling of materials necessary to protect the essential machinery and capital equipment at one of Boeing's large manufacturing plants. Approximately 30% of the total capital equipment was considered essential to regain present production levels. The Boeing costs are shown in Table 3. To arrive at a cost estimate to protect all U.S. manufacturing industry against a full-scale attack, it was assumed that the cost of preparation in relation to the replacement cost at Boeing would hold for U.S. industry at large. Thus, with a knowledge of the Boeing and the U.S. capital equipment replacement cost at 1975 prices, a straight-line extrapolation was made to arrive at an estimate to protect the essential capital equipment of the total U.S. manufacturing industry. This is also shown in Table 3.

Question 27.a.

If the answer to the foregoing is (2) or (4), what are your reasons for selecting defense industry for hardening or other nuclear preparedness measures, as opposed to civilian or essential civilian industries?

Answer

The answer to the foregoing is (1).

Question 27.b.

Do you consider that, in the event of a nuclear attack on the U.S., it will be more essential to rebuild war-related industry first or industry essential to civilian recovery first? On what do you base this view?

Answer

Initially, the most important factor in general recovery is survival (see question 5). Therefore, the first thing that must be done is to rebuild those industries that provide the basics of life; i.e., food, clothing, and shelter. Living standards will during this period be far below prewar standards. It is then necessary to reconstitute the productive capacity of society, and this will generally involve rebuilding *basic* industries such as steel, electric power, fuel production, etc. Since these industries are essential to *both* "defense industry" and "essential civilian industry," to attempt to classify them as one or the other is largely a matter of semantics. In the final phase of recovery, the mix of civilian versus defense products produced will depend on the external threats and international situation existing at the time.

Since the Soviets are preparing to survive and win any war, it would appear that the ability to reconstitute the industrial base of the U.S. to provide for continued defense will be necessary to the survival of the Western World and democratic governments.

Question 27.c.

If your estimate of the costs of preparing industry against nuclear attack is not inclusive, what would the costs be for protecting other or all segments of industry?

Answer

The cost estimates provided to the Committee are inclusive.

Question 27.d.

Are your estimates of the costs of industrial protection based on a limited attack on U.S. industrial and military targets or on an attack against the U.S. economy as a whole? What is the basis for making this assumption?

Answer

Our estimates of the costs of industrial protection and of the time required for recovery are based on a full-scale attack against the U.S. economy as a whole. This assumption was made since, from the U.S. point of view, it represents what should be a worst case type of attack which would place the greatest possible stress on the industrial protection measures.

Question 27.e.

Are your estimates of costs and recovery periods based on a single, limited attack, a series of limited attacks, a single massive or "national" attack, or a series of massive attacks? What is the *basis for this assumption*?

Answer

Our estimates were based on a single, full-scale attack on economic and political assets. If part of the available weapons had been directed against military targets, industrial and population damage would have been lower and recovery would occur more rapidly.

Question 27.f.

How would an alteration in this assumption affect your cost and recovery period estimates?

Answer

An alteration in the duration of the attack (single vs. continuing) would change our estimates of recovery time. Economists who participated in the Strategic Bombing Survey of Europe after World War II concluded that the collapse of the German economy was brought about by repetitive attacks carried out over many months and years. This may well turn out to be a possible response to a full-fledged civil and industrial defense effort. However, it argues for and requires types of forces the U.S. does not now possess; that is, those having long-term survivability (years); survivable and/or

replaceable command and control; denial capabilities to enemy reconnaissance (antisatellite forces); and survivable and/or replaceable reconnaissance assets. Repetitive attacks carried out over many months or a few years could probably deny industrial recovery. Today, only the Soviets with their survivable ICBMs, survivable command and control, and nationwide civil defense are in any way postured or prepared to adopt such a strategy.

Question 27.g.

How did you arrive at the comparative estimates of recovery time for the U.S. and the USSR? What kinds of attacks were these comparative estimates predicated on?

Answer

The comparative estimates of recovery time were based on calculation of damage to population and industry using the approaches and factors outlined in the answers to questions 1, 1.d, 25, and 26, together with the results of large-scale economic studies evaluating the factors outlined under question 5. The estimates are based on a massive, full-scale war involving the strategic nuclear arsenals of the U.S. and the USSR. The results of the economic studies are consistent with the results of the in-depth study of the Seattle-Tacoma-Everett industrial area study, wherein it was assumed that the area received its share of a full-scale nuclear attack on the entire U.S. and that during reconstruction no outside help would be available from other areas of the United States.

Question 28.

Would your advocacy of civil and industrial protective measures also include favoring ballistic missile defense systems? If so, would you favor wide-area systems to protect population and cities or point defenses to protect specific targets? If the latter, would you recommend ballistic missile defenses for both military and industrial targets? What are the advantages and disadvantages you see in the deployment of ballistic missile defenses? Why wouldn't such deployment lead to the opening of the defensive arms race which the SALT I treaty closed in 1972?

Answer

I would not advocate ballistic missile defensive systems for two reasons:

a. The technology of ABM systems is still such that the cost of developing and deploying such systems is greater than the cost to the opponent to counter them with offensive system improvements.

b. Since the ABM Treaty of 1972, the United States has cut back on its research of ABM systems while the Soviet Union has continued a vigorous development effort. It is my judgment that the Soviet Union is or soon will be far enough ahead of the U.S. to beat us in any ABM defense race. Moreover, the Soviet Union's present lead in civil defenses would be an asset to them in an ABM defense race.

Question 29.

The thrust of your testimony is that the United States now requires civil and industrial defense in order to be able to bargain successfully in some undefined confrontation in the indefinite future. Have you considered what measures the Soviet Union might employ to vitiate any American civil and industrial defense programs. If so, what are they?

Answer

I would summarize the thrust of my testimony as being that the United States requires civil and industrial defenses in order to bargain without extremely unfavorable coercion in any confrontation which the Soviet leaders believe is important enough to execute their civil defense measures. Although the Soviets may not today have the military capability to support such a confrontation, the trends shown in Figures A-2 and A-3 of the study report are such that they will have what I fear to be sufficient capability within the next 2 to 5 years.

We have considered the measures that the Soviet Union might employ to vitiate any American civil and industrial defense programs we might elect to undertake. However, as we have shown, the methods required to negate effective passive defenses require such a large number of weapons that this approach is not practicable. Even if the Soviets were willing to assume the gigantic costs and commit the large resources required to manufacture this large an arsenal, it is doubtful that sufficient nuclear materials could be produced for this number of warheads. Further, as long as the number of delivery vehicles is bounded by Strategic Arms Limitation agreements, there is no practical way the Soviets can overpower effective passive defenses.

Question 30.

How many years do you consider it would take the United States to implement the civil and industrial preparedness measures that you advocate?

Answer

Full and complete implementation of a population evacuation program to include the initial planning, production of training materials, identification and training of a basic cadre of people (such as the National Guard, local police, etc.) for implementation of evacuation plans, and rudimentary education of the population would probably require from 5 to 10 years. However, we believe that action which could be accomplished within 1 to 2 years could substantially improve the survivability of the U.S. population. The very *existence* of this capability should create uncertainties in the Soviet's minds, which in themselves would be a deterrent to implementation of their evacuation program.

We believe that a credible, expedient industrial protection program could be developed for most industries in about 5 years. This allows 2 to 3 years to do industrial studies and tests similar to those conducted by Boeing plus 2 years to develop and train industry cadres and stockpile minimum essential tools and materials.

Question 31.

Do you foresee any technological innovations during the period of time which would render these preventive measures obsolete before they are completed? If so, what would they be? If not, why?

Answer

There does not appear to be any technological innovations in the offing which would render these preventive measures obsolete before they are completed. Moreover, there do not appear to be any such innovations within the forseeable future.