PROTECTION OF VITAL RECORDS AGAINST NUCLEAR WEAPONS EFFECTS

Introduction

We have been very much impressed by the assemblage of talent exhibited by our predecessors throughout this program on the subject of records management. It should be clear at the outset, and it probably will be, that we cannot be considered to be experts such as you have been hearing. However, with your indulgence we will do what is a common practice in the technical community. That is, we will make simplifying assumptions on those things about which we know little, in this case records management, and quickly get to a more familiar topic, namely protection from weapons effects.

Although civil defense and vital records protection does not necessarily mean protection against the effects of nuclear weapons only, we have restricted our comments to such effects. As far as the nuclear effects are concerned, we mean those accompanying a nuclear bomb explosion and characterized by an environment of air blast, ground shock, and of thermal and nuclear radiation. Typical records, as we understand it, range from standard office correspondence to photographic film, and may include books, papers, maps, photographs, and other documentary materials. Our approach will be to discuss protection philosophies which would prevent destruction of such records by the primary effects of nuclear weapons.

As has been said many times in the past, in connection with protective construction, the state of the art seems to always lag behind the need. People were talking of the design of structures suitable against high explosives when they were faced with the 20 kt bomb (such as the one exploded over Hiroshima); by the time they allowed for the 20 kt bomb, they were facing the megaton bomb carried by a bomber and today, of course, we face the ICBM. Furthermore, when discussing this subject we are inclined to think in terms of the effects of a single bomb when it appears that in the late 60's and early 70's it would be possible for the enemy to have and to use thousands of ICBM's, meaning that each target area could conceivably receive many hits or near hits. Naturally it would be impractical to completely prevent obsolescence in protective construction with such rapidly changing requirements. On the other hand, to reduce the lag in the state of the art of protective design, we must be more clever in extrapolating the needs of the future while weighing the desired lifetime of the structure with economic considerations.

Nuclear Explosion Phenomena

Before we discuss protection and construction criteria, let us digress a few moments on the weapon itself. It is generally not a pleasant subject, but appreciating and understanding the bomb is essential to developing suitable protection barriers.

When a nuclear weapon explodes, the fission products of the chain reaction and the surrounding air attain temperatures of millions of degrees, approaching the temperature in the center of the sun, thereby vaporizing the bomb casing and other weapon parts. The approximate distribution of total energy accompanying such an explosion is shown in Figure 1. About 50% of the total is blast energy, and the remainder is in the form of thermal and nuclear radiation. Expansion of the heated high-pressure gases creates the roughly spherical and highly luminous mass known as the fireball and depicted in Figure 2 for an air burst. Some indication of its peak brightness is afforded by the fact that the fireball from a one megaton bomb, when observed from 60 miles away, would appear to be 30 times as brilliant as the noon sun.

The fireball expands rapidly and starts to rise. Figure 3 shows the fireball and shock front from an air burst at an early stage of development, and Figure 4, depicting a later stage, shows the Mach front pressure wave as it travels along the ground surface. Within 10 seconds the fireball diameter from a one megaton bomb is about 1-1/2 miles and is rising at about 200 mph. The fireball cools with time and within a minute is no longer visible. Condensation of the residues forms the characteristic radioactive mushroom cloud which generally remains visible for about an hour before it is dispersed by the winds. The characteristics of the cloud at an early stage are shown in Figure 5. The expanding cloud, at a later stage, is shown in Figure 6. The top of this cloud may rise to a height of 25 miles. A more dramatic illustration of the appearance of a mushroom cloud is given by Figure 7.

In a surface burst the intensely hot fireball contacts the ground surface, vaporizing a large volume of surface material. It has been estimated that if only 5% of the energy in a one megaton bomb was expended in this way, about 20,000 tons of soil—an amount covering an average city block to a depth of about 4 feet—would be vaporized and sucked into the fireball. This material mixes with the fission products, and, on later cooling, gradually descends to the earth as radioactive particles referred to as fallout.

Nuclear Blast Effects

With this physical picture of the exploding bomb itself, let us return to the question of its effects and set the stage for determining what we are attempting to protect against. As we mentioned earlier, these effects are nuclear radiation, thermal radiation, air blast, and ground shock.

To appreciate the nuclear radiation effects and the necessary steps for protection, we must know: (1) the possible effects such radiation may have on our materials of interest; (2) the expected level of exposure from a nuclear burst; and (3) the efficiency of various shielding materials.

The units of nuclear radiation most often used are called roentgens. As an indication of the amount of radiation associated with a roentgen, doses of more than 450 roentgens may be expected to kill 50% of those exposed and a dose upwards of 700 r will cause 100% fatalities. A dose of less than 200 r is not likely to be lethal. As far as records are concerned, such materials are much less sensitive to radiation exposure than to blast damage. Tests verifying this fact were carried out at the Nevada Test Site in 1955 by exposing record storage equipment, containing samples of known physical and chemical composition, at various ranges from ground zero. Results of these tests support the conclusion that the amount of protection required for blast provides more than adequate shielding against nuclear radiation in the absence of human beings or other radiation sensitive substances.

Unlike the conventional TNT bomb, the nuclear bomb releases an appreciable percentage of its energy in the form of thermal radiation, and at a very rapid rate. Within a millionth of a second a one megaton nuclear bomb releases 10^{15} calories of radiant heat (one thousand million million calories) which is roughly equivalent to the energy in the amount of gasoline needed to drive a compact type car 40,000 times around the world at the equator. This thermal radiation, similar to that generated by the sun, except for its shorter duration, is filtered by the air through which it passes, so that, at ranges of interest, the significant portions which remain are the types having long wave lengths; in other words, wave lengths which lie in the visible and infrared regions of the spectrum.

At ranges beyond the fireball the thermal radiation is rapidly depleted, and its effect is usually confined to the ignition of combustible materials. The use of incombustible materials in the records storage structure is usually adequate to cope with the thermal radiation problem. However, when dense concentrations of combustible materials occur in a given locality, and when certain weather conditions prevail, the fires ignited by the thermal radiation can develop into an all-consuming conflagration called a fire storm, which generates intense heat and exhausts the local supply of oxygen. Safeguarding of records under these conditions requires shielding from the heat; survival of humans would also demand such protection, and an emergency oxygen supply as well.

The air blast can be loosely described as a traveling wave of compressed air moving at supersonic speed. Accompanying the main blast wave is the wind generated by the detonation which can also have supersonic speeds when the overpressure exceeds about 20 psi. This blast wind generates what is called dynamic pressure.

The compressed air effect (called overpressure) exerts an inward squeezing or crushing force on the exterior walls of structures, while the dynamic pressure acts in the familiar manner of high winds in tending to move exposed objects in the direction of the blast. In passing over the ground surface, the blast wave exerts a downward pressure on the soil which causes squeezing forces in the soil acting both vertically and horizontally.

Since the blast force acting on the surface is applied suddenly rather than gradually, the effect is like that of a giant blow, creating ground vibrations similar to those of an earthquake but often much more violent. These forces are often called "ground shock," and require measures similar to those used in designing against earthquakes. In the case of records storage, these forces may require anchorage of the record containers to prevent sliding and overturning.

Relative Effects on Exposed and Buried Structures

Figure 8 compares the relative importance of certain considerations as they apply to structures located on the ground surface and to those which are buried. It is apparent that, compared to the buried structure, the surface structure receives much higher blast pressures, is afflicted with problems of sliding and overturning from blast wind, is exposed to damage from flying debris, and is at a disadvantage from the standpoint of radiation shielding. As shown in Figure 9, advantages of the surface structure are those related to normal operating conditions rather than blast conditions, such as ease of access and fewer problems with ground water and ventilation. These considerations largely account for the fact that failures of buried structures under nuclear blast are much less common than failures of structures located above ground and are usually confined to surface features such as entrances, and intake and exhaust ducts. The presence of earth cover is a bonus in providing the least expensive form of shielding from both nuclear and thermal radiation. It should be noted that, under certain conditions, a structure located on the ground surface can receive the advantages of complete burial through the use of a properly designed earth mound encasing the structure.

Examples of Blast Damage

The following series of illustrations is presented to give some indication of the damage potential of a nuclear blast. Figure 10 shows a three-quarter view of a multistory camera bunker located at the Eniwetok Proving Ground. This structure is similar to another bunker (Ref. 4) shown in detail in Figure 11. The bunker of Figure 11 received severe damage from a nuclear detonation in the multi-megaton range which created blast pressures far greater than the anticipated value. The damage consisted of failure at the sill of the heavy steel blast door located at the front of the bunker, as postulated in the series of events shown in Figure 12, the door finally being wedged in the vertical shaft at the rear of the structure. One beneficial result of this incident is the subsequent series of laboratory tests initiated by Holmes & Narver at Massachusetts Institute of Technology, aimed at reducing the uncertainties inherent in estimating the strength of concrete under stress conditions similar to those which existed in the door sill. (Refs. 5, 6, and 7).

Figure 13 is a postshot view of the damage. The zone surrounding the door opening is severely pitted with impact craters, suggesting that this area could have been sprayed with a jet of flying debris. Further evidence of airborne particles is shown by the rounded appearance of edges and corners as if by sandblasting.

The abandoned structure was in the path of an additional shot which caused further extensive damage as shown in Figure 14. An interesting feature here is the peeling away of a large portion of the reinforcing steel in the sidewall of the bunker. The bars have the appearance of strings of spaghetti and the imprint of the bar grid pattern is still visible in the concrete surface. A further view of the damage is shown in Figure 15.

A structure of special interest from the standpoint of record protection, because it simulates a conventional bank vault, is shown in Figure 16. This vault was involved in a test sponsored by the Federal Civil Defense Administration in Operation Plumbbob at the Nevada Test Site (Ref. 8). The vault door, facing the blast, was subjected to a dynamic pressure of several hundred psi. The principal result, shown in Figure 17, was severe damage to the reinforced concrete sidewalls of the structure, involving the peeling away of the reinforcing bars already discussed in connection with the camera bunker. It is evident that while grids of reinforcing bars are essential to the integrity of reinforced concrete construction, they do constitute planes of weakness, and under certain conditions of exposure special measures are needed at critical points in such construction to prevent damage. However, in this case the steel plate lining encased in the concrete remained intact. The door itself was structurally undamaged and was opened with no difficulty.

Figure 18 shows the grand opening.

These case histories do not necessarily imply that the design of blast-resistant, completely exposed surface-mounted structures is a futile effort. The experience of our firm in having designed and built a major portion of the blast resistant construction actually subjected to nuclear detonations in both the kiloton and megaton ranges (Ref. 4) indicates that certain types of surface structures can be built to survive hundreds of psi. However, there is a lesser degree of confidence in such structures than in similar earth-covered structures because they are much more vulnerable to unpredictable variations in the nature of the blast wave.

Progressing to still smaller structures, a series of record containers of varying sizes and strengths was tested by the research staff of the National Records Management Council and cooperating agencies in Operation Teapot at the Nevada Test Site (Ref. 9). These consisted of safes and file safes, (Classes A, B, and C), and insulated and uninsulated file cabinets. These containers, completely exposed to the blast, and containing microfilm, correspondence, telegraphic tape and similar items, were located at pressure levels of about 8 to 50 psi. Figure 19 shows a preshot view of a portion of this equipment at the 50 psi range. File cabinets, transfer files, steel shelving, and similar equipment with similar contents were located within structures at pressure ranges of roughly 2 to 8 psi.

Nuclear radiation damage to the contents was nil, except for some slight effect on purified sulfite paper. In general, blast damage to the completely exposed containers was total at ranges in excess of about 18 psi, as shown in Figure 20. Figure 21 is a preshot view of a Class C safe at the 19 psi range, and Figure 22 is a postshot view of the remains, 560 feet from the original position. The containers housed within structures were essentially undamaged.

Approaches to Protective Design

Let us now consider, philosophically at least, some approaches to actual protective design. In the attempt to beat the bomb, two general courses of action can be considered: dispersal, which relies on remoteness from potential ground zero locations; and hardening, which relies on built-in protection against the various bomb effects (air blast, ground shock, radiation, etc.).

An example of the dispersal approach is the vital records center recently constructed at a location about 50 airline miles from the Vandenberg Air Force Base, and shown in Figure 23. This is not a large structure; the floor area is approximately 24 feet by 41 feet. The facility is completely "soft" in its resistance to blast effects except for the above average radiation resistance provided by the windowless reinforced concrete walls and reinforced concrete roof, which also afford a dustproof and fireproof internal environment.

Under normal day-to-day operating conditions the ventilating air is filtered, and a slight positive interior pressure is maintained to prevent dust accumulation. Should fallout conditions lead to a radiation intensity exceeding a predetermined level, the ventilation system is shut down through the action of sensing devices mounted on the roof.

The hardening philosophy can be exemplified by the group shelter shown in exterior view in Figure 24. It should be emphasized that, although this is not a vital records center, it is readily adaptable to such a function.

The structure consists of a Multiplate corrugated semi-circular steel arch of the type commonly used by the Navy for ammunition storage, and similar in many respects to the type of structure often used for highway culverts (Ref. 10). The arch covers a reinforced concrete floor slab 25 feet by 48 feet. A mechanical utility room is located at one end in a corrugated steel pipe, and a similar pipe sloping upward provides an access to the entrance at the surface. A cutaway view of the interior is shown in Figure 25. Principal features include: (1) minimal accommodations for 100 people for a period of two to four weeks; (2) a blast resistance of at least 35 psi; (3) a reduction in radiation from fallout by a factor of about 1/10,000 of the intensity on the surface; and (4) complete sealup without outside air for 3 hours, and maximum button-up (using outside air) for one week.

Required Levels of Protection

How much protection should be provided? One important consideration in this regard is the location with respect to military or population-industry targets. In the heart of target cities, resistance is needed against: (1) air blast; (2) ground shock; (3) flooding due to ruptured water mains (or blast generated water waves if the weapon is detonated near the surface of an adjacent body of water); (4) thermal effects including heat from burning structures; and (5) flying debris. In the case of records centers in the basements of buildings, debris protection includes safeguarding against the consequences of collapse of the entire building above as well as protection from the debris of adjacent structures. Only a nominal degree of radiation shielding is necessary unless items such as transistors and photographic and X-ray supplies are being stored.

In rural areas—say in locations exceeding about 25 miles from major target areas—required protection is minimal. However, incombustible construction is desirable in the storage structure because of the long range thermal effects of large yield weapons.

Another important factor in establishing the amount of protection to be provided is the extent to which safety of personnel is to be considered. At close-in distances, the requirements for safeguarding of personnel become very stringent compared to those for records protection, primarily because of the need for such additional requirements as ventilation, water, food, sanitation, light, radiation shielding, monitoring, and decontamination facilities, etc. In the heart of target cities adequate personnel protection may demand shielding against all effects associated with a pressure level of 100 psi or more.

Hardened Vital Record Storage Concepts

Generally, in the heart of target cities, the only suitable place for records storage is to be found in locations below ground level, such as in basements. A schematic cross-sectional view of a hypothetical vault appropriate to this environment is indicated in Figure 26. The box shape is dictated by the available space. Such construction can become extremely massive and correspondingly expensive and is especially costly when installed in existing buildings. The vault shown features a compressible layer of material on the roof to absorb the impact occasioned by possible collapse of the floors above.

In some instances when the volume of record storage is small, and where some inconvenience in access is acceptable, small containment structures can be used, located flush with the floor surface or mounted flush with the surface of an exterior wall. For maximum hardness, the structure should be circular in section rather than rectangular, and can consist of concrete pipe or corrugated steel pipe. Such structures can be made resistant to hundreds of psi (Ref. 11 and 12). This approach is illustrated in concept in Figure 27 which shows a longitudinal section through a floor-mounted structure of this type, utilizing corrugated metal pipe. Figure 28 shows a horizontal version of the same thing, using reinforced concrete pipe. This horizontal configuration gives more convenient access and may be desirable where lack of property-line restrictions and other interferences permits its use.

If sufficient yard space is available, larger structures below ground become feasible, the restrictions imposed by the cramped basement quarters are avoided, and there is more freedom to choose efficient structural forms. In many cases the presence of the underground structure imposes no significant restriction on the normal use of the yard space above. Figure 29 shows in concept a cutaway perspective view of a buried arch-type structure of this nature. The material can be either reinforced concrete or steel. Maximum strength per unit of structural material is obtained using a dome shape, shown conceptually in Figure 30. In this case, the construction material is reinforced concrete.

Costs

Protective construction is seldom cheap, and costs mount as hardening requirements increase. It is impossible to give anything but a gross indication of such costs. More accurate estimates require a preliminary design for specific conditions, and several such designs would be needed to arrive at minimum costs for any given facility. Very approximately, the cost of a conventional "soft" structure, located on the ground surface, with reinforced concrete walls and roof, may lie in the range of $8 to $12 per square foot of floor area, based on the structure alone, excluding mechanical, electrical, and sanitary facilities. Hardening such a structure to 100 psi may more than triple these costs because of the need for thicker walls, earth cover, and a special entrance structure. A hardened arch-type structure can be economical, under certain conditions, and a hardened dome type enclosure may be optimum when built in sizes large enough to permit the use of more than one floor level.

Heating, ventilating, and air conditioning can add $5 to $8 per square foot, and electrical features $4 to $6 per square foot. Water supply and sanitary features can be as much as $300 per person. These features would be necessary if personnel protection is to be considered.

No generalization as to costs is possible when protective construction involves locating storage facilities in existing buildings, except to state that these more restrictive conditions would probably cause an increase in construction expense.

Concluding Remarks

In the short time available, it has not been possible to cover in adequate detail the various aspects of protective construction relating to records storage facilities. However, if recent events impel an active interest in protective construction, it is our hope that what we have presented can serve as a useful guideline in the planning and execution of such programs.

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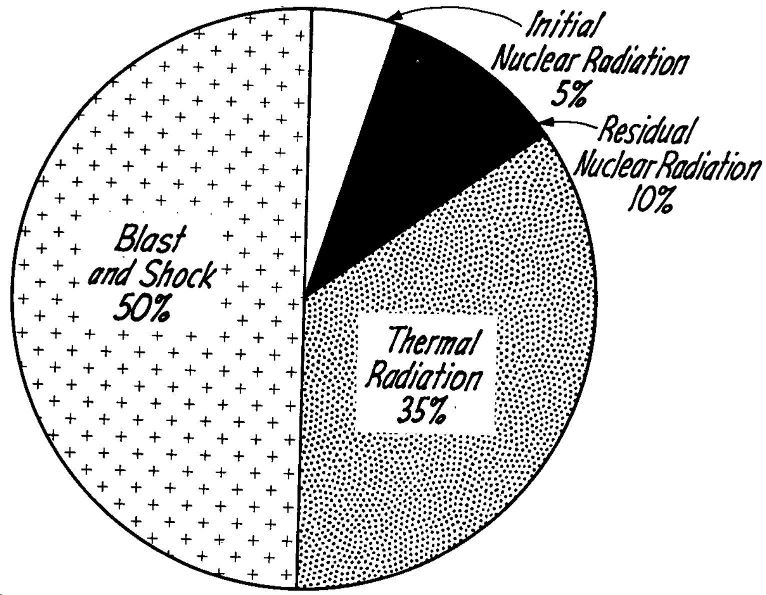
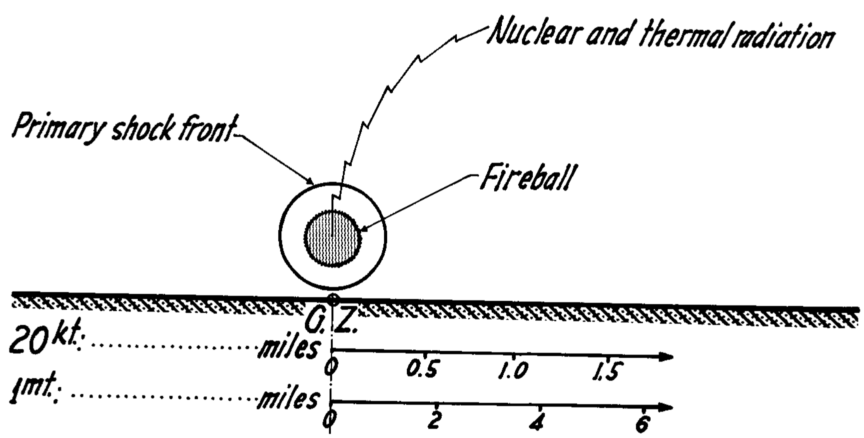


DISTRIBUTION OF ENERGY IN A TYPICAL AIR BURST

FIGURE 1



AIR BURST
(0.5 seconds after 20 kt event) (1.8 seconds after 1 mt event)

FIGURE 2

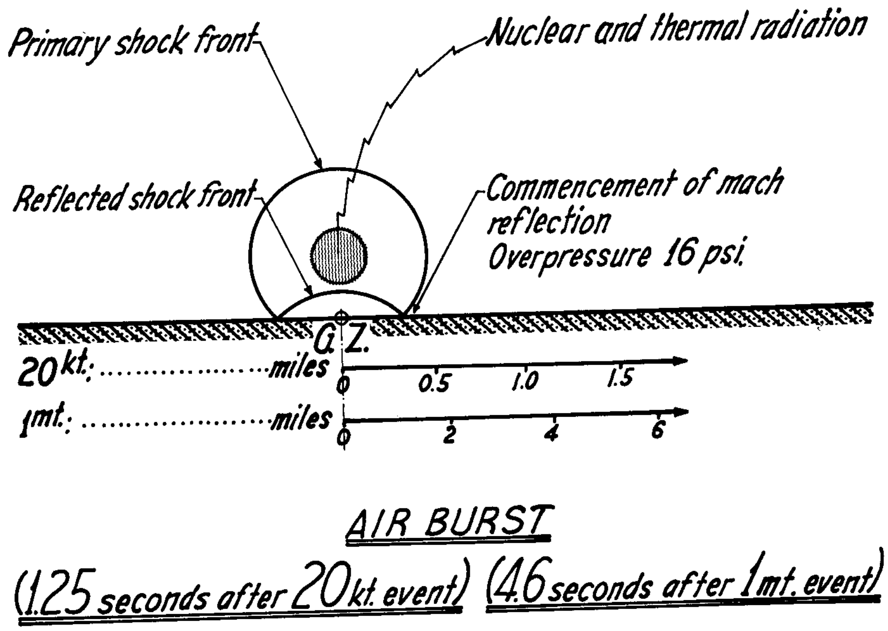


FIGURE 3

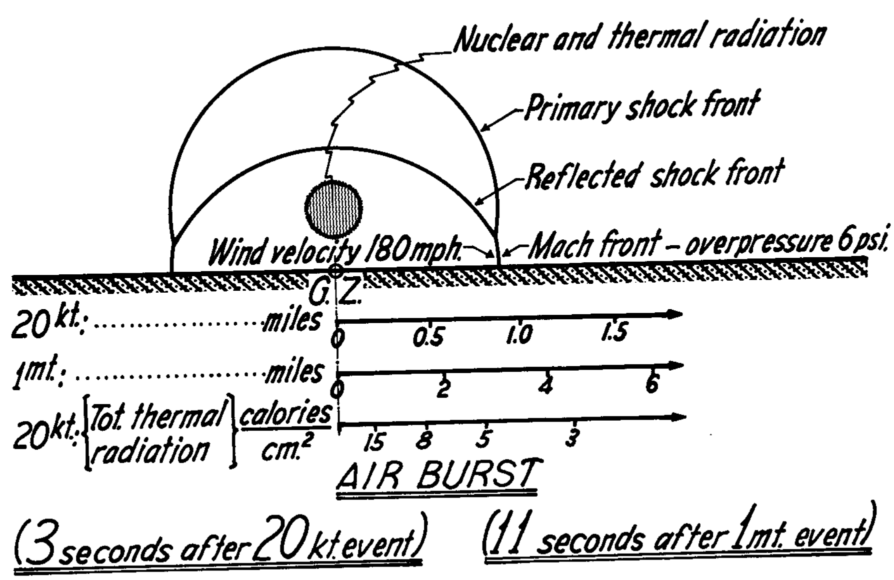


FIGURE 4

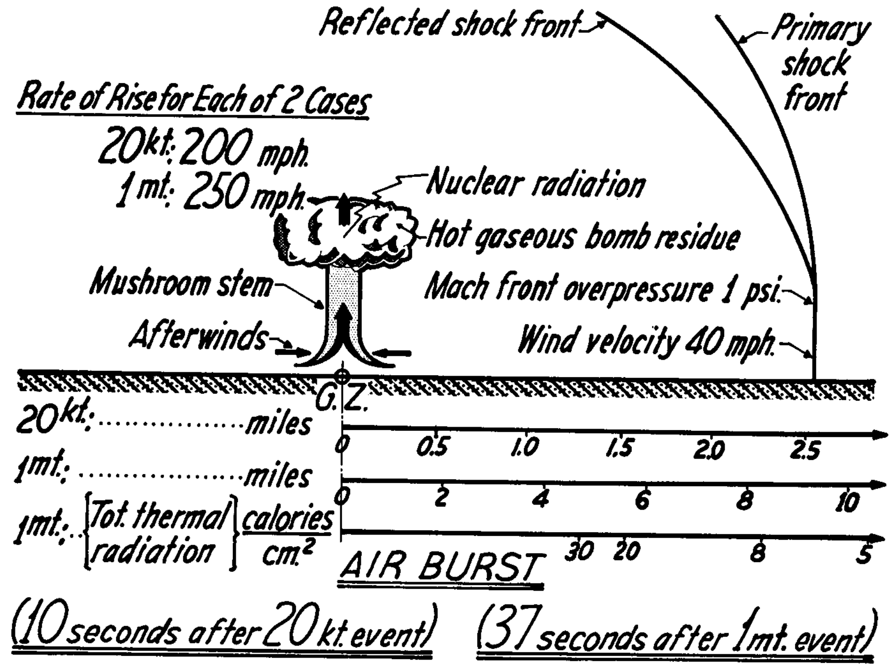


FIGURE 5

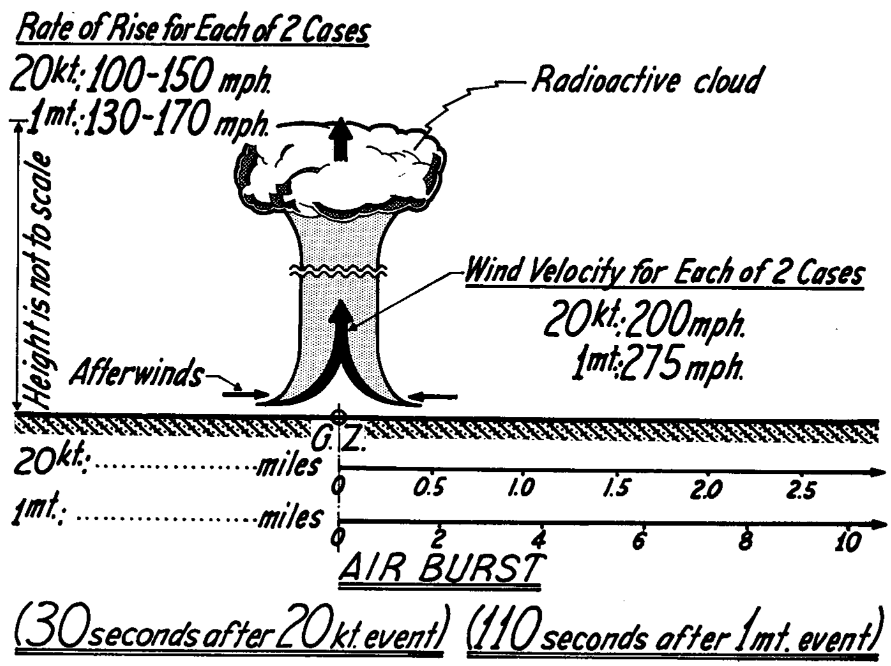
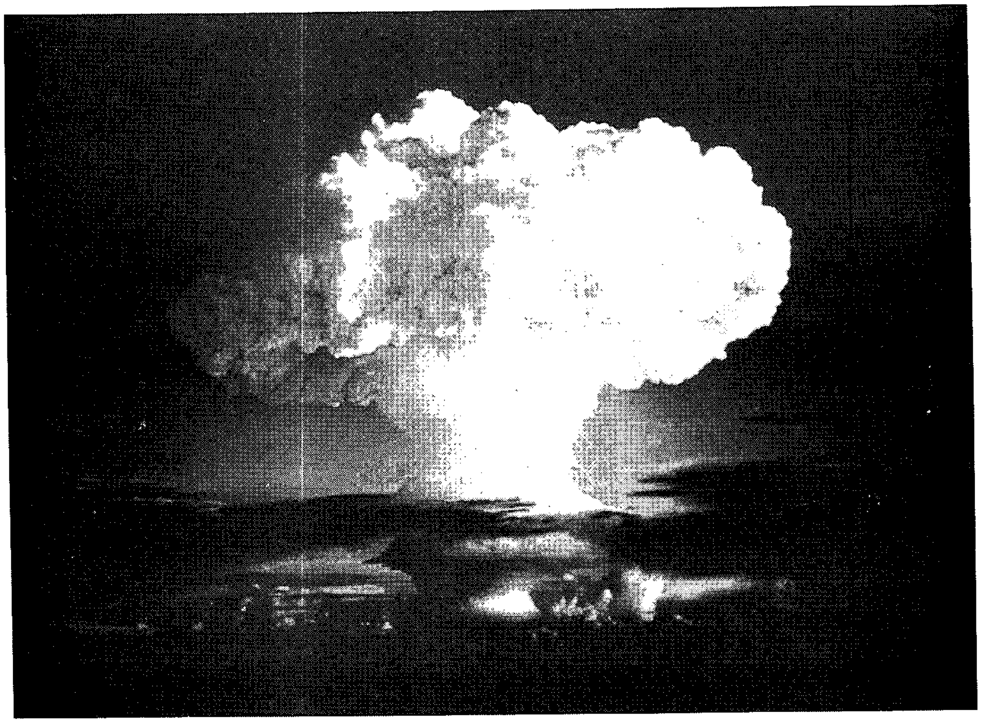
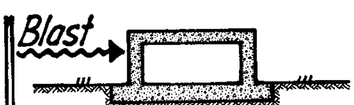
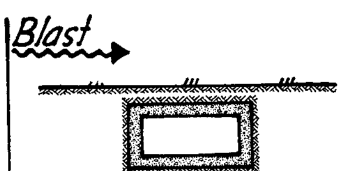


FIGURE 6



MUSHROOM CLOUD FROM A SURFACE BURST
IN THE MEGATON RANGE

FIGURE 7

		
Maximum Incident Blast Pressure in % of Peak Pressure in Blast Wave	200% to 800%, or more	100%
Sliding and Overturning Forces	High	None
Damage Susceptibility from Flying Debris	High	Low
Radiation Protection	May Require Thick Walls and Roof	Largely Inherent In Earth Cover

CHARACTERISTICS OF SURFACE AND BURIED STRUCTURES

FIGURE 8

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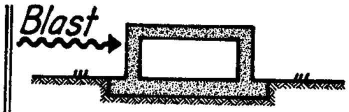
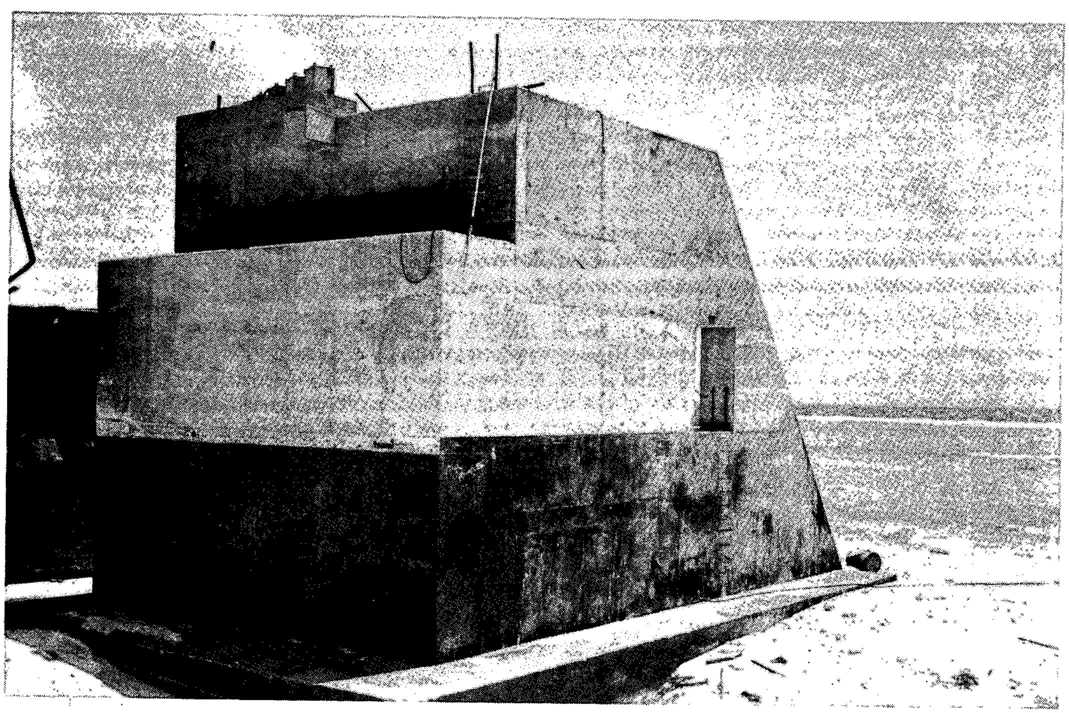


Concealment	May Be Difficult	Readily Accomplished
Access	Easy	May Be Difficult
Ground Water Problems	Less Serious Than for Buried Structure	May Be Serious
Special Ventilation Requirements Under Normal Operating Conditions	May Not Be Needed	Probably Required

CHARACTERISTICS OF SURFACE AND BURIED STRUCTURES

FIGURE 9



GENERAL PRE-SHOT VIEW OF CAMERA BUNKER

FIGURE 10

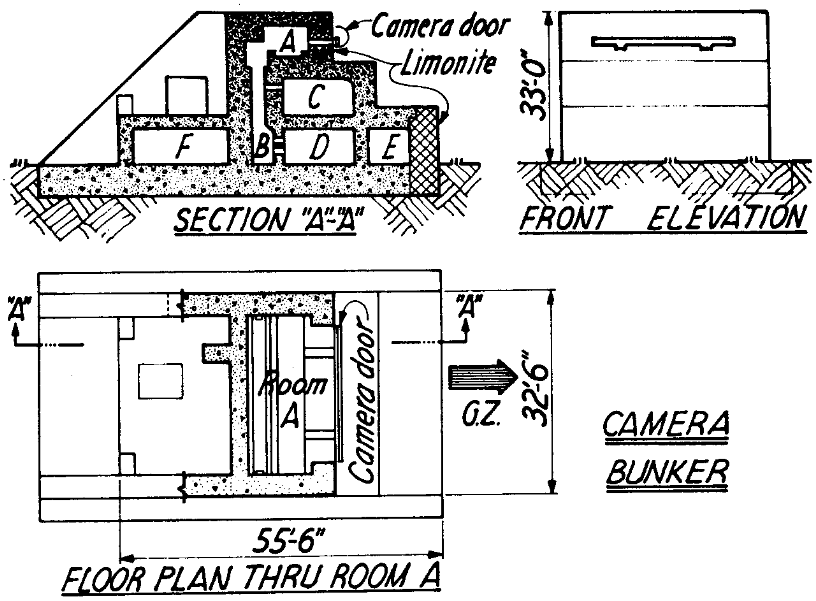


FIGURE 11

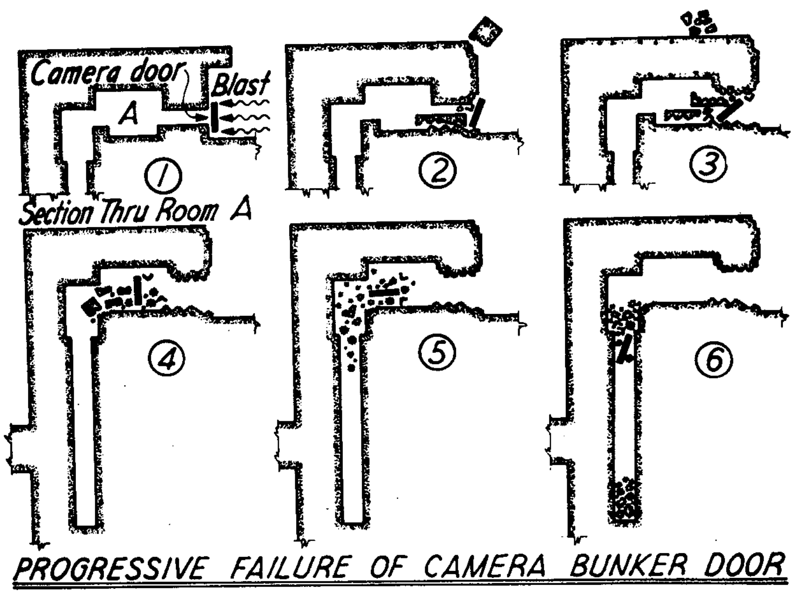
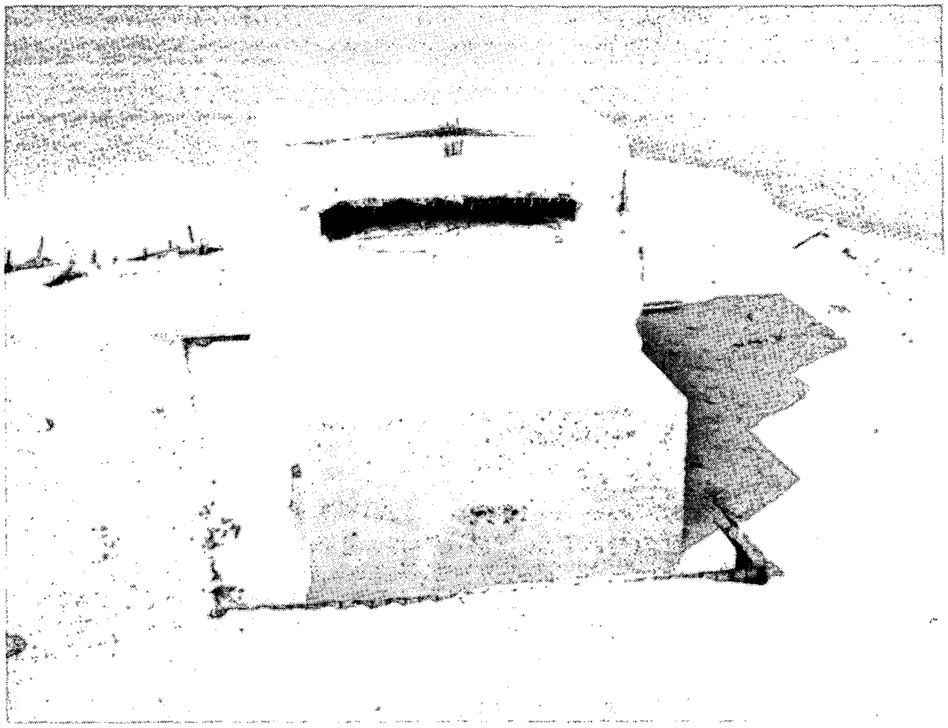
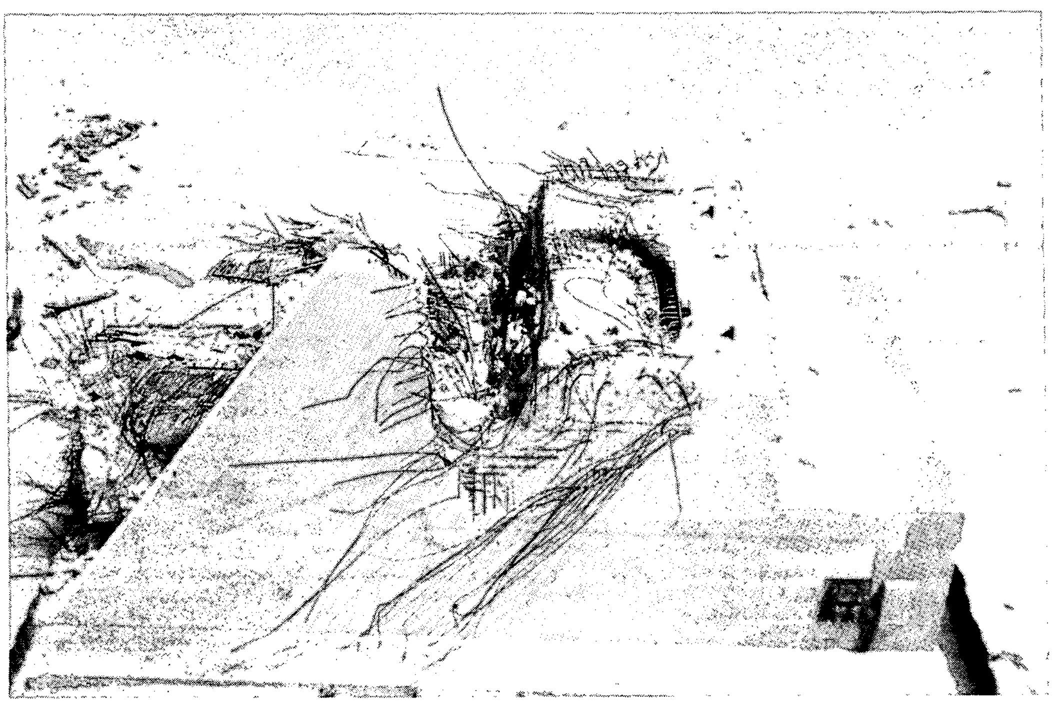


FIGURE 12



DAMAGE TO FRONT OF CAMERA BUNKER

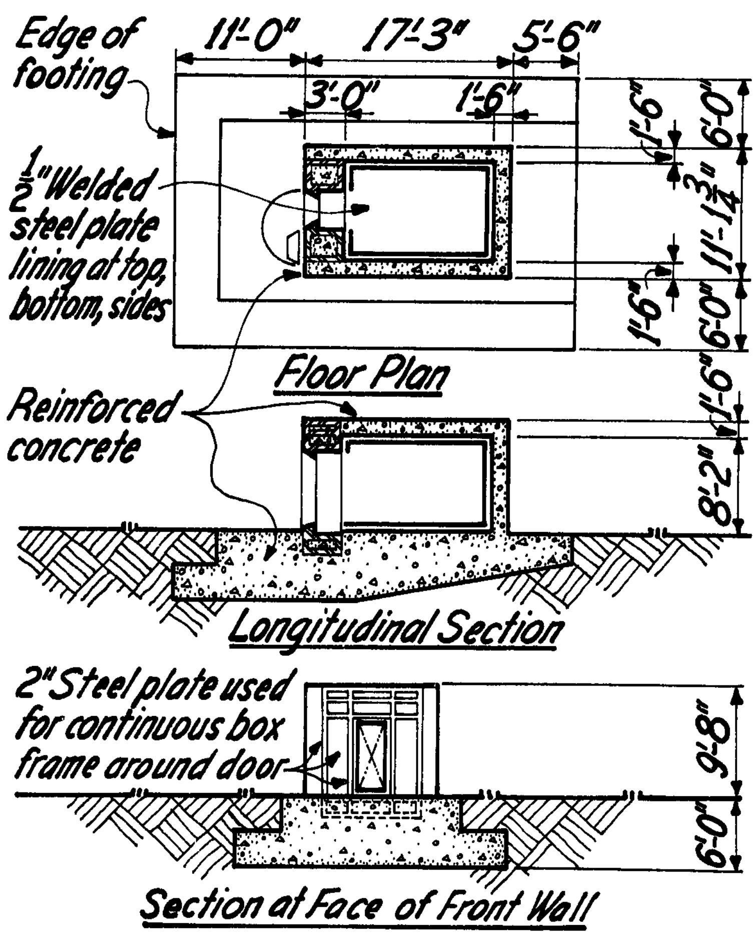
FIGURE 13



DETAIL VIEW OF DAMAGE TO SIDEWALL AND ROOF OF CAMERA BUNKER

FIGURE 14

GENERAL VIEW OF DAMAGE TO SIDEWALL AND ROOF OF CAMERA BUNKER
FIGURE 15



PROTECTIVE STORAGE VAULT

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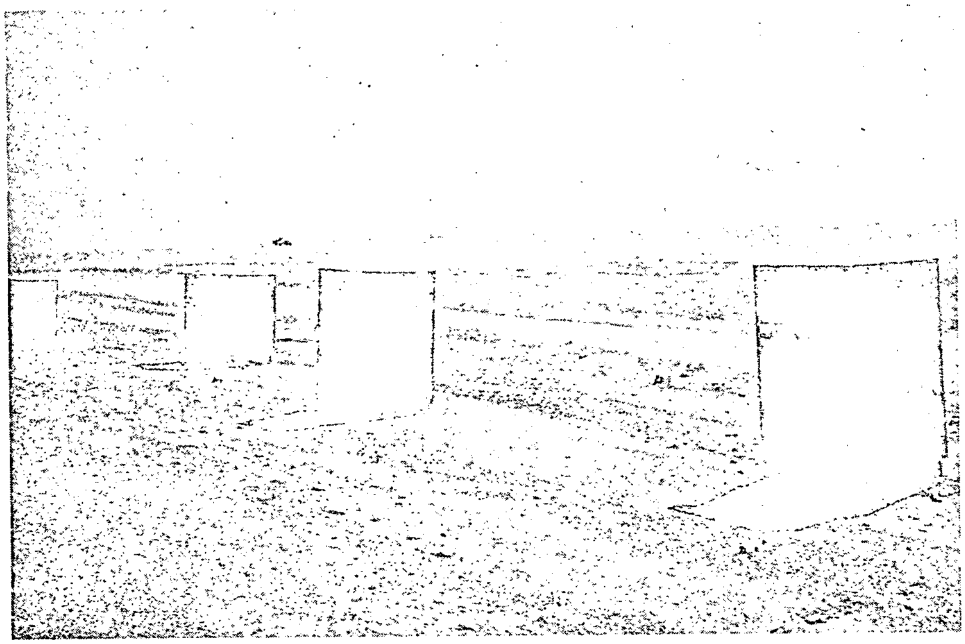
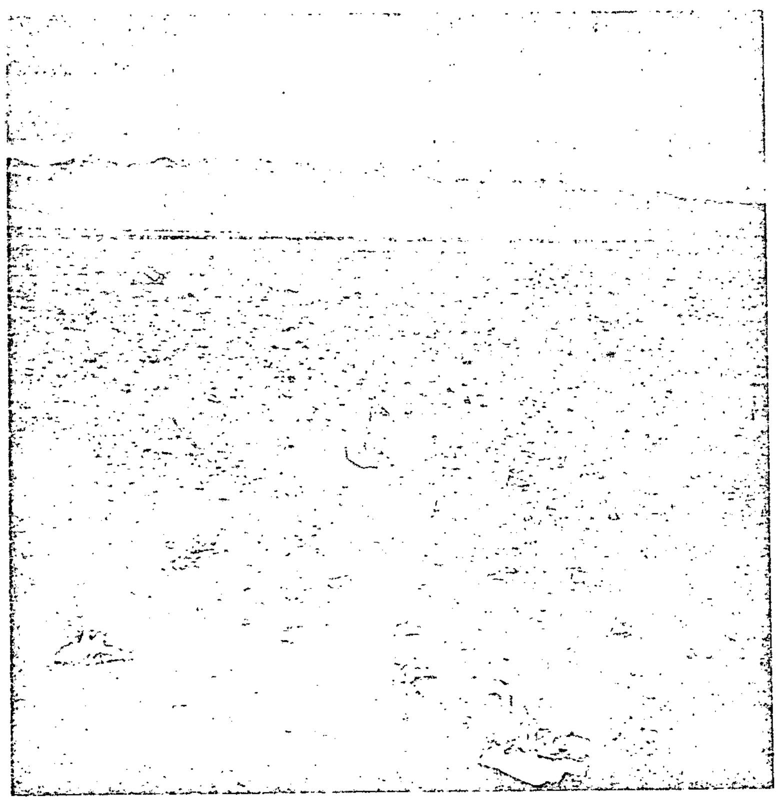
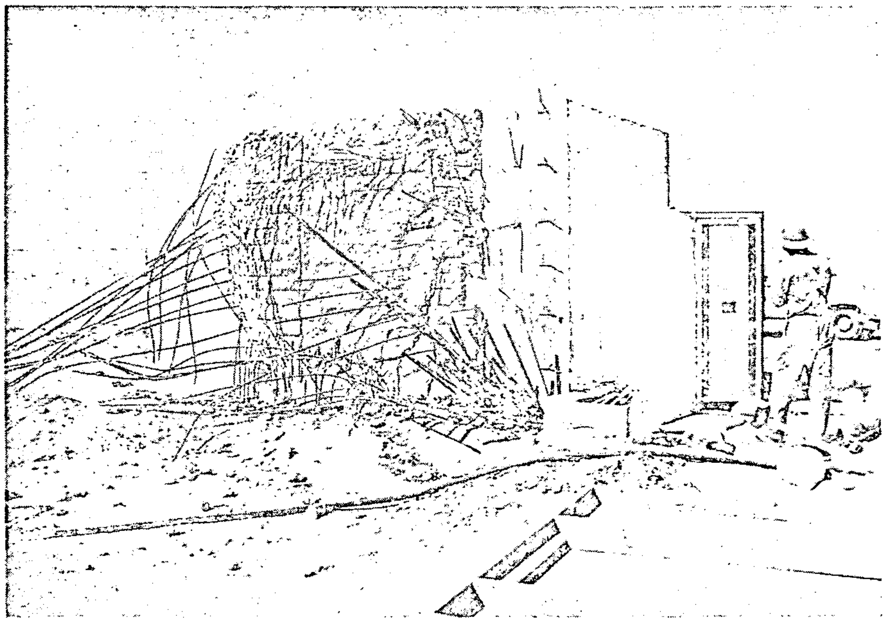
FIGURE 16



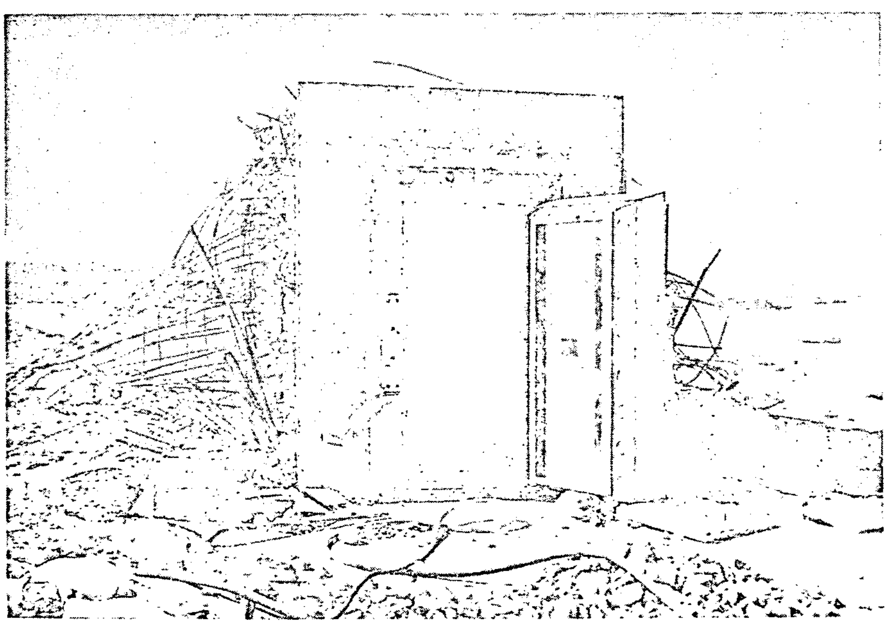
PRE-SHOT VIEW OF STORAGE EQUIPMENT
FIGURE 19



POST-SHOT VIEW OF STORAGE EQUIPMENT
FIGURE 20



DAMAGE TO SOUTH WALL OF STORAGE VAULT
FIGURE 17



POST-SHOT VIEW OF STORAGE VAULT DOOR
FIGURE 18

PRE-SHOT VIEW OF CLASS C SAFE
FIGURE 21

POST-SHOT VIEW OF CLASS C SAFE
FIGURE 22

Approved For Release 2006/09/25 : CIA-RDP73-00402R000100140019-9

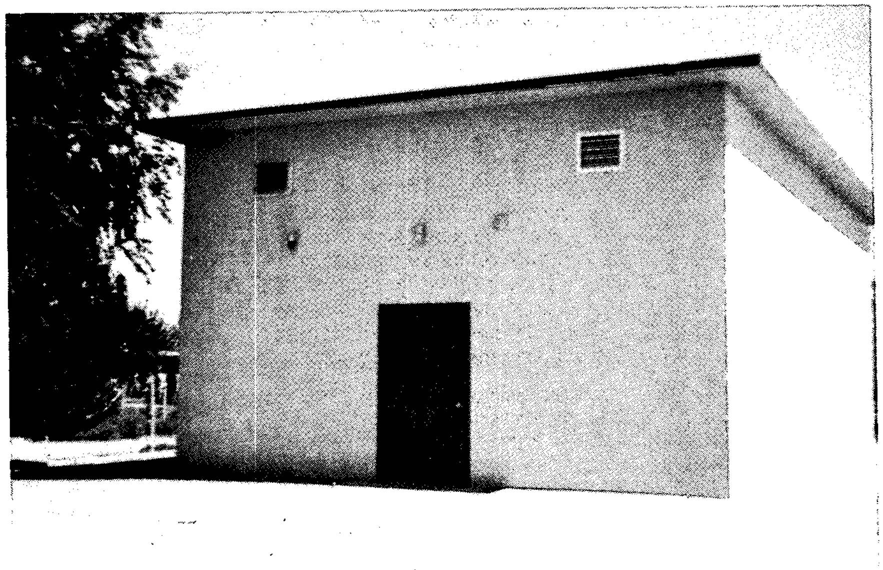
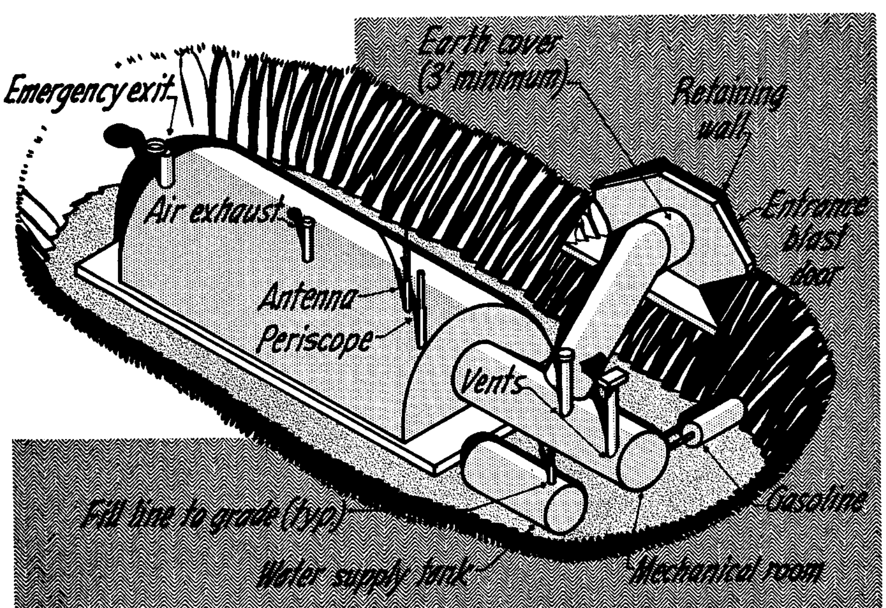
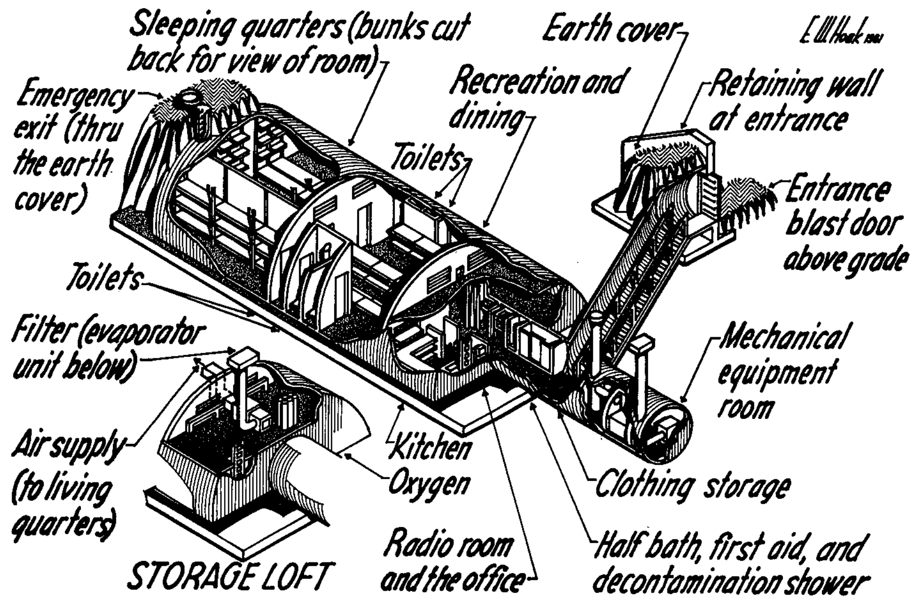


FIGURE 23



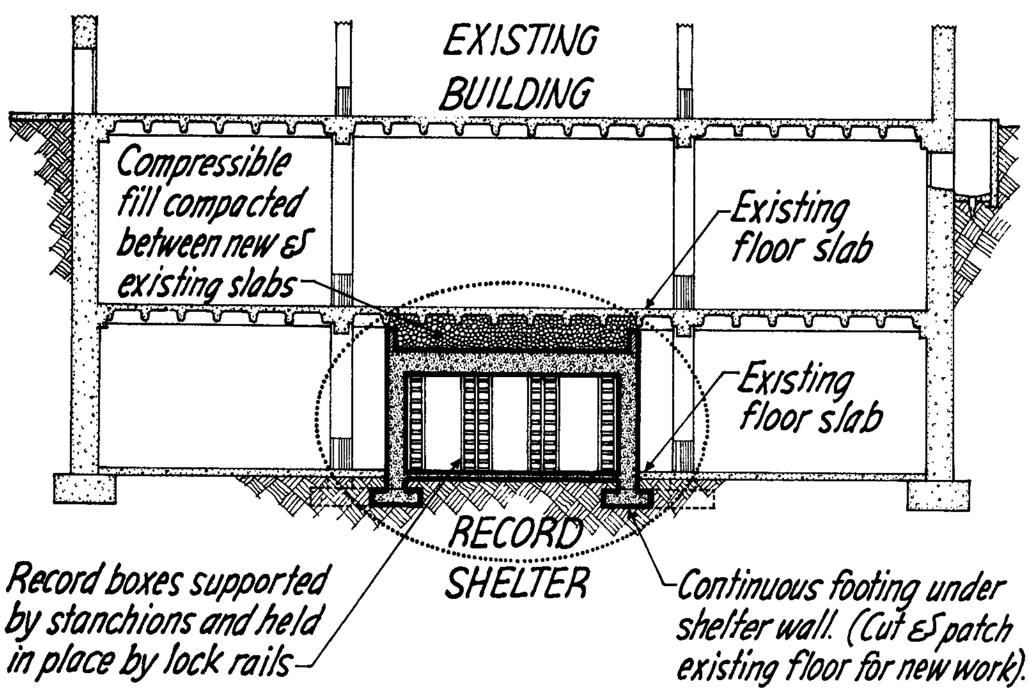
GROUP SURVIVAL SHELTER – EARTH COVER NOT SHOWN

FIGURE 24



GROUP SURVIVAL SHELTER - CUTAWAY INTERIOR VIEW

FIGURE 25



FREESTANDING RECORD SHELTER IN BASEMENT

FIGURE 26

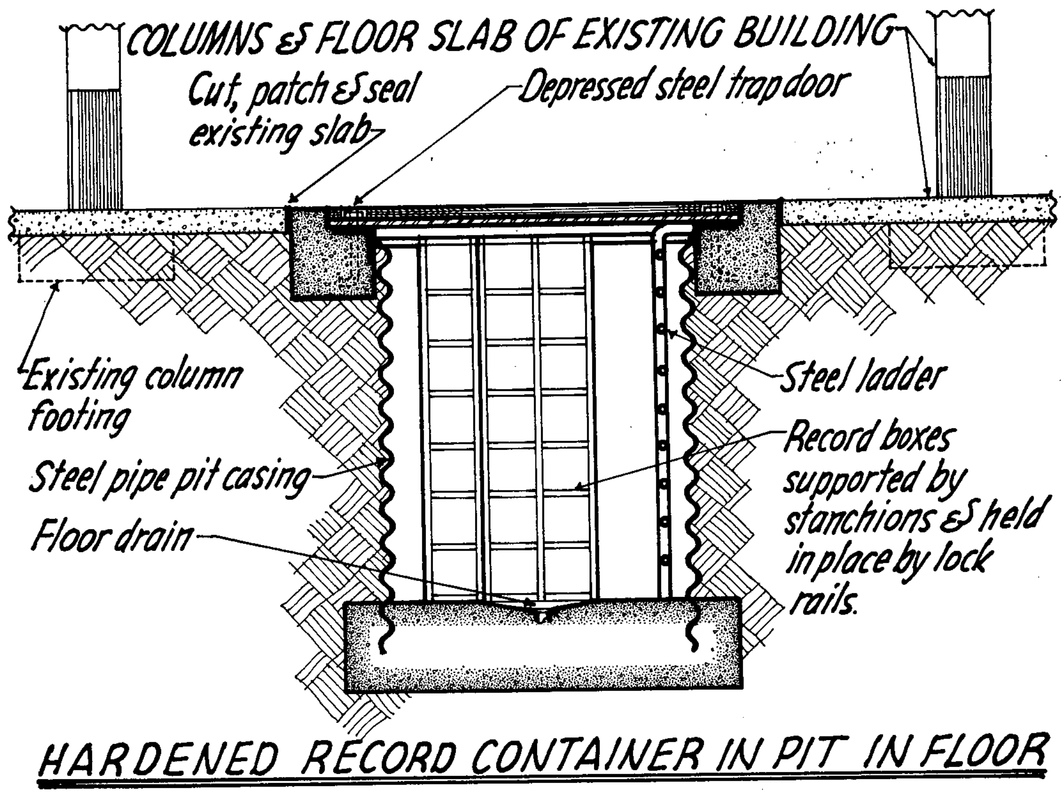


FIGURE 27

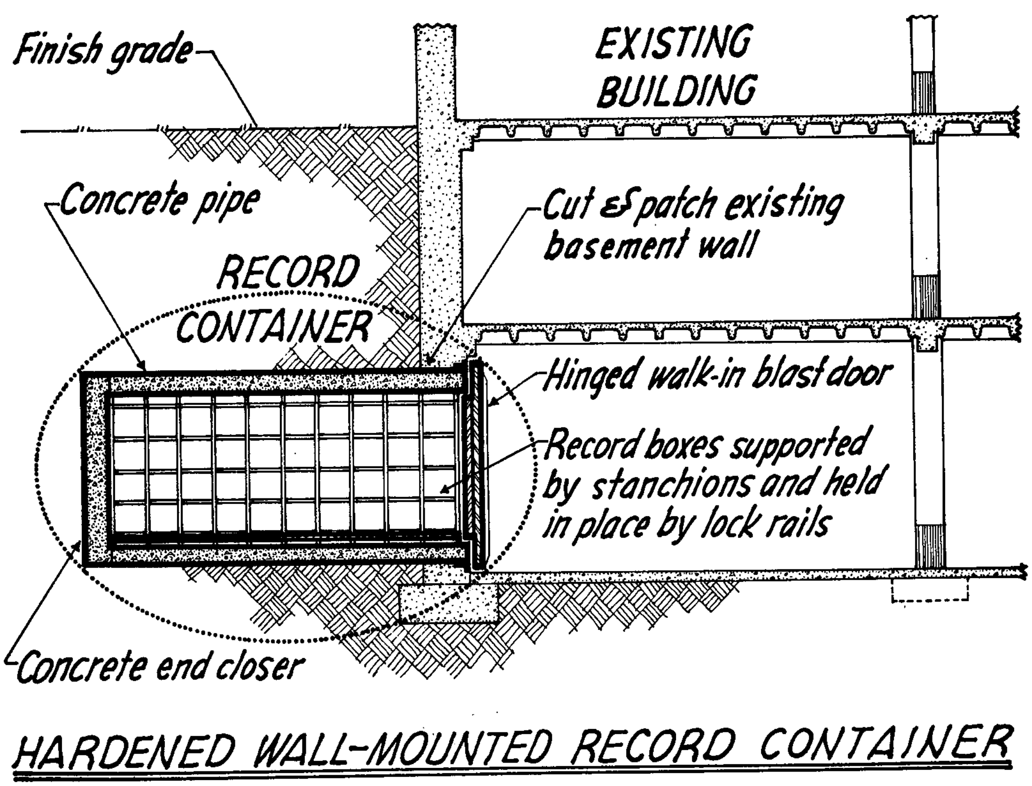
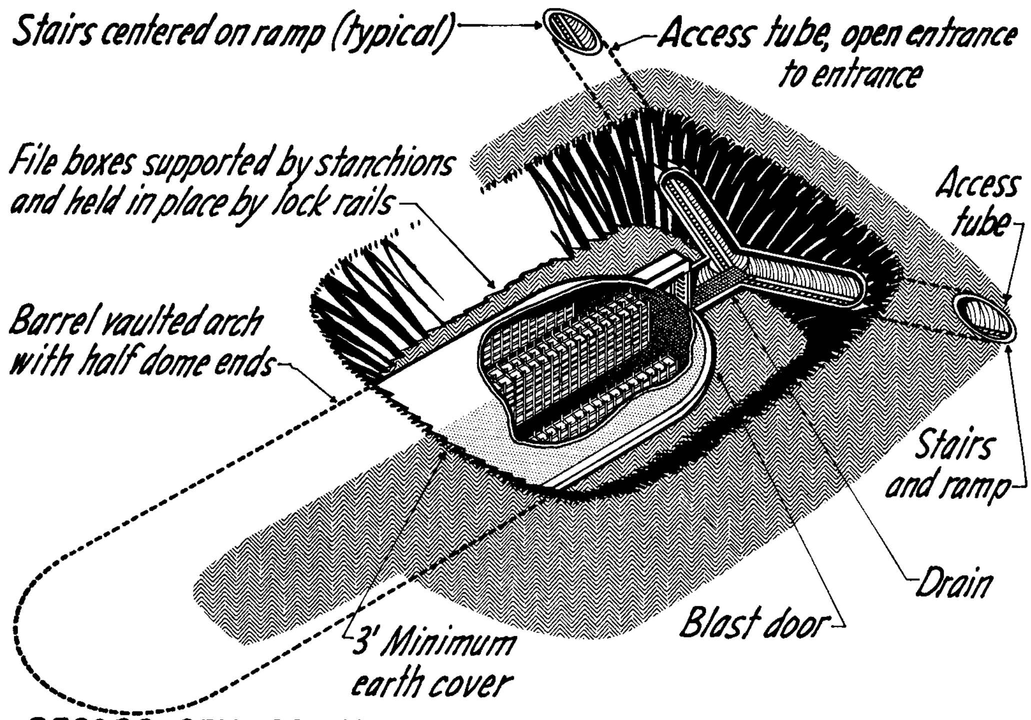
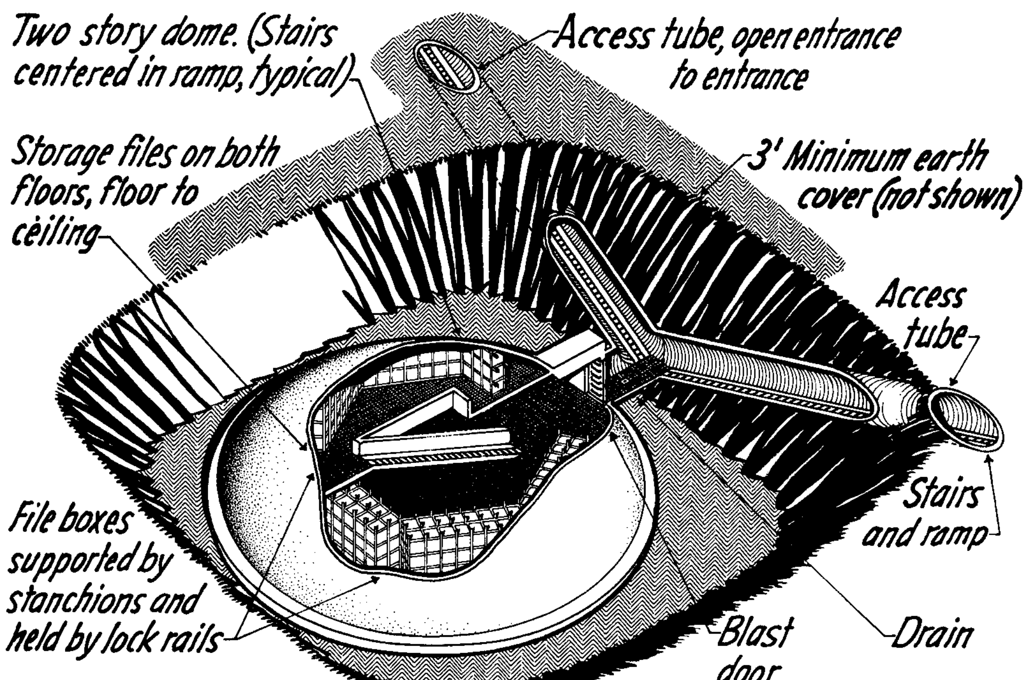


FIGURE 28



RECORD CENTER IN A BURIED ARCH - ARCH & FILL CUTAWAY

FIGURE 29



RECORD CENTER IN A BURIED DOME - DOME & FILL CUTAWAY

FIGURE 30