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## Chapter 5

# Shelter, the Greatest Need

### ADEQUATE SHELTER

To improve your chances of surviving a nuclear attack, your primary need would be an adequate shelter equipped for many days of occupancy. A shelter that affords good protection against fallout radiation and weather would be adequate in more than 95% of the *area* of the United States. However, even in almost all areas not endangered by blast and fire during a massive nuclear attack, the fallout protection provided by most existing buildings would not be adequate if the winds blew from the wrong direction during the time of fallout deposition.

To remain in or near cities or other probable *target areas*, one would need better protection against blast, fire, and fallout than is provided by most shelters in buildings. Blast tests have proved that the earth-covered expedient fallout shelters described in this book can survive blast effects severe enough to demolish most homes.<sup>5</sup>

This chapter is concerned primarily with expedient shelters that give excellent protection against fallout radiation. These earth-covered fallout shelters could be built in 48 hours or less by tens of millions of Americans following field-tested, written instructions.<sup>8</sup> Expedient blast shelters are discussed in Appendix D. The special blast doors and other design features needed for effective blast protection require more work, materials, and skill than are needed for expedient fallout shelters.

If average Americans are to do their best when building expedient shelters and life-support equipment for themselves, they need detailed information about *what* to do and about *why* it is to their advantage to do it. We are not a people accustomed

to blindly following orders. Unfortunately, during a crisis threatening nuclear war, it would take too long to read instructions explaining why each important feature was designed as specified. Therefore, only a few reasons are included in the step-by-step, illustrated instructions given in Appendix A for building 6 types of earth-covered expedient shelters during a crisis.

In this chapter, reasons will be given for designing a Pole-Covered Trench Shelter as specified in the Oak Ridge National Laboratory instructions given in Appendix A.2. The two pages of drawings and plans given at the end of Appendix A.2 show the parts of this shelter, except for the essential shelter-ventilating pump installed in its entrance trench. The following account of how an urban family, after evacuating, used these instructions to build such a shelter in less than 36 hours also includes explanations of various radiation dangers and of simple means to build protection against these dangers.

This family, like scores of other families recruited to build shelters or life-support equipment, was offered a sum about equivalent to laborers' wages if its members completed the experiment within a specified time. The test period began the moment the family received the written, illustrated instructions preparatory to evacuating by car, as mentioned in the preceding chapter. Like the other test families, this family was paid for all of its materials used. If a family worked hard and completed the project in half the specified time, it was paid a cash bonus. Throughout such tests workers were guided only by the written instructions, which were improved after each successive test.

The successful outcome of almost all the shelter-building experiments indicates that tens of millions of Americans in a nuclear war crisis would work hard and successfully to build earth-covered expedient shelters that would give them better protection against fallout, blast, and fire than would all but a very small fraction of existing buildings. However, this belief is dependent on two conditions: (1) that in a desperate, worsening crisis our country's highest officials would supply strong, motivating leadership; and (2) that Americans would have received—well in advance—shelter-building and other practical, tested survival instructions.

## SHELTER AGAINST RADIATION

The family previously pictured evacuating by car (Fig. 4.3) drove 64 miles to build a shelter at the site shown in Fig. 5.1. Although the August sun was very hot in this irrigated Utah valley, the family members did not build in the shade of nearby trees. To avoid digging through roots, they carried the poles about 150 feet and dug their trench near the edge of the cornfield.

The father and the oldest son did most of the work of making the shelter. The mother and second

son had health problems; the two youngest children were not accustomed to work.

The family followed an earlier version of the plans and instructions given in Appendix A for building a Pole-Covered Trench Shelter. Because the earth was firm and stable, the trenches were dug with vertical walls. If the earth had been less stable, it would have been necessary to slope the walls—increasing the width at the top of the main trench from  $3\frac{1}{2}$  to 5 feet.

Before placing the roof poles, the workers assured themselves a more comfortable shelter by covering the trench walls. They had brought a large number of the plastic garbage bags required in their home community and split some bags open to make wall coverings. Bed sheets or other cloth could have been used.

The room of this 6-person shelter was  $3\frac{1}{2}$  feet wide,  $4\frac{1}{2}$  feet high, and  $16\frac{1}{2}$  feet long. A small stand-up hole was dug at one end, so each tall occupant could stand up and stretch several times a day.

The trenches for entry and emergency exit were dug only 22 inches wide, to minimize radiation entering the shelter through these openings. One wall of these two narrow trenches was an extension of the

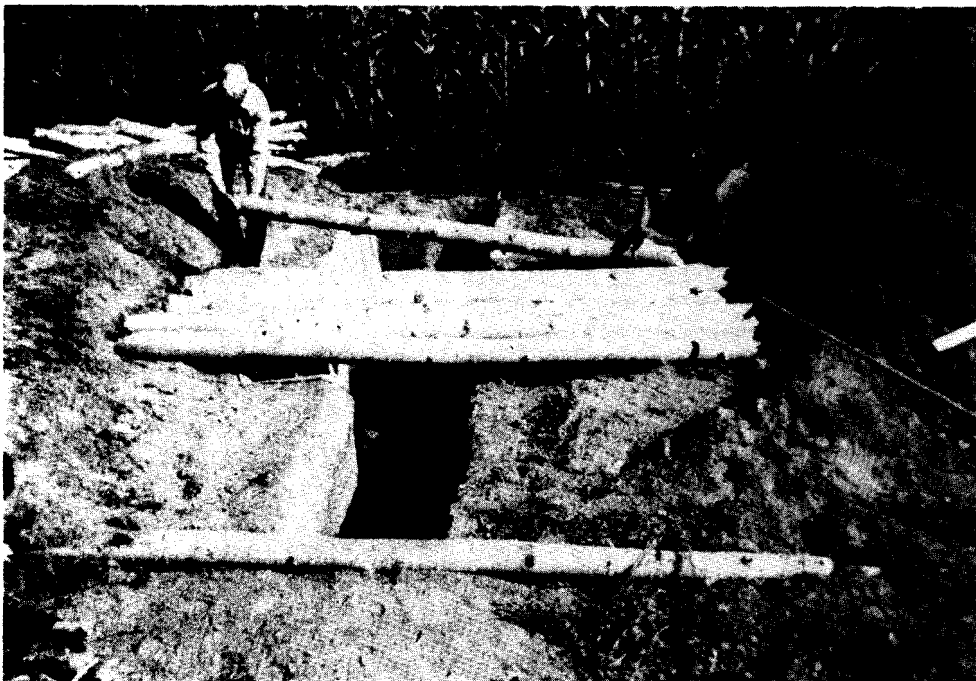


Fig. 5.1. Placing 9-foot poles for the roof of a Pole-Covered Trench Shelter.

room wall shown on the right in Fig. 5.1. The family sat and slept along the left wall, to be better shielded from radiation coming through the openings.

This shelter was designed so that its main trench could be enlarged to make a much more livable room without disturbing its completed roof. For this reason, the 9-foot roofing poles were placed off-center, with the two extra feet resting on the ground to the right of the main room.

Whenever practical, expedient shelters should be built so that they can be readily enlarged to make semi-permanent living quarters. After it becomes safe to emerge for limited periods, occupants could sleep and spend much of their waking time in such a rainproof dugout that affords excellent protection against continuing radiation. In cold weather, living in a dugout like this is more comfortable than living in a tent or shack. After the fallout radiation dose rate outdoors has decayed to less than about 2 R per hour, the small vertical entry could be enlarged and converted to a steeply inclined stairway.

The importance of giving inexperienced shelter builders detailed instructions is illustrated by the unnecessary work done by the young women shown in Fig. 5.2. They had agreed to try to build a Pole-Covered Trench Shelter, working unassisted and using only hand tools. Because the summer sun in Utah was hot, they selected a shady site under a large tree. The brief instructions they received included no advice on the selection of a building site. Cutting and digging out the numerous roots was very difficult for them and required several of the 22 hours they spent actually working.

Another disadvantage of making a shelter under trees is that more of the gamma rays from fallout particles on the leaves and branches would reach and penetrate the shelter than if these same particles were on the ground. Many gamma rays from fallout particles on the ground would be scattered or absorbed by striking rocks, clods of earth, tree trunks, or houses before reaching a belowground shelter.

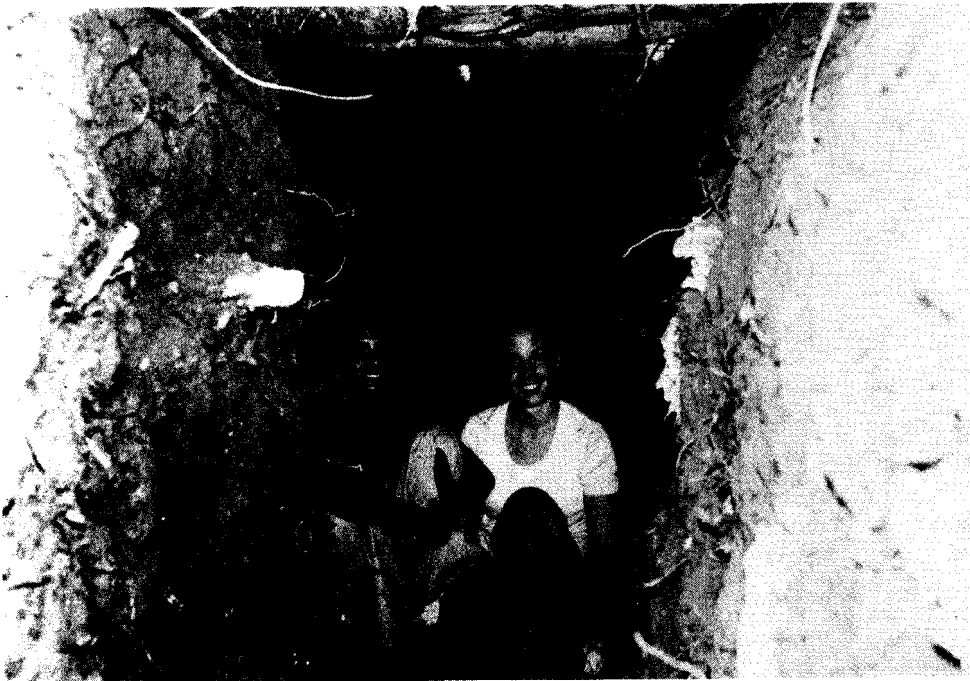


Fig. 5.2. Two non-athletic college girls who completed a 4-person Pole-Covered Trench Shelter in 35½ hours, despite tree roots.

## TYPES OF SHIELDING

Shelters provide protection against radiation by utilizing two types of shielding: **barrier shielding** and **geometry shielding**.

- **Barrier shielding** is shown by Fig. 5.3, a simplified illustration. (In a real fallout area, a man in an open trench would have fallout particles all over and around him.) The 3-foot thickness of earth shown (or a 2-foot thickness of concrete) will provide an effective barrier, attenuating (absorbing) about 99.9% of all gamma rays from *fallout*. (In the illustration, only a single fallout particle 3 feet from the edge of the trench is considered.) Only one gamma ray out of 1000 could penetrate the 3 feet of earth shown and strike the person in the trench. Rays from particles farther away than 3 feet would be negligible; rays from particles closer than 3 feet would be attenuated according to the thickness of earth between the fallout particle and the man in the trench.

However, the man in the trench would not be protected from "skyshine," which is caused by gamma rays scattering after striking the nitrogen, oxygen, and other atoms of the air. The man's exposed head, which is just below ground level, would be hit by about one-tenth as many gamma rays

as if it were 3 feet above ground (Fig. 5.3). Even if all fallout could be kept out of the trench and off the man and every part of the ground within 3 feet of the edges of the trench, skyshine from heavy fallout on the surrounding ground could deliver a fatal radiation dose to the man in the open trench.

Skyshine reaches the ground from all directions. If the man were sitting in a deeper trench, he would escape more of this scattered radiation, but not all of it. For good protection he must be protected overhead and on all sides by barrier shielding.

The barrier shielding of the Pole-Covered Trench Shelter shown in Fig. 5.4 was increased by shoveling additional earth onto its "buried roof." After father and son had mounded earth about 18 inches deep over the centerline of the roof poles, a large piece of 4-mil-thick polyethylene was placed over the mound. This waterproof material served as a "buried roof" after it was covered with more earth. Any rainwater trickling through the earth above the plastic would have run off the sloping sides of the "buried roof" and away from the shelter.

- **Geometry shielding** reduces the radiation dose received by shelter occupants by increasing the distances between them and fallout particles, and by

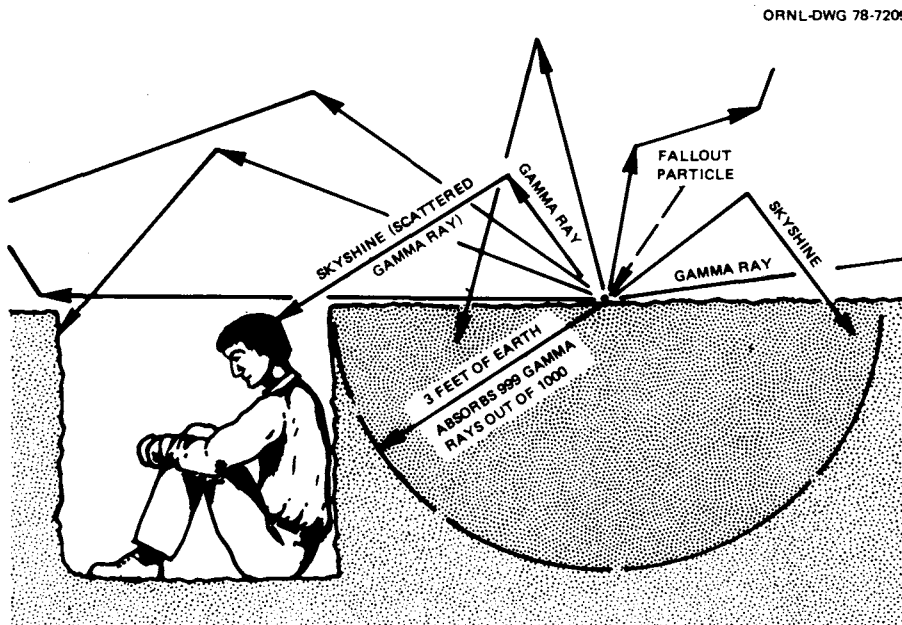


Fig. 5.3. Simplified illustration of barrier shielding and skyshine (scattered gamma radiation). An open trench provides poor protection.



Fig. 5.4. Increasing the barrier shielding over a Pole-Covered Trench Shelter.

providing turns in the openings leading into the shelter. Figure 5.5 is a sectional drawing of the shelter entry built by the Utah family.

The farther you can keep away from a source either of light or of harmful radiation, the less light or other radiation will reach you. If fallout particles are on the roof of a tall building and you are in the basement, you will receive a much smaller radiation dose from those particles than if they were on the floor just above you. Likewise, if either visible light or gamma rays are coming through an opening at the far end of a passageway, less will reach you at the other end if the passageway is long than if it is short.

Turns in passageways are very effective in reducing the amount of radiation entering a shelter through them. A right-angle turn, either from a vertical or horizontal entry, causes a reduction of about 90%.

Note: *Fallout* shelters need not provide additional shielding to protect occupants against initial nuclear radiation that is emitted from the fireballs of nuclear explosions. (See Figs. 1.1 and 1.4.) Large nuclear weapons would be employed in an attack on the United States. The initial nuclear radiation from the sizes of explosions that may endanger Amer-

icans would be greatly reduced in passing through the miles of air between the fireballs and those fallout shelters far enough away to survive the blast effects. The smaller an explosion, the larger the dose of initial nuclear radiation it delivers at a given blast overpressure distance from ground zero. (For a discussion of the more difficult shielding requirements of blast shelters that would enable occupants to survive blast effects much closer to explosions and therefore would be subjected to much larger exposures of initial nuclear radiation, see Appendix D, Expedient Blast Shelters.)

Figure 5.6 shows the completed shelter after it was occupied by the family of six just 32½ hours after receiving the shelter-building instructions and beginning preparations to evacuate. (This family won a bonus for completion within 36 hours and also a larger bonus given if all members then stayed inside continuously for at least 72 hours.) To get a better idea of how six people can live in such a small shelter, look at the drawings at the end of Appendix A.2. In warm or hot weather, shelters, especially crowded ones, must be well ventilated and cooled by an adequate volume of outdoor air pumped through them. This family had built an efficient homemade air pump (a KAP) and used it as described in Chapter 6 and Appendix B.

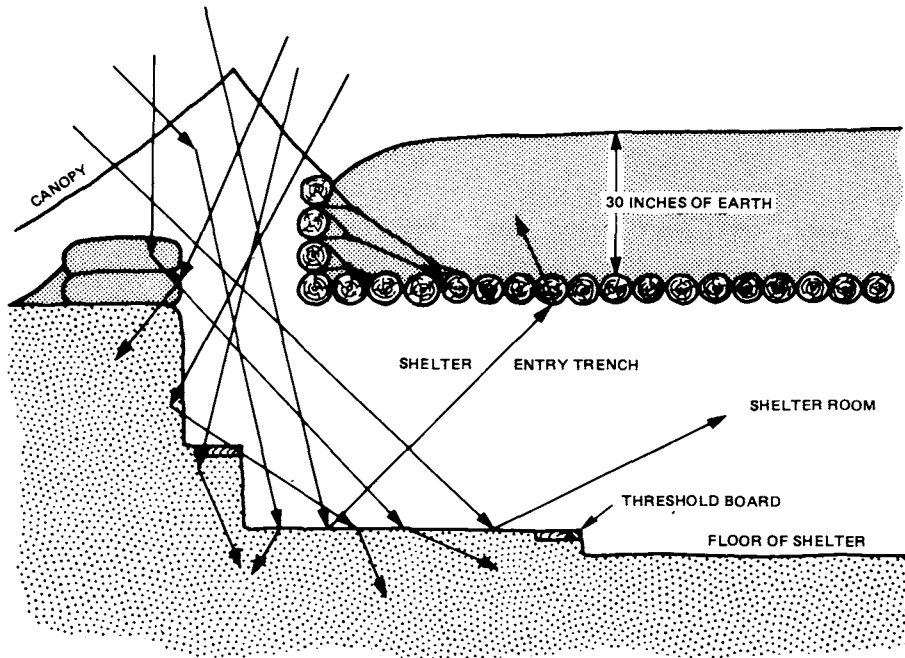


Fig. 5.5. Skyshine coming into a shelter through a vertical entry would be mostly absorbed while turning into and traveling down the entryway trench.



Fig. 5.6. Earth mounded over a  $3\frac{1}{2}$ -foot-wide Pole-Covered Trench Shelter. The canvas canopy would protect the vertical entry against both fallout and rain. (A smaller canopy over the air duct-emergency exit at the other end is obscured by the mounded earth.)

All of the earth excavated in digging the trenches was mounded over the roof poles, making a covering 30 inches deep. This shelter had a protection factor (PF) of over 300; that is, persons inside would receive less than 1/300th of the gamma-ray dose of fallout radiation that they would receive if they were standing outside in the open.

To have made the roof covering more than 36 inches thick would not have increased the protection against radiation very much, unless the entry trench and the air duct-emergency exit trench had been dug considerably longer. Field tests have shown that some families, given only 48 hours, cannot dig the longer trenches, cut the additional poles, and shovel on the additional earth necessary for a shelter that would offer significantly better protection than the shelter shown here. The Pole-Covered Trench Shelter and the other shelters described in Appendix A all have been built by untrained families within 48 hours, the minimum time assumed to be available to Americans before a possible attack if the Russians should begin to evacuate their cities.

## EARTH ARCHING USED TO STRENGTHEN SHELTERS

Several types of expedient shelters can be made to withstand greater pressures if their roofs are built of *yielding* materials and covered with enough earth

to attain "earth arching." This arching results when the yielding of the roof causes part of the load carried by the roof to be shifted to the overlying earth particles, which become rearranged in such a way that an arch is formed. This arch carries the load to surrounding supports that are less yielding. These supports often include adjacent earth that has not been disturbed.

To attain earth arching, the earth covering the yielding roof must be at least as deep as half the width of the roof between its supports. Then the resultant earth arch above the roof carries most of the load.

(A familiar example of effective earth arching is its use with sheet metal culverts under roads. The arching in a few feet of earth over a thin-walled culvert prevents it from being crushed by the weight of heavy vehicles.)

Figure 5.7 shows how a flexible roof yields under the weight of 30 inches of earth mounded over it and how earth arching develops. After the arch is formed, the only weight that the yielding roof supports is the weight of the small thickness of earth between the roof and the bottom of the arch.

Protective earth arching also results if a shelter is covered with a material that compresses when loaded, or if the whole roof or the whole shelter can be pushed down a little without being broken.

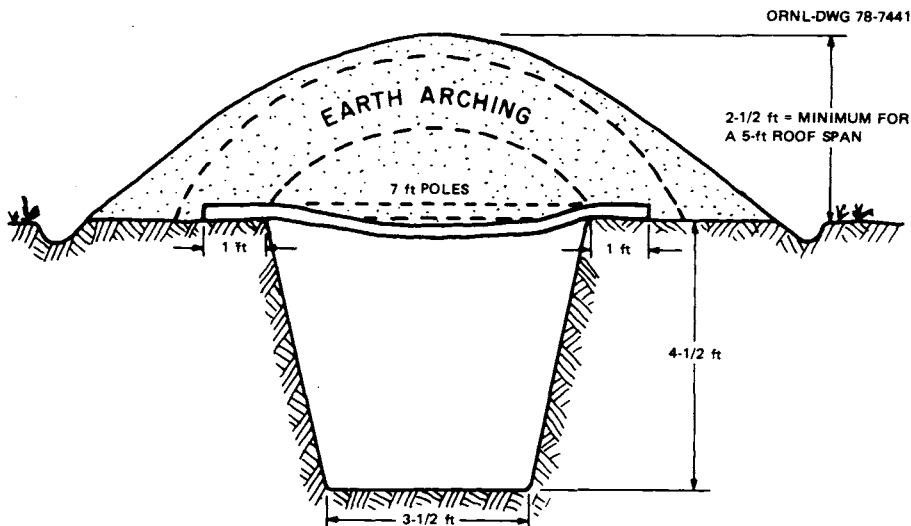


Fig. 5.7. Earth arching over a yielding roof enables a shelter to withstand much greater pressures.

## SHELTER AGAINST BETA AND ALPHA PARTICLES

In addition to the invisible, light-like gamma rays, fallout particles radiate two types of hazardous invisible *particles*: beta and alpha particles. These radiations would be minor dangers to informed people in fallout areas, especially to those who had entered almost any kind of shelter before the fallout began to be deposited in their area.

- Beta particles are high-speed electrons given off by some of the radioactive atoms in fallout. Only the highest-energy beta particles can penetrate more than about 10 feet of air or about  $\frac{1}{8}$  inch of water, wood, or human body tissue. Any building that keeps out fallout particles will prevent injury from beta radiation.

The only frequently serious dangers are from (1) internal beta-radiation doses from fallout-contaminated food or drink, and (2) beta burns from **fresh** fallout particles. **Fresh** fallout particles are no more than a few days old and therefore very radioactive. If **fresh** particles remain for at least several tens of minutes in contact with the skin, beta burns are likely to result. If only thin clothing separates **fresh** fallout particles from the skin, a considerably longer time will elapse before their radiation causes beta burns.

In dry, windy weather, **fresh** fallout particles might get inside one's nose and ears, along with dust and sand, and could cause beta burns if not promptly washed off or otherwise removed.

Prompt washing will prevent beta burns. If water is not available, brushing and rubbing the fallout particles off the skin will help.

If a person is exposed outdoors where there is heavy, **fresh** fallout for a long enough time to receive a large dose of gamma radiation, the highest-energy beta radiation given off by **fresh** fallout particles on the ground may be a relatively minor danger to his eyes and skin. Even ordinary glasses give good protection to the eyes against such beta radiation, and ordinary clothing gives good protection to the skin.

Ordinary clothing will shield and protect the body quite well from all but the highest-energy beta particles given off by **fresh** fallout deposited on the clothing. Fallout-contaminated clothing should be removed as soon as practical, or at least brushed and beaten before entering a shelter room, to rid it of as many fallout particles as possible. (Fallout particles that are many days old will not cause beta burns unless large quantities are on the body for hours.)

Most of the knowledge about beta burns on human skin was gathered as a result of an accident during the largest U.S. H-bomb test in the tropical Pacific.<sup>6</sup> Winds blew the fallout in a direction not anticipated by the meteorologists. Five hours after the multimegaton surface burst, some natives of the Marshall Islands noticed a white powder beginning to be deposited on everything exposed, including their bare, moist skin. Unknown to them, the very small particles were fresh fallout. (Most fallout is sand-like, but fallout from bursts that have cratered calcareous rock, such as coral reefs and limestone, is powdery or flakey, and white.) Since the natives knew nothing about fallout, they thought the white dust was ashes from a distant volcanic eruption. For two days, until they were removed from their island homes and cared for by doctors, they paid practically no attention to the white dust. Living in the open and in lightly constructed homes, they received from the fallout all around them a calculated gamma-ray dose of about 175 R in the two days they were exposed.

The children played in the fallout-contaminated sand. The fallout on these islanders' scalps, bare necks, and the tops of their bare feet caused itching and burning sensations after a time. Days later, beta burns resulted, along with extreme discoloration of the skin. Beta burns are not deep burns; however, it took weeks to heal them. Some, in spite of proper medical attention, developed into ulcers. (No serious permanent skin injury resulted, however.)

For survivors confined inside crowded, unsanitary shelters by heavy fallout, and without medicines, beta burns could be a worse problem than were similar burns to the Marshall Islanders.

All of the Marshall Islanders unknowingly ate fallout-contaminated food and drank fallout-contaminated water for two days. Mainly as a result of this, radioactive iodine was concentrated in their thyroid glands, and thyroid abnormalities developed years later. (There is a simple, very low-cost means of attaining almost complete protection against this delayed hazard: taking minute prophylactic doses of a salt, potassium iodide. This will be discussed in Chapter 13.)

In dry, dusty, windy areas the human nasal passages usually filter out much dust. A large part of it is swallowed and may be hazardous if the dust is contaminated with fallout. Under such dry, windy conditions, beta burns also could be caused by large amounts of dust lodged inside the nasal passages. Breathing through a dust mask, towel, or other cloth



would give good protection against this localized hazard. In conclusion: persons under nuclear attack should make considerable effort to protect themselves from beta radiation.

- **Alpha particles**, identical to the nuclei of helium atoms, are given off by some of the radioactive atoms in fallout. These particles have very little penetrating power: 1 to 3 inches of air will stop them. It is doubtful that alpha particles can get through unbroken skin; they cannot penetrate even a thin fabric.<sup>6</sup> Alpha particles are hazardous only if materials that emit them (such as the radioactive element plutonium) enter the body and are retained in bone, lung tissue, or other parts of the body. Any shelter that excludes fallout particles affords excellent protection against this radiation danger. Unless survivors eat or drink fallout-contaminated food or water in considerably larger quantities than did the completely uninformed natives of the Marshall Islands, danger from alpha particles would be minor.

## PROTECTION AGAINST OTHER NUCLEAR WEAPONS EFFECTS

- **Flash burns** are caused by the intense rays of heat emitted from the fireball within the first minute following an explosion.<sup>6</sup> This thermal radiation travels at the speed of light and starts to heat or burn exposed people and materials before the arrival of the blast wave. Thermal radiation is reduced—but not eliminated—if it passes through rain, dense clouds, or thick smoke. On a clear day, serious flash burns on a person's exposed skin can be caused by a 20-megaton explosion that is 25 miles away.

A covering of clothing—preferably of white cloth that reflects light—can reduce or prevent flash burns on those who are in a large part of an area in which thermal radiation is a hazard. However, in areas close enough to ground zero for severe blast damage, the clothing of exposed people could be set on fire and their bodies badly burned.

- **Fires** ignited by thermal radiation and those resulting from blast and other causes especially would endanger people pinned down by fallout while in or near flammable buildings. Protective measures against the multiple dangers from fire, carbon monoxide, and toxic smokes are discussed in Chapter 7.

- **Flash blindness** can be caused by the intense light from an explosion tens of miles away in clear weather. Although very disturbing, the blindness is not permanent; most victims recover within seconds

to minutes. Among the Hiroshima and Nagasaki survivors (people who had been in the open more than persons expecting a nuclear attack would be), there were a number of instances of temporary blindness that lasted as long as 2 or 3 hours, but only one case of permanent retinal injury was reported.<sup>6</sup>

Flash blindness may be produced by scattered light; the victim of this temporary affliction usually has not looked directly at the fireball. Flash blindness would be more severe at night, when the pupils are larger. Retinal burns, a permanent injury, can result at great distances if the eye is focused on the fireball.

People inside any shelter with no openings through which light can shine directly would be protected from flash burns and eye damage. Persons in the open with adequate warning of a nuclear explosion can protect themselves from both flash blindness and retinal burns by closing or shielding their eyes. They should get behind anything casting a shadow—quickly.

## SKIN BURNS FROM HEATED DUST (THE POPCORNING EFFECT)

When exposed grains of sand and particles of earth are heated very rapidly by intense thermal radiation, they explode like popcorn and pop up into the air.<sup>6</sup> While this dust is airborne, the continuing thermal radiation heats it to temperatures that may be as high as several thousand degrees Fahrenheit on a clear day in areas of severe blast. Then the shock wave and blast winds arrive and can carry the burning-hot air and dust into an open shelter.<sup>6,9</sup> Animals inside open shelters have been singed and seriously burned in some of the nuclear air-burst tests in Nevada.<sup>9</sup>

Thus Japanese working inside an open tunnel-shelter at Nagasaki within about 100 yards of ground zero were burned on the portion of their skin that was exposed to the entering blast wind, even though they were protected by one or two turns in the tunnel.<sup>4</sup> (None of these Japanese workers who survived the blast-wave effects had fatal burns or suffered serious radiation injuries, which they certainly would have suffered had they been outside and subjected to the thermal pulse and the intense initial nuclear radiation from the fireball.)

Experiments conducted during several nuclear test explosions have established the amount of thermal radiation that must be delivered to exposed earth to produce the popcorning effect.<sup>6</sup> Large air bursts may result in exposed skin being burned by hot

dust and heated air produced at overpressure ranges as low as 3 or 4 psi. However, calculations indicate that the large surface bursts most likely to endanger Americans would not result in the occupants of small, open shelters being burned by these effects—except at somewhat higher overpressures.

Protection is simple against the heated dust and very hot air that may be blown into an open shelter by the blast. When expecting an attack, occupants of an *open* shelter should keep towels or other cloths in hand. When they see the bright light from an explosion, they should cover their heads and exposed skin. If time and materials are available, much better protection is given by making expedient blast doors, as described in Appendix D. When occupants see the very bright light from a large explosion miles away, they can close and secure such doors before the arrival of the blast wave several seconds later.

## ESSENTIAL LIFE-SUPPORT EQUIPMENT

Shelters can be built to give excellent protection against all nuclear weapon effects, except in places within or very close to cratered areas. But most shelters would be of little use in areas of heavy fallout unless supplied with enough life-support equipment to enable occupants to stay in the shelters until conditions outside become endurable. In heavy fallout areas most high-protection-factor shelters would be crowded; except in cold weather, most would need a ventilating pump to remove warmed air and bring in enough cooler outdoor air to maintain survivable temperature-humidity conditions. Means for storing adequate water is another essential life-support requirement. These and other essential or highly desirable life-support needs are covered in following chapters.

## BASEMENT SHELTERS

The blast and fire effects of a massive, all-out attack of the magnitude possible in 1987 would destroy or damage most American homes and other buildings and endanger the occupants of shelters inside them. Outside the blast and/or fire areas, the use of shelters inside buildings would not be nearly as hazardous. However, an enemy might also target some areas into which large numbers of urban Americans had evacuated before the attack, although such targetting is not believed to be included in Soviet strategy.

Earth-covered expedient shelters in a blast area give better protection against injury from blast, fire, or fallout than do almost all basements. But during the more likely kinds of crises threatening nuclear war most urban Americans, including those who

would evacuate into areas outside probable blast areas, probably would lack the tools, materials, space, determination, physical strength, or time required to build good expedient shelters that are separate from buildings and covered with earth. As a result, most unprepared urban citizens would have to use basements and other shelters in existing structures, for want of better protection.

Shelters in buildings, including basement shelters, have essentially the same requirements as expedient shelters: adequate shielding against fallout radiation, strength, adequate ventilation-cooling, water, fallout radiation meters, food, hygiene, etc. Sketches and short descriptions of ways to improve the fallout protection afforded by home basements are to be found in widely distributed civil defense pamphlets, including two entitled "In Time of Emergency," and "Protection in the Nuclear Age." In 1987, millions of copies of these pamphlets are stockpiled for possible distribution during a crisis. Unfortunately, most of such official instructions were written years ago, when the deliverable megatonnage and the number of Soviet warheads were small fractions of what they are today. Official civil defense instructions now available to average Americans do not inform the reader as to what degree of protection against fallout radiation (what protection factor) is given by the different types of do-it-yourself shelters pictured. There is no mention of dependable ways to provide adequate cooling-ventilation, an essential requirement if even a home basement is to be occupied by several families in warm or hot weather. Outdated or inadequate information is given about water, food, the improvement of shelter in one's home, and other survival essentials.

No field-tested instructions at present are available to guide householders who may want to strengthen the floor over a home basement so that it can safely support 2 feet of shielding earth piled on it. In areas of heavy fallout, such strengthening often would be needed to safely support adequate overhead shielding, especially if the house were to be jarred by a light shock from a distant explosion. In the following paragraphs, a way to greatly improve the fallout protection afforded by a typical home basement is outlined. If improved in this manner, a basement would provide excellent fallout protection for several families.

First, earth should be placed on the floor above to a depth of about one foot. Earth can be carried efficiently by using sacks or pillowcases, using the techniques described in Chapter 8 for carrying water. If earth is not available because the ground is frozen

or because of the lack of digging tools, other heavy materials (containers of water, heavy furniture, books, etc.) should be placed on the floor above. These materials should weigh enough to produce a loading of about 90 pounds per square foot—about the same weight as earth one foot thick. This initial loading of the floor joists causes them to carry some of the weight that otherwise would be supported by the posts that then are to be installed.

Next, a horizontal beam is installed so as to support all of the floor joists under their centers. Figure 5.8 shows a beam and one of its supporting posts. Such a supporting beam preferably is made by nailing three 2×6s securely together. (Three 2×4s would serve quite well.)

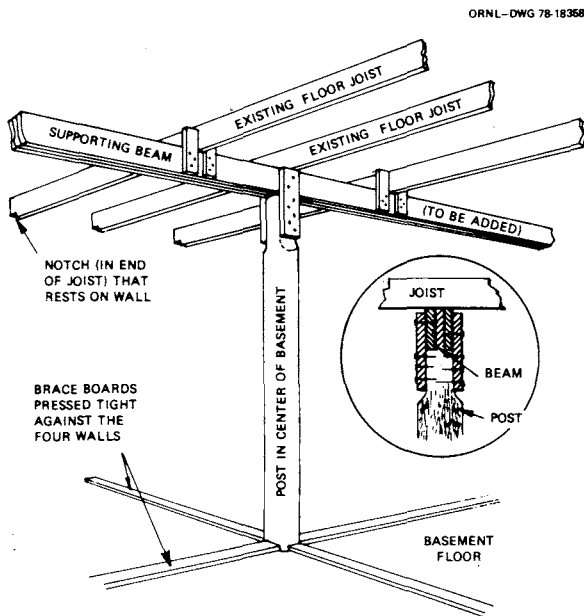


Fig. 5.8. Supporting beam and one of its posts installed to increase the load of shielding material that can be carried safely by the floor above a home basement.

Cut posts to fit exactly under the beam. If trees at least 4 inches in diameter are not available, make posts by nailing boards together. Position the two outermost posts within 2 feet of the ends of the beam. Space the posts at even intervals, with each post under a floor joist. A post under every third joist is ideal; this usually means a spacing between posts of about  $4\frac{1}{2}$  feet. If the basement is 20 feet long, 5 posts are enough. Nail each post to the beam, and secure the bases of each with brace boards laid on the basement floor, as illustrated.

Finally, place a second 1-foot-thick layer of earth on the floor above. If the basement windows are protected with boards and if all but a part of one window and all the aboveground parts of the basement walls are covered with earth 2 feet thick, the basement shelter will have a protection factor of several hundred against fallout radiation.

Adequate ventilation and cooling should be assured by using a homemade air pump (a KAP), made and installed as described in Appendix B. Forced ventilation is especially necessary if more than one family occupies the basement in warm or hot weather.

More work and materials are required to improve a home basement in this manner than are needed to build a covered-trench shelter for one family. An earth-covered shelter separate from buildings will provide equally good protection against radiation, better protection against blast, and much better protection against fire.

If a family cannot build a separate, earth-covered shelter outdoors, often it would be advisable to make a very small shelter in the most protected corner of the basement. Such an indoor shelter should be of situp height (about 40 inches for tall people) and no wider than 3 feet. Its walls can readily be built of chairs, benches, boxes, and bureau drawers. Interior doors make an adequately strong roof. Expedient shielding materials, to be placed on the roof and the two exposed sides, can be ordinary water containers and bureau drawers, boxes, and pillow cases filled with earth or other heavy materials. Or, if heavy-duty plastic trash bags or 4-mil polyethylene film are available, make expedient water containers and use them for shielding. To do so, first line bureau drawers, boxes, pillow cases, trash cans, etc. with plastic. Place the lined containers in position to shield your shelter, then fill these expedient water containers with drinkable water (see Chapter 8).

As demonstrated by hot-weather occupancy tests of such very small indoor shelters, a small KAP or other air pump must be operated to maintain a forced flow of air through such a crowded shelter, to prevent intolerable temperature-humidity conditions. (See Chapter 6 for ventilation-cooling requirements, including the provision of an adequately large opening in each end of a shelter.) In some basements a second small KAP would be needed in hot weather to pump outdoor air through the basement. This KAP could be operated by pulling

a cord from within the small shelter, using an improvised "pulley" as described in Appendix B.

## **PUBLIC SHELTERS**

In the event of an unexpected attack, many unprepared Americans should and would take refuge in nearby marked public shelters. Throughout the populated areas that would not be subjected to blast, fire, or heavy fallout, the use of public shelters could save millions of lives. All persons concerned with survival should remember that the large majority of officially surveyed and marked shelters give better protection against radiation than most unimproved home basements.

Persons preparing to go to public shelters should be aware that many lack forced ventilation and that the blowers and fans of most forced ventilation systems would be stopped by loss of electric power due to electromagnetic pulse effects or by other effects of nuclear explosions on electrical systems. A blast wave at an overpressure range as low as 1 psi (144 pounds per square foot) would wreck most shelter-ventilating fans. In 1987, no water or food normally is stocked. A person who brought to a public shelter 10 large plastic trash bags and 10 pillow slips, to make 10 expedient water bags in which 60 gallons of water could be stored (as described in Chapter 8), would help both himself and dozens of other shelter occupants. If he hoped to share the basement in a strange family's home, his chances of being welcomed would be improved if he brought a small homemade shelter-ventilating pump and other survival items. The same small pump would be impractical in a large public shelter. An Oak Ridge National Laboratory study completed in 1978 found that if all citizens were to go to National Shelter Survey (NSS) shelters within one mile of their homes, 69% of those who found space would be in shelters rated for 1000 or more occupants.<sup>10</sup> The average number of shelter spaces in this largest class of public shelters was 3179. The prospect of living in an unequipped shelter crowded with this many unprepared people—each of whom would have only 10 square feet of floor space—is a strong motivation to work hard to build and equip a small, earth-covered shelter.

## **DECIDING WHAT KIND OF SHELTER TO BUILD OR USE**

Before deciding what kind of shelter you and your family should build or use, it is best to read all of

this book. Your final decision should include consideration of ways to provide life-support equipment discussed in following chapters. At this stage, however, the reader will find it helpful to review important reasons why different types of shelters offer the best hope of survival to different people, in different areas, and under different conditions.

This book is written primarily to improve the survival chances of people who cannot or do not build permanent shelters. The information which follows will help you select the best expedient or available shelter for your family.

## **SHELTER NEAR OR IN YOUR HOME**

If your home is 10 or more miles from an average target such as a major airport with long runways, or is 20 or more miles from a great city with several strategic targets, you are fortunate: you can prudently build or use a shelter close to home. No one can foretell accurately which way the winds will blow or where weapons will explode, so, if practical, you should build a shelter that gives better protection against fallout, blast, and fire than shelters in buildings. Most people living outside targeted areas could build such a shelter in two days or less, using one of the designs of earth-covered expedient shelters detailed in Appendix A.

Even if you plan to evacuate, you should decide where you would take shelter nearby in case you were unable to do so. There is always a chance that an attack may be launched without warning, giving insufficient time to evacuate. Or the missile aimed at the area in which you live may miss its target. If your targeted home area were not hit, moderately heavy fallout might be the only danger; even an improved basement shelter would be adequate in that case.

## **EARTH-COVERED EXPEDIENT FAMILY SHELTERS**

**Advantages** of earth-covered, expedient family shelters:

- \* Better protection against heavy fallout, blast, and fire than afforded by the great majority of shelters in buildings.

- \* The possibility of building in favorable locations, including places far removed from target areas, and places where it is impractical to build or to improve large group-shelters giving good protection.

- \* The opportunity for men, women, and children to work together to provide good protection in minimum time.

- \* A better chance to benefit from thoughtful preparations made in advance than would be the case in public shelters where water, food, etc. must be shared.

- \* Less risk of personality clashes, hysteria under stress, exposure to infectious diseases, and other problems that arise when strangers are crowded together for days or weeks.

**Disadvantages** of earth-covered, expedient shelters:

- \* It may be difficult to meet the requirement for time, space, people able to work hard, materials, and tools—and to get all these together at the building site.

- \* Building is difficult if heavy rain or snow is falling or if the ground is deeply frozen. (However, untrained Americans have built good fallout shelters with shielding provided by 5 or more feet of packed snow,<sup>11</sup> including a winter version of the Crib-Walled Pole Shelter described in Appendix A. The practicality of several Russian designs of snow-covered expedient shelters also has been demonstrated by winter construction tests in Colorado.<sup>12</sup>)

- \* The fewer occupants of family shelters could not provide as many helpful skills as would be found in most public shelters, with tens-to-thousands of occupants.

- \* The lack of instruments for measuring changing radiation dangers. However, the occupants could make a homemade fallout meter by following the instructions in Appendix C, or buy a commercial instrument *before* a rapidly worsening crisis arises.

## PUBLIC AND OTHER EXISTING SHELTERS

**Advantages** of the great majority of public and other existing shelters, most of which are in buildings:

- \* Their immediate availability in many localities, without work or the need to supply materials and tools.

- \* The provision of fair-to-excellent fallout protection—generally much better than citizens have available in their homes.

- \* The availability in some shelters of fallout meters and occupants who know how to use them and who can provide other needed skills.

- \* The chance for persons who are not able to carry food or water to a public shelter to share some brought by the more provident occupants.

**Disadvantages** of the great majority of public and other existing shelters available to large numbers of people:

- \* The location of most of them in targeted areas.

- \* Poor protection against blast, fire and carbon monoxide.

- \* Lack of water and means for storing it, and lack of stocked food.

- \* No reliable air pumps, which are essential in warm or hot weather for supplying adequate ventilating-cooling air to maintain endurable conditions in fully occupied shelters—especially belowground.

- \* Uncertainties regarding the availability of fallout meters and occupants who know how to use them.

- \* No dependable lights, sanitary facilities, or other life-support equipment, with few exceptions.

- \* The crowding together of large numbers of people who are strangers to each other. Under frightening conditions that might continue for weeks, the greater the number of people, the greater would be the risks of the spread of infectious diseases and of hysteria, personality clashes, and the development of other conflicts.

## BELOWGROUND EXPEDIENT EARTH-COVERED FALLOUT SHELTERS

(Appendix A details two designs of belowground shelters, three designs of aboveground shelters, and one design that affords excellent protection built either below or aboveground).

**Advantages** of belowground, earth-covered expedient fallout shelters:

- \* They afford better protection than do aboveground, earth-covered types.

- \* Less time, work, and materials are required to build them than to build equally protective aboveground designs.

- \* If built sufficiently separated from houses and flammable woods, they provide much better protection against fire hazards than do shelters in buildings.

- \* If dug in stable earth, even types with unshored earth walls give quite good blast protection up to overpressure ranges of at least 5 psi — where most homes and buildings would be destroyed by blast or fire.

**Disadvantages** of belowground expedient fallout shelters:

- \* They are not practical in areas where the water table or rock is very near the surface.

- \* It is impractical to build them in deep-frozen ground.

- \* They are usually more crowded and uncomfortable than improved basement shelters.

## EXPEDIENT BLAST SHELTERS

**Advantages** of expedient blast shelters:

- \* Occupants of expedient blast shelters described in Appendix D could survive uninjured in extensive blast areas where fallout shelters would not prevent death or injury.

- \* Blast doors would protect occupants from shock waves, dangerous overpressures, blast winds, and burns on exposed skin caused by the popcorning effect and heated air.

- \* The expedient blast shelters described in Appendix D of this book were built and blast tested in Defense Nuclear Agency blast tests. Their air-supply systems were not damaged by blast effects that would have bent over or broken off the aboveground, vertical air-supply pipes typical of even expensive imported Swiss and Finnish permanent family blast shelters. (Notwithstanding this weakness, such permanent blast shelters will save many lives.) The horizontal blast doors of these tested expedient blast shelters were not damaged because they were protected on all sides by spiked-together blast-protector logs surrounded by ramped earth. (In contrast, the horizontal blast door of the most expensive blast shelter described in a widely distributed Federal Emergency Management Agency pamphlet (number H-12-3) is unprotected on its sides. This untested blast door probably would be torn off and blown away if struck by a strong blast wave, following blast winds, and pieces of houses and trees that would be hurled hundreds of feet.)

- \* The blast-tested expedient blast valve described in Appendix D will prevent entry of

blast waves through a shelter's ventilation pipes and resultant destruction of the ventilation pump and possible injury of occupants.

**Disadvantages** of expedient blast shelters:

- \* They require more time, materials, tools, skill, and work than are needed for building expedient fallout shelters.

- \* Especially expedient blast shelters should be well separated from buildings and woods that if burned are likely to produce dangerous quantities of carbon monoxide and toxic smoke.

- \* Their ventilation openings permit the entry of many more fallout particles than do the ventilation pipes with goosenecks and filters of typical permanent blast shelters. (However, deadly local fallout probably will not be a major danger in the blast areas where the great majority of Americans live, because a rational enemy will employ air bursts to destroy the mostly "soft" targets found in those areas. Air bursts can destroy most militarily significant "soft" targets over about twice as many square miles as can the surface or near-surface bursting of the same weapons. Fortunately, air bursts produce only tiny particles, and only a small fraction of these, while they still are very radioactive, are likely to be promptly brought to earth in scattered "hot spots" by rain-outs and snow-outs. Thus relatively few prompt fatalities or delayed cancer cases from air-burst fallout are likely to result—even from the air bursting of today's smaller Soviet warheads that would inject most of their particles into the troposphere at altitudes from which wet deposition can take place.

**WARNING:** Permanent home fallout and blast shelters described in widely available FEMA pamphlets have protection factors in line with the PF 40 minimum standard for public shelters in buildings. In heavy fallout areas a sizeable fraction of the occupants of PF 40 shelters will receive radiation doses large enough to incapacitate or kill them later. Permanent shelters built specifically to protect against nuclear weapon effects should have PFs much higher than PF 40.

None of the permanent home or family shelters described in official OCD, DCPA, or FEMA free shelter-building instruction pamphlets have been built for evaluation and/or testing — a finding confirmed to the author in 1987 by a retired shelter specialist who for some 20 years served in Washington with FEMA and its predecessors.