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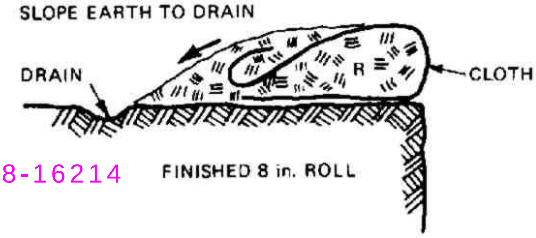


(Illustration of finished earth-filled roll.) ORNL-DWG 78-16214

(6) If a greater thickness of rolls is needed, level the earth on top of a roll; then make another earth-filled roll on this level surface.

13. Cut and haul poles and logs more easily by doing the following:

(1) Take time to sharpen your tools before starting to work no matter how rushed you feel.

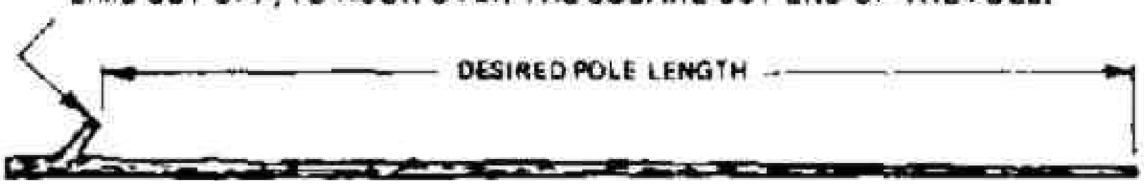
(2) When sawing green trees that have gummy resin or sap, oil your saw with kerosene or diesel fuel. If you don't have these, use motor oil, grease, or even soap.

(3) When felling a small tree, the following method will help make a square cut, keep your saw from being pinched, and help make the tree fall in the desired direction: (a) Saw the tree about one-third through on the side toward which you want it to fall. (b) Then start sawing the opposite side, while another person pushes on the tree with a 10-ft push- pole, pressing the end of the push-pole against the tree about 10 ft above the ground. A push-pole with a forked end or with a big nail on the end is best when you get ready to move it, or to use it for building your shelter. Make and use a measuring stick to speed up measuring and cutting poles and logs to the right lengths.

(4) After a tree has been felled, trim off all limbs and knots so that the pole or log is smooth and will require no additional smoothing

LIMB CUT OFF TO HOOK OVER THE SQUARE-CUT END OF THE ROLE. (ORNL-DWG 78-16210)

ORNL–DWG 78-16210

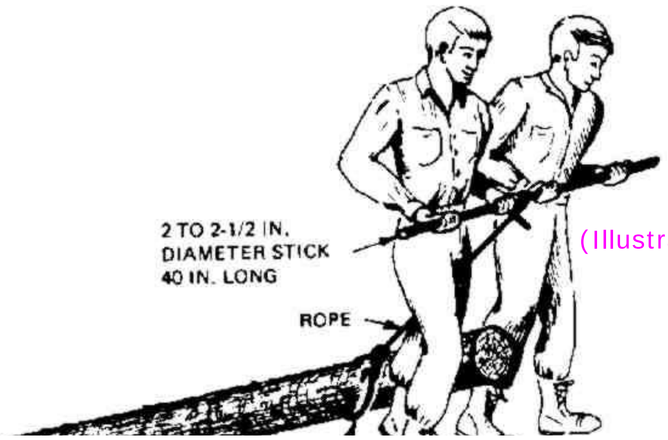


(5) It usually is best first to cut the poles exactly two or three times the final length of the poles to be used in the shelter.

(6) When you are ready to move the poles to the shelter site, drag them rather than trying to carry them on your shoulders. Shouldering them is more tiring, and you could injure yourself severely if you should trip.

To drag a log or several poles by hand: (a) Cut a stick 2 to 2-1/2 in. in diameter and about 3-1/3 ft long; (b) Tie a short piece of 1/4-in. (or stronger) rope to the center of the stick; (c) Make a lasso-like loop at the free end of the rope, so that when it is looped around the log and two people are pulling (see illustration), the front end of the log is raised about 6 in. above the ground. The loop should be tightened around the log about 2 ft. from its end, so that the end of the log cannot hit the backs of the legs of the two people pulling it.

ORNL-DWG 78-16211



(Illustration of 2 men pulling a log.) ORNL-DWG 78-16211

CAUTION: If you drag a log down a steep hill, one person should tie a rope to the rear end of the log, and then follow the dragger, ready to act as the brake if needed.

(7) When you get the poles or logs to the location where you will build the shelter, cut them to the desired minimum diameters and specified lengths, and put all those of one specified type together. Be sure that the diameter of the small end of each pole of one type is at least as large as the minimum diameter specified for its type. Make and use a measuring stick, as previously described.

14. Use snow for shielding material for aboveground shelters if the earth is so deep-frozen that digging is impractical. For a Ridge-Pole Shelter (see Appendix A.5), cover the entire shelter with 5 ft of wetted or well-packed snow. For a Crib- Walled Shelter (see Appendix A.6), fill the cribs and then cover and surround the entire shelter with snow at least 5 ft thick. With wetted or well- packed snow 5 ft thick, the protection factor is about 50. Families have completed these winter shelters within 2 days.
Several hundred pounds of snow can be moved at a time by sledding it on a piece of canvas or other strong material 6 to 8 ft wide. Attach a stick across one end of the material and tie a rope to the ends of the stick, so as to form a 'Y" bridle on which a person can pull.
To keep the occupants of a snow-covered expedient shelter dry and tolerably warm in subfreezing weather, provide sufficient ventilation openings to maintain inside temperatures at a few degrees below freezing. (See Chapter 14, Expedient Clothing.)

15. Make a reliable canopy over the shelter entry. By following the instructions given in Fig. A on the following page, you can make a dependable canopy that ordinary winds will neither tear nor blow down and that will not catch rainwater even if you have no waterproof material stronger than 4-mil polyethylene film.

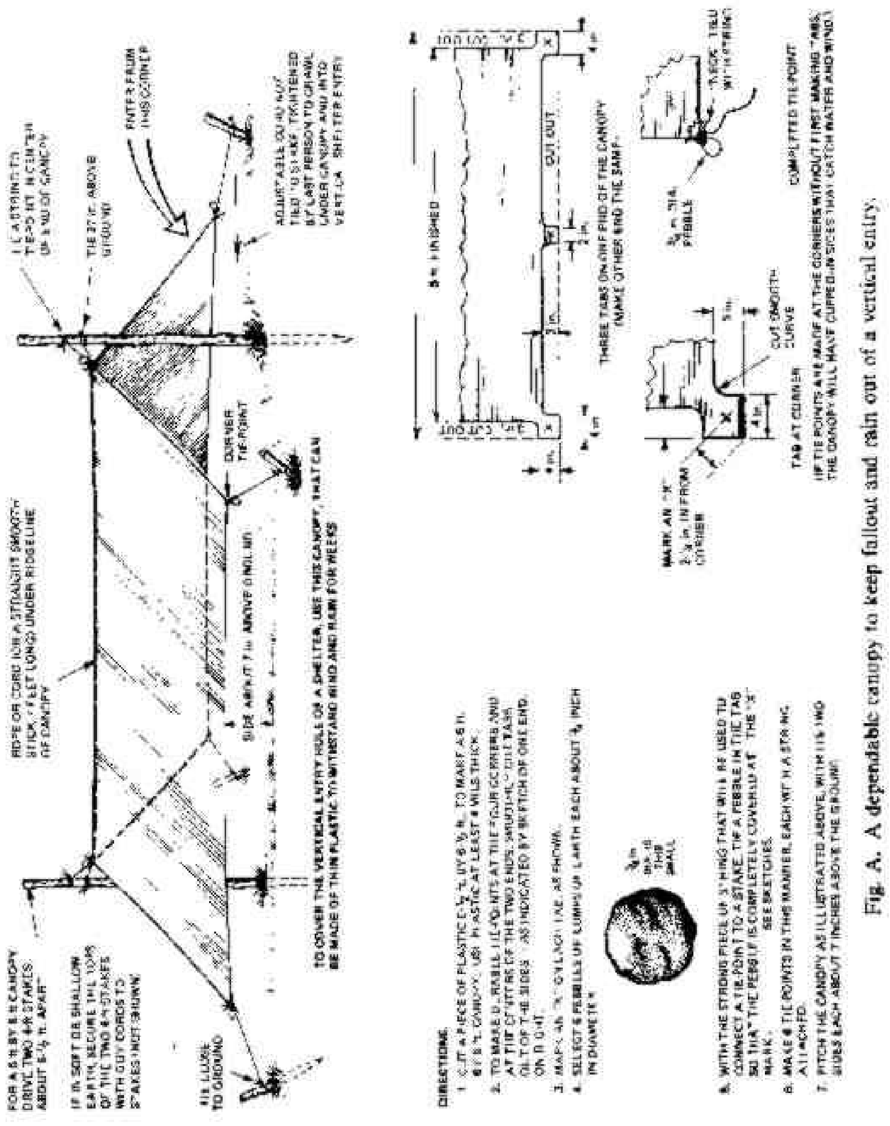
16. Take to your shelter enough window screen or mosquito netting to cover its openings. Except in freezing-cold weather, flies and mosquitoes would soon become a problem in most localities soon after an attack.

17. Work to complete (1) an expedient ventilating- cooling pump (a KAP) and (2) the storage of at least 15 gallons of water per person. This work should be accomplished by the time your shelter is completed. Especially in an area of heavy fallout during warm or hot weather, an earth- covered, high-protection-factor shelter when full of people would be useless unless adequately ventilated and cooled and provided with enough water.

18. In cold weather, restrict air flow through the shelter by hanging curtains of plastic or tightly woven fabric, or by otherwise partially obstructing its two openings. Always be sure to leave at least a few square inches open at the floor level of one opening and at the ceiling height of the other, to provide enough ventilation to prevent a harmful concentration of exhaled carbon dioxide. To prevent exhaled water vapor from wetting

clothing and bedding and reducing its insulating value, keep the ventilation openings as wide open as possible without causing shelter temperatures to be intolerably cold.

Fig. A. A dependable canopy to keep fallout and rain out of a vertical entry. ORNL-DWG 77-20140R



Appendix A.1: Door-Covered Trench Shelter (See illustration at the end of Appendix A. 1)

PROTECTION PROVIDED:

Against fallout radiation:

Protection Factor 250 (PF 250) a person in the open outside this shelter would receive 250 times as much fallout radiation as he would if inside.

Against blast:

Better protection than most homes, if built in very stable earth. Blast tests have indicated that this shelter would be undamaged up to at least the 5-psi overpressure range from large explosions. Without blast doors, the shelter's occupants could be injured at this overpressure range, although probably not fatally.

Against fire:

Excellent, if sufficiently distant from fires producing carbon monoxide and toxic smoke.

WHERE PRACTICAL:

In a location where at least one hollow-core door per occupant is available, and where the earth is very stable and a dry hole or trench 41/2 feet deep can be dug without difficulty. (A family evacuating in a pickup truck or large station wagon can carry enough doors, with doorknobs removed. Strong boards at least 6 feet long and at least one full inch thick, or plywood at least 3/4-inch thick, also can be used to roof this 36-inch-wide trench and to support its overhead earth shielding.)

Warning: Some doors with single-thickness panels if loaded with earth will break before they bend enough to result in protective earth arching.

FOR WHOM PRACTICAL:

For a typical family or other group with two or more members able to work hard for most of 36 hours. (Stronger-than-average families with most members able to work hard have completed this type of shelter is less than 24 hours after receiving step-by-step, well illustrated instructions.)

CAPACITY:

The shelter illustrated is roofed with 3 doors and is the minimum length for 3 persons. (If you have additional doors, or boards and sticks at least 3 ft long, make the entryway trenches 3 or 4 ft longer than illustrated if not pressed for time.)

For each additional person, add an additional door. (If more than about 7 persons are to be sheltered, build two or more separate shelters.)

BUILDING INSTRUCTIONS:

1. Before beginning work, study the drawings and read ALL of the following instructions.
2. Divide the work; CHECK OFF EACH STEP WHEN COMPLETED.
3. By the time the shelter is finished, plan to have completed (1) a ventilating pump (a KAP 16 in. wide and 28 in. high), essential for this shelter except in cool weather, and (2) the storage of at least 15 gallons of water per occupant (see Appendix B and Chapter 8).
4. Start to assemble materials and tools that are listed for the illustrated 3-person shelter.
   A. Essential Materials and Tools for a 3-Person Shelter
      - Three hollow-core doors.
      - A shovel (and a pick, if the earth is very hard).
      - Two to three square yards per person of waterproof materials for rain-proofing the roof. Use materials such as 4-mil polyethylene film, shower curtains, plastic table-cloths, plastic mattress covers, or canvas.
      - Two pieces of plastic or tightly woven cloth (each about 6-1/2 X 6-1/2 ft) to make canopies over the two shelter openings. Also sticks and cords or strips of cloth to support the canopies as described in Fig. A of the introductory section of this appendix.
      - Materials and tools for building a simple shelter-ventilating pump, a KAP 16 in. wide and 28 in. high. (See Appendix B.) Only in cold or continuously breezy, cool weather can tolerable temperatures and humidity be maintained in a crowded underground shelter without an air pump.
      - Containers for storing adequate water. (See Chapter 8.)
   B. Useful Materials and Tools
      - Large cans, buckets, and; or pots with bail handles in which to carry earth and later to store drinking water or human wastes.
      - Two pillowcases and one bedsheet per person-to make "sandbags" around shelter openings and to cover trench walls. (If available, large sheets of 4-mil polyethylene are better than bedsheets,

because they keep earth walls damp and stable. They also help keep shelter occupants dry and clean and prevent earth from falling into their eyes.)

- ° File, knife, pliers, hammer.
- ° Measuring tape, yardstick, or ruler.
- ° Expedient life-support items.

5. To save time and work, SHARPEN ALL TOOLS AND KEEP THEM SHARP.
6. Wear gloves from the start even tough hands can blister and become painful and infected after hours of digging.
7. Check to be sure the earth is stable and firm enough so that a trench shelter with unshored (unsupported), vertical earth walls will be safe from cave-ins. (Interior doors are not strong enough to roof an earth-covered trench wider than 3 ft.)
As a test of the stability of earth, dig a small hole about 18 in. deep. Remove all loose earth from the bottom of the hole. Then make a "thumb test" by pushing your bare thumb into the undisturbed surface at the bottom of the hole. If you can push your thumb into the earth no farther than one inch, the earth should be suitable for this type of shelter. If the earth does not pass the "thumb test," move to another location and try the test again. Continue to relocate and repeat until suitable earth is found, or build a shored-trench or aboveground shelter.
8. Prepare to dig a vertical-walled trench 4-1/2 ft deep and 3 ft wide. To determine the length of the trench, add together the widths of all the doors to be used for roofing it, then subtract 8 in. from the sum. (To avoid arithmetical errors, it is best to lay all the doors side by side on the ground.)
9. Clear any brush, grass, or weeds that are more than a few inches high from the area where the trench will be dug. Also clear the ground around all sides of the trench, to a distance of about 8 ft from the sides and ends of the trench.
10. Stake out a rectangular trench 36 in. wide, with its length as determined above. Also stake out the entrance at one end, as illustrated in Fig. A. 1 at the end of Appendix A.l, and the ventilation trench and opening at the other.
11. Dig the main trench, the entryway trench, and the ventilation trench. Place the excavated earth along both lengthwise sides of the trench, starting at the outside edges of the cleared space. Be sure that no earth is piled closer than 3 ft to the sides of the trench.
12. To be sure that unstable, unsafe earth is not encountered at depths below 18 in., repeat the "thumb test" each time the trench is deepened an additional foot. If the earth does not pass the test, do not dig the trench any deeper; try another location.
13. To keep each trench its full width as it is dug, cut a stick 36 in. long and another 18 in. long; use them repeatedly from the start to check the widths of the main trench and the entry trenches. Keeping the trenches full width will save much work and time later.
14. Carefully level and smooth the ground to a distance of 2-1/2 ft from the sides of the trench, so that the doors will lie flat on the ground up to the edges of the trench.
15. If plenty of sheets, bedspreads, plastic, and: or other materials are available, cover the trench walls with them. Wall coverings should stop one inch from the floor of the trench to prevent their being stepped on and pulled down. Plastic wall coverings keep some types of damp earth walls from drying out and crumbling.
16. To be able to place an adequate thickness of shielding earth all the way to and around the entryway and ventilation hole, stack improvised 'sandbags" around these two openings before placing the earth on the roof. Or use cloth or plastic material to make rolls" of earth, as illustrated in the introductory section of Appendix A.

17. Shovel earth around the rolls, sandbags, or other means used to raise the level of the earth around the two shelter openings. Slope this earth outward, and pack it, so that rainwater on the ground cannot run into the shelter.
18. To rainproof the shelter and to prevent the roofing doors from being dampened and weakened, use available waterproof materials as follows:
    a. If the earth is dry, the easiest and best way to make a rainproof roof is to place the doors directly on the ground, with each of the end doors overlapping an end of the main trench by 4 or 5 in. (Be sure again to level the ground surface as you place each door, so that each lies flat against the ground all the way to the edges of the trench.) Next, mound dry earth over the doors. First place a few inches of earth on the doors near their ends: then mound it about 12 in. deep above the centerline of the trench. Slope the earth to both sides so as to just cover the ends of the doors. Next, smooth off the earth mound, being careful to remove sharp stones that might puncture rainproof materials. Then place waterproof material over the smooth mound, making the "buried roof" shown in Fig. A. 1. Finally, carefully mound an additional 12 to 15 in. of earth on top of the buried roof, again placing it first over the doors near their ends. The earth over the trench should be at least 2 ft thick, so that effective earth arching will support most of the weight of the earth covering and will provide considerable protection if struck by blast.
    b. If the earth is wet, place the waterproof material directly on top of the doors, to keep them dry and strong. To make water run off this waterproof covering and to keep water from collecting on a horizontal surface and leaking through, slope the doors toward one side of the trench by first making one side of the trench about 3 in. higher than the other side. A way to raise one side without increasing the distance the doors must span is to place an earth-filled roll" of bed sheets or other material along one edge of the trench. To keep the waterproof material used to cover the doors from sliding down the slope of the doors when earth is shoveled on, tuck the upper edge of the material under the higher ends of the doors. Finally, mound earth over the doors, first placing it near their ends. The mound should be at least 2 ft deep above the centerline of the roof and about 3 or 4 in. deep over both ends of the doors.

       If more waterproof material is available than is required to make a buried roof (or to cover the doors) and to make the illustrated canopies over the two shelter openings, use this excess material to cover the wet ground on which the doors are placed.
19. Dig small drainage ditches around the completed shelter, to lead runoff water away.
20. To keep rain and/or sand-like fallout particles from falling into the shelter openings, build an open-sided canopy over each opening, as illustrated in Fig. A, shown in the introduction section of Appendix A.
21 Install the air pump (a KAP) in the shelter opening into which air is already naturally moving.
22. If the shelter has a KAP, protection against radiation can be increased by placing containers of water and of heavy foods, or bags of earth, so as to partially block the openings. This would still permit adequate air to be pumped through the shelter, except in very hot weather.
23. For seats, place water and food containers bedding, etc. along the side of the trench that is farther from the off-center entry trenches. If the trench floor is damp, covering it with a waterproof material, tree limbs, or brush will help.
24. Fill all available water containers, including pits which have been dug and lined with plastic, then roofed with available materials. If possible, disinfect all water stored in expedient containers, using one scant teaspoon of a chlorine bleach, such as Clorox, for each 10 gallons of water. Even if only muddy water is available, store it. If you do not have a disinfectant, it may be possible to boil water when needed.
25. Put at least your most useful emergency tools inside your shelter.
26. As time and materials permit, continue to improve your chances of surviving by doing as many of the following things as possible:

(1) Make a homemade fallout meter, as described in Appendix C, and expedient lights. (Prudent people will have made these extremely useful items well ahead of time.)

(2) Install screens or mosquito netting over the two openings, if mosquitoes or flies are a problem. Remember, however, that screen or netting reduces the air flow through a shelter -- even when the air is pumped through with a KAP.

(3) Dig a stand-up hole near the far end of the shelter. Make the hole about 15 in. in diameter and deep enough to permit the tallest of the shelter occupants to stand erect occasionally.

Fig. A. 1. Door-Covered Trench Shelter. ORNL DWG 73-11769R

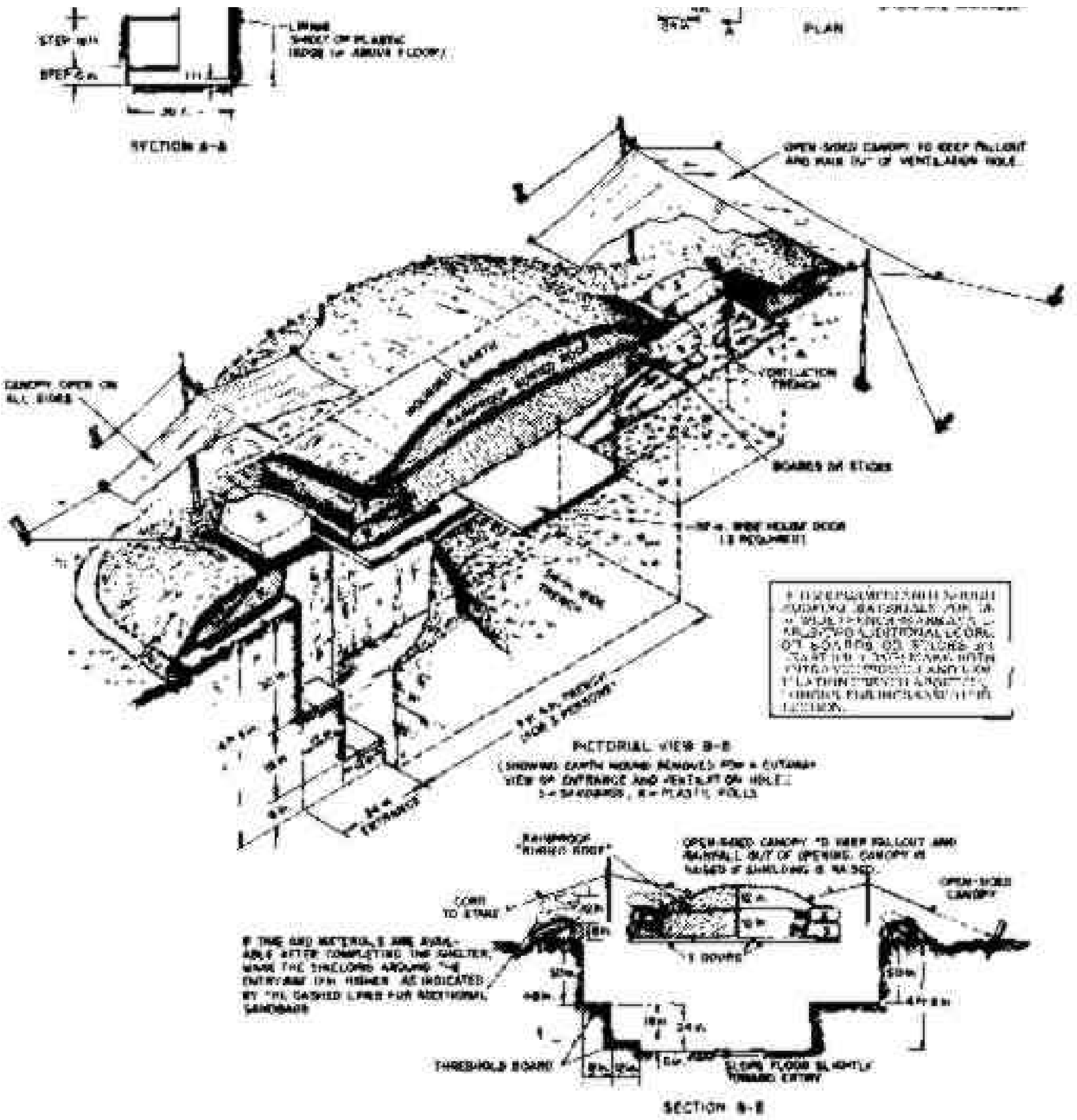


Fig. A.1. Door-Covered Trench Shelter

App. A.2: Pole-Covered Trench Shelter

PROTECTION PROVIDED:

Against fallout radiation:

Protection Factor 300 (PF 300) a person in the open outside this shelter would receive 300 times more fallout radiation than he would if he were inside.

Against blast:

Quite good protection if built in stable earth. Blast tests have indicated that this shelter, if built in stable earth, would not be seriously damaged by blast effects of large explosions at least up to the 7-psi overpressure range. (At 7 psi, most buildings would be demolished.) Without blast doors, occupants of the shelter could be injured, although probably not fatally at this overpressure.

Against fire:

Excellent, if sufficiently distant from fires producing carbon monoxide and toxic smoke.

WHERE PRACTICAL:

In wooded areas with small trees, for builders who have an ax or a bow saw, crosscut or chain saw, and digging tools, or in any location where the necessary poles may be obtained. This shelter is also practical in stable earth, where the water table or rock is more than 4-1/2 ft below the surface.

FOR WHOM PRACTICAL:

This is a practical shelter for a typical family or other group with two or more members able to work hard for most of 48 hours. (Stronger-than-average families with almost all members able to work hard have completed this type of shelter is about 24 hours after receiving step-by-step, well illustrated instructions, before traveling to the wooded building site and beginning to cut trees and haul poles.)

CAPACITY:

The shelter illustrated is the minimum length recommended for 4 persons. For each additional person, add at least 2-3/4 ft to the length of the shelter room. If more than about 10 persons are to be sheltered, build 2 or more separate shelters.

BUILDING INSTRUCTIONS:

1. Before beginning work, study the drawings and read ALL of the following instructions. Divide the work so that some people will be digging while others are cutting and hauling poles. CHECK OFF EACH STEP WHEN COMPLETED.
2. By the time the shelter is finished, plan to have completed: (1) a ventilating pump, and (2) the storage of at least 15 gallons of drinking water per occupant (see Appendix B and Chapter 8).
3. Start to assemble materials and tools. Those listed are for the illustrated 4-person shelter with a room 11 ft long.

   A. Essential Materials and Tools

   ° Saw (bow saw or crosscut preferred) and or ax for cutting poles to the lengths and diameters illustrated.
   ° Shovels (one for each two workers).
   ° Pick (if the ground is hard).
   ° Rainproof roof materials (very important in rainy, cold weather). At least 2 square yards of such material per person would be required; 3 square yards per person would be better. Shower curtains, plastic tablecloths, plastic mattress covers, canvas, and the like can be used. Also needed are 2 pieces of plastic or tightly woven cloth, each about 6 $2 X 61.2 ft, to make canopies over the two shelter openings.
   ° Materials and tools for building a simple shelter-ventilating pump, a KAP 22 in. wide and 36 in. long. (See Appendix B.) Only in cold or continuously breezy, cool weather can tolerable temperatures and humidity be maintained for days in a crowded underground shelter that lacks an air pump.
   ° Containers for storing adequate water. (See Chapter 8.)

B. Useful Materials and Tools

- ° Large cans, buckets, and / or pots with bail handles in which to carry earth and later to store drinking water and human wastes.
- ° Two bed sheets and two pillowcases per person for covering cracks between roofing logs, making "sandbags," and improvising bedsheet-hammocks and bedsheet-chairs.
- ° A file.
- ° A measuring tape, yardstick, or ruler.
- ° Rope, or strong wire (100 ft) to make earth-retaining pole walls close to the shelter openings (as explained in step 19) and for hammock supports, etc.
- ° Chain saw, pick-mattock, hammer, hatchet, pliers.
- ° Kerosene, turpentine, or oil to keep hand saws from sticking in gummy wood.
- ° Expedient life-support items recommended in this book.
- ° Mosquito netting or window screen to cover the openings, if mosquitoes or flies are likely to be a problem.

4. To save time and work, SHARPEN ALL TOOLS AND KEEP THEM SHARP.
5. Wear gloves from the start even tough hands can blister after hours of chopping and digging, and become painful and infected.
6. If possible, select a location for the shelter that is in the open and at least 50 ft from a building 9r woods. Remember that on a clear day the thermal pulse (flash of heat rays) from a very large nuclear explosion may cause fires as far away as 25 miles.
7. If the site chosen is on a steep slope, locate the shelter with its length crosswise to the direction of the slope.
8. Stake out the outlines of the trench, driving stakes as indicated in Fig. A.2.l at the end of Appendix A.2. If more than 4 persons are to be sheltered, increase the length of the shelter room by 2 ft 9 in. for each additional person.
9. Clear the ground of saplings and tall grass within 10 ft of the staked outlines so that later the excavated earth can be easily shoveled back onto the completed shelter roof.
10. Start digging, throwing the first earth about 10 ft beyond the staked outlines of the trench. Less able members of the family should do the easier digging, near the surface. Those members who can use an ax and saw should cut and haul poles. See the introductory section of this appendix for the know-how to make this hard work easier.
11. Pile all excavated earth at least 2 ft beyond the edges of the trench, so roofing poles can be laid directly on the ground. To make sure that the trenches are dug to the specified full widths at the bottoms, cut and use two sticks one 42 in. long and the other 22 in. long to check trench widths repeatedly.
12. At the far end of-the shelter dig the ventilation trench-emergency exit, making it 22 in. wide and 40 in. deep. This will help provide essential ventilation and cooling. In cold weather or when fallout is descending, canvas or plastic curtains should be hung in the two openings to control the air flow.
13. Make and install threshold boards, to keep the edges of earth steps and earth ledges from being broken off. (In damp earth, it is best to install threshold boards before roofing the shelter.) If boards are lacking, use small poles.
14. Unless the weather is cold, build a shelter- ventilating pump a KAP 20 in. wide X 36 in. high. (If the weather is *cold,* building a KAP can be safely delayed until after the shelter is completed.) A KAP should be made before a crisis, or, if possible, before leaving home.
15. Obtain fresh-cut green poles, or, as a second choice, sound, dry, untreated poles. Use no poles smaller in diameter than those specified in the accompanying drawings. For ease in hauling, select poles no more than 50% larger in diameter than those specified.

16. Lay the poles side by side over the trench. Alternate the large and small ends to keep the poles straight across the trench. If roof poles 9 ft long are being used to roof a 5-ft-wide trench, be sure to place the roof poles so that their ends extend 2 ft farther beyond one side of the trench than beyond the other side. This will enable shelter occupants, after the stoop-in shelter is completed, to widen the shelter room 2 ft on one side. First, it can be widened to provide a 2-ft- wide sleeping ledge. Later, it can be further deepened to make space for additional expedient hammocks or for double-bunk beds of poles or boards built on each side of the shelter.
17. For ease and safety later when hanging expedient bedsheet-hammocks and bed sheet-chairs in the completed shelter, place loose loops around roof poles in the approximate locations given by the diagram on the second shelter drawing, Fig. A.2.2. Make these loose loops of rope, or strong wire, or 16-in-wide strips of strong cloth, such as 50cv polyester bedsheet rolled up to form a "rope". (For making hammocks and seats, see Chapter 14. These are not essential, although decidedly useful.)
18. Cover the cracks between the logs with cloth, leaves, clay, or any other material that will keep dirt from falling down between the cracks. CAUTION: DO NOT try to rainproof this flat roof, and then simply cover it with earth. Water will seep through the loose earth cover, puddle on the flat roofing material, and leak through the joints between pieces of roofing material or through small holes.
19. Place 6-ft-long poles, one on top of the other, next to the entrances. This will keep earth to be placed on top of the entryway trenches from falling into the openings. Secure these poles with wire or rope. (See View A-A1 in Fig. A.2.l.) If wire or rope is not available, make earth-filled "rolls" to hold the earth nearly vertical on the trench roof next to each opening. (See the introductory section of this appendix.)
20. Mound earth to a center depth of about 18 in. over the shelter roof (as shown in View B-B1 in Fig. A.2.1.) to form the surface of the future "buried roof." Be sure to slope both sides of the mound. Then smooth its surface and remove sharp roots and stones that might puncture thin rain proofing materials to be placed upon it.
21. Place the waterproofing material on the "buried roof." If small pieces must be used, lay them in shingle-like fashion, starting at the lower sides of the mounded earth.
22. Cover the buried roof with another 18 in. of mounded earth, and smooth this final earth surface.
23. Finish the entrances by placing some shorter poles between the two longer poles next to each entryway. Bank and pack earth at least 6 in. deep around the sides of the entrances, so that .rainwater on the ground cannot run into the shelter entrances.
24. Dig surface drainage ditches around the outside of the mounded earth and around the entrances.
25. Place a piece of water-shedding material over each of the entrances, forming an open-ended canopy to keep fallout and rain from the shelter openings. (See Fig. A in the introductory section of Appendix A.) Almost all fallout would settle on these suspended canopies, rather than falling into shelter openings or would fall off their edges and onto the ground like sand.
26. Hang the KAP from the roof of the trench opening into which outdoor air can be felt flowing, so that air will be pumped in the direction of the natural flow of air. (If you have no KAP, make and use a small Directional Fan.)
27. Fill all available water containers, including pits which have been dug and lined with plastic, then roofed with available materials. If possible, disinfect all water stored in expedient containers, using one scant teaspoon of a chlorine bleach, such as Clorox, for each 10 gallons of water. Even if only muddy water is available, store it. If you do not have a disinfectant, it may be possible to boil water when needed.
28. Put all of your emergency tools inside your shelter.
29. As time and materials permit, continue to improve your chances of surviving by doing as many of the following things as possible:
    (1) Make a homemade fallout meter, as described in Appendix C, and expedient lights. (Prudent people will have made these extremely useful items well ahead of time.)

(2) Make and hang expedient bedsheet-hammocks and bedsheet-chairs, following the installation diagram shown in Fig. A.2.2.

(3) Install screens or mosquito netting over the two openings, if mosquitoes or flies are a problem. Remember, however, that screen or netting reduces the air flow through a shelter even when the air is pumped through with a KAP.

(4) Dig a stand-up hole near the far end of the shelter. Make the hole about 15 in. in diameter and deep enough to permit the tallest of the shelter occupants to stand erect occasionally.

Fig. A.2.1. Pole-Covered Trench Shelter. ORNL DWG 74-11755R

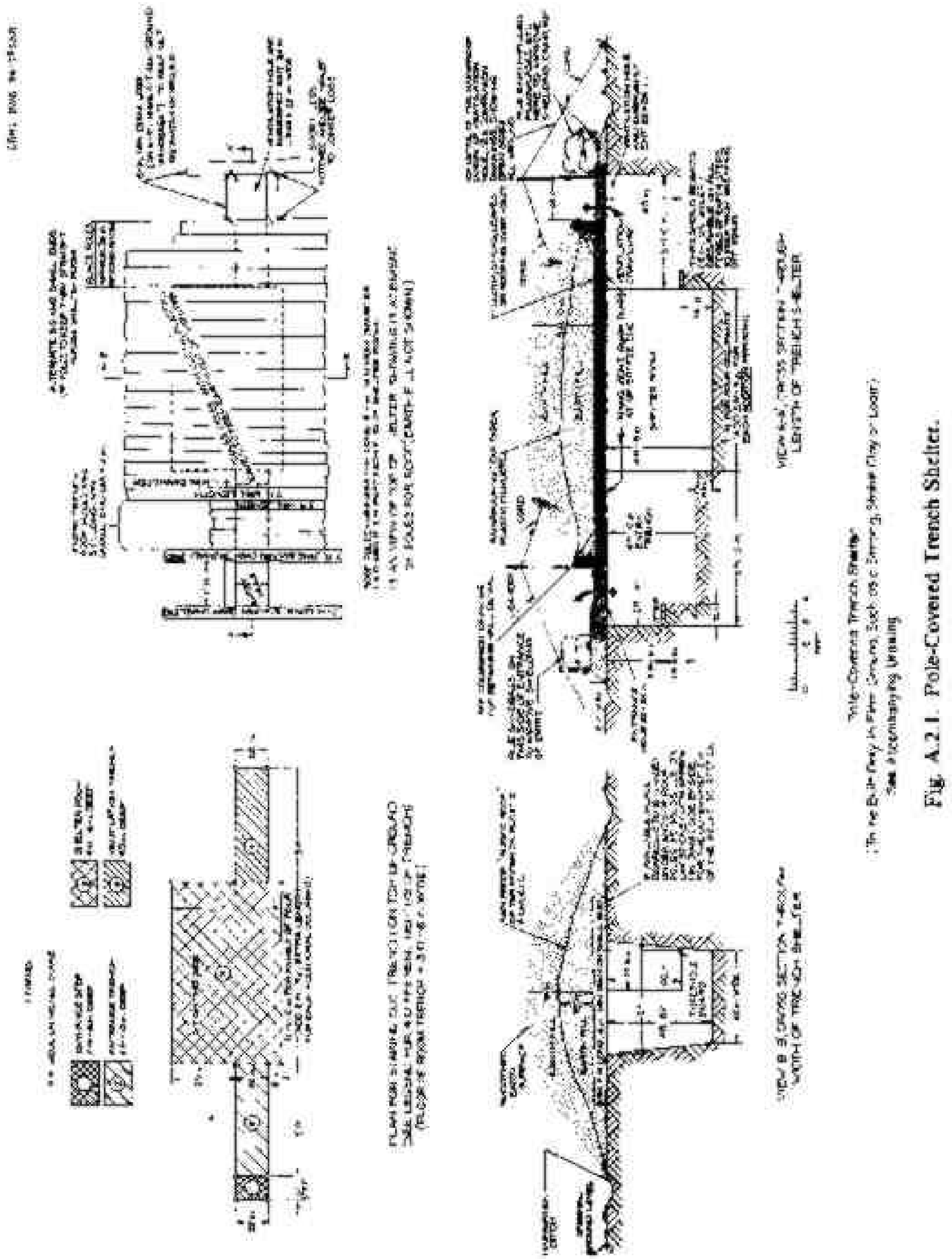
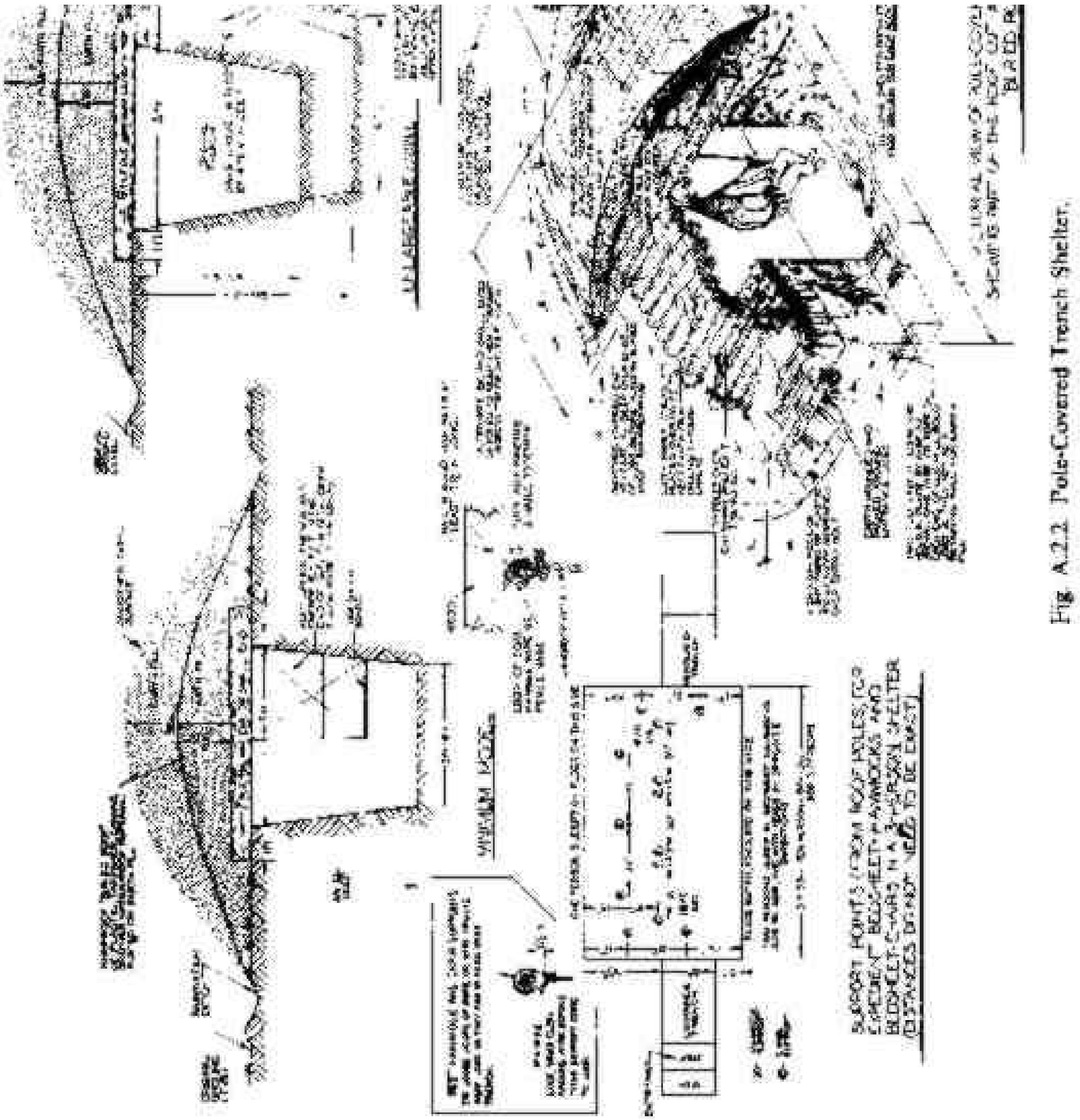


Fig.. A.2.2. Pole-Covered Trench Shelter ORNL DWG 74-11756R



Appendix A.3: Small Pole Shelter

PROTECTION PROVIDED:

Against fallout radiation:

This shelter has a protection Factor 1000 (PF 1000), if the shelter is covered with at least 3 ft of earth. That is, a person in the open outside this shelter will receive a gamma ray dose 1000 times greater than he will receive inside the shelter. See drawings at the end of Appendix A.3.

Against blast:

This shelter is excellent for preventing fatalities if it is built with strong expedient blast doors; it is still quite good if built without them. These instructions are for fallout shelters. The instructions for making blast doors and other essentials for adequate blast protection are given in Appendix D. Without blast doors, occupants are likely to suffer serious injuries above 7 psi.

Against fire:

Excellent, if sufficiently distant from fires that produce carbon monoxide and toxic smoke.

WHERE PRACTICAL:

In wooded areas with small trees, for builders who have a saw (bow saw, crosscut, or chain saw) and digging tools. Any location is suitable if the necessary poles may be obtained there. Try to avoid roots for belowground, semi-buried, or aboveground construction. However, aboveground construction requires the excavation and movement of so much earth that it is not practical for 2-day construction by families with only hand tools.

FOR WHOM PRACTICAL:

This shelter is excellent for families or other groups with most members able to work hard 12 hours a day for 2 days. Keep in mind that most people do not realize how hard and long they can work if given a strong enough incentive.

CAPACITY:

The drawings and lists of materials given in these instructions are for a 12-person shelter. For each additional occupant beyond 12, add 1 ft to the length of the shelter room.

This shelter requires less work and materials per occupant if its room is sized for about 24 persons, because the entrances are the same regardless of the length of the room. (To make the shelter room twice as long, each of the horizontal, ladder-like braces on the floor and near the ceiling of the room can be made with two poles on a side, rather than one long pole on a side.)

If the room is sized for more than 24 people, management and hygiene problems become more difficult when it is occupied.

For 12 people to live for many days in this shelter without serious hardship, the benches and bunks must be built with the dimensions and spacing given in the illustration. Or, materials must be available for making and suspending 12 expedient bedsheet hammocks that can be converted each day into 12 bedsheet-chairs.

BUILDING INSTRUCTIONS:

1. Study both of the two drawings (Fig. A.3.1 and A.3.2 at the end of Appendix A.3) and read all of these instructions before beginning work. CHECK OFF EACH STEP WHEN COMPLETED.
2. By the time the shelter is finished, plan to have completed
   (1) a ventilating pump (a KAP 24 in wide and 36 in. high), essential except in cold weather, and
   (2) the storage of at least 15 gallons of water per occupant.
3. Start to assemble the required materials. For building a 12-person Small-Pole Shelter, the materials are:
   ° Green poles. No pole should have a small end of a smaller diameter than the minimum diameter specified for its use by Figs A.3.1 and A.3.2. The table below lists the number and sizes of poles needed to build a 12-person Small-Pole Shelter.
     a To be shortened to fit for cross-braces.
     b Width equals the distance measured across a single layer of poles when a sufficient number of poles are laid on the ground side by side and touching, to cover a rectangular area.
     c For supports during construction.

Pole Length	Minimum Diameter of Small End	Number of Poles Required	Width
6 ft 2 in.	5 in.	2	-
3 ft 1 in.	5 in.	12	-

2 ft 4 in.a	5 in.	12	-
10 ft 8 in.	5 in.	-	7 ft.
8 ft 8 in.	5 in.	-	7 ft.
10 ft 6 in.	4 in.	4	-
7 ft 2 in.	4 in.	-	47 ft.
5 ft 6 in.a	4 in.	12	-
6 ft 10 in.	4 in.	-	3 ft.
6 ft 3 in.	4 in.	8	-
2 ft 6 in.a	4 in.	16	-
2 ft 3 in.	4 in.	4	-
5 ft 2 in.	3-1/2 in.	-	8 ft.
3 ft 10 in.	3-1/2 in.	-	36 ft.
10 ftc	2 in.	12	-

NOTE: The above list does not include flooring materials, to be placed between the poles of the ladder-like braces on the earth floor.

° Rain-proofing materials: Preferably one 100-ft roll, 12 ft wide, of 6-mil polyethylene. The minimum amount needed is 200 sq. ft. of 4-mil polyethylene, or 200 sq. ft of other waterproof plastic such as tablecloths, shower curtains, and or vinyl floor covering. Also include 100 ft. of sticks for use in drainage ditch drains (1/2-in. diameter, any lengths).

° Nails, wire, and; or cord: Ten pounds of 40-penny nails plus 4 pounds of 16-penny nails are ideal. However, 7 pounds of 16-penny nails can serve.

° Boards for benches and overhead bunks, if bedsheet-hammocks are not to be used. (Boards are desirable, but not essential; small poles can be used instead.) 2 X 4-in. boards 70 feet for frames (or use 3-in.-diameter poles). 1 X 8-in. boards 100 feet (or use 1-to 2-in-diameter poles).

° Materials to build a homemade ventilating pump (a KAP 24 in. wide and 36 in. high see Appendix B) and to store at least 15 gallons of water per occupant (see Chapter 8).

4. Desirable muscle-powered tools for building a 12-person, Small-Pole Shelter are listed below. Most builders have succeeded without having this many tools. A backhoe, chain saws, and other mechanized equipment would be helpful, but not essential.

5. To help drain the floor, locate the shelter so that the original ground level at the entrance is about 12 inches lower than the original ground level at the far end of the shelter unless the location is in a very flat area.

Tools	Quantity
Ax, long-handle	2
Bow-saw, 28-in.	2
(or 2-man crosscut saw)	1

Pick	2
Shovel, long-handle	3
Claw hammer	2
File, 10-in.	1
Steel tape, l0-ft	1

(Also useful: a 50-ft steel tape and 2 hatchets)

6. Stake out the trench for the entire shelter. Even in very firm ground, if the illustrated 12-person shelter is being built, make the excavation at the surface 9 ft 8 in. wide and 18 ft long (3 ft longer than the entire length of the wooden shelter). The sloping sides of the excavation are necessary, even in very firm earth, to provide adequate space for backfilling and tamping. (The trench illustrated in Fig. A.3.l is 6 ft 4 in. deep, to minimize work when providing only for excellent fallout protection. For improved blast protection, the trench should be at least 7 ft deep.)
7. Check the squareness of the staked trench outline by making its diagonals equal.
8. Clear all brush, tall grass, and the like from the ground, to a distance of 10 ft all around the staked location so that later you can easily shovel loose earth back onto the roof.
9. If the ground is unstable, excavate with sides that are appropriately less steep.
10. When digging the trench for the shelter, use a measuring stick 7 ft 8 in. long (the minimum bottom width) to repeatedly check the excavation width.
11. When digging with a shovel, pile the earth dug from near ground level about 10 ft. away from the edges of the excavation. Earth dug from 5 or 6 ft below ground level then can easily be piled on the surface only 1 to 5 ft from the edge of the excavation.
12. Finish the bottom of the excavation so that it slopes vertically 1/2 in. per foot of length toward the entrance, and also slopes toward the central drain ditch. (Later, sticks covered with porous fabric should be placed in the ditches, to serve like a crushed-rock drain leading to a sump.)
13. While some persons are excavating, others should be cutting green poles and hauling them to the site. Cut poles that have tops no smaller than the specified diameters for each type of pole (not including the bark).
14. For ease in handling poles, select wall and roof poles with top diameters no more than 50% larger than the specified minimum diameters.
15. Sort the poles by size and lay all poles of the same size together, near the excavation.
16. Before the excavation is completed, start building the ladder-like, horizontal braces of the shelter frame. Construct these braces on smooth ground near the excavation. Place two straight poles, each 10 ft 6 in. long (with small-end diameters of 4 in.), on smooth ground, parallel and 6 ft 2 in. apart. Hold these poles securely so that their outer sides are exactly 6 ft 2 in. apart, by driving two pairs of stakes into the ground so that they just touch the outsides of the two long poles. Each of the four stakes should be located about one foot from the end of a pole. To keep the 10 ft 6 in. poles from being rotated during the next step, nail two boards or small poles across them perpendicularly as temporary' braces, about 4 ft apart.
   Then with an ax or hatchet, slightly flatten the inner sides of the two poles at the spots where the ends of the 6 cross-brace poles will be nailed. Next, saw each cross-brace pole to the length required to fit snugly into its place. Finally, toenail each cross-brace pole in place, preferably with two 40-penny nails in each end.
17. Place the lower, ladder-like horizontal brace of the main room on the floor of the completed excavation.
18. Build the frame of the main room. Near the four corners of the room, secure four of its wall poles in their final vertical positions by nailing, wiring, or tying temporary brace-poles to the inner sides of these 4 wall

poles and to the inner sides of the two long poles of the ladder-like horizontal brace on the bottom of the excavation. To keep the two pairs of vertical wall poles exactly 6 ft 2 in. apart until the upper ladder-like horizontal brace is secured in its place, nail a temporary horizontal brace across each pair of vertical poles, about 1 ft below their tops.

19. To support the upper ladder-like horizontal brace, nail blocks to the inner sides of the four vertical wall poles, as shown in the lower right- hand corner of the pictorial view, Fig. A.3.2. If you have large nails, use a block about 3 in. thick and 6 in. long, preferably cut from a green, 4-in.- diameter pole.

20. In the finished shelter, DO NOT leave any vertical support poles under the long poles of the upper ladder-like horizontal brace; to do so would seriously reduce the usable space along the walls for benches, bunks, and occupants.

21. While some workers are building the frame of the main room, other workers should make the four ladder-like horizontal braces for the two entrances, then make the complete entrances. To keep the ladder-like horizontal braces square during construction and back-filling, nail a temporary diagonal brace across each one.

22. When the four wall poles and the two ladder-like horizontal braces of the main room are in place, put the remaining vertical wall poles in place, touching each other, until all walls are completed. When placing the wall poles, keep them vertical by alternately putting a butt and a top end uppermost. Wall poles can be held in position by backfilling and tamping about a foot of earth against their lower ends, or they can be wired in position until backfilled.

23. Be sure to use the two 5-in.-diameter poles (6 ft 2 in. long) by placing one next to the top and the other next to the bottom of each of the main doorways to the room. Study the drawings. Use braces, each 2 ft 3 in. long, to hold apart the top and bottom of each doorway thus making sure that a 24-in.-wide air pump can swing in either doorway.

24. To prevent earth from coming through the cracks between wall poles, cover the walls with cloth, plastic, rugs, roofing, or even cardboard. If none of these are available, use sticks, twigs, or grass to cover the wider cracks.

25. After all horizontal bracing and vertical wall poles are in place, begin backfilling, putting earth between the walls and trench sides. Pay particular attention to the order of filling. The earth fill behind all the walls must be brought up quite evenly, so that the earth fill behind one side is no more than 12 in. higher at any one time than the earth on the opposite side. Lightly tamp the earth fill in 6-in. layers. A pole makes a good tamper; do not use a mechanical tamper.

26. Next, lay the roof poles side by side, touching each other on top of the wall poles. Cover at least the larger cracks with plastic, roofing, boards, or sticks to keep earth from falling through. If the earth is sandy, cover the whole roof with some material such as bed sheets or plastic to keep sand from running through the cracks.

    CAUTION: Do not try to rainproof this flat roof and simply cover it with earth. If you do, water will seep straight through the loose earth cover, puddle on the flat roofing material, and leak through the joints between pieces of roofing material or through small holes.

27. Mound earth over the shelter, piling it about 15 in. deep along the centerline of the roof and sloping it toward the sides of the roof, so that the earth is only about 2 in. deep over the ends of the roof poles. (Preparatory to mounding earth onto the roof, place grade stakes in position so you will be able to know the locations and depths of roof poles as you cover them.) Continue these slopes to two side drainage ditches. Smooth this mounded earth with a rake or stick and remove any sticks or rocks likely to puncture the rainproof roofing material to be laid on it.

28. Place rain-proofing material on top of the smooth, mounded earth as shown in sections of the drawings in Fig. A.3.l to make a "buried roof." Plastic film, such as 4-mil polyethylene, is preferable. Roofing material, plastic shower curtains and tablecloths, or canvas can also be used. Be sure to overlap adjoining pieces.

29. Place the rest of the earth cover over the shelter, being sure that the corners of the shelter have at least 2-1/2 ft of earth over them. Mound the dirt, smoothing its surface so that water will tend to run off to the surface drainage ditches which should be dug all around the edges of the mounded earth..

30. Build the benches and overhead bunks. If boards are available, use them; if not, use small, straight poles. On each side, build a row of benches and bunks 9 ft long, centered in the shelter. In order to use the shelter space to the greatest advantage, make the heights and widths of the benches and bunks the same as the thoroughly tested heights (14 in. and 4 ft 5 in.) and widths (16 in. and 24 in.) given by Fig. A.3.2. Also be sure to space their vertical supports 3 ft apart so two adults can sit between each pair of vertical bunk supports.

31. Narrow the ends of the overhead bunks so that the aisle between them is about 28 in. wide for a distance of 38 in. from each doorway. This allows room for installation and operation of an expedient air pump (a KAP) for prevention of dangerous overheating in warm weather.

32. Place a canopy (open on all sides) over each entrance, to minimize the entry of sand-like fallout particles or rain.

33. To improve the floor, lay small poles between the lower brace poles, so that the floor is approximately level. Or, use sticks covered with scrap boards.

34. Fill all available water containers, including pits which have been dug and lined with plastic, then roofed with available materials. If possible, disinfect all water stored in expedient containers, using one scant teaspoon of chlorine bleach, such as Clorox, for each 10 gallons of water. Even if only muddy water is available, store it. If you do not have a disinfectant, it may be possible to boil water when needed.

35. Put all of your emergency tools inside your shelter.

36. As time and materials permit, continue to improve your chances of surviving by doing as many of the following things as possible:

    (1) Make a homemade fallout meter, as described in Appendix C, and expedient lights. (Prudent people will have made these extremely useful items well ahead of time.)

    (2) Install screens or mosquito netting over the two openings, if mosquitoes or flies are a problem. Remember, however, that screen or netting reduces the air flow through a shelter -- even when the air is pumped through with a KAP.

EXPEDIENT VENTILATION AND COOLING:

(Those workers who are to work only on the shelter itself, if pushed for time, need not read this section before beginning their work.)

Install a KAP (one that is 24 in. wide and 36 in. high) near the top of the doorway through which you can feel air naturally flowing into the shelter room at that time. (If the direction of the natural air flow changes, move the KAP to the other opening.) To enable the KAP to efficiently pump fresh air from the outdoors all the way through the shelter, block the lower half of the doorway in which the KAP is installed with a quickly removable covering, such as a plastic-covered frame made of sticks. Be sure to connect the KAP's pullcord only 11 in. below its hinge line. This prevents excessive arm motions which would cause unnecessary fatigue.

If short of time or materials, make a small Directional Fan.

In windy or cold weather, control the natural flow of air through the shelter by hanging adjustable curtains in the doorways at both ends, and or by making and using trapdoors on the tops of the vertical entryways. For adjustable curtains, use pieces of plastic, each with a supporting stick attached to its upper edge. This allows for different sized openings in the doorways: (1) an opening under the lower edge of the adjustable curtain at the air intake end of the room, and (2) an opening over the top of the curtain at the air-exhaust end of the room. In cold weather, this arrangement usually will provide adequate chimney-type ventilation for the shelter without using an air pump.

Fig. A.3.1. Plan and Elevation of Small-Pole Shelter (ORNL-DWG 71-3428 R4)

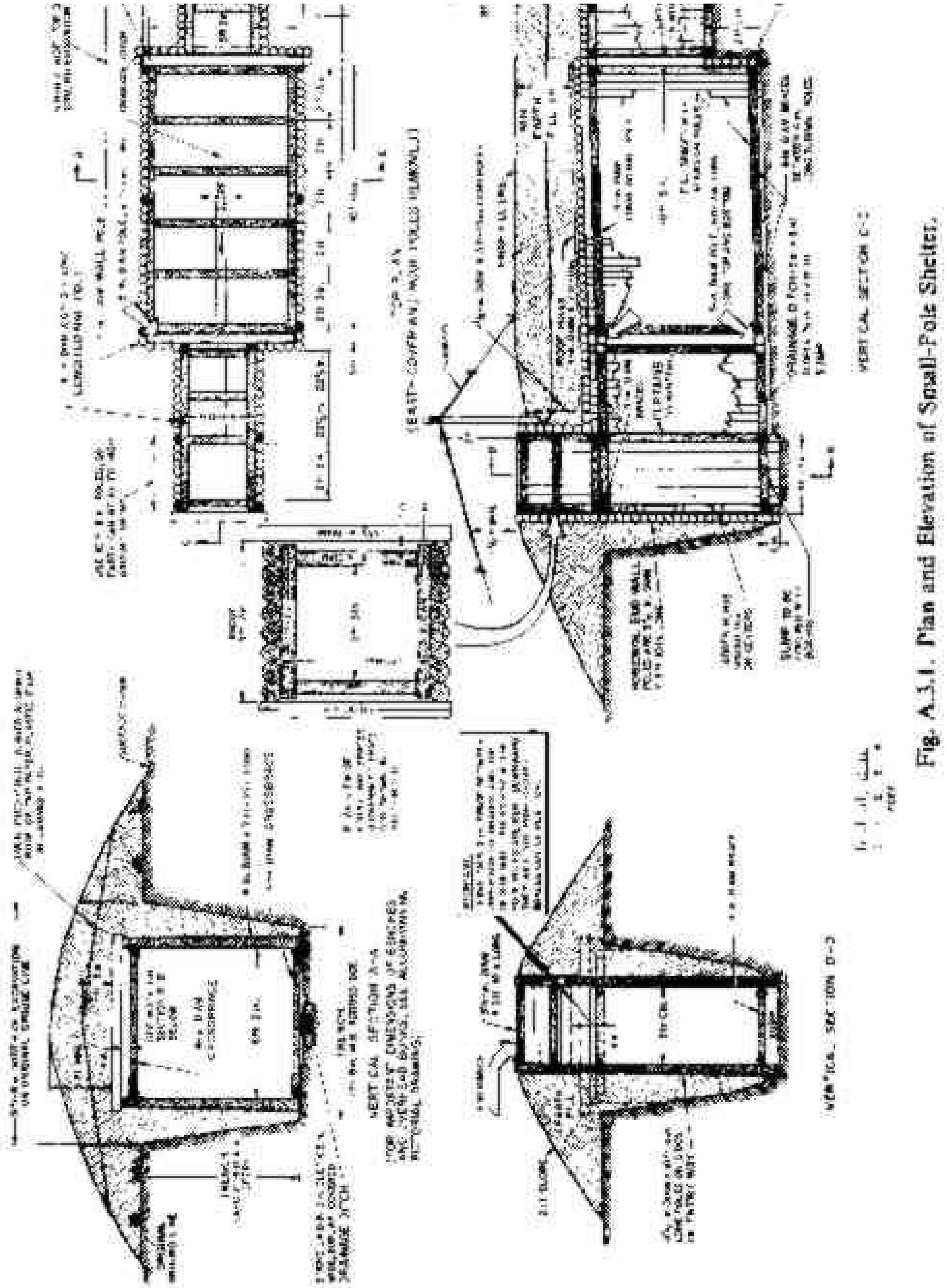
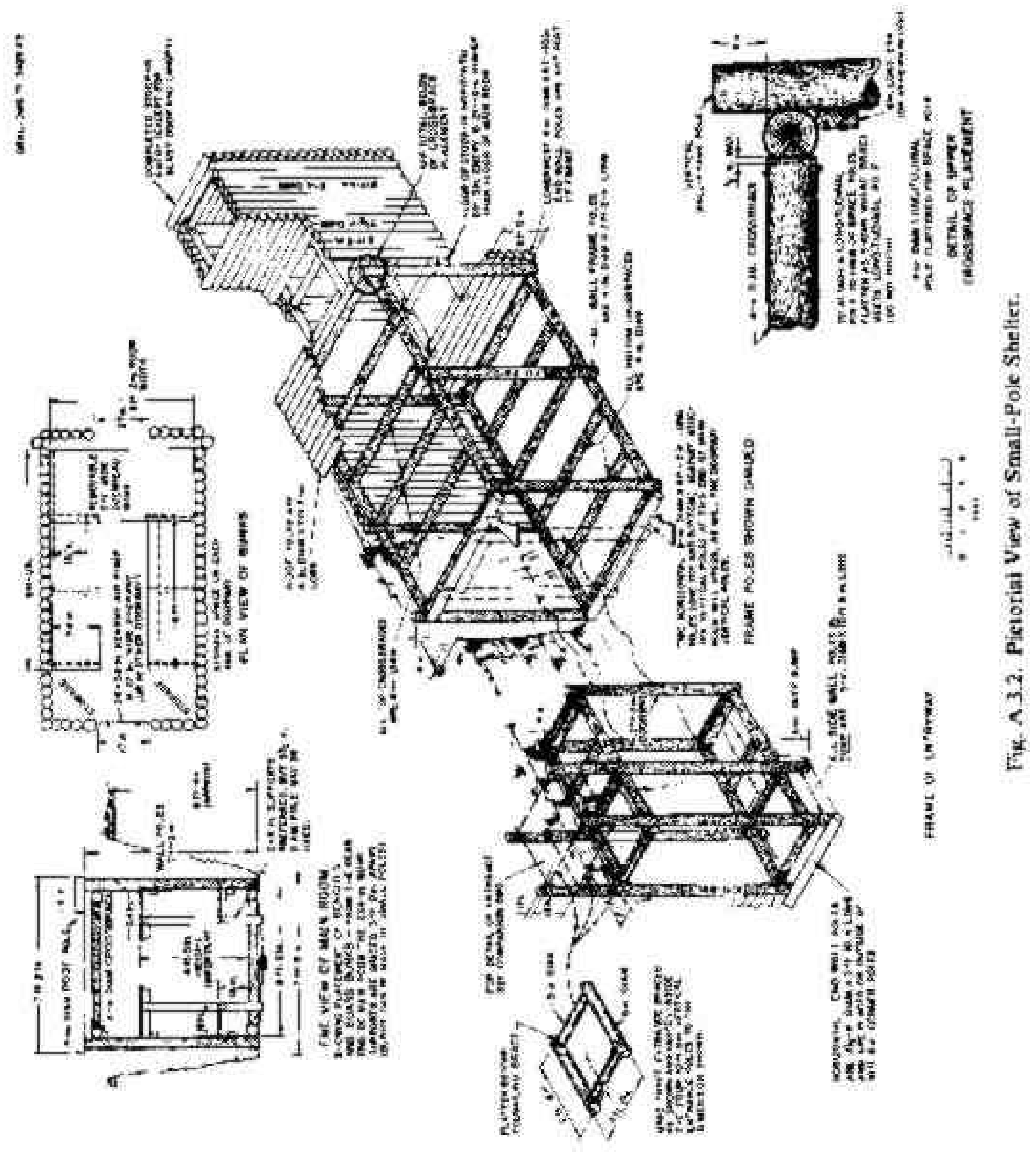


Fig. A.3.2. Pictorial View of Small-Pole Shelter (ORNL-DWG 71-3429 R3)



Appendix A.4: Aboveground, Door-Covered Shelter

PROTECTION PROVIDED:

Against fallout radiation:

Protection Factor about 200 (PF 200) if covered with 30 in. of earth. (A person in the open outside this shelter would receive about 200 times more fallout radiation than if he were inside.) The drawing at the end of Appendix A.4 shows the earth cover only 20 in. thick, resulting in a PF of about 100.

Against blast:

Better protection than most homes. Blast tests have indicated that this shelter would be undamaged at least up to the 5-psi overpressure range from large explosions. Without blast doors the shelter's occupants could be injured at this overpressure range, although probably not fatally.

Against fire:

Fair, if the cloth in the entries is covered with mud and if the shelter is sufficiently distant from fires producing carbon monoxide and toxic smoke.

WHERE PRACTICAL:

This shelter is ideal in a location where at least one hollow-core door per occupant is available, where a dry trench at least 14 inches deep can be dug without difficulty, but the water table or rock is too close to the surface for a covered-trench shelter to be practical. (A family evacuating in a pickup truck or large station wagon can carry enough doors, with doorknobs removed. Strong boards at least 6 feet long and at least one full inch thick, or plywood at least 3/4-inch thick, also can be used to roof this shelter and to support its overhead earth shielding.

Warning: Some doors with single-thickness panels if loaded with earth will break before they bend enough to result in protective earth arching.

FOR WHOM PRACTICAL:

For a typical family or other group with two or more members able to work hard for most of 36 hours, this shelter is very practical. Very little building skill is needed. An urban family of six, with 14- and 12-year-old sons and 13- and 9-year-old daughters, completed this shelter, sized for six persons, in one long working day: 13 hours and 43 minutes after receiving the step-by-step, will illustrated instructions at their Florida home 10 miles from the rural building site. This family used its pickup truck to carry them, the interior doors, and other survival items.

CAPACITY:

The shelter illustrated in Fig. A.4 is the minimum length for 4 persons. It is roofed with 6 doors.

For each additional person, add another door. (If more than about 7 persons are to be sheltered, build 2 or more separate shelters.)

BUILDING INSTRUCTIONS:

1. Before beginning work, study the drawing and read ALL of the following instructions. Divide the work so that some will be digging while others are building an air pump, storing water, etc. CHECK OFF EACH STEP WHEN COMPLETED.
2. By the time the shelter is finished, plan to have completed a ventilating pump (a 16-in.-wide by 24- in.-high KAP essential except in cold weather) and the storage of 15 gallons of water per occupant. (See Appendix B and Chapter 8.)
3. Start to assemble the materials and tools needed. For the illustrated 4-person shelter, these are:

   A. Essential Materials and Tools

   ° Six doors. Boards or plywood at least 5/8-in. thick can be used to replace one or more of the doors.

   ° At least 4 double-bed sheets for each of the first four persons, and 3 double-bed sheets for each additional person to be sheltered or enough pieces of fabric and or of plastic to cover at least as large an area as the sheets would cover. (This material is for making aboveground shelter walls, to serve as sand bags.)

   ° Rain-proofing materials (plastic film, shower curtains, plastic tablecloths, mattress protectors, etc.) 15 square yards for the first 4 persons and 2-1/2 square yards for each additional person.

   ° A shovel (one shovel for each two workers is desirable). A pick or mattock if the ground is very hard.

- ° A knife (the only essential tool for making a small shelter-ventilating KAP) and materials for a KAP 16 in. wide and 24 in. high. (See Appendix B.)
- ° Containers for storing water. (See Chapter 8.)

B. Useful Materials and Tools

- ° Two or more buckets, large cans and or large pots with bail handles to carry earth, and later to store water or wastes.
- ° Saw (or ax or hatchet) to cut a few boards or small poles.
- ° Hammer and at least 15 small nails (at least 2-1/2 in. long).
- ° Tape measure, yardstick, or ruler.
- ° Additional cloth and/ or plastic equivalent in size to 2 more double-bed sheets for each person.
- ° Additional waterproof material 2 more square yards per person.
- ° Pillowcases, or cloth or plastic bags to serve as earth-filled sand bags. The more, the better.

4. To save time and work, sharpen all tools and keep them sharp.
5. Wear gloves from the start, to help prevent blisters and infections.
6. Select a building site where there is little or no chance of the ground being covered with water, and where the water table (groundwater level) is not likely to rise closer than 18 inches to the surface.
7. To avoid the extra work of digging among roots, select a site away from trees, if practical.
8. To lessen the dangers of fire and smoke from nearby houses or trees that might catch fire, locate your shelter as far as is practical from houses and flammable vegetation.
9. Before staking out your shelter, provide one door per person to roof the main room plus one additional door for each of the two entries. Be sure the door knobs have been removed. Use the two widest doors to roof the entries.
10. To be sure that all the walls will be in the proper positions to be roofed with the available doors, lay all the doors on the ground, touching each other and in the same relative positions they will have when used to roof the shelter. When all the roof doors are on the ground, side by side, determine the exact length of the shelter room. (Note that Fig. A.4 illustrates a shelter sized for only 4 persons.)
11. Stake out the shelter
12. Make the earth-filled "rolls" that will form the aboveground walls of your shelter. To make walls out of the rolls:

(1) Use doors as vertical forms to hold the earth-filled rolls in place until the walls are completed. (These are the same doors that you will use later to roof the shelter.)

(2) Brace the door-forms with 36-in.-long braces (boards or sticks) that press against the doors, as shown in Fig. A.4. Nail only the upper braces, using only very small nails.

(3) After the forms for the two inner sides of the shelter have been finished, put parts of the long sides of bed sheets on the ground, as illustrated. (Or use other equally wide, strong cloth or plastic material.) About a 2- ft width of cloth should be on the ground, and the rest of each sheet should be folded up out of the way, over the outsides of the door-forms. Adjacent sheets should overlap about 1 ft when making a roll than is longer than one sheet.

(4) Shovel earth onto the parts of the sheet on the ground to the height of the rolls you are making, as shown. Note that the roll to be made on one side is 2 in. higher than the roll on the other side.

(5) Shape the surface of the shoveled-on earth as illustrated, to hold the hooks" of cloth to be formed when the exposed sides of the sheets are folded down.

(6) Fold down the upper side of each sheet while pulling on it to keep it tight and without wrinkles. It should lie on the prepared earth surface, including the small narrow trench, as illustrated in the first section of this appendix.

(7) Pack earth onto the part of the folded-down sheet that is in the narrow, shallow trench. Then, as shown in the sketches at the bottom of the accompanying drawing, fold back the loose edge over this small amount of packed earth to form a "hook." (The hook keeps the weight of the earth inside a roll from pulling the cloth out of its proper position.)

(8) Make a roll first on one side of the shelter, then on the other, to keep the heights of the earth on both sides of the shelter about equal. This will keep the unequal heights of earth from pushing the door-forms out of their vertical positions.

(9) Add additional earth on top of the rolls so that the height of the level earth surface, out to the full width of a roll, is the same as the height of the cloth-covered part of the roll that is against the door-form.

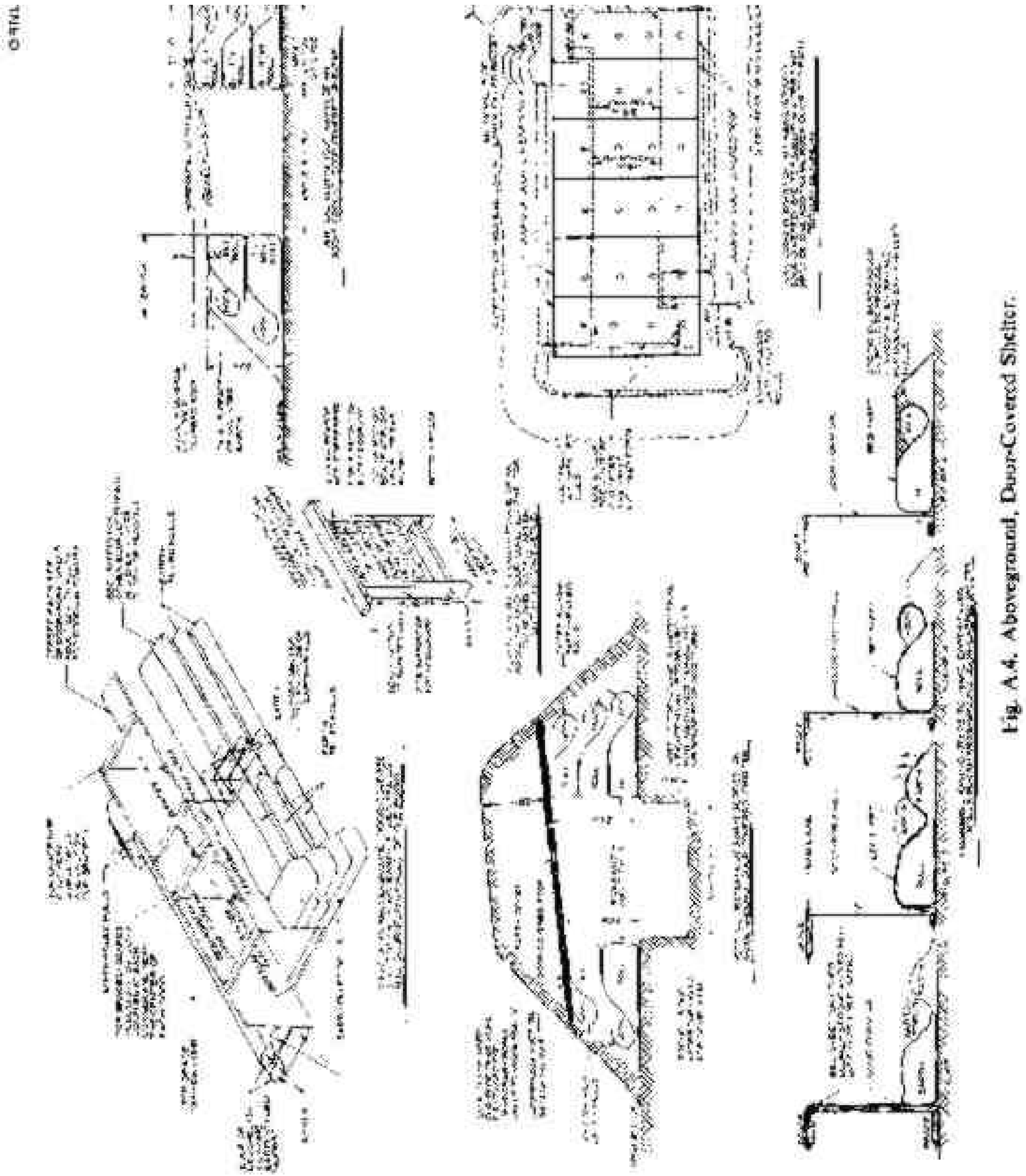
(10) When the roll walls have been raised to their planned heights on both sides of the shelter, remove the braces and the door forms - being careful to keep the brace nails from damaging the doors.

(11) The door-forms of the side-walls of the shelter can be removed before building the end-walls.

13. When smoothing the earth surfaces of the final tops of the roll walls on both sides, check to see that they have the same slope as the lower sides of the roof doors will have after they are placed on the roll walls. (A slope is necessary so that rainwater reaching the waterproof covering to be placed over the doors will run off the lower side.) Study Fig. A.4.
14. After the side-walls have been completed (except for their ends that form the sides of an entry) and after the door-forms have been removed, use the same doors for forms to build the two 22-in.-wide entries.
15. Use earth-filled "sand bags" (made of pillowcases or sacks, and/ or the tucked-in ends of earth- filled rolls) to make the outer ends of each entryway.
16. Make the two doorway frames if lumber, nails, and a saw are available. Make each frame as high as the wall on each side of it, and slope the top board of each frame so that it will press flat against the door to be supported. (If materials for a frame are lacking, place a single 2 by 4-in. board or a pole about 6 ft. long across the top of the entry, in the position shown in Fig. A.4 for the top of the doorway frame.)
17. After carefully removing all the temporary braces from the door-forms and the doors themselves, improve the slopes of the tops of all supporting walls so that the doors will be supported evenly and, without being twisted, will make contact with the smooth, sloping earth or cloth upon which they will rest.
18. If more than enough waterproof plastic or similar material is available to cover all the roof doors, also cover the tops of the walls on which the roof doors will rest. This will keep the doors from absorbing water from damp earth.
19. Dig the illustrated 14-in.-deep, 36-in.-wide trench inside the shelter. (If the water table is too high to dig down 14 in.., in some locations the walls can be raised to a height of 38 in. by cutting turf sods and laying them on top of the walls. Another way the wall height can be increased is by making additional rolls.)
20. Place the roof doors in their final positions, and cover them with waterproof material (if available). Be sure the waterproof material is folded under the higher edges of the doors to keep the material from slipping downward on the sloping doors as earth is shoveled onto the roof.
21. Extend the waterproof material on top of the doors a couple of feet beyond the lower ends of the doors if enough material is available to cover all of the roof doors.
22. When shoveling the first layer of earth onto the rainproof material protecting the doors, avoid hitting and possibly puncturing it with rocks or sharp pointed roots in the earth.
23. To make earth arching more effective in supporting most of the earth to be placed on the roof doors, first mound earth on and near the ends of the doors.
24. Cover the roof with at least 20 in. of earth. Make sure that there also is a thickness of at least 20 in. of earth at the corners of both the room and entries.

25. To prevent surface water from running into the shelter if it rains hard, mound packed earth about 5 in. high just inside the two entries. Rain can be kept out by a small canopy or awning that extends 2 or 3 ft in front of the outermost edge of a doorway that roofs an entry.
26. If any waterproof material remains, use it to cover the floor of the shelter.
27. If the weather is warm or hot, install a 16-in.-wide by 24-in.-high air pump (a KAP). Attach its hinges to the board across the roof of the entry into which outside air is moving naturally at the time. (If short of time or materials for a KAP, make a small Directional Fan.)
28. Cover all exposed combustible material with mud, earth, or other fireproof material, to reduce the chance of exposed cloth being ignited from a nuclear explosion or heat from a nearby fire.
29. Fill all available water containers, including pits which have been dug and lined with plastic, then roofed with available materials. If possible, disinfect all water stored in expedient containers, using one scant teaspoon of a chlorine bleach, such as Clorox, for each 10 gallons of water. Even if only muddy water is available, store it. If you do not have a disinfectant, it may be possible to boil water when needed.
30. Put at least your most useful emergency tools inside your shelter.
31. As time and materials permit, continue to improve your chances of surviving by doing as many of the following things as possible:
    (1) Make a homemade fallout meter, as described in Appendix C, and expedient lights. (Prudent people will have made these extremely useful items well ahead of time.)
    (2) Install screens or mosquito netting over the two openings, if mosquitoes or flies are a problem. Remember, however, that screen or netting reduces the air flow through a shelter even when the air is pumped through with a KAP.
32. See Illustration Next Page.

Fig. A.4. Aboveground, Door-Covered Shelter. (ORNL-DWG 74-8132R)



Appendix A.5: Above Ground Ridge-Pole Shelter

PROTECTION PROVIDED:

Against fallout radiation:

Protection Factor 300 (PF 300) if covered with 24 in. of earth. (A person in the open outside this shelter would receive about 300 times more fallout radiation than if he were inside.) See the accompanying drawing at the end of Appendix A.5.

Against blast:

Better protection than most homes. Blast tests have indicated that this shelter would be undamaged at least up to the 5-psi overpressure range from large explosions. Without blast doors, the shelter's occupants could be injured at this overpressure range, although probably not fatally.

Against fire:

Good, if the shelter is sufficiently distant from fires producing carbon monoxide and toxic smoke.

WHERE PRACTICAL:

This shelter is a practical design in many wooded areas and wherever enough poles are available, and in locations where belowground expedient shelters are impractical because the water table or rock is too close to the surface for a covered-trench shelter.

FOR WHOM PRACTICAL:

This shelter is excellent for a family or other group with five or more members able to work hard for most of 48 hours, with at least one member able to saw and fit poles and use the hand tools listed on the following page. (A group of rural Florida families, with 12 of the 15 members able to work, completed a shelter like this 23 hours and 40 minutes after receiving the step-by-step, well illustrated instructions 12 miles from the wooded building site. They used only muscle-powered tools, and moved over 50 tons of sandy shielding earth.)

CAPACITY:

The shelter illustrated in Fig. A.5 is the minimum length for 5 persons. For each additional person, add 1 ft to the length of the ridgepole and shelter room. (If more than about 15 persons are to be sheltered, build 2 or more separate shelters.)

BUILDING INSTRUCTIONS:

1. Before beginning work, study Fig. A.5 and read ALL of the following instructions.
2. Divide the work. CHECK OFF EACH STEP WHEN COMPLETED.
3. By the time the shelter is finished, plan to have completed a ventilating pump (a KAP 20 in. wide and 26 in high, essential for this shelter except in cool weather) and the storage of at least 15 gallons of water per occupant. (See Appendix B and Chapter 8.)
4. Start to assemble the materials. For the illustrated 5-person shelter, these are:

   A. Essential Materials and Tools

   ° Poles. (Fresh-cut, green poles are best, sound, untreated poles are satisfactory.) See the following list for the number of poles required for a 5-person shelter.

      a This width equals the distance measured across the tops of a single layer of poles when a sufficient number of poles are laid on the ground side by side *with all the same ends in a straight line and touching.* (These poles will be placed butt-ends down to form the walls of the shelter room.)

      b This width equals the distance measured across a single layer of poles when a sufficient number of poles are laid on the ground side by side and *touching, with large ends and small ends alternating so to cover a rectangular area.*

c To be cut into the various lengths needed to close the ends of the main room and also to close a part of each entryway.

Use	Pole Length	Minimum Diameter of Small End	Number of Poles Required	Width When All Are Laid on the Ground
For main room:				
Ridgepole	4 ft 9 in.	6 in.	1	
Column-posts	4 ft 3 in.	5 in.	2	
Footing log	8 ft 0 in.	6 in.	1	
Cross braces	6 ft 2 in.	3 in.	2	
Roof poles	9 ft 0 in.	4 in.	-	5 ft a
Vertical end-wall poles	5 ft 0 in.	3-1/2 in.	-	14 ft b
Slanting end-wall poles and extras	6 ft 6 in.	3-1/2 in.	-	18 ft b
For outer sections of entryways:				
Horizontal poles	8 ft 0 in.	3-1/2 in.	4	
Cross braces (material for 16)	5 ft 0 in.	3 1/2 in.	6	
Wall poles	3 ft 4 in.	3 in.	-	32 ft b
Roof poles	2 ft 8 in.	2-1/2 in.	-	12 ft b
For inner sections of entryways:				
Long, sloping poles	14 ft 0 in.	4 in.	4	
Cross braces	1 ft 8 in.	4 in.	8	

	c			
Vertical support poles	4 ft 0 in. c	4 in.	8	
Roof poles	3 ft 0 in.	2-1/2 in.	-	13 ft b

- ° A saw and an ax or hatchet, to cut green poles. (A bow saw or crosscut saw serves well and often is more dependable than a chain saw. Having an extra blade for a bow saw may be essential.)
- ° Two shovels (one shovel for each two workers is desirable). A pick will also be needed, if the earth is hard.
- ° Large buckets, cans, or pots with bail handles in which to carry earth, and later to store water or wastes.
- ° A knife.
- ° A hammer and at least 80 nails (3 in. or longer). If these are not at hand, rope, wire, or strips of cloth can be used to lash poles together. At least 200 ft. of rope or strong wire will be needed, or two additional bed sheets for each person to be sheltered. (Other fabric of equal strength can be used.) The cloth can be cut or torn into foot-wide strips and twisted slightly to make rope."
- ° Three double-bed sheets for the illustrated 5-person shelter or a piece of strong fabric or plastic of about the same size. One additional sheet for each additional 2 occupants. (If sufficient sheets or other material are not available, use many sticks and small poles, placed across the 9-ft side poles.)
- ° At least 2 square yards per person of rain-proofing material (shower curtains, plastic tablecloths, plastic mattress covers, or the like) essential in rainy, cold weather.
- ° Materials for building a ventilating pump, a KAP 20 in. wide and 26 in. high. (See Appendix B.)
- ° Containers for storing 15 gallons of water per occupant. (See Chapter 8.)

B. Useful Tools and Materials

- ° Additional saws, axes, hatchets, shovels, and large buckets or cans.
- ° A chain saw if there is a person in the group who is skilled at operating one.
- ° Kerosene, turpentine, or oil to keep a handsaw from sticking in green, gummy wood.
- ° A measuring tape, yardstick, or ruler.
- ° One bed sheet for each person to be sheltered, or a piece of strong fabric or plastic of about the same size.
- ° A total of 40 square yards of rain-proofing materials for the illustrated 5-person shelter and 3-1/2 square yards for each additional person. (Even thin plastic will serve for the "buried roof.")

5. To save time and work, SHARPEN ALL TOOLS AND KEEP THEM SHARP.
6. Wear gloves from the start even tough hands can blister after hours of digging and chopping and can become painful and infected.
7. Select a shelter location where there is little chance of the ground being covered with water if it rains hard. (If you are sure the water table will not rise to cover the floor of a shallow excavation, you can save work by first lowering the area of the planned main room by a foot or two. After the shelter is roofed, the excavated earth can be shoveled back to help cover the completed pole roof.) To avoid the extra work of cutting roots when excavating earth, select a site at least as far away from a tree as the tree is tall.
8. For a shelter that is completely aboveground, clear grass, weeds, etc. from the area where the shelter is to be built. (This reduces the possible problem of chiggers, ticks, etc.) Do not remove any earth at this stage.

9. Stake out the entire shelter. Check the squareness of the shelter room by making its diagonals equal. Then drive two lines of stakes to mark the outside edges of the completed earth covering. Place these stakes 4 ft outside the future positions of the lower ends of the roof poles.

10. Check the squareness of the future floor area inside the two lines marking where the two V-shaped, 4-in.-deep trenches will be dug, to secure the lower ends of the sloping side-poles of the room. These two parallel lines are 14 ft 6 in. apart. When the two diagonals joining the ends of these two parallel lines are equal in length, the area between them has square corners.

11. While some persons are staking out the shelters, others should be cutting green poles and hauling them to the site. Cut poles that have tops with diameters (excluding bark) no smaller than the diameters specified on the illustration for each type of pole.

12. To make the hauling and handling of the longer poles easier, select poles with top diameters no more than 50% larger than the specified minimum diameters.

13. Sort the poles by length and diameter and lay all poles of each size together, near the excavation.

14. AS SOON AS POLES ARE BROUGHT TO THE SITE, SOME WORKERS SHOULD START BUILDING THE FOUR LADDER- LIKE HORIZONTAL BRACES FOR THE ENTRYWAYS TO AVOID DELAYS LATER. Study the drawing. Then construct these braces on smooth ground near the excavation. Place two straight poles, each 8 ft long (with small-end diameters of 3-1/2 in.), on smooth ground, parallel and so that their outer sides are 3 ft apart. Hold these poles securely so that their outer sides are exactly 3 ft apart, by driving two pairs of stakes into the ground so that they just touch the outsides of the two long poles. Each of the four stakes should be located about one foot from the end of a pole. To keep the 8-ft poles from beingrotated during the next step, nail two boards or small poles across them perpendicularly, as temporary braces, about 4 ft apart.

    Then with an ax or hatchet, slightly flatten the inner sides of the two poles at the spots where the ends of the 4 cross-brace poles will be nailed. Next, saw each cross-brace pole to the length required to fit snugly into its place. Finally, toenail each cross-brace pole in place, preferably with two large nails in each end.

15. If more than 5 persons are to be sheltered, use 3 column-posts for 6 to 9 persons, and 4 column- posts for 10 to 14 persons.

16. For each additional person beyond 5, make the ridgepole and the footing log each 1 foot longer than shown in Fig. A.5.

17. After notching the footing log (see drawing), place it in a trench dug deep enough so that the bottoms of its notches are about 4 inches below the surface of the ground.

18. Carefully dig the 4-in.-deep, V-shaped, straight trenches in which the lower ends of the 9-ft wall poles will rest. Dig each of these two parallel trenches 7 ft 3 in. from the center line of the footing log.

19. Carefully notch a "V" only about 1/4-in. deep in the top of each of the two outer column-posts. Then saw off the other ends so that each is 4 ft 3 in. long. (When they are placed on the notched footing log and the ridgepole is placed on them, the upper side of the ridgepole will be about 4 ft 4 in. above the ground.)

20. Place the two outer column-posts in their notches in the footing log, and secure the base of each column-post against sideways movement by placing two small-diameter, 4-ft horizontal poles just below the ground level on both sides, as illustrated. Then temporarily place and brace the ridgepole in position.

21. For shelters sized for more than 5 occupants, make and place the inner column-post, or posts. To avoid cutting a "V"-notched column-post too short, first carefully "V"-notch each remaining column-post, cut it about 1 in. too long, and trim it off to fit in its final position under the ridgepole.

22. If nails at least 4 in. long are available, nail sloping cross-braces to the inner sides of the column-posts. If nails are not available, notch slightly bowed cross-braces and the column-post as illustrated; then lash or wire them in position. (Strips of ordinary bed sheets, torn about a foot wide and twisted together slightly, can be made to serve as lashing rope.") To hold the tops of the column-posts securely against the upper ends of the cross-braces, a tightened rope" loop that encircles the tops of the column-posts can be used.

23. Next put four of the larger-diameter, 9-ft roof- poles in position, with the outsides of the outermost two roof poles each only about 1 in. from an end of the ridge pole.

24. Place the rest of the 9-ft roof-poles in position, making sure that all their small ends are uppermost, and that they are pressed together and overlap on the ridgepole at least as far as illustrated. Pack earth between their lower ends. If the earth is clay, put small spacers of wood between the ends.

25. At each end of the shelter room, build extra shelter space and an entryway. First position two 14-ft poles with their upper ends resting on the outermost wall poles. Study Fig. A.5. Place the two 14-ft poles 20 in. apart, parallel, and equally distant from the centerline of the ridgepole. Nail four 20-in.-long spacer-poles between each pair of 14-ft poles, as illustrated. To make sure that the upper ends do not move before earth pressure holds them in place, tie the upper ends of the 1 4-ft poles together. Drive a stake against the lower end of each 14-ft pole, to keep it from slipping outward. Under the center of each 14-ft pole, place two supporting, vertical posts.

26. Dig 4-in.-deep trenches for the lower ends of the sloping end-wall poles of the main room. These poles must be cut to length so that their upper ends will be about 4 in. above the outermost 9-ft roof pole against which they lean. Dig narrow, vertical trenches, about 8 in. deep, for all vertical wall poles that do not press against horizontal brace poles near the ground.

27. Start placing the sloping end-wall poles. First place the longest pole, then the shorter poles all touching.

28. Across the open spaces between the 9-ft roof poles, place limbs and/ or sticks roughly horizontally, as shown in the lower left-hand drawing. Be sure to use limbs or sticks that have diameters of at least 1/2 in. and put them no farther apart than 6 in. Leave needles and leaves on the limbs. Do not leave sharp ends sticking upward. Do not place more than a 6-in.-thick mass of limbs and leaves over the side-poles. The thickness of the earth cover necessary for excellent fallout protection might be unintentionally reduced by making the limb cover too thick.

29. Place bed sheets (or 4-mil-thick polyethylene film or equally sturdy material) over the limbs and sticks to keep earth from falling through the roof.

30. To prevent sand or dry earth from falling between the cracks where the poles are side by side, cover these parts of the roof with cloth, plastic, or paper. If these materials are not available, use sticks, leaves, and grass. (In tick or chigger season, avoid using grass, or leaves from on or near the ground.)

31 After the entryways are completed, begin to cover the shelter with earth. Starting from the ground up, put on a full l-ft thickness of earth cover. First raise its height about a foot on one side or end of the shelter, and then on the other repeatedly. This is to prevent unequal loading from tipping the shelter or pushing it over. (Do not excavate any earth closer than 3 ft to the line of stakes marking the final outer edge of the completed, 2-ft-thick earth cover.)

32. Fill the spaces between the entryways and the main room only with earth. (An equal thickness of wood or other light material provides much less protection against radiation.)

33. Before placing the rain-proofing material for the 'buried roof," smooth the surface of the l-ft thick earth cover. This will prevent sharp rocks or sticks from puncturing the plastic or other rain-proofing material. If you do not have sufficient waterproofing materials to cover the whole roof, use what is available to rainproof the central part, on both sides of the ridgepole.

34. To prevent rainwater on the ground outside from running into the entryways, make mounds of packed earth about 4 inches high across the entryway floors, about 2 ft from their outer ends. Dig a shallow drainage ditch completely around the earth mounded over the shelter.

35. Unless the weather is cold, install your shelter ventilating KAP in the entry into which you can feel air moving naturally. (If short of time or materials, make a small Directional Fan.)

36. Complete the storage of water and other essentials.

37. To prevent fallout or rain from falling onto the floor of the outer entryways, place a small awning (not illustrated) over each opening.

38. Fill all available water containers, including pits which have been dug and lined with plastic, then roofed with available materials. If possible, disinfect all water stored in expedient containers, using one scant teaspoon of a chlorine bleach, such as Clorox, for each 10 gallons of water. Even if only muddy water is available, store it. If you do not have a disinfectant, it may be possible to boil water when needed.

39. Put all of your emergency tools inside your shelter.

40. As time and materials permit, continue to improve your chances of surviving by doing as many of the following things as possible:

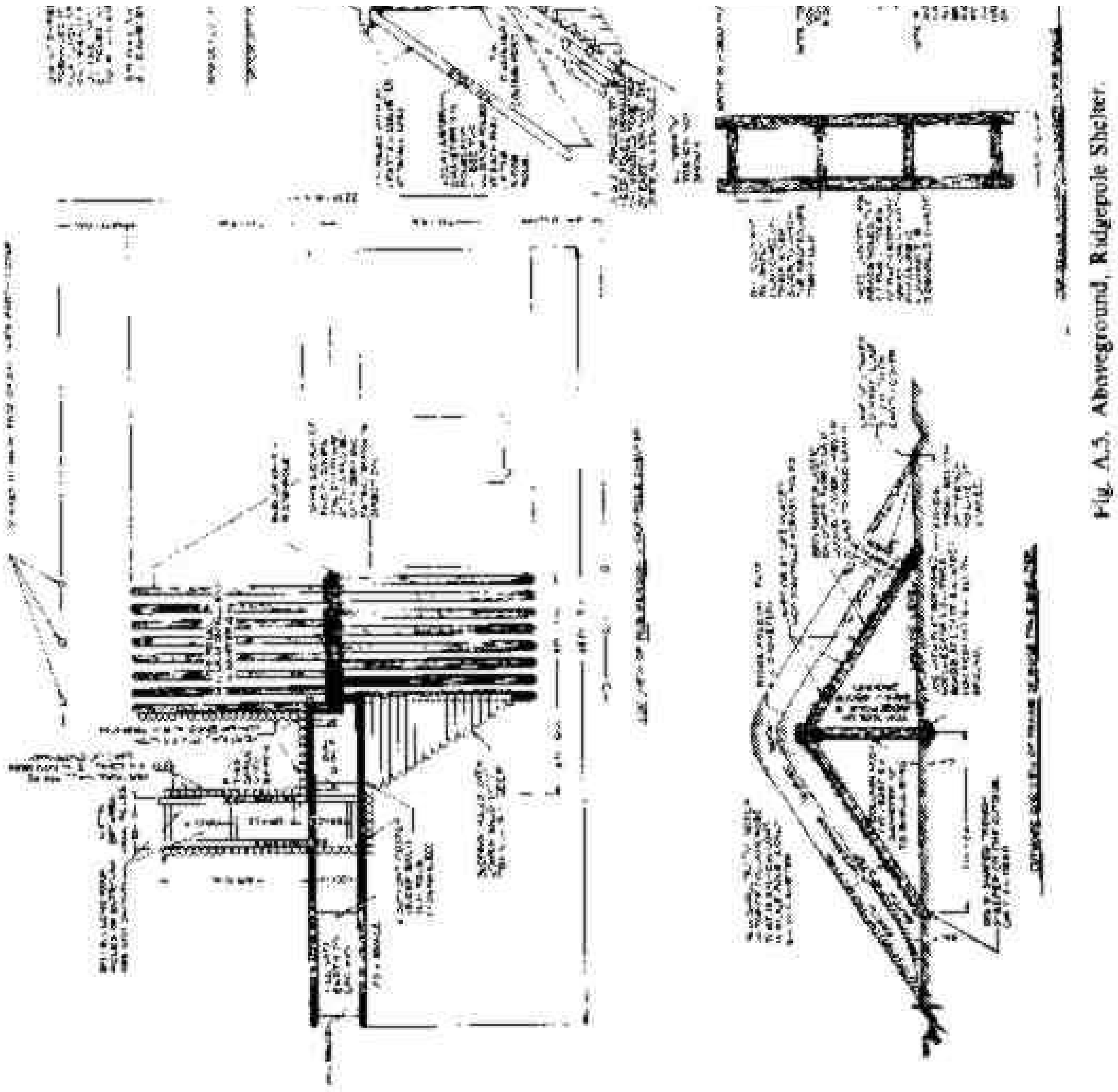
    (1) Make a homemade fallout meter, as described in Appendix C, and expedient lights. (Prudent people will have made these extremely useful items well ahead of time.)

    (2) Make and hang expedient bedsheet-hammocks.

    (3) Install screens or mosquito netting over the two openings, if mosquitoes or flies are a problem. Remember, however, that screen or netting reduces the air flow through a shelter even when the air is pumped through with a KAP.

    (4) Dig a stand-up hole near the far end of the shelter. Make the hole about 15 in. in diameter and deep enough to permit the tallest of the shelter occupants to stand erect

Fig. 5.A. Aboveground, Ridgepole Shelter.



Appendix A.6: Above Ground Crib-Walled Shelter

PROTECTION PROVIDED:

Against fallout radiation:

Protection Factor 200 (PF 200) if the earth-filled cribs are built to the full width of 3 ft, as illustrated in Fig. A.6 at the end of these instructions. A person in the open outside this shelter would receive about 200 times as much fallout radiation as he would if inside. If earth is mounded to the top of the walls and 3 ft deep over the roof, the protection factor can be raised to PF 500 or better. See the accompanying drawing at the end of Appendix A.6.

Against blast:

Better protection than most homes. Without blast doors, occupants could be injured although probably not fatally at lower overpressure ranges than those that would destroy this shelter.

Against fire:

Poor, if the shelter is built as illustrated. The cloth and outer poles would be unprotected from thermal pulse and other possible sources of intense heat. However, if earth is mounded around the walls so as to cover all exposed cloth and wood, good fire protection would be provided.

WHERE PRACTICAL:

The crib-walled shelter is practical in many wooded areas and whenever enough poles are available, or in locations where belowground expedient shelters are impractical because the water table or rock is too close to the surface for a covered- trench shelter.

FOR WHOM PRACTICAL:

This is a very practical shelter for a family or group with three or more members able to work very hard for most of 48 hours. An unskilled family with an ax or saw and materials found in most American homes can build this shelter. No nails are required. Groups with the nails, tools, skill, and the number of workers required to build a Ridgepole Shelter are advised to do so; a Crib-Walled Shelter requires almost twice the total length of poles and more work to provide shelter for a given number of persons.

CAPACITY:

The shelter illustrated in Fig. 6. 1 is the minimum length for 5 persons. For each additional person, add 1-1/2 ft to the length of the room. (If more than about 12 persons are to be sheltered, build 2 or more separate shelters.)

BUILDING INSTRUCTIONS:

1. Before beginning work, study the drawing and read ALL of the following instructions.
2. Divide the work. CHECK OFF EACH STEP WHEN COMPLETED.
3. By the time the shelter is finished, plan to have completed a ventilating pump (a KAP 20 in. wide and 26 in. high, essential for this shelter except in cool weather) and the storage of at least 15 gallons of water per occupant. (See Appendix B and Chapter 8.)
4. Start to assemble materials and tools.

   A. Essential Materials and Tools

   ° Poles. (Fresh-cut, green poles are best; sound, untreated poles are satisfactory.) For the illustrated 5-person shelter, the required poles are listed on the following page.

      a This width is the distance measured across a single layer laid on the ground side by side and touching, with large ends of poles when a sufficient number of them are and small ends alternating so as to cover a rectangular area.

Use	Pole Length	Minimum Diameter of Small End	Number of Poles Required	Width When All Are Laid on the Ground a
Sides of longest crib	12-1/2 ft	3 in.		7 ft
Sides of middle-sized crib	10 ft	3 in.		7 ft
Sides of shortest crib	7 ft	3 in.		7 ft
Ends of all cribs	3-1/2 ft	3 in.		21 ft
Vertical poles at the corners of all cribs	3-1/2 ft	2 in.	56	
Main roof	9 ft	3-1/2 in.		12 ft
Entryway roofs	5 ft.	2-1/2 in.		22 ft

° A saw (preferably a bow saw with an extra blade, or a crosscut saw) and/ or an ax for cutting green poles.

° Containers for storing 15 gallons of water per occupant. (See Chapter 8.)

° A shovel (one for each two workers is desirable).

° A pick (if the ground is very hard).

° Two to five large cans, buckets, and/ or pots with bail handles, in which to carry earth and to store water or wastes later.

° A knife.

° A minimum of 300 ft of wire at least as strong as clothesline wire. Second choice would be 300 ft of rope, or (third choice) 8 double-bed sheets that could be torn into 1-ft wide strips and twisted slightly to serve as rope. For each additional person beyond 5, supply 20 ft of wire or rope or half a double-bed sheet.

° Rainproof roofing materials at least 2 square yards per person. Such materials as plastic film, shower curtains, plastic tablecloths or plastic mattress covers can be used. These materials are essential for prolonged shelter occupancy in rainy, cold weather.

° Fifteen double-bed sheets (or equal square-yardage of other strong cloth or plastic).

° Materials for building a ventilating pump, a KAP 20 inches wide and 30 in. high. (See Appendix B.)

B. Useful Materials and Tools

° Additional saws and shovels, chain saw, pick-mattock, hammer, hatchet.

° Kerosene, turpentine, or oil to keep a hand-saw from sticking in gummy wood.

° A file.

° Two additional double-bed sheets per person, or equivalent square-yardage of other equally strong fabric or plastic.

° A measuring tape, yardstick, or ruler.

- ° Old newspapers (about 15 pounds).
- ° A total of 30 square yards of rain-proofing materials for the illustrated 5-person shelter, and 3 square yards for each additional person to be sheltered. (Even thin plastic will serve to make a rainproof "buried roof.")

5. To save time and work, SHARPEN ALL TOOLS AND KEEP THEM SHARP.
6. Wear gloves from the start. Even tough hands can blister and become painful and infected after hours of digging and chopping.
7. Select a shelter location where there is little or no chance of the ground being covered with water by a hard rain.
8. If the building site is near the edge of a woods, pick a site at least 40 ft from the nearest trees to avoid roots.
9. Clear off grass, weeds, etc., from the area where you plan to build the shelter this also will help to avoid chiggers or ticks. Do not remove any earth.
10. Stake out the entire shelter, locating the 6 required cribs. BE SURE TO MAKE THE INSIDE LENGTH OF THE MAIN ROOM EQUAL TO THE NUMBER OF PERSONS TO BE SHELTERED MULTIPLIED BY 1-1/2 FT. The illustrated shelter is sized for 5 persons, and the poles listed are those required for this 5-person shelter.
11. While some persons are staking out the shelter, others should be cutting green poles and hauling them to the site. Cut poles with tops no smaller than the diameters specified. (Note: the specified diameters do not include bark.)
12. Select poles with small-end diameters no more than 50% larger than the specified minimum diameters, to make handling of the long wall and roof poles easier.
13. Sort the poles by length and diameter and lay all poles of each size together, near the excavation.
14. Use larger trees and poles, up to 6 in. in diameter, to make the 3-1/2-ft-long end-poles of the cribs (Fig. A.6). Do not use poles with small-end diameters of less than 3 in. for the side-wall poles of the cribs. For vertical brace-poles, use poles with diameters of at least 2 in., cut off at the height of the upper side of the uppermost horizontal poles against which they are tied.
15. Be sure to cut off all limbs so that the poles are quite smooth. Usually it is easier to drag smoothed poles to the building site before cutting them into the required lengths. Pull them by the small, lighter ends.
16. Determine if there are enough long poles to make the side-poles of the two cribs forming the sides of the shelter room without splicing two shorter poles together. If the shelter is being built for more than 7 persons, it will require side poles that are longer than 15-1/2 ft. Therefore, if a shelter for more than 7 persons is being built, it would be best to use 2 cribs placed end-to-end on each side of the shelter room, instead of a single crib as illustrated by Fig. A.6.
17. Place the lowermost four poles of each of the cribs in their final positions, so that all the bases of the crib-walls are in position on the ground. Use the thicker, heavier poles at and near the bottom of each crib. BE SURE THE ROOM IS LONG ENOUGH TO PROVIDE 1-1/2 FT OF ROOM LENGTH FOR EACH PERSON TO BE SHELTERED.
18. To build each crib:
    (1) Place two 3-1/2-ft end-poles on the ground. Put two of the side-poles on top of the two end-poles so that the ends of all four poles extend 3 in. (no more) beyond where they cross. The thicker poles should be used first to add stability.
    (2) Stack additional pairs of end-poles and side- poles to form the crib, keeping each wall of the crib vertical, until the tops of the uppermost side-poles are at least 42 in. above the ground. To keep the uppermost poles of the crib about level while the crib is being raised, alternate the large ends and small ends of poles.

(3) Place a pair of small, vertical brace-poles in each of the four corners of the crib. The tops of the vertical brace-poles should be no higher above the ground than the upper sides of the crib's uppermost horizontal poles.

(4) Tie each pair of vertical brace-poles together tightly at bottom, middle, and top. For tying, use 3-ft lengths of strong wire, rope, or slightly twisted, foot-wide strips of cloth at least as strong as cotton bed sheeting. Square knots with back-up overhand knots are best, but three overhand knots one on top oft he other will hold.

(5) If the crib is more than 8 ft long, place an additional pair of vertical brace-poles, with one in position at the outside center of each long crib-wall. Tie this pair of vertical brace- poles together permanently just above the ground, but not yet in the middle or near the top of the crib. Temporarily tie each of these center vertical brace-poles to the uppermost side-pole of the wall it touches.

(6) Line the crib with cloth or plastic film, making sure that several inches of the lining hangs over the uppermost poles. So that the lining will not be pulled down when the crib is being filled with earth, tie the upper edge of the lining to the uppermost wall pole about every 2 ft. First cut a small hole through which to thread a tie-string or a 2-in.-wide tie-strip of cloth. (If plenty of cloth and/ or plastic is available for lining the cribs, secure the lining by simply wrapping a greater width of the upper edge of the lining around the uppermost crib wall-pole.)

(7) Permanently tie together the pair of vertical center brace-poles, using horizontal ties at their centers and just below the uppermost horizontal wall-poles of the crib. Use the strongest material you have for these horizontal ties across the center of the crib.

(8) Excavate earth 10 ft or so beyond the outer sides of the cribs. To save work, carry it in buckets and dump it inside the cribs. (Two children can carry a heavy bucket of earth by running a strong, 4-ft stick through the bail or handle of the bucket and tying the bail to the center of the stick before lifting.) Save earth closer to the cribs to put on the roof.

(9) Fill the lined crib with earth from which almost all grass, roots, and the like have been removed. Avoid placing hard lumps of earth in contact with the lining. Fill the crib so that the surface of the earth inside it is about 4 in. above the upper sides of the uppermost horizontal poles.

19. Line the narrow spaces between adjacent cribs with cloth or plastic; then fill these spaces with earth a little at a time, tamping repeatedly so as to avoid leaving air spaces.

20. Place the 9-ft roof poles over the main room. (If poles are unavailable and boards 1-1/2 in. thick are available, use two thicknesses of boards.) Use the strongest roof poles (or double-thickness boards nailed together) nearest the entryways. Then put shorter, 5- or 6-ft poles or boards over the entryways.

21 To keep earth from falling through the cracks between the roof poles, put sticks in the larger cracks and cover the roof with two or more thicknesses of cloth, plastic, or other material. Newspapers will do, if better materials are lacking.

22. Put earth on the roof to the depths shown for the illustrated "buried roof." Be sure to slope all sides and smooth this gently mounded earth surface so that the buried roof will shed water.

23. So that the earth cover near the outer edges of the roof will be a full 2 ft thick, make the earth cover slope steeply near the edges. Steep earth slopes can be made and kept stable by using large lumps of turf to make a steep bank, or by using earth-filled "rolls" of cloth or other material along the edges of a roof.

24. Put in place the waterproof material of the buried roof.

25. Pile on the rest of the earth cover, as illustrated, to at least a full 2-ft thickness.

26. Smooth the surface of the earth cover, including the sides, so that rain will run off. Do not walk on the finished roof.

27. To prevent rainwater on the ground outside from running into the entryways, make mounds of packed earth about 4 in. high across the entryway floors. Make the mounds about 2 ft from the outer ends of the floors. Dig a shallow drainage ditch completely around the shelter.

28. Unless the weather is cold, install your shelter ventilating KAP in the entry into which you can feel air moving naturally. (If short of time or materials, make a small Directional Fan.)

29. To prevent fallout or rain from falling onto the floor of the outer entryways, place small awnings (not illustrated) over the openings.

30. If time and energy are available, mound earth all around the shelter. Doing so will reduce fire hazards by covering flammable materials; it also will increase fallout protection.

31. Fill all available water containers, including pits which have been dug and lined with plastic, then roofed with available materials. If possible, disinfect all water stored in expedient containers, using one scant teaspoon of a chlorine bleach, such as Clorox, for each 10 gallons of water. Even if only muddy water is available, store it. If you do not have a disinfectant, it may be possible to boil water when needed.

32. Put all of your emergency tools inside your shelter.

33. As time and materials permit, continue to improve your chances of surviving by doing as many of the following things as possible:

    (1) Make a homemade fallout meter, as described in Appendix C, and expedient lights. (Prudent people will have made these extremely useful items well ahead of time.)

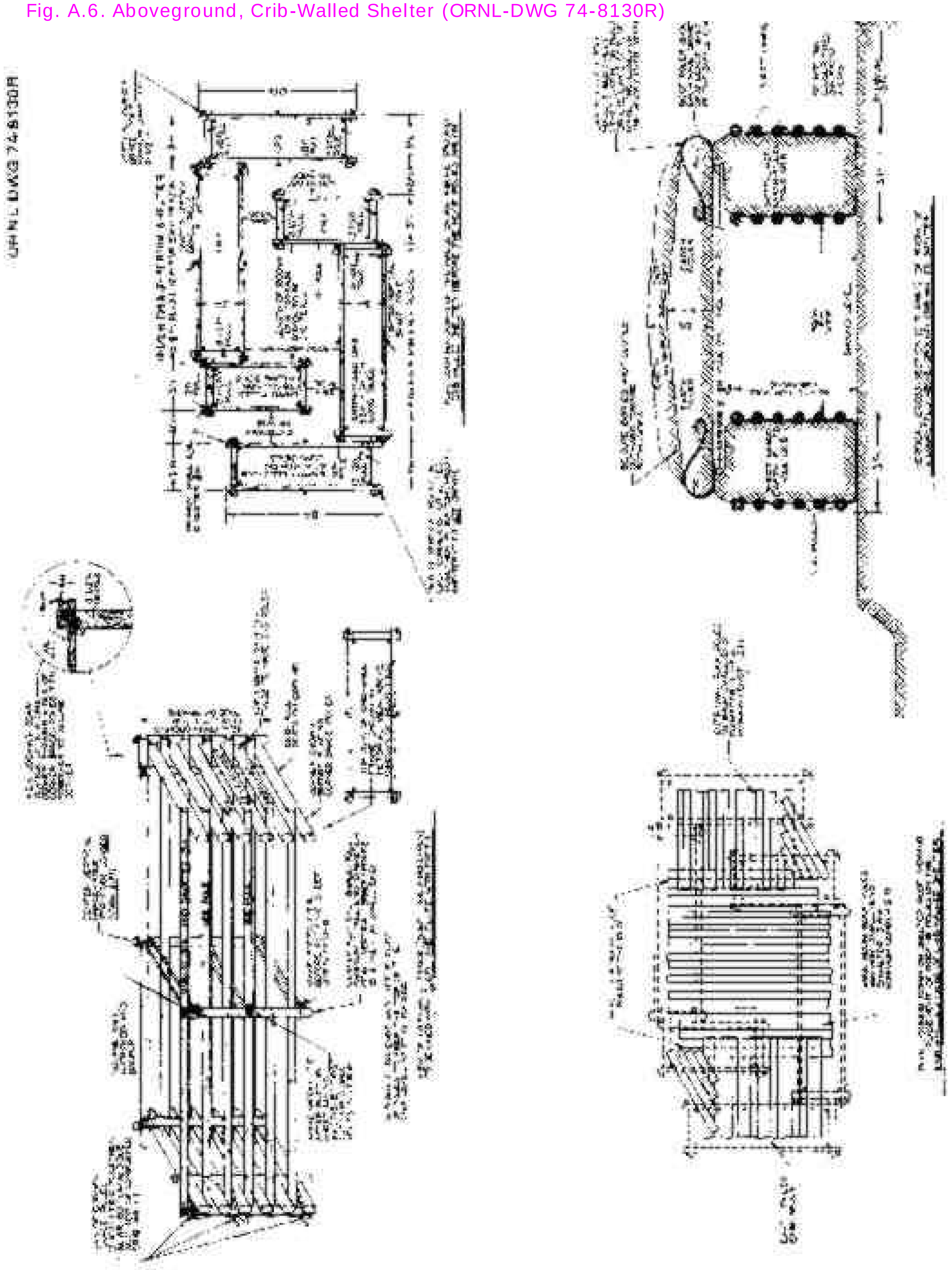
    (2) Make and hang expedient bedsheet-hammocks.

    (3) Install screens or mosquito netting over the two openings, if mosquitoes or flies are a problem. Remember, however, that screen or netting reduces the air flow through a shelter even when the air is pumped through with a KAP.

    (4) Dig a stand-up hole near the far end of the shelter. Make the hole about 15 in. in diameter and deep enough to permit the tallest of the shelter occupants to stand erect occasionally.

34. See Below for Illustration of an Above Ground, Crib-Walled Shelter.

Fig. A.6. Aboveground, Crib-Walled Shelter (ORNL-DWG 74-8130R)



Appendix B: How to Make and Use a Homemade Shelter-Ventilating Pump

I. THE NEED FOR SHELTER AIR PUMPS:

In warm weather, large volumes of outside air MUST be pumped through most fallout or blast shelters if they are crowded and occupied for a day or more. Otherwise, the shelter occupants' body heat and water vapor will raise the temperature-humidity conditions to DANGEROUSLY high levels. If adequate volumes of outdoor air are pumped through typical belowground shelters in hot weather, many times the number of persons could survive the heat than otherwise could survive in these same shelters without adequate forced ventilation. Even in cold weather, about 3 cubic feet per minute (3 cfm) of outdoor air usually should be pumped through shelters, primarily to keep the carbon dioxide exhaled by shelter occupants from rising to harmful concentrations.

The KAP (Kearny Air Pump) is a practical, do- it-yourself device for pumping adequate volumes of cooling air through shelters with minimum work. The following instructions have been improved repeatedly after being used by dozens of small groups to build KAPs including families, pairs of housewives, and children. None of these inexpert builders had previously heard of this kind of pump, yet almost all groups succeeded in making one in less than 4 hours after assembling the materials. Their successes prove that almost anyone, if given these detailed and thoroughly tested instructions, can build a serviceable, large-volume air pump of this simple type, using only materials and tools found in most American homes.

If possible, build a KAP large enough to pump through your shelter at least 40 cubic feet per minute (40 cfm) of outdoor air for each shelter occupant. If 40 cfm of outdoor air is pumped through a shelter and distributed within it as specified below, even under heat-wave conditions the effective temperature of the shelter air will not be more than 20 F higher than the effective temperature outdoors. (The effective temperature is a measure of air's effects on people due to its heat, humidity, and velocity.) The 36-inch-high by 29-inch-wide KAP described in these instructions, if used as specified, will pump at least 1000 cfm of outside air through a shelter that has the airflow characteristics outlined in these instructions.

If more than 25 persons might be expected to occupy a shelter during hot weather, then it is advisable to build a larger KAP. The 72-inch-high by 29-inch-wide model described can pump between 4000 and 5000 cfm.

To maintain tolerable temperature-humidity conditions for people in your shelter during hot weather, you must:

- Pump enough outdoor air all the way through the shelter (40 cfm for each occupant in very hot, humid weather).
- Distribute the air evenly within the shelter. If the KAP that pumps air through the shelter does not create air movement that can be felt in all parts of the shelter in hot weather, one or more additional KAPs will be needed to circulate the air and gently fan the occupants.
- Encourage the shelter occupants to wear as little clothing as practical when they are hot. (Sweat evaporates and cools best on bare skin.)
- Supply the occupants with adequate water and salt. For prolonged shelter occupancy under heat-wave conditions in a hot part of the country, about 4 quarts of drinking water and 1/3 ounce (1 tablespoon) of salt per person are required every 24 hours, including salt in food that is eaten. Normal American meals supply about 1/4 ounce of salt daily. Salt taken in addition to that in food should be dissolved in the drinking water.
- Pump outdoor air through your shelter day and night in warm weather, so that both the occupants and the shelter are cooled off at night.

Almost all of the danger from fallout is caused by radiation from visible fallout particles of heavy, sand- like or flaky material. The air does not become radioactive due to the radiation continuously given off by fallout particles.

The visible fallout particles rapidly "fall out" of slow moving air. The air that a KAP pumps through a shelter moves at a low speed and could carry into the shelter only a very small fraction of the fallout particles that cause the radiation hazard outside. This fraction, usually not dangerous, can be further reduced if occupants take the simple precautions described in these instructions.

CAUTION:

Before anyone starts to build this unusual type of air pump, ALL WORKERS SHOULD READ THESE INSTRUCTIONS AT LEAST UP TO SECTION V, INSTALLATION. Otherwise mistakes may be made and work may be divided inefficiently.

When getting ready to build this pump, all workers should spend the first half-hour studying these instructions and getting organized. Then, after materials are assembled, two inexperienced persons working together should be able to complete the 3-foot model described in the following pages in less than 4 hours. To speed up completion, divide the work; for example, one person can start making the flaps while another begins work on the pump frame.

II. HOW A KAP WORKS

As can be seen in Figs. 1 and 2, a KAP operates by being swung like a pendulum. It is hinged at the top of its swinging frame. When this air pump is pulled by a cord as illustrated, its flaps are closed by air pressure and it pushes air in front of it and "sucks" air in back of it. Thus a KAP pumps air through the opening in which it swings. This is the power stroke. During its power stroke, the pump's flaps are closed against its flap-stop wires or strings, which are fastened across the face of the frame.

Fig. 1. Section through the upper part of a doorway, showing operation of a KAP. (ORNL-DWG 66-12320A)

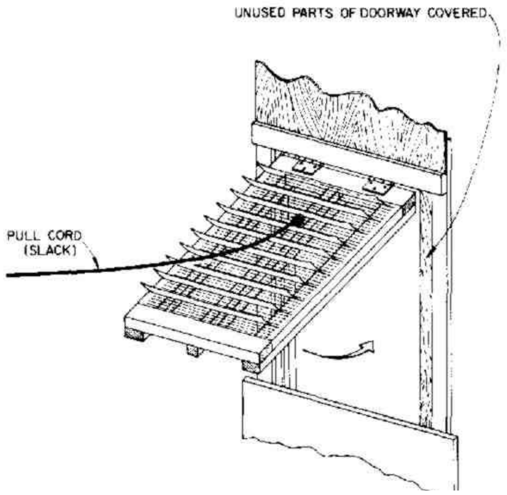
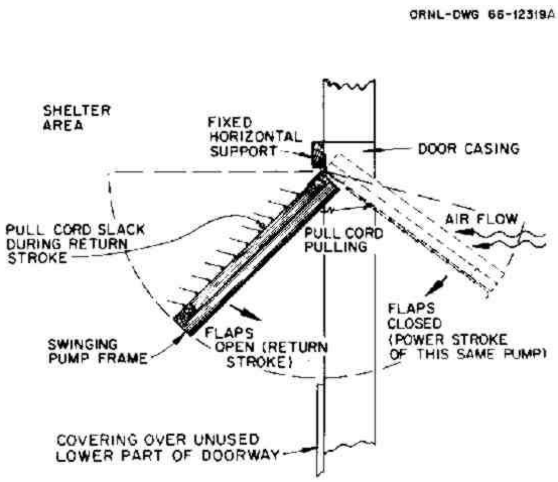


Fig. 2. KAP in doorway (with flaps open during its return stroke). (ORNL-DWG 66-12319A)



When a KAP swings freely back as a pendulum on its return stroke, all its flaps are opened by air pressure. The pumped air stream continues to flow in the direction in which it has been accelerated by the power stroke, while the pump itself swings in the opposite direction (see Fig. 2). Thus the flaps are one-way valves that operate to force air to flow in one direction, where desired.

The KAP can be used: (1) to supply outdoor air to a shelter, (2) to distribute air within a shelter, and/or to fan the occupants.

1. To force outdoor air through a shelter, an air- supply KAP usually is operated as an air-intake pump by pulling it with a cord (see Fig. 1). (Only rarely is it necessary to operate a KAP as an air- exhaust pump by pushing it with a pole, as described in the last section of these instructions.)
2. To distribute air within a shelter and/or to fan the occupants, air-distribution KAPs may be hung overhead and operated as described later.

III. INSTRUCTIONS FOR BUILDING A KAP:

In this section, instructions are given for making a KAP 36 inches high and 29 inches wide, to operate efficiently when swinging in a typical home basement doorway 30 inches wide. If your doorway or other ventilation opening is narrower or wider than 30 inches, you should make your KAP 1 inch narrower than the narrowest opening in which you plan to install it. Regardless of the size of the KAP you plan to build, first study the instructions for making the 36 X 29-inch model.

In Section VII you will find brief instructions for making a narrower and even simpler KAP, one more suitable for the narrow openings of small trench shelters and other small expedient shelters. Section VIII covers large KAPs, for large shelters.

A. Materials Needed for a KAP 36 inches High by 29 inches Wide:

The preferred material is listed as first (1st) choice, and the less-preferred materials are listed as (2nd), (3rd), and (4th) choices. It is best to assemble, spread out, and check all your materials before beginning to build.

1. The pump frame and its fixed support:
   - Boards for the frame:
     - (1st) 22 ft of 1 X 2-in. boards. (A nominal 1 X 2-in. board actually measures about 3/4 x I-3/4 in., but the usual, nominal dimensions will be given throughout these instructions.) Also, 6 ft of 1 X 1-in. boards. Soft wood is better.
     - (2nd) Boards of the same length that have approximately the same dimensions as 1 X 2- in. and 1 X 1-in. lumber.
     - (3rd) Straight sticks or metal strips that can be cut and fitted to make a flat-faced KAP frame.
   - Hinges: (1st) Door or cabinet butt-hinges; (2nd) metal strap-hinges; (3rd) improvised hinges made of leather, woven straps, cords, or 4 eye-screws which can be joined to make 2 hinges. (Screws are best for attaching hinges. If nails are used, they should go through the board and their ends should be bent over and clinched flattened against the surface of the board.)
   - A board for the fixed horizontal support: (1st) A 1 X 4-in. board that is at least 1 ft longer than the width of the opening in which you plan to swing your pump; (2nd) A wider board.
   - Small nails (at least 24): (1st) No. 6 box nails, about 1/2 in. longer than the thickness of the two boards, so their pointed ends can be bent over and clinched); (2nd) other small nails.
2. The flaps (See Figs. 1, 2, 6, 7, and 8):
   - Plastic film or other very light, flexible material -- 12 square feet in pieces that can be cut into 9 rectangular strips, each 30 X 5-1/2 in.: (1st) polyethylene film 3 or 4 mils thick (3 or 4 one-thousandths of an inch); (2nd) 2-mil polyethylene from large trash bags; (3rd) tough paper.
   - Pressure-sensitive waterproof tape, enough to make 30 ft of tape 3/4 in. to 1 in. wide, for securing the hem-tunnels of the flaps: (1st) cloth duct tape (silver tape); (2nd) glass tape; (3rd)

scotch tape; (4th) freezer or masking tape, or sew the hem tunnels. (Do not use a tape that stretches: it may shrink afterward and cause the flaps to wrinkle.)

3. The flap pivot-wires:

   (1st) 30 ft of smooth wire at least as heavy and springy as coat hanger wire, that can be made into very straight pieces each 29 in. long (nine all-wire coat hangers will supply enough);

   (2nd) 35 ft of somewhat thinner wire, including light, flexible insulated wire;

   (3rd) 35 ft of smooth string, preferably nylon string about the diameter of coat hanger wire.

4. The pull cord:

   - (1st) At least 10 ft of cord; (2nd) strong string; (3rd) flexible, light wire.

5. The flap-stops:

   - (1st) 150 ft of light string; (2nd) 150 ft of light, smooth wire; (3rd) 150 ft of very strong thread; (4th) 600 ft of ordinary thread, to provide 4 threads for each stop-flap.
   - (1st) 90 tacks (not thumbtacks); (2nd) 90 small nails. (Tacks or nails are desirable but not essential, since the flap-stops can be tied to the frame.)

B. Tools:

A hammer, saw, wire-cutter pliers, screwdriver, scissors, knife, yardstick, and pencil are desirable. However, only a strong, sharp knife is essential for making some models.

C. Building a KAP 36 inches High by 29 inches Wide:

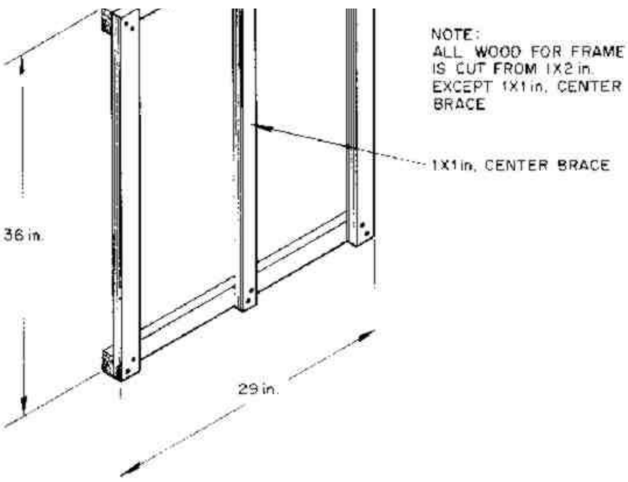
A 36 X 29-in. KAP is most effective if operated in an air-intake or exhaust opening about 40 in. high and 30 in. wide. (If your shelter might have more than 25 occupants in hot weather, read all these instructions so you will understand how to build a larger pump, briefly described in Section VIII.)

NOTE THAT THE WIDTHS AND THICKNESSES OF ALL FRAME PIECES ARE EXAGGERATED IN ALL ILLUSTRATIONS.

1. The frame

   a. Cut two pieces of 1 X 2-in. boards, each 36 in. long, and two pieces of 1 X 2-in. boards, each 29 in. long; then nail them together (see Fig. 3). Use nails that do not split the wood, preferably long enough to go through the boards and stick out about 1/2 in. on the other side. (To nail in this manner, first put blocks under the frame so that the nail points will not strike the floor.) Bend over nail points which go through.
   Next, cut and nail to the frame a piece of 1 X 1-in. lumber 36 in. long, for a center vertical brace. (If you lack time to make or to find a 1 X 1-in. board, use a 1 X 2-in. board.) Figure 3 shows the back side of the frame; the flap valves will be attached on the front (the opposite) side.

Fig. 3. KAP frame (looking at the back side of the frame). ORNL 71-7003



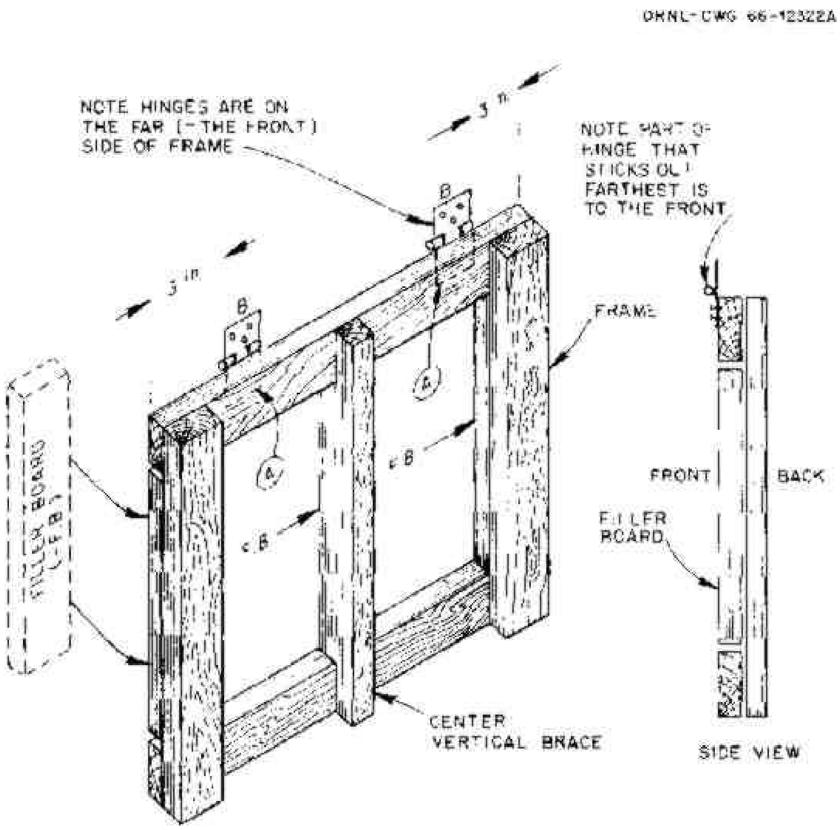
b. To make the front side smooth and flat so that the flaps will close tightly, fill in the spaces as follows: Cut two pieces of 1 X 2-in. boards long enough to fill in the spaces on top of the 36-in. sides of the frame between the top and bottom horizontal boards, and nail these filler boards in place. Do the same thing with a 1 X 1-in. board (or a board the size of that used for the center brace) as a filler board for the center brace (see Fig. 4).

If the frame is made of only one thickness of board 3/4 in. to 1 in. thick, it will not be sufficiently heavy to swing back far enough on its free-swinging return stroke.

2. The hinges

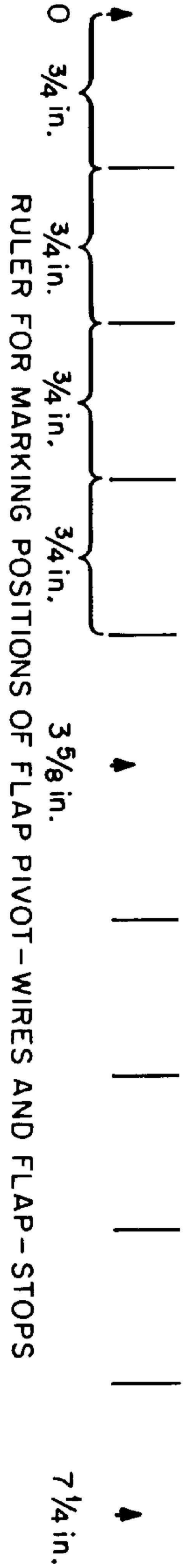
Ordinary door butt-hinges are best. So that the pump can swing past the horizontal position, the hinges should be screwed onto the front of the frame, at its top, in the positions shown in Fig. 4. (Pick one of the 29-in. boards and call it the top.) If you do not have a drill for drilling a screw hole, you can make a hole by driving a nail and then pulling it out. Screw the screw' into the nail hole.

Fig. 4. Completing the frame. ORNL- DWG 66-12322A



3. The pivot-wires and flaps

a. Make 9 flap pivot-wires. If you have smooth, straight wire as springy and thick as coat hanger wire, use it to make nine 29-in.-long straight lengths of wire. If not, use wire from all-wire coat hangers or use strings. First cut off all of the hook portion of each coat hanger, including the twisted part. If you have only ordinary pliers, use the cutter to "bite" the wire all around; it will break at this point if bent there. Next, straighten each wire carefully. Straighten all the bends so that each wire is straight within 1/4 in., as compared to a straight line. Proper straightening takes 1 to 5 minutes per wire. To straighten, repeatedly grasp the bent part of the wire with pliers in slightly different spots, each time bending the wire a little with your other hand. Then cut each wire to a 29-in. length. Finally, bend no more than 1/2 in. of each end at a right angle and in the same plane that is, in directions so that all parts of the bent wire will lie flat against a smooth surface. The bent ends are for secure attachment later (see Fig. 8).



) polyethylene flaps that will be the hinged valves of the KAP. First cut 9 strips, making :rip 30 in. long by 5-1/2 in. wide (see Fig. 5). To cut plastic flaps quickly and accurately, ɔng strip of plastic 30 in. wide. Then cut off a flap in this way: (1) draw a cutting guideline ide board 5-1/2 in. from an edge; (2) place the 30-in.-wide plastic strip so that it lies on ard, with one of the strip's side edges just reaching the edge of the board; (3) place a board over the plastic on the first board, with a straight edge of this second upper board ıe guideline on the lower board; and finally (4) cut off a flap by running a sharp knife he straight edge of the upper board.

Fig. 5 7004A

To form a hem along one of the 30-in. sides of a 5-1/2 X 30-in. rectangular strip, fold in a 1-in. hem. This makes the finished flap 4-1/2 in. wide.

To hold the folded hem while taping it, paper clips or another pair of hands are helpful. For each hem, use two pieces of pressure-sensitive tape, each about 1 in. wide and 16 in. long. Or make the hem by sewing it very close to the cut edge to form a hem-tunnel (see Fig. 5).

After the hem has been made, cut a notch with scissors in each hemmed corner of the flap (Figs. 6 and 8). Avoid cutting the tape holding the hem. Each notch should extend downward about 1/2 in. and should extend horizontally from the outer edge of the flap to 1/4 in. inside the inner side of the frame, when the flap is positioned on the frames as shown in Fig. 6.

Fig. 6. Sizes of notches in flaps. ORNL-DWG 66-12324

ORNL-DWG 66-12324

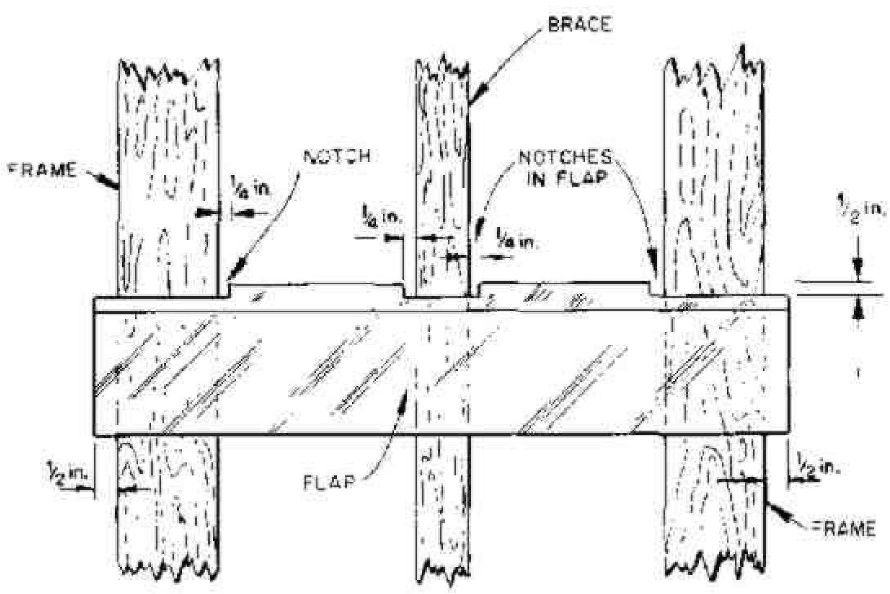


Fig. 6. Sizes of notches in flaps.

Also cut a notch in the center of the flap (along the hem line) extending 1/2 in. downward and extending horizontally 1/4 in. beyond each of the two sides of the vertical brace (see Fig. 6). The notch MUST be wider than the brace. [However, if you are building a pump using wire netting for flap-stops (see Fig. 13), then do NOT cut a notch in the center of each flap.]/P>

c. Take the 9 pieces of straightened wire and insert one of them into and through the hem-tunnel of each flap, like a curtain rod running through the hem of a curtain. Check to see that each flap swings freely on its pivot-wire, as illustrated by Fig. 7. Also see Fig. 8.

Fig. 7. End view. ORNL-DWG 66-12325

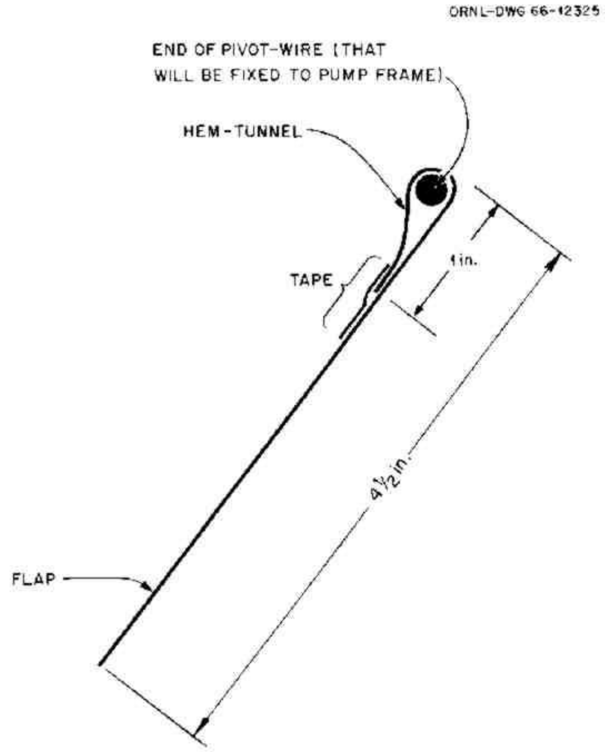


Fig. 7. End view.

Fig. 8. Flap. ORNL DWG 71-7005A

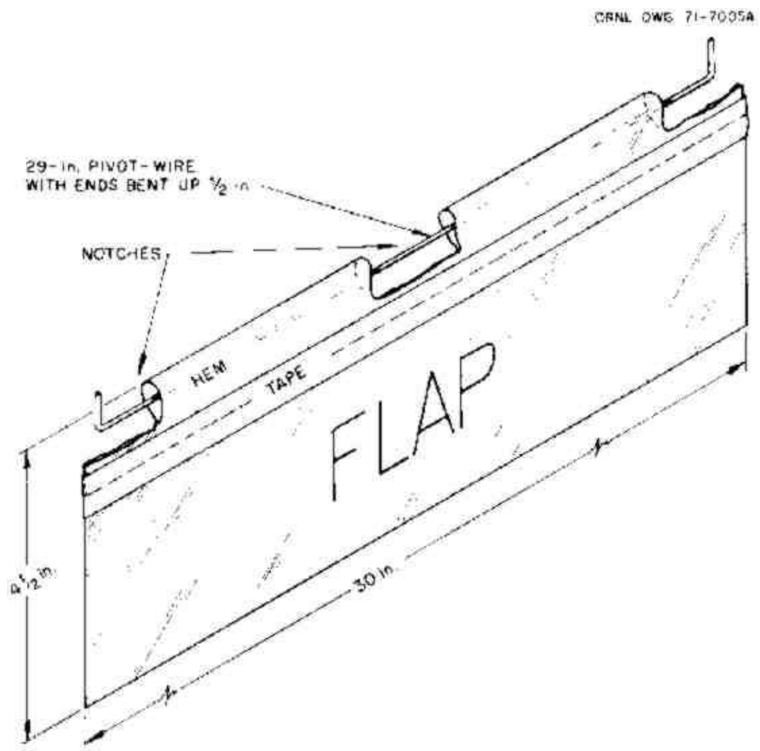


Fig. 8.

Ruler for Marking Positions of Flap Pivot - Wires and Flap-Stops

d. Put aside the flaps and their pivot-wires for use after you have attached the flap-stops and the hinges to the frame, as described below.

e. Using the ruler printed on the edge of this page, mark the positions of each pivot-wire (the arrowheads numbered 0, 3-5/8, 7-1/4 in.) and the position of each flap-stop (the four marks between each pair of numbered arrowheads on this ruler). All of these positions should be marked both on the vertical sides of the 36-in.-long boards of the frame and on the vertical brace. Mark the position of the uppermost pivot-wire (the "0" arrowhead on this ruler) 1/4 in. below the top board to which the hinges have been attached (see Figs. 9 and 10).

Fig. 9. (Frame 3/4 View) ORNL DWG 71-7006A

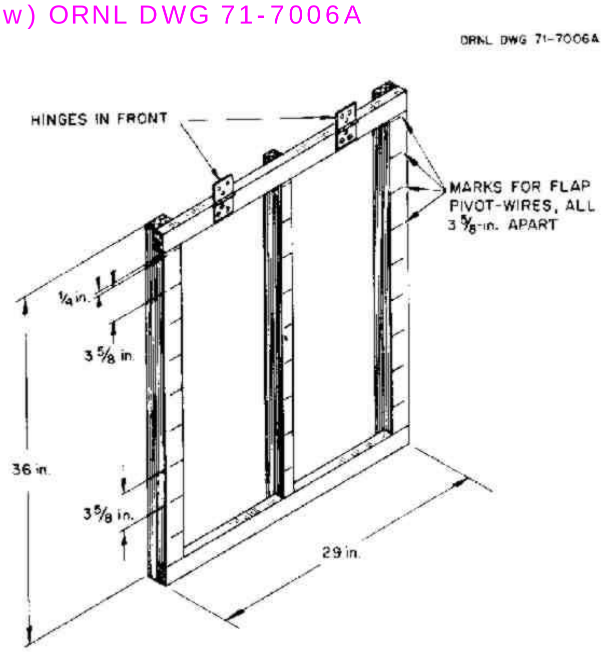


Fig. 9.

Fig. 10. (Top of Frame Straight on View) ORNL-DWG 66-12328A

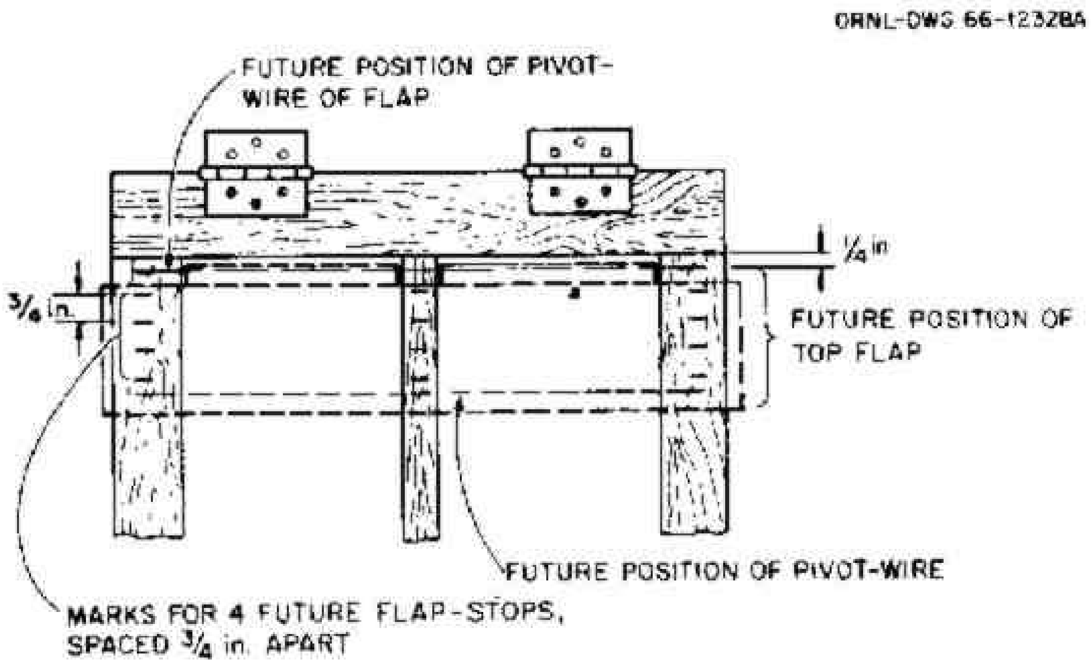


Fig. 10.

4. The Flap-Stops

So that the flaps may swing open on only one side of the frame (on its front, or face), you must attach horizontal flap-stops made of strings or wires across the face of the frame. (See Figs. 10 and 11.) Nail or tie four of these flap-stops between the marked points where each pair of the horizontal pivot-wires for the flaps will be placed. Be careful not to connect any flap-stops in such a way that they cross the horizontal open spaces in which you later will attach the flap pivot-wires.

Fig. 11. Positions of pivot-wires and flap-stops. ORNL -DWG 71-7007A

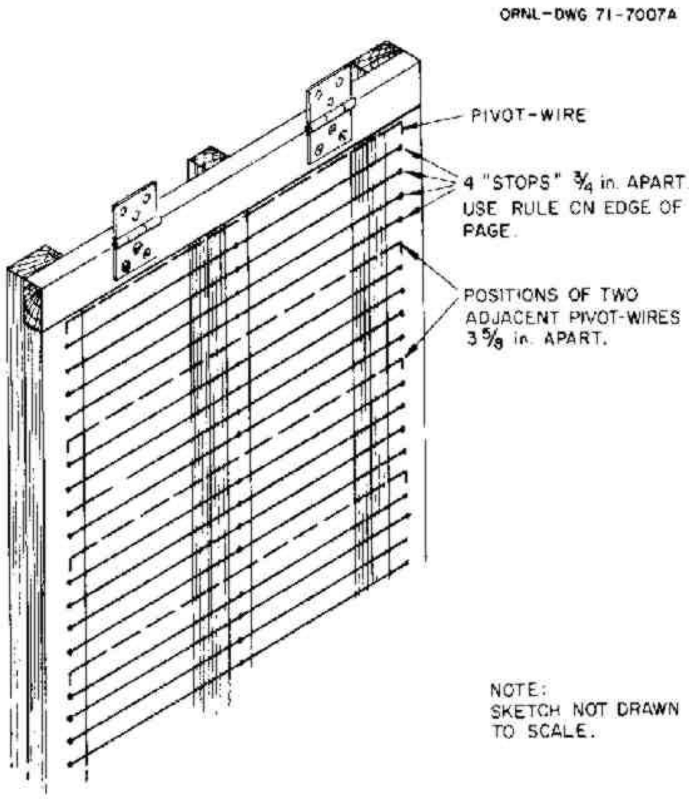


Fig. 11. Positions of pivot-wires and flap-stops.

If you have tacks (NOT thumbtacks) or very small nails, drive three in a horizontal line to attach each flap-stop-one in each of the two vertical 36-in. sides of the frame and one in the vertical center brace (see Fig. 11). First, drive all of these horizontal lines of tacks about three-quarters of the way into the boards. Then, to secure the flap-stop string or thin wire quickly to a tack, wind the string around the tack and immediately drive the tack tightly into the frame to grip the string (see Fig. 11).

If you have no tacks or nails, cut notches or slots where the flap-stops are to be attached. Cut these notches in the edges of the vertical sides of the frame and in an edge of the center brace. Next, secure the flap-stops (strings or wires) by tying each one in its notched position. This tying should include wrapping each horizontal flap-stop once around the vertical center brace. The stops should be in line with (in the same plane as) the front of the frame. Do not stretch flap-stops too tightly, or you may bend the frame.

5. Final assembly

a. Staple, nail, or tie the 9 flap pivot-wires or pivot-strings (each with its flap attached) in their positions at the marked 3-5/8 in. spacing. Start with the lowest flap and work upward (see Fig. 11). Connect each pivot-wire at both ends to the 36-in. vertical sides of the frame. Also connect it to the vertical brace. BE CAREFUL TO NAIL THE PIVOT-WIRES ONLY TO THE FRAME AND THE BRACE. DO NOT NAIL ANY PLASTIC DIRECTLY TO THE WOOD. All flaps must turn freely on their pivot-wires.

If any flap, when closed, overlaps the flap below it by more than 1 in.. trim off the excess so that it overlaps by only 1 in.

b. Screw (or nail, if screws are not available) the upper halves of the hinges onto the horizontal support board on which the KAP will swing. (A l-in.-thick board is best, 3-1/2 in. wide and at least 12 in. longer than the width of the doorway or other opening in which this KAP is to be installed.)

Be careful to attach the hinges in the UNUSUAL, OUT-OF-LINE POSITION shown in Fig. 12.

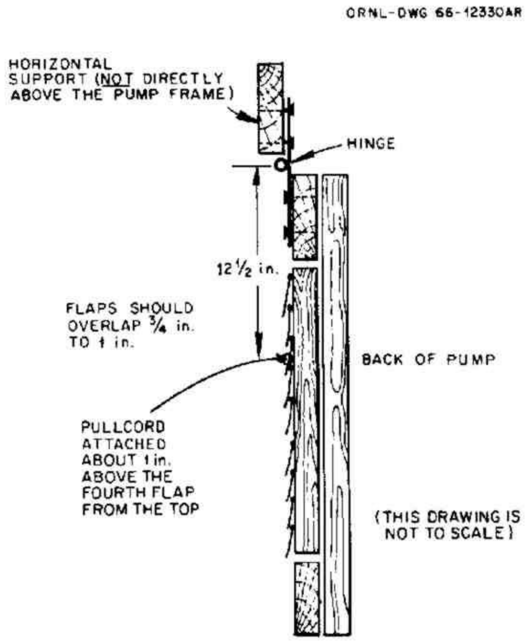
CAUTIONS: Do NOT attach a KAP's hinges directly to the door frame. If you do, the hinges will be torn loose on its return stroke or on its power stroke.

If you are making a KAP to fit into a rectangular opening, make its frame 4 in. SHORTER than the height of its opening and 1 in. NARROWER than the width of the opening.

c. For this 3-ft model, tie the pull-cord to the center brace about 12-1/2 in. below the hinge line, as shown in Fig. 12. (If you tie it lower, your arm movements will waste energy.) Use small nails or wire to keep the tie end from slipping up or down on the center brace. (For a more durable connection, see Fig. 22.)

Cut a slot in the flap above the connection of the pull-cord to the vertical brace, deep enough so that this flap will close completely when the KAP is being pulled. Tape the end and edges of the slot.

Fig. 12. Hinge is attached so pump can swing 180 degrees. ORNL-DWG 66-12330AR



IV. MORE RAPID CONSTRUCTION:

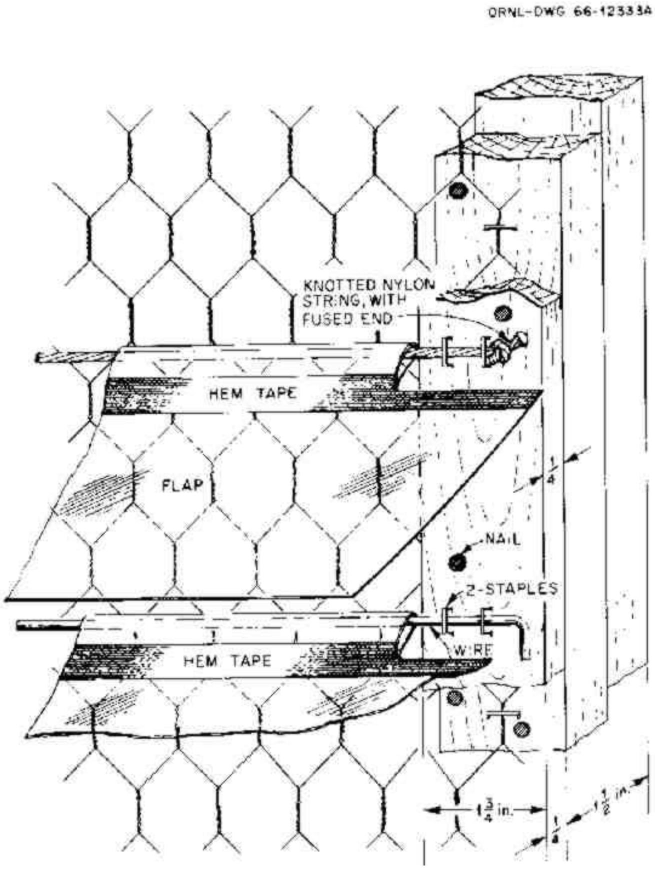
(Skip this section if you cannot easily get chicken wire and 1/4 in.-thick boards.)

If chicken wire and boards about 1/4 in. thick are available, use the chicken wire for flap-stops. By using these materials, the time required to build a given KAP can be reduced by about 40%. One-inch woven mesh is best. (Hardware cloth has sharp points and is unsatisfactory.)

Figure 13 illustrates how the mesh wire should be stapled to the KAP frame. Next, unless the KAP is wider than 3 ft, the front of the whole frame (except for the center brace) should be covered with thin boards approximately 1/2 in. thick, such as laths. Then the pivot-wires, with their flaps on them, should be stapled onto the 1/4 in.-thick boards. This construction permits the flaps to turn freely in front of the chicken-wire flap-stops.

With this design, the center of each pivot-wire should NOT be connected to the center brace, nor should the center of the flap be notched. However, pivot-wires that are attached this way must be made and held straighter than pivot-wires used with flap-stops made of straight strings or wires.

Fig. 13. Flaps attached 1/4 inch in front of chicken wire used for flap-stops. ORNL-DWG 66-12333A



Note in Fig. 13 that each pivot-wire is held firm and straight by 2 staples securing each end. The wire used should be at least as springy as coat hanger wire. If string is used instead of wire, nylon cord about the diameter of coat hanger wire is best for the pivot-strings.

If the KAP is wider than 3 ft, its center vertical brace should also be covered with a 1/4 in.-thick board, and each pivot-wire should be attached to it. Furthermore, the center of each flap should be notched.

V. INSTALLATION AND ACCESSORIES:

A. Minimum Open Spaces Around a KAP:

To pump its maximum volume, an air-supply KAP with good metal hinges should be installed in its opening so that it swings only about 1/2 in. above the bottom of the opening and only 1/2 in. to 1 in. from the sides of the opening.

B. Adequately Large Air Passageways:

When using a KAP as an air-supply pump to force air through a shelter, it is essential to provide a low-resistance air passageway all the way through the shelter structure from an outdoor air-intake opening for outdoor air to a separate air-exhaust opening to the outdoors (see Fig. 14).

A low-resistance air passageway is one that is no smaller in cross-sectional area than half the size of the KAP pumping the air. For example, a 36 X 29-in. KAP should have a passageway no smaller than about 3-1/2 sq. ft. An air-supply KAP of this size will force at least 1000 cubic feet per minute (1000 cfm) through a shelter having such openings, if it is installed as illustrated in Fig. 14.

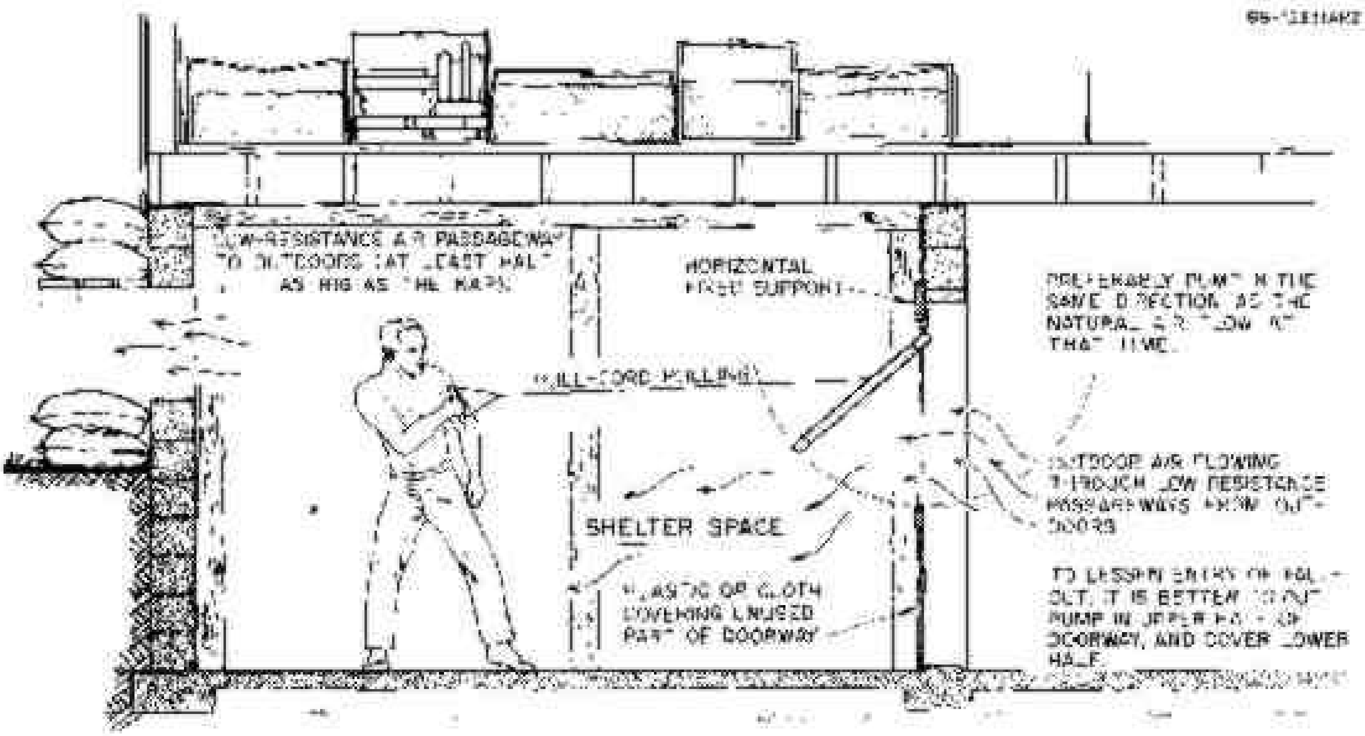


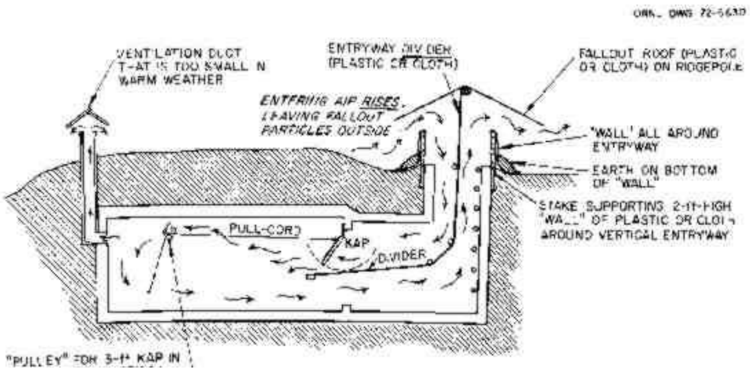
Fig. 14.

If smaller air passageways or air-exhaust openings are provided, the volume of air pumped will be greatly reduced. For example, if the air-exhaust opening is only l-3/4 sq. ft (1/4 the size of this KAP), then this KAP will pump only about 500 cfm. And if the air-exhaust opening is only a 6 X 6-in. exhaust duct (1/4 sq. ft), then this same 36 X 29-in. KAP will pump only about 50 cubic feet per minute. This would not provide enough outdoor air for more than one shelter occupant in a well-insulated shelter under heat-wave conditions in the hottest humid parts of the United States. In contrast, when the weather is freezing cold and the shelter itself is still cold enough to absorb the heat produced by the shelter occupants, this same 6 X 6-in. exhaust duct and the air-intake doorway will cause about 50 cfm of outdoor air to flow by itself through the shelter without using any pump. The reason: body heat warms the shelter air, and the warm air rises if cold air can flow in to replace it. Under these cold conditions provided the air is distributed evenly throughout the shelter by KAP or otherwise -- 50 cfm is enough outdoor air for about 17 people.

To provide adequately large air passageways for air-supply KAPs used to ventilate shelters in buildings, in addition to opening and closing doors and windows, it may be necessary to build large ducts (as described below). Breaking holes in windows, ceilings, or walls is another way to make large, efficient air passageways.

Figure 15 illustrates how a 3-ft KAP can be used as a combined air-supply and air-distribution pump to adequately ventilate a small underground shelter that has an exhaust opening too small to provide enough ventilation in warm weather. (A similar installation can be used to ventilate a basement room having only one opening, its doorway.) Note how, by installing a divider in the doorway and entryway, the single entryway is converted into a large air-intake duct and a separate, large air-exhaust duct. To obtain the maximum increased volume of fresh outdoor air that can be pumped through the shelter a total of about 1000 cfm for a 36 X 29-in. KAP the divider should extend about 4 ft horizontally into the shelter room, as shown in Fig. 15. The 6 ft at the end of the divider (the almost-horizontal part under the KAP) can be made of plywood, provided it is installed so that it can be taken out of the way in a few seconds.

Fig. 15. Ventilating a shelter when the air-exhaust opening is too small. ORNL DWG 72-6630



Note how the entry of fallout into a shelter can be minimized by covering the entryway with a "roof" and by forcing the slow-moving entering air to rise over an obstruction (the "wall") before it flows into the shelter. The sand-like fallout particles fall to the ground outside the "wall."

C. Adequate Distribution of Air Within the Shelter:

To make sure that each shelter occupant gets a fair share of the outdoor air pumped through the shelter, air distribution KAPs should be used inside most large shelters. These KAPs are used within the shelter, separate from and in addition to air-supply KAPs (see Fig. 16). Air-distribution KAPs can serve in place of both air-distribution ducts and cooling fans. For these purposes, one or more 3-ft-high KAPs hung overhead from the shelter ceiling are usually most practical. If KAPs cannot readily be hung from the ceiling, they can be supported on light frames made of boards or metal, somewhat like those used for a small child's swing.

Fig. 16. The use of air distribution KAPs. ORNL DWG 72-7547

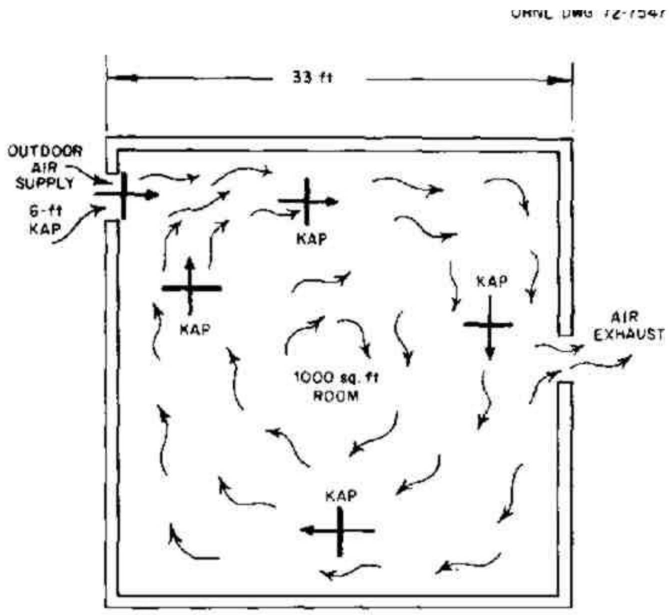


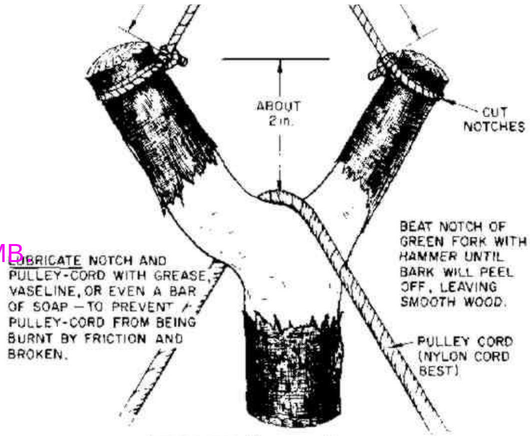
Fig. 16. The use of air-distribution KAPs.

You should make and use enough KAPs to cause air movement that can be felt in all parts of your shelter. Remember that if KAPs are installed near the floor and the shelter is fully occupied, the occupants' bodies will partially block the pumped airflow more than if the same KAPs were suspended overhead.

As a general rule, for shelters having more than about 20 occupants, provide one 3-ft air-distribution KAP for every 25 occupants. In relatively wide shelters, these interior KAPs should be positioned so that they produce an airflow that circulates around the shelter, preventing the air that is being pumped into the shelter from flowing directly to the exhaust opening. Figure 16 illustrates how four KAPs can be used in this way to distribute the air within a shelter and to fan the 100 occupants of a 1000-sq.-ft shelter room. Avoid positioning an air-distribution KAP so that it pumps air in a direction greater than a right angle turn from the direction of airflow to the location of the KAP.

D. Operation with a Pulley:

A small KAP especially one with improvised hinges or one installed at head-height or higher can be pulled most efficiently by running its pull-cord over a pulley or over a greased homemade pulley" such as described in Figs. 17' and 18.



IMPROVISED "PULLEY" FROM A WIDE-ANGLED FORKED LIMB.

Fig. 17.

Fig. 17. IMPROVISED "PULLEY" FROM A WIDE-ANGLED FORKED LIMB ORNL DWG 71-7242

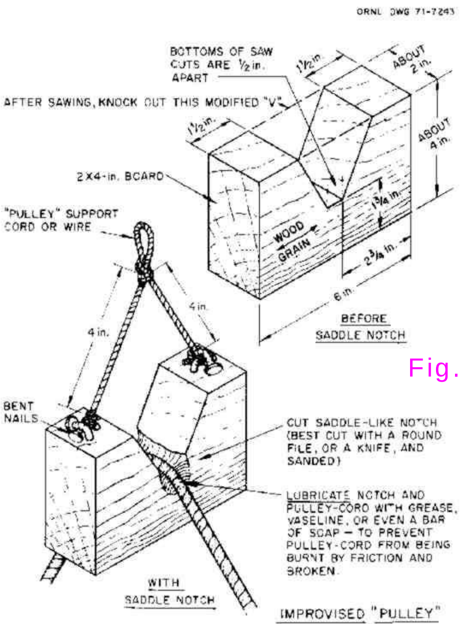


Fig. 18. IMPROVISED "PULLEY" ORNL DWG 71-7243

A pulley should be hung at approximately the same height as the hinges of the KAP, as illustrated in Fig. 15. To make a comfortable hand-hold on which to pull down- ward, tie two or three overhand knots in a strip of cloth on the end of the pull-cord. (Such a "pulley" can also be used to operate a bail-bucket to remove water or wastes from some shelters, without anyone having to go outside.)

E. Quick-Removal Brackets:

The air-supply KAP that pumps air through your shelter is best held in its pumping position by mounting it in homemade quick-removal brackets (see Fig. 19) for the following reasons:

- A KAP provided with quick-removal brackets can be taken down easily and kept out of the way of persons passing through its doorway when it is not in use. It can be kept in a place where people are unlikely to damage it.
- By installing two sets of quick-removal brackets in opposite shelter openings, you can quickly reverse the direction in which the KAP pumps air, to take advantage of changes in the direction of natural airflow through the shelter.

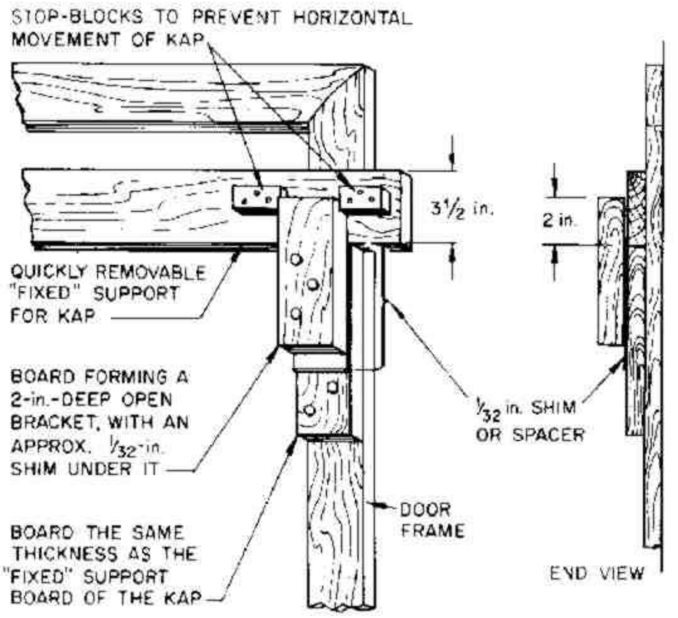


Fig. 19. Quick-removal bracket for KAP. ORNL DWG 72-6365A

- If the KAP is installed on quick-removal brackets, in an emergency a person standing beside the KAP could grasp its frame with both hands, lift it upward a few inches to detach it, and carry it out of the way all in 3 to 5 seconds. Being able to move the KAP quickly could prevent blast winds from wrecking the pump, which might also be blown into your shelter possibly injuring occupants. In extensive areas where fallout shelters and their occupants would survive the blast effects of typical large warheads, more than 4 seconds would elapse between the time shelter occupants would see the extremely bright light from the explosion and the arrival of a blast wave strong enough to wreck a KAP or other pumps left exposed in a ventilation opening.

Note in Fig. 19 that the KAP's "fixed" support- board (a 3-1/2 in.-wide board to which its hinges are attached) is held in a bracket only 2 inches deep. To prevent too tight a fit in the bracket, be sure to place a 1/32-in. shim or spacer (the cardboard back of a writing tablet will do) between two boards of the bracket, as illustrated. Also, make spaces about 1/16 inches wide between the lower inner corners of the stop-blocks and the sides of the outer board. To prevent your hands from being cut, you should put tape over the exposed ends of wires near the frame's outer edges of a KAP that you want to be able to remove rapidly.

In a small expedient shelter, a small KAP can be quickly jerked loose if its "fixed" support-board is attached to the roof with only a few small nails.

VI. OPERATION AND MAINTENANCE:

A. Pumping:

Operate your 3-foot KAP by pulling it with an easy, swinging motion of your arm. To pump the maximum volume of air, you should pull the KAP toward you until its frame swings out to an almost-horizontal position. Then quickly move your hand so that the pull-cord is kept slack during the entire, free-swinging return stroke. Figure 24 in Section VIII, LARGE KAPs, illustrates this necessary motion.

Be sure to provide a comfortable hand-hold on the pull-cord (see Fig. 14). Blisters can be serious under unsanitary conditions.

To pull a KAP via an overhead pulley with minimum effort, sit down and pull as if you were tolling a bell-except that you should raise your hand quickly with the return stroke and keep it raised long enough so that the pull-cord remains slack during the entire return stroke. Or, if the pulley is not overhead, operate the KAP by swinging your extended arm back and forth from the shoulder.-

B. Placement to Take Advantage of the Natural Direction of Air Flow:

A KAP can pump more air into a shelter if it is installed so that it pumps air through the shelter in the direction in which the air naturally flows. Since this direction can be reversed by a wind change outdoors, it is desirable to provide a way to quickly remove your pump and reposition it so that air can be pumped in the opposite direction. This can be done in several ways, including making one set of quick- removal brackets for one air opening and a second set for the other.

C. Maintenance:

To operate your KAP efficiently, keep the flaps in good repair and make sure that there is the minimum practical area of open spaces in and around the KAP through which air can flow back around the pump frame, opposite to the pumped direction. So keep at least some extra flap material in your shelter, along with some extra tape and the few tools you may need to make repairs.

VII.NARROW KAPs AND SMALL KAPs:

A. Narrow KAPs:

To swing efficiently in an entrance or emergency exit of an expedient trench shelter that is 22 in. wide, a KAP is best made 20 in. wide and 36 in. high. One of less height is not as efficient as a 36-in.-high model and has to be pulled uncomfortably fast. So, when ventilation openings can be selected or made at least 38 in. high, make your pump 36 in. high.

In a narrow trench shelter, it is best to have the pull-cord run the full length of the trench, along the trench wall that occupants will face when sitting. Then each occupant can take a turn pulling the pump without having to change seats.

Good metal hinges on a narrow KAP allow it to swing properly if pulled with the pull-cord attached to one side of the frame. (Pumps with improvised hinges and large pumps must be pulled from a connection point on their center vertical brace to make them swing properly.) Therefore, if you have small metal hinges and need a KAP no wider than 20 inches, build a rectangular frame without a vertical center brace. Make two pull-cord attachment points, one on each side of the frame and each 9 inches below the top of the frame. (For a small KAP, a satisfactory attachment point can readily be

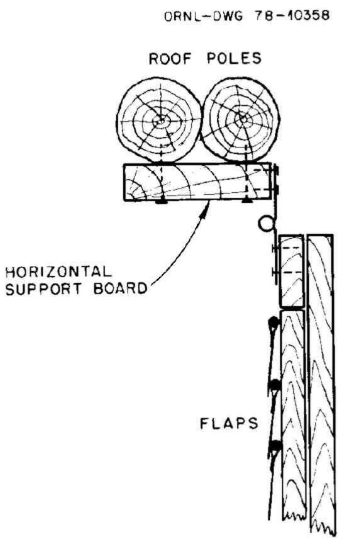


Fig. 20. ROOF POLES. HORIZONTAL SUPPORT BOARD. ORNL-DWG 78-10358

Fig. 20.

made by driving two nails so that their heads cross, and wiring them together.) Then if a change in wind direction outside causes the direction of natural air flow in the trench to become opposite to the direction in which air is being pumped, you can move your KAP to the opening at the other end of the trench. The pull-cord can easily be connected to the other side of the frame, and convenient pumping can be resumed quickly.

So that the horizontal support board can be nailed easily to the roofing poles or boards of an entry trench, it is best to use cabinet hinges. Screw them onto an edge of the support board, in the UNUSUAL, OUT-OF-LINE POSITION shown in Fig. 20. This hinge connection allows the pump to swing a full 180 degrees. To facilitate moving the horizontal support board, connect it to the roof with a few small nails, so that it can be pulled loose easily and quickly.

B. Small KAPs:

If the only available opening in which a KAP can be installed is small, build a KAP to fit it. Use narrower boards to make the frame and make the flaps of thinner material, such as the polyethylene of large plastic trash bags. For pumps 24 inches or less in height, make the finished flaps only 3-1/2 inches wide and space their pivot-wires 3 inches apart. The flaps should overlap no more than inch. A KAP 24 inches high will pump enough outdoor air for only a few people, except in cold weather.

Small, yet efficient KAPs can be made even if the only materials available are straight sticks about 1-1/4 inches in diameter, strips of cloth to tie the frame together and to make the hinges and the pull cord, polyethylene film from large trash bags for the flaps, freezer or duct tape (or needle and thread) to make the flap hems, coat hanger wire or string for the pivot- wire, and string or ordinary thread for the flap-stops. A sharp knife is the only essential tool. Figure 21 shows a way to easily tie sticks securely together and to attach strings or threads for stop-flaps, when small nails and tacks are not available. The flap-stop strings or threads should be secured by wrapping them several times around each stick to which they are attached, so they will be gripped by the out-of-line knife cuts.

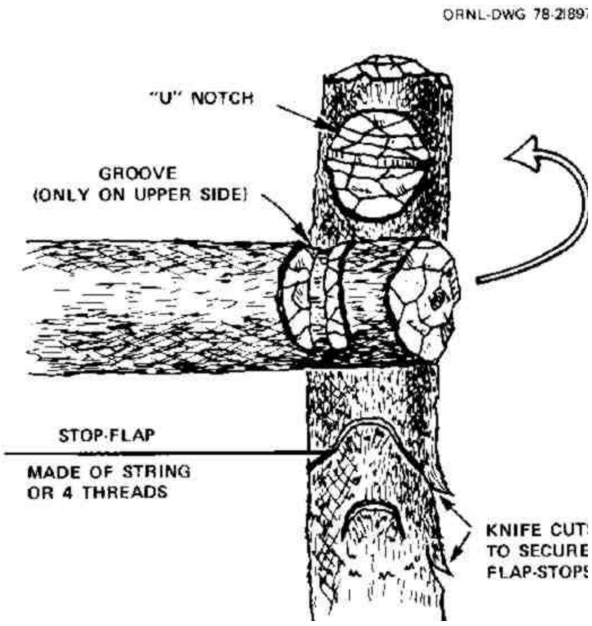


Fig. 21. Sticks ready to be tied together to make a KAP frame. ORNL-DWG 78-21897

VIII. LARGE KAPs:

A. Construction:

A 6-ft-high by 29-in.-wide model can be constructed in the same way as a 3-ft model except that it should have both horizontal and vertical center braces (1 X 2-in. boards are best). To increase the strength of a 6-ft KAP, all parts of its double- thickness frame and its vertical center brace should be made of two thicknesses of 1 X 2-in. softwood boards, securely held together with clinched nails. Also, to increase the distance that the pump will swing back by itself during its return stroke, it is worthwhile to attach a 6-ft piece of 1 X 2-in. board (not illustrated) to the back of each side of the frame. Do NOT attach weights to the bottom of the frame; this would slow down the pumping rate.

This 6-ft-high pump requires 18 flaps, each the same size as those of the 36-in.-high KAP. The flaps on the lower part of a large KAP must withstand hard use. If 1/2-in.-wide strips of tape are attached along the bottom and side edges of these lower flaps, then even flaps made of ordinary 4-mil polyethylene will remain serviceable for over 1000 hours of pumping. However, the lower flaps of large KAPs can advantageously be made of 6-mil polyethylene. The width and spacing of all flaps should be the same as those of the 36-in.-high model.

The pull-cord should be attached to the vertical center brace of a 6-ft KAP about 16-1/2 in. below the hinge line. A 3/16-in. nylon cord is ideal.

To adequately ventilate and cool very large and crowded shelters in buildings, mines, or caves, KAPs larger than 72 X 29 in. should be used. You can take better advantage of large doorways, elevator shaft openings, etc., by "tailor-making" each large air- supply KAP to the size of its opening that is, by making it as large as is practical. The frame and brace members should be appropriately strengthened, and one or more "Y" bridles should be provided, as described in the section below. A 7-ft-high X 5-1/2 ft- wide KAP, with a 1/4 in.-diameter pull-cord attached 18 in. below its hinge line, and with two "Y" bridles for its two operators, pumped air at the rate of over 11,000 cubic ft per minute through a large basement shelter during tests.

To make a durable connection of the pull-cord to the center vertical brace: (1) Attach a wire loop (Fig. 22) about l6-1/2 in. below the hinge line. This loop can be made of coat hanger wire and should go around the center vertical brace. This fixed loop should be kept from slipping on the center brace by bending four 6-penny nails over it in front as illustrated, and two smaller nails in back. (2) Make a free-turning, triple-wire loop connected to the fixed loop. (3) Cover part of the free-turning loop with tape and tie the pull-cord to this loop. Tie the pull-cord tightly over the taped part.

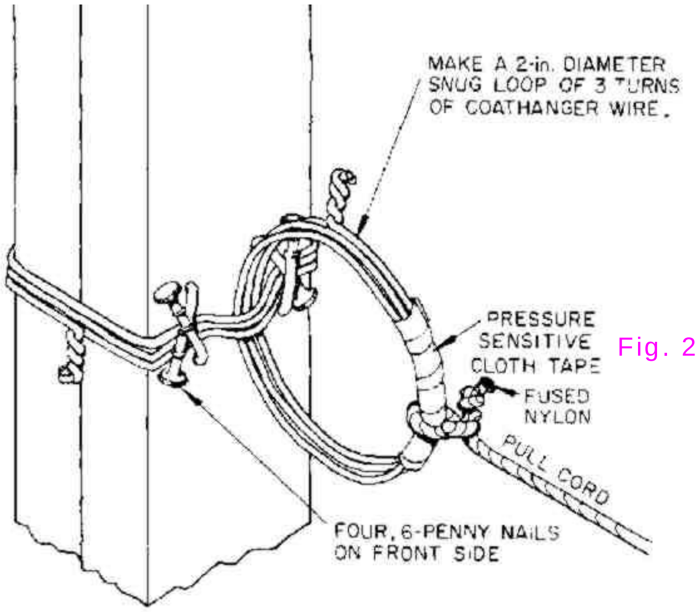


Fig. 22. (Pull Cord to center vertical brace) ORNL DWG 72-8204

Fig. 22.

B. Operation of Larger KAPs:

A larger KAP can be pulled most easily by providing it with a "Y" bridle (see Fig. 23) attached to the end of its pull-cord.

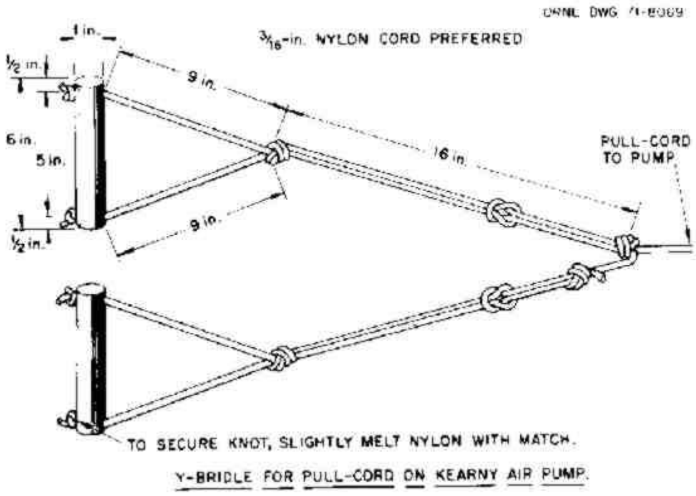


Fig. 23. Y-bridle for pullcord on KAP. ORNL DWG 71-8069

A man of average size and strength can operate a 6 ft X 29 in. KAP by himself, pumping over 4000 cubic feet per minute through a typical large shelter without working hard; tests have shown that he must deliver only about 1/20 of a horsepower. However, most people prefer to work in pairs when pulling a 6-ft KAP equipped with a "Y" bridle, when pumping over 3000 cfm.

To pump the maximum volume of air with minimum effort, study Fig. 24 and follow the instructions given below for operating a large KAP.

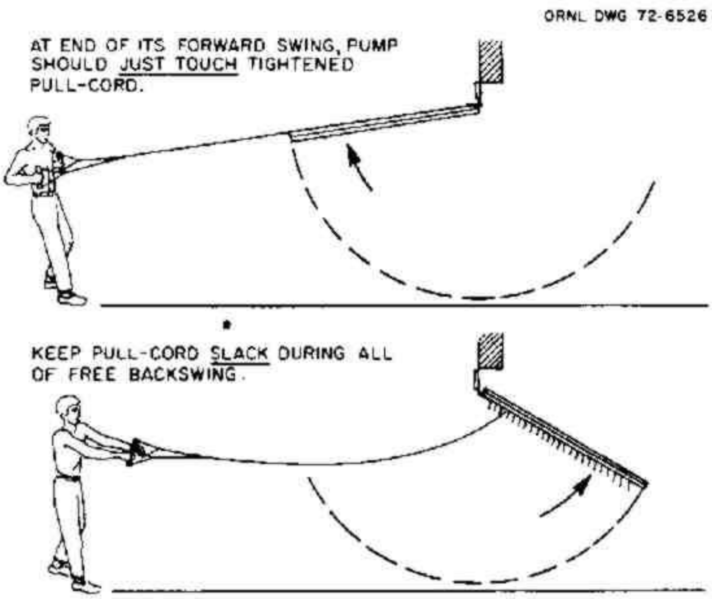


Fig. 24.

Fig. 24. AT END OF ITS FORWARD SWING, PUMP SHOULD JUST TOUCH TIGHTENED PULL-CORD. ORNL DWG 72-6526

1. Gradually start the pump swinging back and forth, moving your arms and body as illustrated and pulling mostly with your legs and body.
2. Stand at such a distance from the pump that you can pull the pump toward you until the forward- swinging pump just touches the tightly stretched pull-cord and at such a distance that you can keep the pull-cord slack during the whole of the pump's free backswing.

3. To be sure you do not reduce the amount of air pumped, rapidly move your arms forward as soon as the forward-swinging pump touches the tightened pull-cord. Hold your arms forward until the pump again starts to swing toward you.

IX. SOLUTIONS TO SPECIAL PROBLEMS:

A. Increasing the Usefulness of Shelters by Supplying 40 cfm per Planned Occupant:

If a shelter is fully occupied for days during hot weather and is cooled both day and night by pumping through it and distributing at least 40 cubic feet per minute of outdoor air for each occupant more than is required to maintain tolerable temperatures at night these advantages result:

- ° The shelter occupants will be exposed to effective temperatures less than 2oF higher than the current effective temperatures outdoors, and at night will get relief from extreme heat.
- ° The floors, walls, etc. of a shelter so ventilated will be cooled at night to temperatures well below daytime temperatures. Therefore, during the day a considerable fraction of the occupants' body heat will flow into the floors, walls, and other parts of the shelter and less body heat will have to be carried out by the exhaust air during the hottest hours of the day. Thus daytime temperatures will be reduced.
- ° Since the shelter occupants will be cooler and will sweat less, especially at night, they will need less water than they would require if the shelter were ventilated at a rate of less than 40 cfm per occupant. (If the outdoor air is very hot and desert-dry, it usually is better to supply less than 40 cfm per occupant during the hottest hours of the day.)
- ° If the shelter were to be endangered by the entry of outside smoke, carbon monoxide or other poisonous gases, or heavy descending fallout under windy conditions, ventilation of the shelter could be temporarily restricted or stopped for a longer period than would be practical if the shelter itself were warmer at the beginning of such a crisis period.
- ° The shelter could be occupied beyond its rated capacity without problems caused by overcrowding becoming as serious as would be the case if smaller- capacity air pumps were to be installed and used.

B. Pre-Cooling Shelters:

If the shelter itself is cooler than the occupants, more of the body heat of occupants can flow into its cool walls, ceiling, and floor. Therefore, it would be advantageous to pre-cool a shelter that may soon be occupied, especially during hot weather. KAPs (or other air pumps or fans) can be used to pre-cool a shelter by forcing the maximum volume of cooling outdoor air through the shelter and by distributing it within the shelter. A shelter should be pre-cooled at all times when the air temperature outdoors is lower than the air temperature inside the shelter. Then, if the pre-cooled shelter is used, the occupants will be kept cooler at a given rate of ventilation than if the shelter had not been pre-cooled, because the air will not have to carry all of their body heat out of the shelter.

C. Increasing the Effectiveness of a KAP:

If you want to increase the volume of air that a KAP with good metal hinges can force through a shelter, install side baffles (see Fig. 25). Side baffles should be rigidly fixed to form two stationary "walls," one on each side of the swinging pump frame. They can be made of plywood, boards, doors, table tops, or even well-braced plastic. A space or clearance of 1/2 to 1 in. should be maintained between the inner side of each baffle and the outer side of the swinging frame.

By installing side baffles you may be able to increase the volume of air your KAP will pump by as much as 20%, if it is in good repair and the openings around it are small.

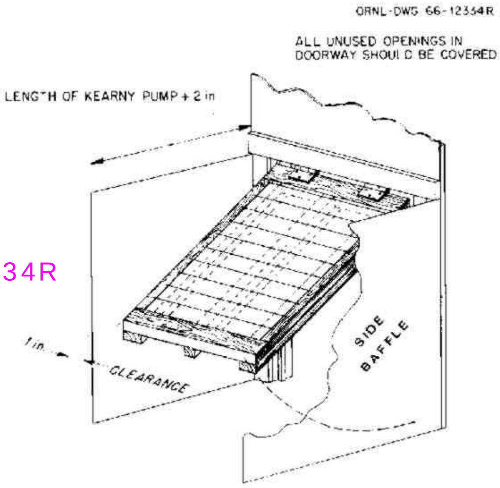


Fig. 25. Side baffles. ORNL-DWG 66-12334R

D. Operating a KAP as an Exhaust Pump:

In some shelters, a KAP can be operated most effectively by using it as an exhaust pump. This can be done by pushing it with a push-pole attached to its center vertical brace. Push-pole operation is sometimes the best way to suck" outdoor air into a shelter by pumping air out of the shelter in the natural direction of air flow; for example, up an elevator shaft or up a stairwell. This method is especially useful in those basement shelters in which air-intake openings are impractical for installing KAPs. This would be the case if the air-intake openings are small, exposed windows or holes broken in the ceiling of a shelter in a building.

To pump a large KAP most effectively with a push-pole, stand with your back to the KAP and grasp the push-pole with both hands. Using mostly your leg muscles, push the KAP by pulling the free end of its push-pole toward you.

Figure 26 shows an improvised, flexible connection of a push-pole attached to the center brace of a large KAP 28 in. from the top of its frame.

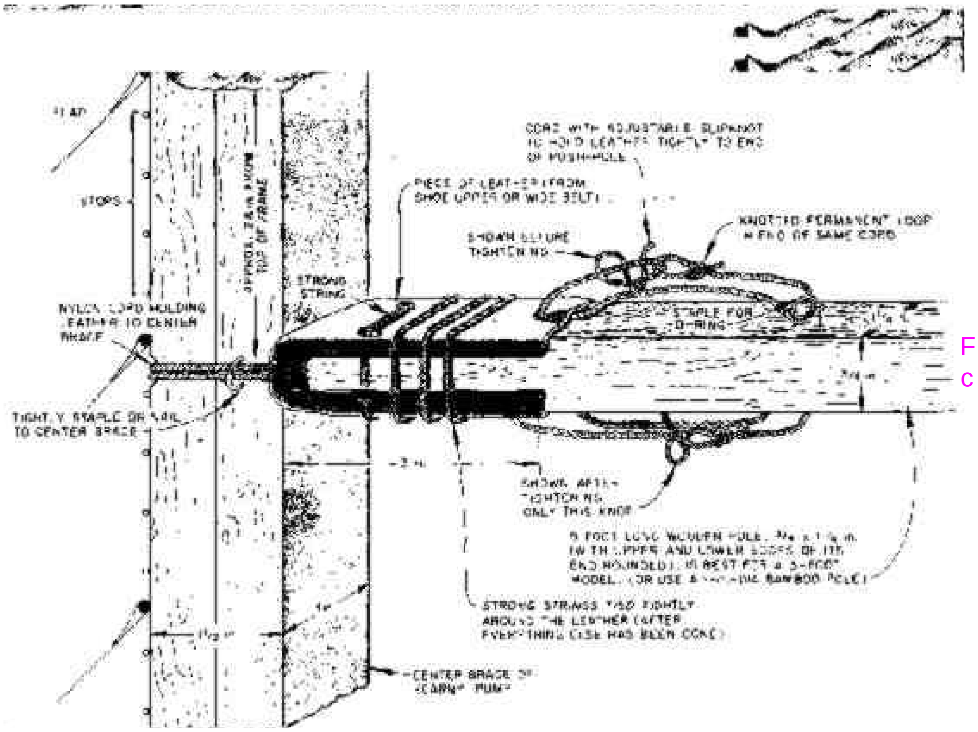


Fig. 26. Push-pole flexible connection. ORNL DWG 66-12332R

E. Ventilating a Shelter with Only One Opening:

Some basement rooms that may be used as shelters have only one opening, the doorway. A KAP can be used to ventilate such a shelter room if enough well-mixed and distributed air is moving just outside the doorway, or if air from outdoors can be pumped in by another KAP and made to flow in a hallway or room and pass just outside this doorway. Figure 27 indicates how to ventilate such a one-opening room by operating a 3-ft KAP as an air-intake pump in the upper part of the doorway.

Below such a doorway KAP, a "divider" 6 ft to 8 ft long can be installed. The divider permits exhaust air to flow out of the room without much of it being "sucked" back into the room by the KAP swinging above it. Plywood, reinforced heavy cardboard, or even well-braced plastic can be used to make a divider. It should be installed so that, in a possible emergency, it can be jerked out of the way in a few seconds.

When used with a divider, a 36 X 29 in. KAP can pump almost 1000 cubic feet of air per minute into and out of such a shelter room. Although 1000 cubic feet of well distributed air is sufficient for several times as many as 25 shelter occupants under most temperate climate conditions, it is enough for only about 25 people in a one-entry room under exceptionally severe heat-wave conditions. Furthermore, to make it habitable for even 25 people under such conditions, the air in this room must be kept from rising more than 20 F above the temperature outdoors. This can be done using a second air-supply KAP to pump enough outdoor air through the building and in some cases also using air-distribution KAPs in spaces outside the one-entry room. The KAP in the doorway of a one-entry room should supply 40 cfm per occupant of this room.

In order to prevent any of the used, warmed, exhaust air from the one-entry room from being "sucked" by the doorway KAP back into the room, a stiffened rectangular duct can be built so as to extend the exhaust-opening (in the lower part of the doorway) several feet outside the room. Such a duct can be built of plastic supported by a frame of small boards. It can be used to discharge the exhaust air far enough away from the KAP and downstream in the airflow outside the one-opening room so that no exhausted air can be "sucked" back into the room.

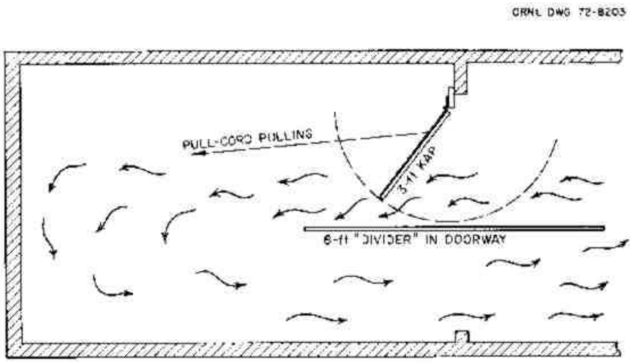


Fig. 27. Use of a "divider" to ventilate a shelter with only one opening. ORNL DWG 75-8203

F. Installing a KAP in a Steel-Framed Doorway;

If you need to install a KAP in a steel-framed doorway and it is not feasible to screw or otherwise permanently connect it to the doorway, you can attach the KAP by using a few boards and some cord, as illustrated by Figs. 28 and 29. The two horizontal boards shown extending across the doorway are squeezed tightly against the two sides of the wall in which the doorway is located by tightening two loops of cord, one near each side of the doorway. One loop is illustrated. A cord is first tightened around the two horizontal boards. Then the looped cord is further tightened by binding it in the center with another cord, as illustrated.

Two large "C" clamps serve even better than two looped cords. However, secure support for a swinging KAP still requires the use of a vertical support board on each side of the doorway, as illustrated.

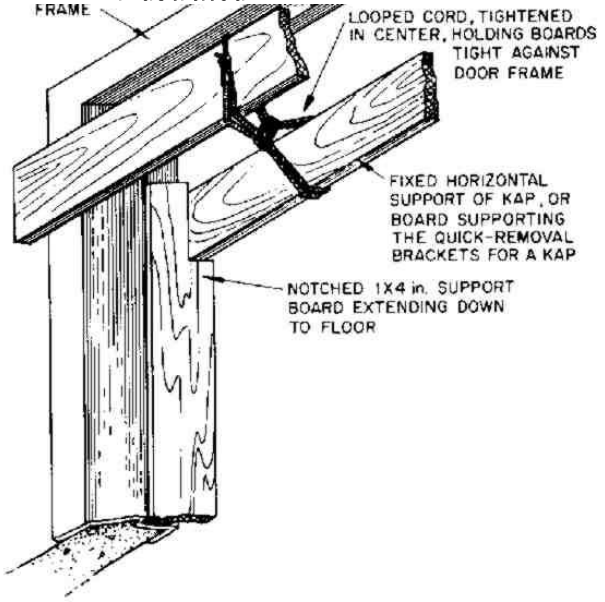


Fig. 28. STEEL DOOR FRAME. ORNL DWG 72-6564

Figure 29 shows a quick-removal bracket supported by two horizontal boards tightened across the upper part of a doorway by looped cords, as described above. Also, stud

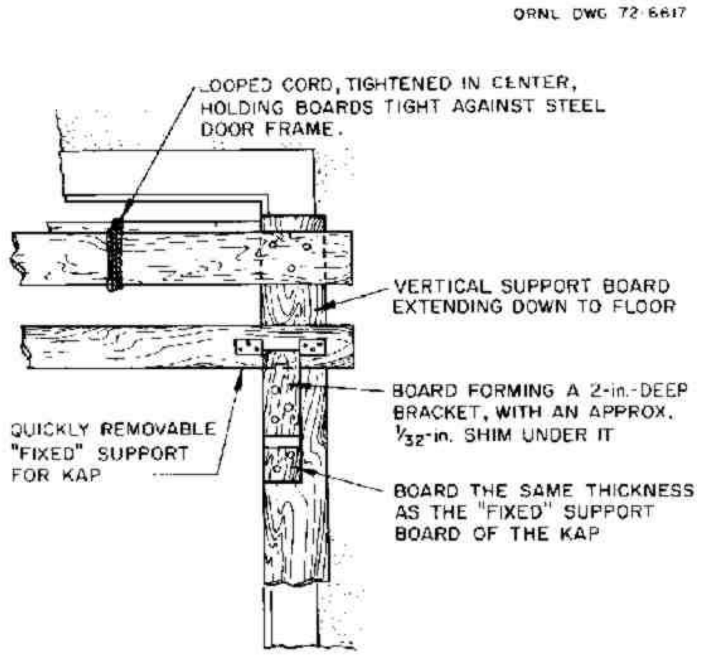


Fig. 29.

Fig. 29. (Quick Removal Bracket on Doorway) ORNL DWG 72-6617

G. Building More Durable KAPs:

If you are building KAPs in normal times, you may want to use materials that will make your pumps last longer, even though these materials are more difficult to obtain and are more expensive.

Durability tests have shown that the KAP parts that wear out first are the flaps and the pulleys. In 6-ft KAPs. the lower flaps are subject to hard use. Lower flaps made of 6-oz (per sq. yd), clear, nylon-reinforced, plied vinyl have lasted undamaged for over 1000 hours of full-stroke pumping, without having their edges reinforced. Lower flaps made of 6- mil nylon-reinforced polyethylene, without edge reinforcements, have lasted for 1000 hours with only minor damage.

The best pulley tested was a marine pulley such as that used on small sailboats, with a Delrin (DuPont) 2-in.-diameter wheel and 3/16-in. stainless steel shaft. This pulley was undamaged after operating a 6-ft KAP for 324 hours. The pulley appeared to be good for hundreds of hours of further operation.

The best pulley-cords tested were of braided dacron or nylon.

H. Using Air Filters:

To supply shelter occupants with filtered air usually would be of much less importance to their survival and health than to provide them with adequate volumes of outdoor air to maintain tolerable temperatures. However. filtering the entering air could prove worthwhile, provided:

- Your shelter is not in an area likely to be subjected to blast, or it is a blast shelter with blast doors and blast valves protecting everything inside.
- Work on filters is started after you have completed more essential work, including the building of a high-protection-factor shelter, making, installing, and testing the necessary number of KAPs, storing adequate water, making a homemade fallout meter, etc.
- You have enough low-resistance filters (such as fiberglass dust filters used in furnaces and air-conditioners) and other materials for building the necessary large, supported filter in front of your KAP.
- Your KAP can pump an adequate volume of air through the filter and shelter.
- The filter is installed so that it can be easily removed if shelter temperatures rise too high.

To prevent a filter used with a KAP from causing too great a reduction in the volume of air that the KAP can pump through your shelter, you must use large areas of low-resistance filter material. An example: In one ventilation test, a large basement shelter was used which had two ordinary doorways at its opposite ends. These served as its air-intake and its air-exhaust openings. A 72 X 29 in. KAP operating in one doorway pumped almost 5000 cubic feet per minute through the shelter. But when a filter frame holding 26 square feet of l-in.-thick fiberglass dust filters was placed across the air-intake stairwell, the KAP could pump only about 3400 cfm through this filter and the shelter.

Appendix C: A Homemade Fallout Meter – the KFM

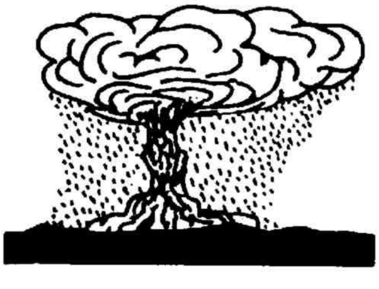
How to Make and Use It

FOLLOWING THESE INSTRUCTIONS MAY SAVE YOUR LIFE

The complete KFM instructions include patterns to be cut out and used to construct the fallout meter. At the end of the instructions are extra patterns on 4 unnumbered pages. The reader is urged to use these extra patterns to make KFM's in normal peacetime and to keep the complete instructions intact for use during a recognized crisis period.

If Xerox copies of the patterns are used, they should be checked against the originals in order to make sure that they are the same size as the originals. Some older copiers make copies with slightly enlarged dimensions. Even slightly enlarged copies of all the KFM patterns can be made satisfactory provided: (1) on the PAPER PATTERN TO WRAP AROUND KFM CAN, the distances between the 4 marks for the HOLES FOR STOP- THREAD are corrected; and (2) the dimensions of the FINISHED-LEAF PATTERN are corrected.

Fig. (Nuclear Ground Burst Explosion - Drawing)



These instructions, including the heading on this page and the illustrative photos, can be photographed without additional screening and rapidly reproduced by a newspaper or printer. If you keep the KFM instructions intact, during a worsening crisis you will be able to use them to help your friends and thousands of your fellow citizens by making them available for reproduction.

I. The Need for Accurate and Dependable Fallout Meters:

If a nuclear war ever strikes the United States, survivors of the blast and fire effects would need to have reliable means of knowing when the radiation in the environment around their shelters had dropped enough to let them venture safely outside. Civil defense teams could use broadcasts of surviving radio stations to give listeners a general idea of the fallout radiation in some broadcast areas. However, the fallout radiation can vary widely from point to point and the measurements are likely to be made too far from most shelters to make them accurate enough to use safely. Therefore, each shelter should have some dependable method of measuring the changing radiation dangers in its own area.

During a possible rapidly worsening nuclear crisis, or after a nuclear attack, most unprepared Americans could not buy or otherwise obtain a fallout meter -- an Instrument that would greatly improve their chances of surviving a nuclear war. The fact that the dangers from fallout radiation--best expressed in terms of the radiation dose rate, roentgens per hour (R/hr) -- quite rapidly decrease during the first few days, and then decrease more and more slowly, makes it very important to have a fallout meter capable of accurately measuring the unseen, unfelt and changing fallout dangers. Occupants of a fallout shelter should be able to minimize the radiation doses they receive. In order to effectively minimize the radiation doses, a dependable measuring instrument is needed to determine the doses they receive while they are in the shelter and while they are outside for emergency tasks, such as going out to get badly needed water. Also, such an instrument would permit them to determine when it is safe to leave the shelter for good.

Untrained families, guided only by these written instructions and using only low cost materials and tools found in most homes, have been able to make a KFM by working 3 or 4 hours. By studying the operating sections of these instructions for about 1-1/2 hours, average untrained families have been able to successfully use this fallout meter to measure dose rates and to calculate radiation doses received, permissible times of exposure, etc.

The KFM (Kearny Fallout Meter) was developed at Oak Ridge National Laboratory. It is understandable, easily repairable, and as accurate as most civil defense fallout meters. In the United States in 1986 the least expensive commercially available dose-rate meter that is accurate and dependable and that measures high enough dose rates for wartime use is a British instrument that retails for $375. Comparable American instruments retail for over $1000.

II. Survival Work PRIORITIES During a Crisis:

Before a nuclear attack occurs is the best time to build, test and learn how to use a KFM. However, this instrument is so simple that it could be made even after fallout arrives provided that all the materials and tools needed (see lists given in Sections V, VI, and VII) and a copy of these instructions have been carried into the shelter.

Before building a KFM, persons expecting a nuclear attack within a few hours or days and already in the place where they intend to await attack should work with the following priorities:

(A) Build or improve a high-protection-factor shelter (if possible, a shelter covered with 2 or 3 feet of earth and separate from flammable buildings). At the same time, make and install a KAP (a homemade shelter-ventilating pump) - if instructions and materials are available. If not available, at least make a Directional Fan. Also store at least 15 gallons of water for each shelter occupant-- if containers are available.

(B) Assemble all materials for one or two KFM s.

(C) Make and store the drying agent (by healing wallboard gypsum, as later described) for both the KFM and its dry-bucket.

(D) Complete at least one KFM.

III. How to Use These Instructions to Best Advantage:

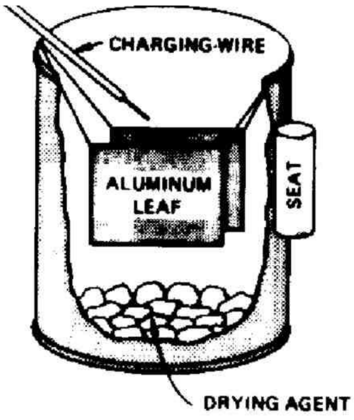
1. Read ALOUD all of these instructions through section VII, "Tools Needed," before doing anything else.
2. Next assemble all of the needed materials and tools.
3. Then read ALOUD ALL of each section following Section VII before beginning to make the part described in that section.

A FAMILY THAT FAILS TO READ ALOUD ALL OF EACH SECTION DESCRIBING HOW TO MAKE A PART, BEFORE BEGINNING TO MAKE THAT PART, WILL MAKE AVOIDABLE MISTAKES AND WILL WASTE TIME.

4. Have different workers, or pairs of workers, make the parts they are best qualified to make. For example, a less skilled worker should start making the drying agent (as described in Section VIII) before other workers start making other parts. The most skilled worker should make and install the aluminum-foil leaves (Sections X and XI).
5. Give workers the sections of the instructions covering the parts they are to build--so they can follow the step-by-step instructions, checking off with a pencil each step as it is completed.
6. Discuss the problems that arise. The head of the family often can give better answers if he first discusses the different possible interpretations of some instructions with other family members, especially teenagers.
7. After completing one KFM and learning to use it, if time permits make a second KFM--that should be a better instrument.

IV. What a KFM IS and How It Works:

Fig. 215a. Charged KFM



A KFM is a simple electroscope-ionization chamber fallout meter with which fallout radiation can be measured accurately. To use a KFM, an electrostatic charge must first be placed on its two separate aluminum-foil leaves. These leaves are insulated by being suspended separately on clean, dry insulating threads.

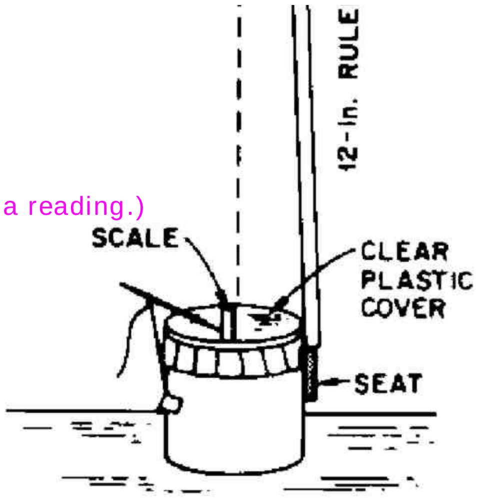
To take accurate readings, the air inside a KFM must be kept very dry by means of drying agents such as dehydrated gypsum (easily made by heating gypsum wallboard, "sheetrock") or silica-gel. (Do not use calcium chloride or other salt.) Pieces of drying agent are placed on the bottom of the ionization chamber (the housing can) of a KFM.

An electrostatic charge is transferred from a homemade electrostatic charging device to the two aluminum-foil leaves of a KFM by means of its charging-wire. The charging-wire extends out through the transparent plastic cover of the KFM.

When the two KFM leaves are charged electrostatically, their like charges (both positive or both negative) cause them to be forced apart. When fallout gamma radiation (that is similar to X rays but more energetic) strikes the air inside the ionization chamber of a KFM, it produces charged ions in this enclosed air. These charged ions cause part or all of the electrostatic charge on the aluminum-foil leaves to be discharged. As a result of losing charge, the two KFM leaves move closer together.

A KFM-maker who wants visual proof that his instrument can be partially or wholly discharged by ionizing radiation should persuade his dentist to place the charged KFM about 20 inches directly below a typical dental X-ray machine. For example, when a typical 90 kvp machine was set at 15 milliamps and for a 1/20th second pulse, its columnated X-ray beam partially discharged the KFM's separated aluminum-foil leaves, promptly reducing the initial reading of 15 mm to 9 mm. Other types of machines will require different settings. Many dental X-ray machines are not accurately calibrated, nor do they produce gamma rays, so such tests should not be used in an attempt to check the accuracy of a KFM.

Fig. 215b. (How to position yourself to take a reading.)



To read the separation of the lower edges of the two KFM leaves with one eye, look straight down on the leaves and the scale on the clear plastic cover. Keep the reading eye 12 inches above the SEAT. The KFM should be resting on a horizontal surface. To be sure the reading eye is always at this exact distance, place the lower end of a 12-inch ruler on the SEAT, while the upper end of the ruler touches the eyebrow above the reading eye. It is best to hold the KFM can with one hand and the ruler with the other. Using a flashlight makes the reading more accurate.

If a KFM is made and maintained with the specified dimensions and of the specified materials, ITS ACCURACY IS AUTOMATICALLY AND PERMANENTLY ESTABLISHED BY UNCHANGING LAWS OF NATURE. Unlike factory made radiation measuring instruments, A KFM NEVER NEEDS TO BE CALIBRATED OR TESTED WITH A RADIATION SOURCE. A KFM is used with a watch and the following table that is based on numerous calibrations made at Oak Ridge National Laboratory.

The millimeter scale is cut out and attached (see photo illustrations on the following page) to the clear plastic cover of the KFM so that its zero mark is directly above the two leaves in their discharged position when the KFM is resting on a horizontal surface. A reading of the separation of the leaves is taken by noting the number of millimeters that the lower edge of one leaf appears to be on, on one side of the zero mark on the scale, and almost at the same time noting the number of millimeters the lower edge of the other leaf appears to be on, on the other side of the zero mark. The sum of these two apparent positions of the lower edges of the two leaves is called a KFM reading. The drawing appearing after the photo illustrations shows the lower edges of the leaves of a K FM appearing to be 9 mm on the right of zero and 10 on the left, giving a KFM reading of 19 mm. (Usually the lower edges of the leaves are not at the same distance from the zero mark.)

As will be fully explained later, the radiation dose rate is determined by:

1. charging and reading the KFM before exposure;
2. exposing it to radiation for a specified time in the location where measurement of the dose rate is needed -- when outdoors, positioning the KFM about 3 ft. above the ground;

3. reading the KFM after its exposure;
4. calculating, by subtraction, the difference between the reading taken before exposure and the reading taken after exposure;
5. using this table to find what the dose rate was during the exposure -- as will be described later.

DIFF IN READ INGS	TIME INTERVAL OF AN EXPOSURE Difference between the reading before exposure and the reading after exposure (8 ply standard foil leaves) 15 SEC. R/HR	1 MIN. R/HR	4 MIN. R/HR	16 MIN. R/HR	1 HR. R/HR
2 mm	6.2	1.6	0.4	0.1	0.03
4 mm	12.	3.1	0.8	0.2	0.06
6 mm	19.	4.6	1.2	0.3	0.08
8 mm	26.	6.2	1.6	0.4	0.10
10 mm	31.	7.7	2.0	0.6	0.13
12 mm	37.	9.2	2.3	0.6	0.15
14 mm	43.	11.0	2.7	0.7	0.18

Instructions on how to use a KFM are given after those detailing how to make and charge this fallout meter. To get a clearer idea of the construction and use of a KFM, look carefully at the following photos and read their captions.

A. An Uncharged KFM. The charging wire has been pulled to one side by its adjustment-thread. This photo was taken looking straight down at the upper edges of the two flat, 8-ply aluminum leaves. At this angle the leaves are barely visible, hanging vertically side by side directly under the zero mark, touching each other and with their ends even. Their suspension-threads insulate the leaves. These threads are almost parallel and touch (but do not cross) each other where they extend over the top of the rim of the can.

B. Charging a KFM by a Spark-Gap Discharge from a Tape That Has Been Electrostatically Charged by Being Unwound Quickly. Note that the charged tape is moved so that its surface is perpendicular to the charging-wire.

Fig. 216a (Top Down view of KFM)

The high-voltage electrostatic charge on the unwound tape (that is an insulator) jumps the spark-gap between the tape and the upper end of the charging-wire, and then flows down the charging-wire to charge the insulated aluminum- foil leaves of the KFM. (Since the upper edges of the two leaves are 3A inch below the scale and this is a photo taken at an angle, both leaves appear to be under the right side of the scale.)

Fig. 216b. (Unwound tape by KFM to produce static charge)

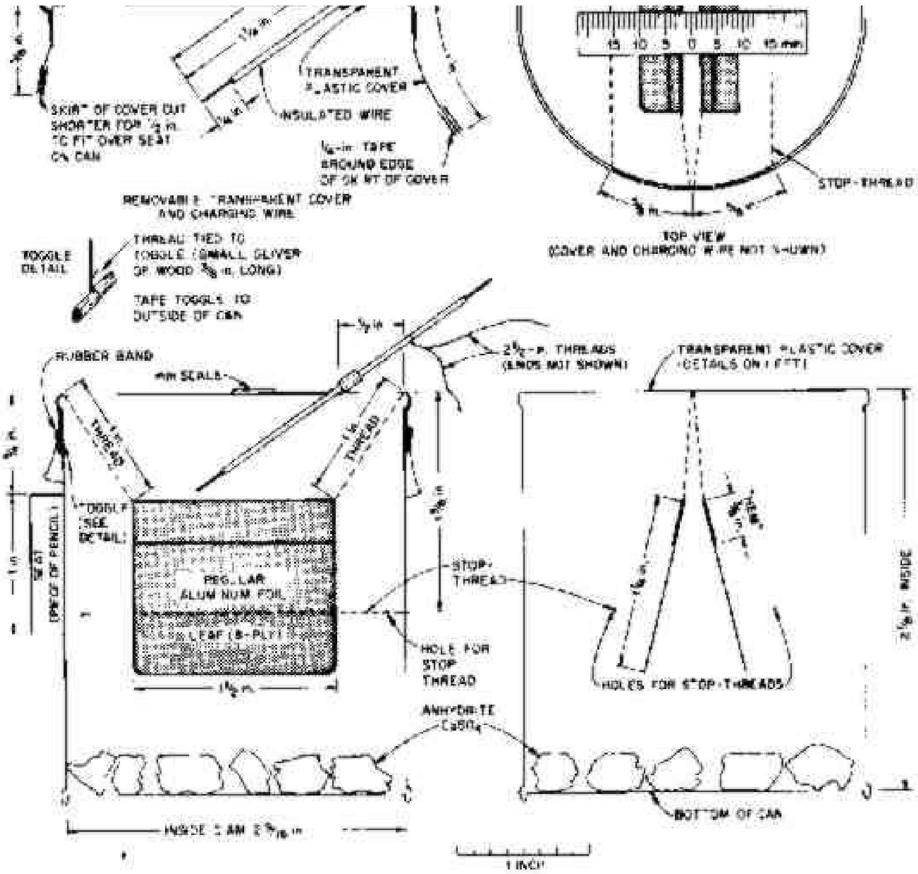
C. A Charged KFM. Note the separation of the upper edges of its two leaves. The charging- wire has been raised to an almost horizontal position so that its lower end is too far above the aluminum leaves to permit electrical leakage from the leaves back up the charging-wire and into the outside air.
Also note the SEAT, a piece of pencil taped to the right side of the can, opposite the charging wire.

Fig. 216c. A Charged KFM

D. Reading a KFM. A 12- inch ruler rests on the SEAT and is held vertical, while the reader's eyebrow touches the upper end of the ruler. The lower edge of the right leaf is under 8 on the scale and the lower edge of the left leaf is under 6 on the scale, giving a KFM reading of 14. For accurate radiation measurements, a KFM should be placed on an approximately horizontal surface, but the charges on its two leaves and their displacements do not have to be equal.

Fig. 216d. Reading a KFM

NOTE: In these photos, the paper scale is taped to the top of the transparent plastic-film cover. It is better to tape the scale to the under side of the cover, where it is less likely to be damaged.



KFM Diagrams (Inside, Top, and Cutaway views)

(This is not a Full Scale Drawing).

V. Materials Needed:

A. For the KFM: (In the following list, when more than one alternative material is given, the best material is listed first.)

1. Any type metal can approximately 2-9/16 inches in diameter inside and 2-7/8 inches high inside, washed clean with soap. (This is the size of a standard 8-ounce can. Since most soup cans, pop cans, and beer cans also are about 2-9/16 inches in diameter inside, the required size of can also can he made by cutting down the height of more widely, available cans as described in Section IX of these instructions.)
2. Standard aluminum foil - 2 square feet. (In 1987, 2 square feet of widely sold U.S. brands of aluminum foil weighed between 8.0 and 8.5 grams. One gram equals 0.035 ounce.) (If only "Heavy Duty" or "Extra Heavy Duty" aluminum foil is available, make 5-ply leaves rather than 8-ply leaves of standard foil; the resultant fallout meter will he almost as accurate.)
3. Doorbell-wire, or other light insulated wire (preferably, but not necessarily) a single-strand wire inside the insulation -- 6 inches.
4. Any type of clean, fine thread that has not been anti-static treated will serve to suspend a KFM's leaves. (Almost all kinds of sewing thread and fly-tying thread manufactured in 1987 are anti-static treated, are poor insulators, and are unsatisfactory.) In 1987 the best widely available excellent insulating thread is un-waxed dental floss; floss is not anti-static treated. Most un-waxed dental floss is too thick and stiff for properly suspending KFM leaves, but, since dental floss is not a twisted thread, you can make flexible strand-threads from it. Make each no more than one- quarter as thick as the floss, and about 12 inches lung. First separate several strands at the end of the floss outside its dispenser. Then separate strands while pulling one way on the end of the strand-thread that you want and the other way on the unwanted strands. Use only a clean needle to touch and separate the strands in the middle 6 inches of the 12-inch-long piece of un-waxed dental floss.

   A widely sold dental floss. Johnson and Johnson's Extra Fine Un-waxed, drawn out of its dispenser without splitting it, makes quite satisfactory leaf-supporting threads. However, better leaf-supporting threads can be made by first separating any dental floss into thinner, more flexible threads.

Update:

Due to changes in manufacturing processes un-waxed dental floss is not reliable for making KFM's. Some un-waxed flosses work while others do not work at all. Most un-waxed flosses will still work for making stop threads or adjustment threads, but are not good for hanging foil leaves.

Most human hair cleaned with shampoo or alcohol works very well to hang foil leaves with and to make stop threads. You can test your hair by hanging foils leaves with it. If the charged leaves do not lose more than one millimeter of charge in three hours, then you can be sure your hair works. All other materials recommend for making KFM's are still good.

This update was developed by Steve Jones and approved by Cresson Kearny.

Editor: *Arnold Jagt March 21, 2003*

Very thin monofilament fishing line or leader is an excellent insulator. The 2-pound- test strength, such as Du Pont's "Stren" monofilament fishing line, is best. "Trilene" 2-pound "nylon leader." a monofilament manufactured by Berkley and Company, also is excellent. (A 4-pound monofilament line will serve, but is disadvantageously stiff.) Some modern monofilament lines or leaders such as "Trilene" contain an additive that makes them pliant, but also makes them poorer insulators for the first several hours after being taken out of their dispenser and used to suspend the leaves of a KFM. However, in about 6 hours the silica gel or anhydrite drying agent in a KFM removes this additive and the monofilament becomes as good an insulator as even strands of un-waxed dental floss.

To minimize the chance of using a piece of monofilament or other thread that has been soiled and thus changed into a poor insulator, always first remove and discard the outermost layer of thread on any spool that has not been kept clean in a plastic bag or other packaging after being initially unwrapped.

During a worsening crisis or after an attack, neither thread that has not been anti-static treated, nor un-waxed dental floss, nor clean 2-pound or 4-pound monofilament line may be available. However, most American homes have an excellent insulator, very thin polyethylene film - especially clean dry cleaners' bags. A narrow insulating strip cut only 1/16 inch wide can be used to suspend each KFM leaf, instead of an insulating thread. (Installed leaves suspended on strips of thin plastic film must be handled with care.)

To cut 1/16-inch-wide strips from very thin polyethylene film, first cut a piece about 6 x 10 inches. Tape only the two 6-inch-wide ends to a piece of paper (such as a brown grocery bag), so that the film is held flat and smooth on the paper. Make 10 marks. 1/16-inch apart, on each of the two tapes that are holding the film. Place alight so that its reflection on the film enables you to see the edge of the film that you are preparing to cut. Then use a very sharp, clean knife or clean razor blade, guided by the edge of a firmly held ruler, to cut 9 strips, of which you will select the best two. When cutting, hold the knife almost horizontal, with the plane of its blade perpendicular to the taped-down film. Throughout this procedure avoid touching the center parts of the strips.

5. A piece of clear plastic film - a 6 x 6 inch square. Clear vinyl (4 mils thick) used for storm-proofing windows is best, but any reasonably stout and clear plastic will serve. The strong clear plastic used to wrap pieces of cheese, if washed with hot water and soap, is good. Do not use weak plastic or cellophane. Plastic film made from cellulose (such as Flex-O-Pane) and roasting bags are too permeable to water vapor.
6. Cloth duct tape ("silver tape"), or masking tape, or freezer tape, or Scotch-type tape -about 10 square inches. (A roll of Scotch Magic Transparent Tape, if available, should be saved for use in charging the KFM).
7. Band-Aid tape, or masking tape, or freezer tape, or Scotch transparent tape, or other thin and very flexible tapes -- about 2 square inches.
8. Gypsum wallboard (sheetrock) -- about 1/2 square foot, best about 1/2 inch thick, for a good homemade drying agent. (Silica gel with dark blue color indicator is an even better drying agent, but is not available in most communities. Available from chemical supply firms that supply high school chemistry classes. With dark blue silica gel in the bottom of a KFM, white typing correction fluid or white ink is needed to make the lower edges of a KFM's aluminum leaves easier to see.)
9. Glue -- not essential, but useful to replace Band-Aid and other thin tapes. "One hour" epoxy is best. Model airplane cement is satisfactory.
10. An ordinary wooden pencil and a small toothpick (or split a small sliver of wood.)
11. Two strong rubber bands, or string.
12. Several small, transparent plastic bags, such as sandwich bags, to cover the KFM when it is exposed where fallout particles may get on it and contaminate it. Or pieces of thin, transparent plastic film, such as that from bread bags. Also small rubber bands or string.

B. For the Charging Devices:

1. Most hard plastic rubbed on dry paper. This is the best method.
   a. Plexiglas and most other hard plastics, such as are used in draftsmen's triangles, common smooth plastic rulers, etc. at least 6 inches long.

b. Dry paper -- Tough paper, such as clean, strong grocery bag or typing paper. Tissue paper, newspaper, or facial tissue such as Kleenex, or toilet paper are satisfactory for charging, but not as durable.

2. Scotch Magic Transparent tape (3/4 inch width is best), or Scotch Transparent Tape, or PVC. (Polyvinyl chloride) insulating electrical tapes, or a few of the other common brands of Scotch type tapes. (Some plastic tapes do not develop sufficiently high voltage electrostatic charges when unrolled quickly.) This method cannot be used for charging a KFM inside a dry-bucket, needed for charging when the air is very humid..

C. For Determining Dose Rates and Recording Doses Received:

1. A watch with a second hand.
2. A flashlight or other light, for reading the KFM in a dark shelter or at night.
3. Pencil and paper -- preferably a notebook.

D. For the Dry-Bucket: A KFM must be charged inside a dry bucket if the air is very humid, as it often is inside a crowded, long-occupied shelter lacking adequate forced ventilation.)

1. A large bucket, pot, or can, preferably with a top diameter of at least 11 inches.
2. Clear plastic (best is 4-mil-thick clear plastic used for storm windows). A square piece 5 inches wider on a side than the diameter of the bucket to be used.
3. Cloth duct tape, one inch wide and 8 feet long (or 4 ft., if 2 inches wide). Or 16 ft. of freezer tape one inch wide.
4. Two plastic bags 14 to 16 inches in circumference, such as ordinary plastic bread bags. The original length of these bags should be at least 5 inches greater than the height of the bucket.
5. About one square foot of wall board (sheetrock), to make anhydrite drying agent.
6. Two 1-quart Mason jars or other airtight containers, one in which to store anhydrite and another in which to keep dry the KFM charging devices.
7. Strong rubber bands -- enough to make a loop around the bucket. Or string.

VI. Useful but not Essential Materials: - Which Could be Obtained Before a Crisis

1. An airtight container (such as a large peanut butter jar) with a mouth at least 4 inches wide, in which to keep a KFM, along with some drying agent, when it is not being used. Keeping a KFM very dry greatly extends the time during which the drying agent Inside the KFM remains effective.
2. Commercial anhydrite with a color indicator, such as the drying agent Drierite. This granular form of anhydrite remains light blue as long as it is effective as a drying agent; it turns pink when it becomes ineffective. Or use silica gel with color indicator, that is dark blue when effective and that turns light pink when it becomes ineffective. Heating in a hot oven or in a can over a fire reactivates them as drying agents and restores their blue color. Obtainable from laboratory supply sources. Use enough to cover the bottom of the KFM's can no more than 1/2 inch deep.
3. Four square feet of aluminum foil, to make a moisture-proof cover for the dry-bucket.

VII. Tools Needed:

- Small nail - sharpened
- Stick, or a wooden tool handle (best 2-2½ inch diameter and at least 12 inches long)
- Hammer
- Pliers
- Scissors

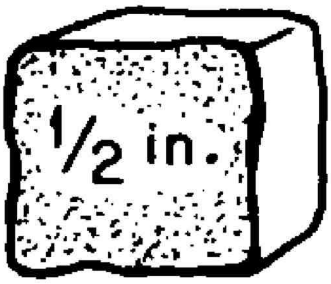
- o Needle - quite a large sewing needle, but less than 2½ inches long Knife with a small blade - sharp Ruler (12 inches)
- o Desirable but not essential tools: a file and a fine-toothed hacksaw blade.

VIII. Make the Drying Agent:

The Easiest Part to Make, but Time Consuming:

1. For a KFM to measure radiation accurately, the air inside its ionization chamber must be kept very dry. An excellent drying agent (anhydrite) can be made by heating the gypsum in ordinary gypsum wallboard (sheetrock). Do NOT use calcium chloride.
2. Take a piece of gypsum wallboard approximately 12 inches by 6 inches, and preferably with its gypsum about 3/8 inches thick. Cut off the paper and glue, easiest done by first wetting the paper. [Since water vapor from normal air penetrates the plastic cover of a KFM and can dampen the anhydrite and make it ineffective in as short a time as two days, fresh batches of anhydrite must be made before the attack and kept ready inside the shelter for replacement. The useful life of the drying agent inside a KFM can be greatly lengthened by keeping the KFM inside an airtight container (such as a peanut butter jar with a 4-inch-diameter mouth) with some drying agent, when the KFM is not being used.]
3. Break the white gypsum filling into small pieces and make the largest no more than 1/2 in. across. (The tops of pieces larger than this may be too close to the aluminum foil leaves.) If the gypsum is dry, using a pair of pliers makes breaking it easier. Make the largest side of the largest pieces no bigger than this.

Illustration - Simple 1/2 In



4. Dry gypsum is not a drying agent. To drive the water out of the gypsum molecules and produce the drying agent (anhydrite), heat the gypsum in an oven at its highest temperature (which should be above 400 degrees F) for one hour. Heat the gypsum after placing the small pieces no more than two pieces deep in a pan. Or heat the pieces over a fire for 20 minutes or more in a pan or can heated to a dull red.
5. If sufficient aluminum foil and time are available, it is best to heat the gypsum and store the anhydrite as follows:
   - a. So that the right amount of anhydrite can be taken quickly out of its storage jar, put enough pieces of gypsum in a can with the same diameter as the KFM, measuring out a batch of gypsum that almost covers the bottom of the can with a single layer.
   - b. Cut a piece of aluminum foil about 8 in. x 8 in. square, and fold up its edges to form a bowl-like container in which to heat one batch of gypsum pieces.
   - c. Measure out 10 or 12 such batches, and put each batch in its aluminum foil "bowl."
   - d. Heat all of these filled "bowls" of gypsum in hottest oven for one hour.
   - e. As soon as the aluminum foil is cool enough to touch, fold and crumple the edges of each aluminum foil "bowl" together, to make a rough aluminum-covered "ball" of each batch of anhydrite.
   - f. Promptly seal the batches in airtight jars or other airtight containers, and keep containers closed except when taking out an aluminum-covered "ball."

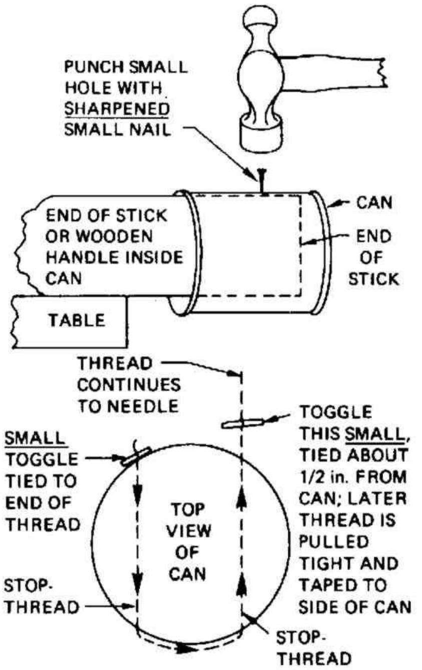
6. Since anhydrite absorbs water from the air very rapidly, quickly put it in a dry airtight container while it is still quite hot. A Mason jar is excellent.
7. To place anhydrite in a KFM, drop in the pieces one by one, being careful not to hit the leaves or the stop-threads. The pieces should almost cover the bottom of the can, with no piece on top of other pieces.
8. To remove anhydrite from a KFM, use a pair of scissors or tweezers as forceps, holding them in a vertical position and not touching the leaves.

IX. Make the Ionization Chamber of the KFM:

(TO AVOID MISTAKES AND SAVE TIME, READ ALL OF THIS SECTION ALOUD BEFORE BEGINNING WORK.)

1. Remove the paper label (if any) from an ordinary 8-ounce can from which the top has been smoothly cut. Wash the can with soap and water and dry it. (An 8-ounce can has an inside diameter of about 2-9/16 inches and an inside height of about 2-7/8 inches.)
2. Skip to step 3 if an 8-ounce can is available. If an 8-ounce can is not available, reduce the height of any other can having an inside diameter of about 2-9/16 inches (such as most soup cans, most pop cans, or most beer cans). To cut off the top part of a can, first measure and mark the line on which to cut. Then to keep from bending the can while cutting, wrap newspaper tightly around a stick or a round wooden tool handle, so that the wood is covered with 20 to 30 thicknesses of paper and the diameter (ideally) is only slightly less than the diameter of the can.

   One person should hold the can over the paper-covered stick while a second person cuts the can little by little along the marked cutting line. If leather gloves are available, wear them. To cut the can off smoothly, use a file, or use a hacksaw drawn backwards along the cutting line. Or cut the can with a sharp, short blade of a pocketknife by: (1) repeatedly stabbing downward vertically through the can into the paper, and (2) repeatedly making a cut about 1/4 inch long by moving the knife into a sloping position, while keeping its point still pressed into the paper covering the stick. Next, smooth the cut edge, and cover it with small pieces of freezer tape or other flexible tape.
3. Cut out the PAPER PATTERN TO WRAP AROUND KFM CAN. (Cut one pattern out of Pattern Page A.) Glue (or tape) this pattern to the can, starting with one of the two short sides of the pattern. Secure this starting short side directly over the side seam of the can. Wrap the pattern snugly around the can, gluing or taping it securely as it is being wrapped. (If the pattern is too wide to fit flat between the rims of the can, trim a little off its lower edge.)



SINGLE THREAD THREADED THROUGH 4 HOLES TO MAKE 2 STOP-THREADS

(Illustration) Single thread threaded through 4 holes to make 2 stop threads.

Pattern to wrap around can (Table to find Dose Rates (R/Hr)

CUT EXACTLY ON SIDE LINES

TOP OF CAN (BELOW LIP)

FASTEN THREADS HOLDING ALUMINUM LEAVES HERE

TOP OF 1 IN. PENCIL (FOR RULER REST)

SEAT

1-INCH PENCIL TAPED SECURE

CENTER LINE

HOLES FOR STOP THREAD

BOTTOM OF CAN (ABOVE LIP)

SIDE SEAM OF CAN

CUT ALONG LINE

HOLES SHOULD BE 1 5/8 IN. BELOW TOP

HOLE FOR STOP THREAD

TABLE USED TO FIND DOSE RATES (R/HR) FROM KFM READINGS

*DIFFERENCE BETWEEN THE READING BEFORE EXPOSURE AND THE READING AFTER EXPOSURE (B.R. Y STANDARD FOIL LEAVES)

DIFF.* IN READINGS	TIME INTERVAL OF AN EXPOSURE 15 SEC. R/HR	1 MIN. R/HR	4 MIN. R/HR	16 MIN. R/HR	1 HR. R/HR
2 mm	6.2	1.6	0.4	0.1	0.03
4 mm	12.	3.1	0.8	0.2	0.06
6 mm	19.	4.6	1.2	0.3	0.08
8 mm	25.	6.2	1.6	0.4	0.10
10 mm	31.	7.7	2.0	0.5	0.13
12 mm	37.	8.2	2.3	0.6	0.15
14 mm	43.	11.	2.7	0.7	0.18

HOLE FOR STOP THREAD

CUT EXACTLY ON SIDE LINES

TOP OF CAN (BELOW LIP)

FASTEN THREADS HOLDING ALUMINUM LEAVES HERE

TOP OF 1 IN. PENCIL (FOR RULER REST)

SEAT

1-INCH PENCIL TAPED SECURE

CENTER LINE

HOLES FOR STOP THREAD

BOTTOM OF CAN (ABOVE LIP)

SIDE SEAM OF CAN

CUT ALONG LINE

HOLES SHOULD BE 1-5/8 IN. BELOW TOP

HOLE FOR STOP THREAD

TABLE USED TO FIND DOSE RATES (R/HR) FROM KFM READINGS

*DIFFERENCE BETWEEN THE READING BEFORE EXPOSURE AND THE READING AFTER EXPOSURE (B.R. Y STANDARD FOIL LEAVES)

DIFF.* IN READINGS	TIME INTERVAL OF AN EXPOSURE 15 SEC. R/HR	1 MIN. R/HR	4 MIN. R/HR	16 MIN. R/HR	1 HR. R/HR
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6 mm	19.	4.6	1.2	0.3	0.08
8 mm	25.	6.2	1.5	0.4	0.10
10 mm	31.	7.7	2.0	0.5	0.13
12 mm	37.	9.2	2.3	0.6	0.15
14 mm	43.	11.	2.7	0.7	0.18

HOLE FOR STOP THREAD

PAPER PATTERN TO WRAP AROUND KFM CAN (GLUE OR TAPE SECURELY TO CAN)

CUT OUT THESE PATTERNS, EACH OF WHICH IS THE EXACT SIZE FOR A KFM.

CAUTION: XEROX COPIES OF THESE PATTERNS MAY BE TOO LARGE.

PATTERN PAGE (A)

4. Sharpen a small nail, by filing or rubbing on concrete, for use as a punch to make the four holes needed to install the stop-threads in the ionization chamber (the can). (The stop-threads are insulators that stop the charged aluminum leaves from touching the can and being discharged.)

5. Have one person hold the can over a horizontal stick or a round wooden tool-handle, that ideally has a diameter about as large as the diameter of the can. Then a second person can use the sharpened nail and a hammer to punch four very small holes through the sides of the can at the points shown by the four crosses on the pattern. Make these holes just large enough to run a needle through them, and then move the needle in the holes so as to bend back the obstructing points of metal.

6. The stop-threads can be installed by using a needle to thread a single thread through all four holes. Use a very clean thread, preferably nylon, and do not touch the parts of this thread that will be inside the can and will serve as the insulating stop-threads. Soiled threads are poor insulators. (See illustrations.)

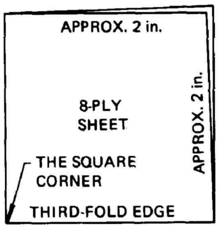
Before threading the thread through the four holes, tie a small toggle (see the preceding sketch) to the long end of the thread. (This toggle can easily be made of a very small sliver of wood cut about 3/8 in. long.) After the thread has been pulled through the four holes, attach a second toggle to the thread, about 1/2 inch from the part of the thread that comes out of the fourth hole. Then the thread can be pulled tightly down the side of the can and the second small toggle can be taped securely in place to the side of the can. (If the thread is taped down without a toggle, it is likely to move under the tape.)

The first toggle and all of the four holes also should be covered with tape, to prevent air from leaking into the can after it has been covered and is being used as an ionization chamber.

X. Make Two Separate 8-Ply leaves of Standard [Not Heavy Duty*] Aluminum Foil:

Proceed as follows to make each leaf:

Fig. 222a (How to fold aluminum foil -1)

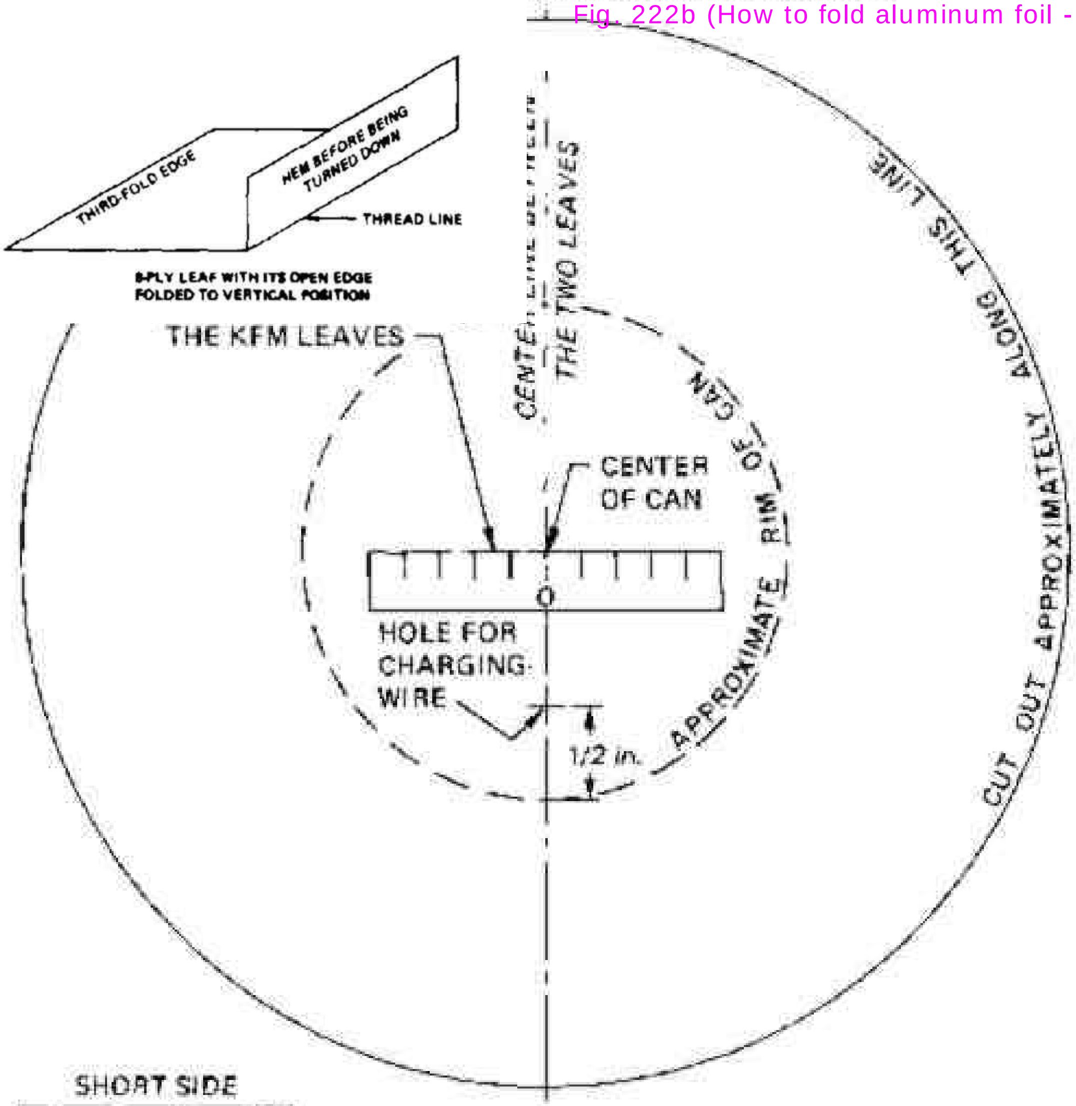


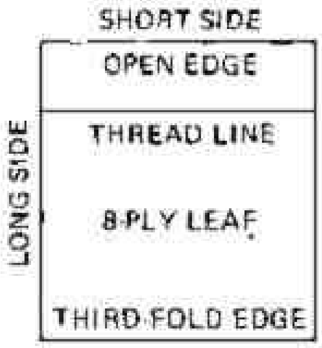
A. For the KFM: (In the following list, when)

1. Cut out a piece of standard aluminum foil approximately 4 inches by 8 inches.
2. Fold the aluminum foil to make a 2-ply (= 2 thicknesses) sheet approximately 4 inches by 4 inches.
3. Fold this 2-ply sheet to make a 4-ply sheet approximately 2 inches by 4 inches.
4. Fold this 4-ply sheet to make an 8-ply sheet (8 sheets thick) approximately 2 inches by 2 inches, being sure that the two halves of the second-fold edge are exactly together. This third folding makes an 8-ply aluminum foil sheet with one corner exactly square.
5. Cut out the FINISHED-LEAF PATTERN, found on the following Pattern Page B. Note that this pattern is NOT a square and that it is smaller than the 8-ply sheet. Flatten the 8 thicknesses of aluminum foil with the fingers until they appear to be a single thin, flat sheet.
6. Hold the FINISHED-LEAF PATTERN on top of the 8-ply aluminum foil sheet, with the pattern's THIRD-FOLD EDGE on top of the third-fold edge of the 8-ply aluminum sheet. Be sure that one lower corner of the FINISHED-LEAF PATTERN is on top of the exactly square corner of the 8-ply aluminum sheet.

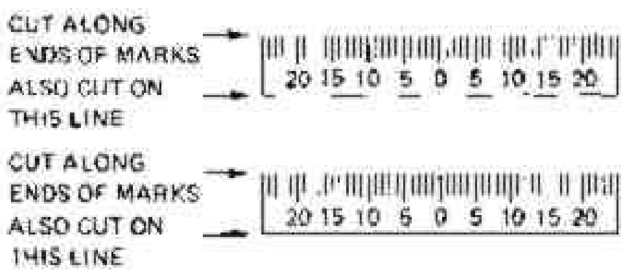
ASTIC COVER FOR KFM CAN

Fig. 222b (How to fold aluminum foil -2)





FINISHED LEAF PATTERN
(CUT OUT EXACTLY ON SIDE LINES)



PAPER SCALE (TO BE CUT OUT)

PATTERN PAGE (B)

CAUTION: XEROX COPIES OF THE FINISHED-LEAF AND THE SCALE PATTERNS MAY BE SLIGHTLY TOO LARGE

7. While holding a straight edge along the THREAD LINE of the pattern, press with a sharp pencil so as to make a shallow groove for the THREAD LINE on the 8-ply aluminum sheet. Also using a sharp pencil, trace around the top and side of the pattern, so as to indent (groove) the 8-ply foil.

8. Remove the pattern and cut out the 8-ply aluminum foil leaf. Then, in order to prevent possible excessive electrical discharge from overly sharp points on the lower corners of the leaf, cut about 11/16-inch (triangle) off each of its two lower corners.

9. While holding a straight edge along the indented THREAD LINE, lift up the OPEN EDGE of the 8-ply sheet (keeping all 8 plies together) until this edge is vertical, as illustrated. Remove the straight edge, and fold the 8-ply aluminum along the THREAD LINE so as to make a flat-folded hem.

10. Open the flat-folded hem of the finished leaf until the 8-ply leaf is almost flat again, as shown by the pattern, from which the FINISHED-LEAF PATTERN has already been cut.

11. Prepare to attach the aluminum-foil leaf to the thread that will suspend it inside the KFM.
*If only heavy duty aluminum foil (sometimes called "extra heavy duty") is available, make 5-ply leaves of the same size, and use the table for the 8-ply KFM to determine radiation dose rates. To make a 5-ply leaf, start by cutting out a piece of foil approximately 4 inches by 4 inches. Fold it to make a 4-ply sheet approximately 2 inches by 2 inches, with one corner exactly square. Next from a single thickness of foil cut a square approximately 2 inches by 2 inches. Slip this square into a 4-ply sheet, thus making a 5-ply sheet. Then make the 5-ply leaf, using the FINISHED-LEAF PATTERN, etc. as described for making an 8-ply leaf.

    If no epoxy glue* is available to hold down the hem and prevent the thread from slipping in the hem, cut two pieces of tape (Band-Aid tape is best; next best is masking or freezer tape; next best, Scotch tape). After first peeling off the paper backing of Band-Aid tape, cut each piece of tape 1/8 inch by 1 inch long. Attach these two pieces of tape to the finished 8-ply aluminum leaf with the sticky sides up, except for their ends. As shown by the pattern on the following pattern page, secure 1/8 inch of one end of a tape strip near one corner of the 8-ply aluminum foil leaf by first turning under this 1/8-inch end; that is, with this end's sticky side down. Then turn under the other 1/8-inch-long end, and attach this end below the THREAD LINE. Slant each tape strip as illustrated on Pattern (C).

BE SURE YOU HAVE READ THROUGH STEP 18 BEFORE YOU DO ANYTHING ELSE.

12. Cut an 8-1/2 inch piece of fine, un-waxed, very clean thread that has not been anti-static treated. See INSTRUCTIONS, Page 6 for excellent insulating threads and substitutes. In l986 most sewing threads are anti-static treated and are too poor insulators for use in a KFM.

    Cut out Pattern (C), the guide sheet used when attaching a leaf to its suspending thread. Then tape Pattern (C) to the top of a work table. Cover the two "TAPE HERE" rectangles on Pattern (C) with pieces of tape, each piece the size of the rectangle. Then cut two other pieces of tape each the same size and use them to ONTO the thread ONTO the guide sheet, on top of the 'TAPE HERE" rectangles.

    Be very careful not to touch the two 1-inch parts of the thread next to the outline of the finished leaf, since oil and dirt even on clean fingers will reduce the electrical insulating value of the thread between the leaf and the top rim of the can.

13. With the thread still taped to the paper pattern and while slightly lifting the thread with a knife tip held under the center of the thread, slip the finished leaf under the thread and into position exactly on the top of the leaf outlined on the pattern page. Hold the leaf in this position with two fingers.

14. While keeping the thread straight between its two taped-down ends, lower the thread so that it sticks to the two plastic strips. Then press the thread against the plastic strips.

15. With the point of the knife, hold down the center of the thread against the center of the THREAD LINE of the leaf. Then, with two fingers, carefully fold over the hem and press it almost flat. Be sure that the thread comes out of the corners of the hem. Remove the knife, and press the hem down completely flat against the rest of the leaf.
16. Make small marks on the thread at the two points shown on the pattern page. Use a ball-point pen if available.
17. Loosen the second two small pieces of tape from the pattern paper, but leave these tapes stuck to the thread.
18. Cut 5 pieces of Band-Aid tape, each approximately 1/8 inch by 1/4 inch, this small. Use 2 of these pieces of tape to secure the centers of the side edges of the leaf. Place the 5 pieces as illustrated in the SIDE VIEW sketch below. Or use tiny droplets of epoxy, applied with a needle, to secure the side edges and to hold down the hem.

Fig. Pg. 224a (Shows size of Band -Aid tape)

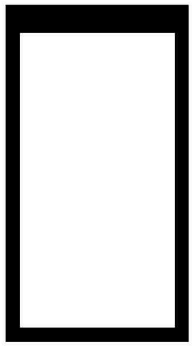
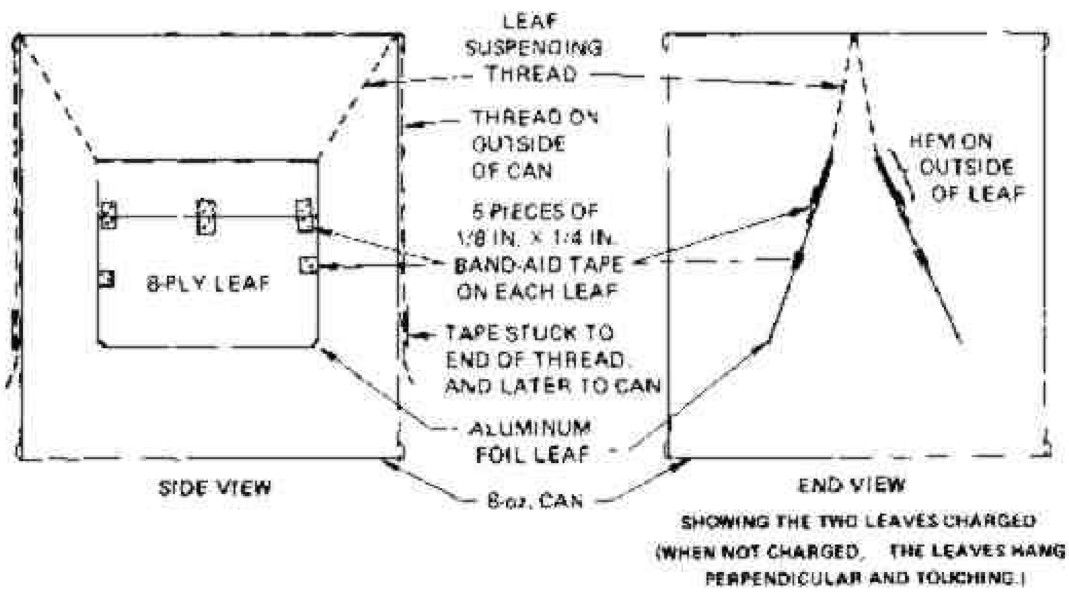


Fig. pg. 224b V IEW 8-oz. CAN SHOWING THE TWO LEAVES CHARGED (WHEN NOT CHARGED. THE LEAVES HANG PERPENDICULAR AND TOUCHING.) ORNL-DWG 76-6542



19. To prevent possible partial discharge from overly sharp lower corners of the leaves, use scissors to cut about 1/16 inch (L) off each lower corner of the two leaves. (Partial discharge from an overly sharp corner may prevent a KFM's leaves from being adequately charged and adequately separated.)
20. To make it easier to take accurate readings:

a. Make a black stripe 1/8-inch wide on the hem side of the lower edge of each leaf, if the drying agent to be used is white anhydrite made from gypsum, or light blue Drierite. It is best to use a waterproof marker, such as black Marko by Flair.

b. Make a white stripe, if the drying agent to be used is dark blue silica gel. Liquid Paper correction fluid, or white ink, serves well.

*If using epoxy or other glue, use only a very little to hold down the hem, to attach the thread securely to the leaf and to glue together any open edges of the plied foil. Most convenient is "one hour" epoxy, applied with a toothpick. Model airplane cement requires hours to harden when applied between sheets of aluminum foil. To make sure no glue stiffens the free thread beyond the upper corners of the finished leaf, put no glue within 1/4 inch of a point where thread will go out from the folded hem of the leaf.

The instructions in step 11 are for persons lacking "one hour" epoxy or the time required to dry other types of glue. Persons using glue instead of tape to attach the leaf to its thread should make appropriate use of the pattern on the following page and of some of the procedures detailed in steps 12 through 18.

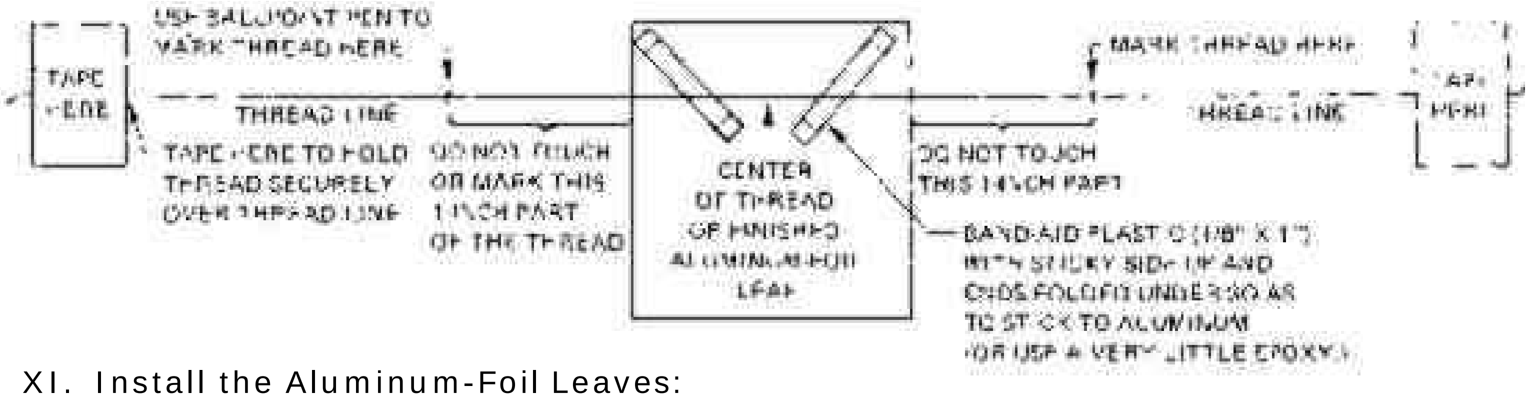
COVER THE TWO "TAPE HERE" RECTANGLES WITH SAME-SIZED PIECES OF TAPE, IN ORDER TO KEEP FROM TEARING THIS PAPER WHEN REMOVING TWO ADDITIONAL PIECES OF TAPE. THEN, BY PUTTING TWO OTHER PIECES OF TAPE THIS SAME SIZE ON TOP OF THE FIRST TWO PIECES, TAPE THE THREAD ONTO THIS GUIDE SHEET, AND LATER ATTACH A LEAF TO THE TAPED-DOWN THREAD.

WARNING:

The parts of the thread that will be inside the Can and on which the leaf will be suspended must serve to insulate the high-voltage electrical charges to be placed on the leaf Therefore, the suspended parts of the thread must be kept very clean.

(Cut out this guide along its border lines and tape to the top of a work table.)

Fig. 225 Pattern (C) how to tape aluminum leaves to thread line.



XI. Install the Aluminum-Foil Leaves:

1. In preparation for suspending the leaves inside the can, make two shallow notches in the top of the rim of the can. Make one notch above each of the two lines ("FASTEN THREADS HOLDING ALUMINUM LEAVES HERE") on the paper Pattern attached to the outside of the can. Make flat-bottomed notches by first filing a V-shaped notch, and then using a fine-toothed hacksaw blade to make the notch rectangular. (If a file and/or a hacksaw blade are not available, the leaf-suspending threads can be taped to the top of the rim of the can.)

2. Use the two small pieces of 'ape stuck to the ends of a leaf-suspending thread to attach the thread to the outside of the can. Attach the tapes on opposite sides of the can, so as to suspend the leaf inside the can. See END VIEW sketch. Each of the two marks on the attached thread MUST rest exactly in a notch (or on the top of the rim of the can, if you are unable to make notches). Be sure that the hem-side of each of the two leaves will face outward. See END VIEW sketch.

3. Position and secure the second leaf, being sure that:

   a. The smooth sides of the two leaves are not wrinkled or bent and face each other, and are flush ("right together") when not charged. See END VIEW sketch and study the first photo illustration, "An Uncharged KFM".

   b. The upper edges of the two leaves are suspended side by side and at the same distance below the top of the can.

   c. The leaf-suspending threads are in their notches in the top of the rim of the can (or are taped with Band-Aid to the top of the rim of the can) so that putting the cover on will not move the threads.

   d. No parts of the leaf-suspending threads inside the can are taped down to the can or otherwise restricted.

   e. The leaf-suspending parts of the threads inside the can do not cross over, entangle or restrict each other.

   f. The threads come together where they go over the rim of the can, and the leaves are flat and hang together as shown in the first photo illustration, "An Uncharged KFM"

   g. The leaves look like these photographed leaves. If not, make new, better leaves and install them.

4. Cover with tape the parts of the threads that extend down the outside of the can, and also cover with more tape the small pieces of tape near the ends of the threads on the outside of the can. Or use epoxy or other waterproof glue to attach the parts of the threads on the outside of the can securely to the can.

5. To make the SEAT, cut a piece of a wooden pencil, or a stick, about one inch long and tape it securely to the side of the can along the center line marked SEAT on the pattern. Be sure the upper end of this piece of pencil is at the same position as the top of the location for the SEAT outlined on the pattern. The top of the SEAT is 3/4 inch below the top of the can. Be sure not to cover or make illegible any part of the table printed on the paper pattern.

6. Cut out one of the "Reminders for Operators" and glue and/or tape it to the unused side of the KFM. Then it is best to cover all the sides of the finished KFM with clear plastic tape or varnish. This will keep sticky-tape on the end of an adjustment thread or moisture from damaging the "Reminders" or the table.

XII.Make the Plastic Cover:

1. Cut out the paper pattern for the cover from the Pattern Page (B).

2. From a piece of clear, strong plastic, cut a circle approximately the same size as the paper pattern. (Storm-window vinyl film, 4 mils thick, is best.)

3. Stretch the center of this circular piece of clear plastic over the open end of the can, and pull it down close to the sides of the can, making small tucks in the "skirt," so that there are no wrinkles in the top cover. Hold the lower part of the "skirt" in place with a strong rubber band or piece of string. (If another can having the same diameter as the KFM can is available, use it to make the cover -- to avoid the possibility of disturbing the leaf-suspending threads.)

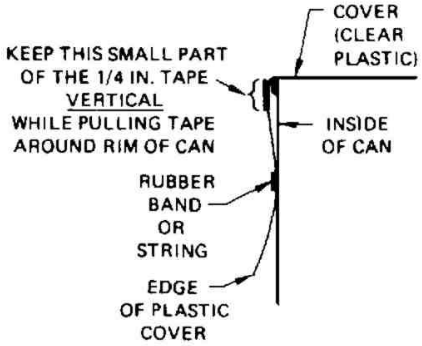


Fig. 226 (Shows positioning of tape and rubber band to secure plastic cover on KFM)

4. Make the cover so it fit snugly, but can be taken off and replaced readily. Just below the top of the rim of the can, bind the covering plastic in place with a 1 :4- inch-wide piece of strong tape. (Cloth duct tape is best. Use two thicknesses. If only freezer or masking tape is available, use three or four thicknesses.)

   Keep vertical the small part of the tape that presses against the rim of the can while pulling the length of the tape horizontally around the can so as to bind the top of the plastic cover snugly to the rim. If this small part of the tape is kept vertical, the lower edge of the tape will not squeeze the plastic below the rim of the can to such a small circumference as to prevent the cover from being removed quite easily.

5. With scissors, cut off the "skirt" of the plastic cover until it extends only about one inch below the top of the rim of the can.

6. Make a notch in the "skirt," about one inch wide, where it fits over the pencil SEAT attached to the can. The "skirt" in this notched area should be only about 5/8 of an inch long, measured down from the top of the rim of the can.

REMINDERS FOR OPERATORS

The drying agent inside a KFM is O.K. if, when the charged KFM is not exposed to radiation, its readings decrease by 1 mm or less in 3 hours.

Reading: With the reading eye 12 inches vertically above the seat. note on the tom scale the separation of the lower edges of the leaves. If the right leaf is at 10 mm and the left leaf is at 3 mm. the KFM reads 10 mm. Never take a reading while a leaf is touching a stop-thread. Never use a reading that is less than 5 mm.

Finding a dose rate: If before exposure a KFM reads 17 mm and if after a l-minute exposure it reads 5 mm. the difference in readings is 12 mm the attached table shows the dose rate was 9.6 R hr during the exposure.

Finding a dose: If a person works outside for 3 hours where the dose rate

Finding how long it takes to get a certain R dose: If the dose rate is 1.6 R hr outside and a person is willing to take a 6 R dose, how long can he remain outside? Answer: 6 R /1.6 R/hr 3.75 hr = 3 hours and 45 minutes.

Fallout radiation guides for a healthy person not previously exposed to a total radiation dose of more than 100 R during a 2-week period:

6 R per day can be tolerated for up to two months without losing the ability to work.

100 R in a week or less is not likely to seriously sicken.

350 R in a few days results in a 50-50 chance of dying, under post-attack conditions.

600 R in a week or less is almost certain to cause death within a few weeks.

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is 2 R hr. what is his radiation dose? Answer: 3 hr x 2 R hr = 6 R.

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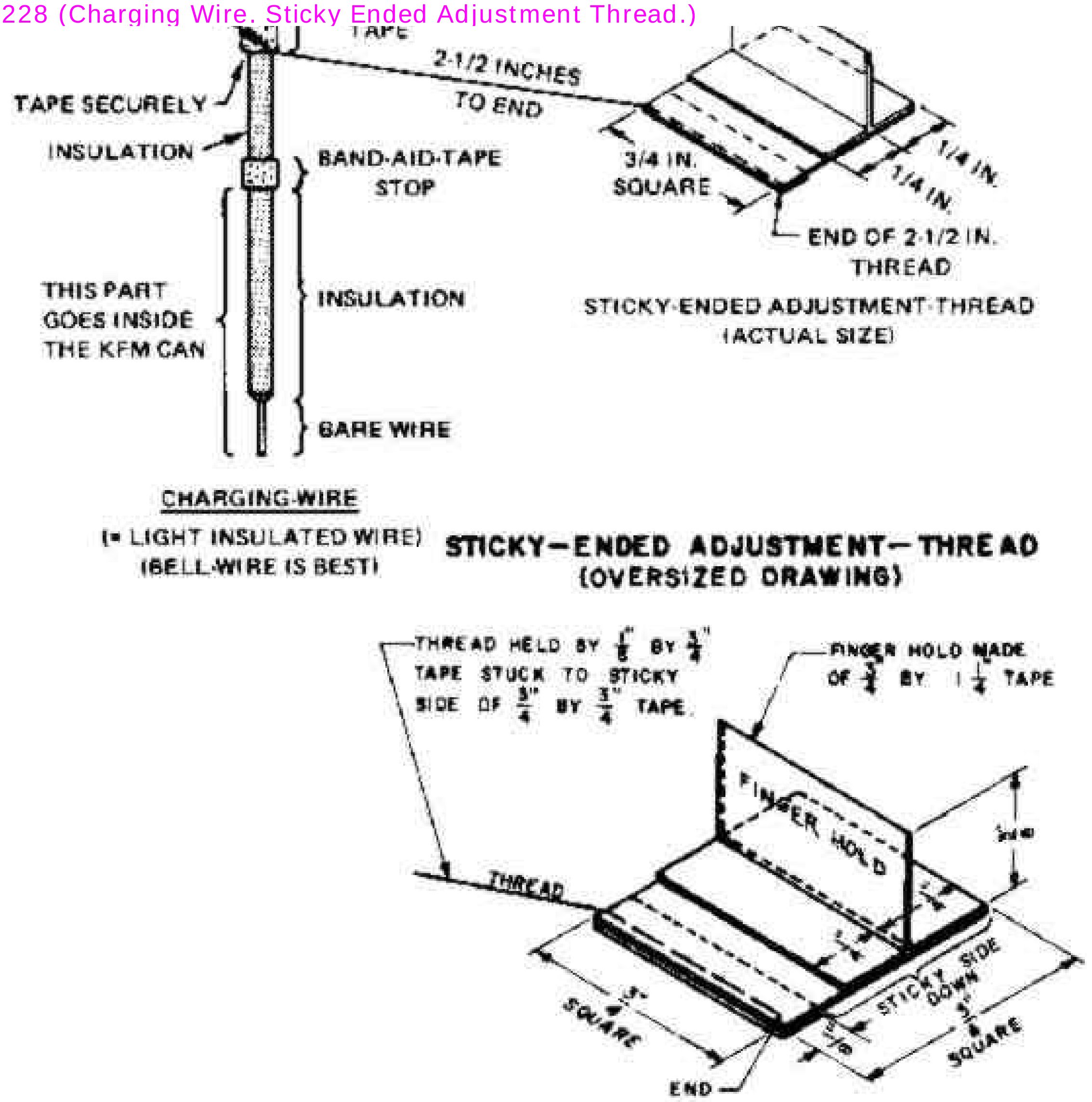
7. Remove the plastic cover, and then tape the lower edges of the "skirt," inside and out, using short lengths of 1/4-inch-wide tape. Before securing each short piece of tape, slightly open the tucks that are being taped shut on their edges, so that the "skirt" flares slightly outward and the cover can be readily removed.

Fig. 228 (Charging Wire. Sticky Ended Adjustment Thread.)



8. Make the charging-wire by using the full-size, exact-size pattern on the right. Doorbell wire with an outside diameter of about 1116 inch is best, but any lightweight insulated wire, such as part of a lightweight two-wire extension cord split in half, will serve. The illustrated wire is much thicker than bell wire. To stop tape from possibly slipping up or down the wire, use a very little glue.

If a very thin plastic has been used for the cover, a sticky piece of tape may need to be attached to the end of the bare-ended adjustment thread, so both threads can be used to hold the charging wire in a desired position.

The best tape to attach to an end of one of the adjustment-threads is cloth duct tape. A square piece 3/4 inch by 3/4 inch is the sticky base. To keep this tape sticky (free of paper fibers), the paper on the can should be covered with transparent tape or varnish. A piece about 1/8 inch by 314 inch serves to stick under one end of the sticky base, to hold the adjustment-thread. A 3/4 inch by 1- 1/4 inch rectangular piece of tape is used to make the finger hold -- important for making adjustments inside a dry-bucket.

With a needle or pin, make a hole in the plastic cover 1/2 inch from the rim of the can and directly above the upper end of the CENTER LINE between the two leaves. The CENTER LINE is marked on the pattern wrapped around the can. Carefully push the CHARGING-WIRE through this hole (thus stretching the hole) until all of the CHARGING-WIRE below its Band-Aid-tape stop is inside the can.

9. From the Pattern Page (B) cut out the SCALE. Then tape the SCALE to the under side of the plastic cover, in the position shown on the pattern for the cover, and also by the drawings. Preferably use transparent tape. Be careful not to cover with tape any of the division lines on the SCALE between 20 on the right and 20 on the left of 0.

10. Put the plastic cover on the KFM can.

XIII. Two Ways to Charge a KFM:

When preparing to charge a KFM, be sure its anhydrite is fresh. (Under humid conditions, sometimes in only 2 days enough water vapor will go through the plastic cover to make the drying agent ineffective.) Be sure no piece of anhydrite is on top of another piece. Re-read VIII 7 and VIII 8.

1. Charging a KFM with Hard Plastic Rubbed on Dry Paper.

   a. Adjust the charging-wire so that its lower end is about 1/16 inch above the upper edges of the aluminum-foil leaves. Use the sticky-tape at the end of one adjustment-thread to hold the charging-wire in this position. Stick this tape approximately in line with the threads suspending the leaves, either on the side of the can or on top of the plastic cover. (If the charging-wire is held loosely by the cover, it may be necessary to put a piece of sticky-tape on the end of each adjustment-thread in order to adjust the charging-wire securely. If a charging-wire is not secure, its lower end may be forced up by the like charge on the leaves before the leaves can be fully charged.)

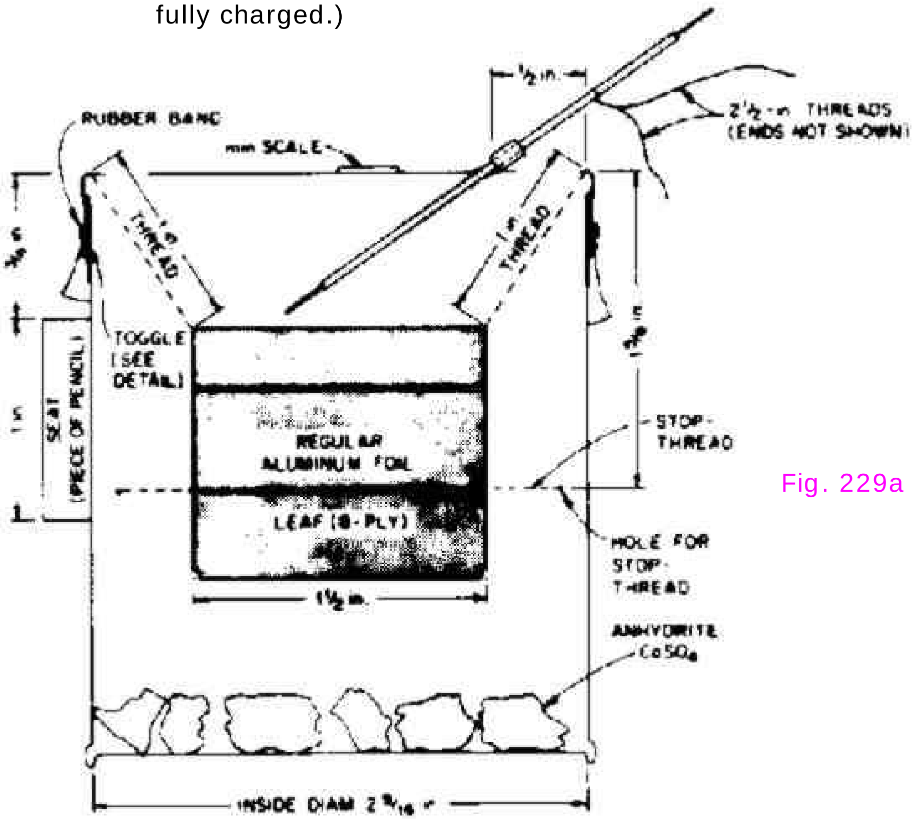


Fig. 229a (Charging a KFM)

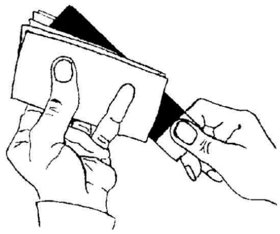
b. Select a piece of Plexiglas, a draftsman's plastic triangle, a smooth plastic ruler, or other piece of hard, smooth plastic. (Unfortunately, not all types of hard plastic can be used to generate a sufficient electrostatic charge.) Be sure the plastic is dry.

For charging a KFM (especially inside a dry-bucket), cut a rectangular piece of hard plastic such as Plexiglas about 1-1/2 by 6 inches. Sharp corners and edges should be smoothed. To avoid contaminating the charging end with sweaty, oily fingers, it is best to mark the other end with a piece of tape, and to hold it only by its taped end.

c. Fold DRY paper (a piece of clean paper bag, or other smooth, clean paper) to make an approximate square about 5 inches on a side and 15 to 20 sheets thick. (This many sheets of paper lessens leakage to the fingers of the electrostatic high-voltage charges to be generated on the hard plastic and on the rubbed paper.)

d. Fold the square of paper in the middle, and move the hard plastic rapidly back and forth so that it in the middle of this folded square is rubbed vigorously on the paper while the outside of this folded square of paper is squeezed firmly between thumb and little finger on one side, and the ends of three fingers on the other. To avoid discharging the charge on the plastic to the fingers, keep them away from the edges of the paper. See sketch.

Fig. 229b (Using plastic and paper to generate a static charge)



e. Move the electrostatically charged part of the rubbed plastic rather slowly past the upper end of the charging-wire, while looking straight down on the KFM. Keep the hard plastic approximately perpendicular to the charging- wire and about 1/4 to 1/2 inch away from its upper end. The charge jumps the spark gaps and charges the leaves of the KFM. Charge the leaves sufficiently to give a reading of at least 15 mm.

f. Pull down on an insulating adjustment-thread to raise the lower end of the charging-wire. (If the charging-wire has been held in its charging position by its sticky ended adjustment-thread being stuck to the top of the clear plastic cover, to avoid possibly damaging the threads: (1) pull down a little on the bare-ended adjustment-thread; and (2) detach, pull down on, and secure the sticky-ended adjustment-thread to the side of the can, so as to raise and keep the lower end of the charging-wire close to the underside of the clear plastic cover.) Do not touch the charging-wire, because its insulation usually is not good enough to prevent the charge from bleeding off into the fingers.

g. To get the most accurate readings possible, lightly bump or shake the charged KFM (to remove any unstable part of the charge) before taking the initial reading.

h. If the initial reading is more than 20 mm, to get the most accurate reading possible carefully partially discharge the leaves (by touching them with the charging-wire while guiding the wire with your fingers on its insulation), to reduce to 20 mm or slightly less the initial reading that you will use. Or completely discharge, and recharge to 20 mm or slightly less.

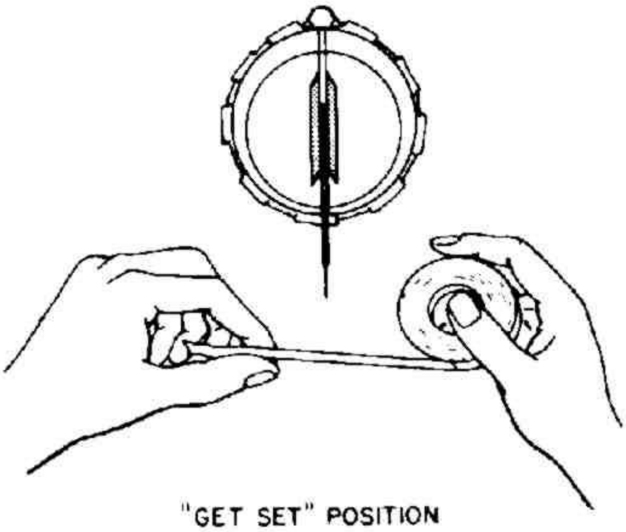
i. To keep a KFM in excellent condition and to enable its drying agent to last much longer before becoming ineffective, put the whole KFM in an airtight container, such as a large peanut butter jar, with drying agent about an inch deep on its bottom. Or at least keep the charging paper and the hard plastic charging strip dry in a sealable container, such as a Mason jar, with some drying agent.

2. Charging a KFM from a Quickly Unwound Roll of Tape. (Quick unwinding produces a harmless charge of several thousand volts on the tape.)

a. Adjust the charging-wire so that its lower end is about 1/16 inch above the upper edges of the aluminum-foil leaves. Use the sticky-tape at the end of one adjustment-thread to hold the charging-wire in this position. Stick this tape approximately in line with the leaves, either on the side of the can or on the plastic cover. (If the plastic cover is weak, it may be necessary to put a piece of sticky-tape on the end of each adjustment-thread, in order to hold the charging-wire securely. If a charging-wire is not secure, its lower end may be forced up by the like charge on the leaves before the leaves can be fully charged.)

b. The sketch shows the "GET SET" position, preparatory to unrolling the Scotch Magic Transparent Tape, PVC, electrical tape, or other tape. Be sure to first remove the roll from its dispenser. Some of the other kinds of tape will not produce a high enough voltage.

c. QUICKLY unroll 10 to 12 inches of tape by pulling its end with the left hand, while the right hand allows the roll to unwind while remaining in about the same "GET SET" position only an inch or two away from the KFM.



"GET SET" POSITION

(Illustration) "Get Set" position

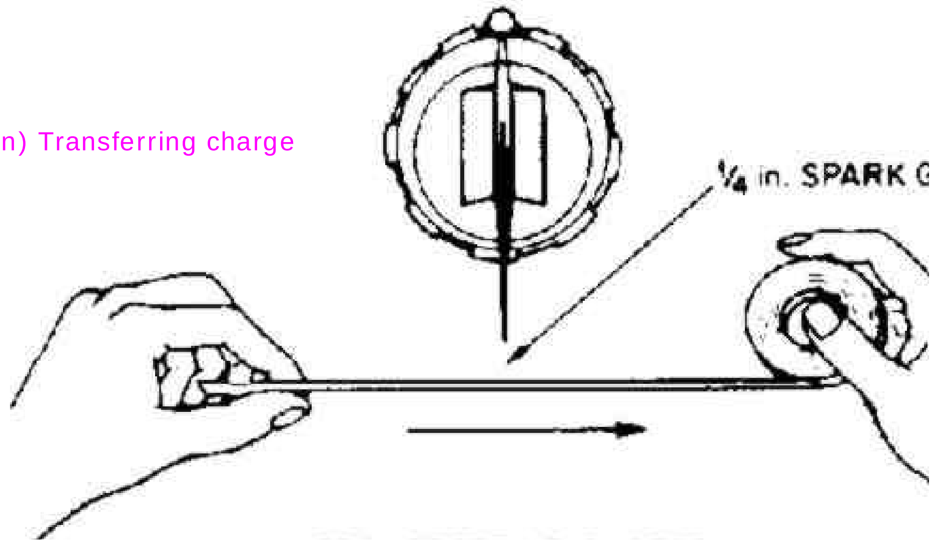
d. While holding the unwound tape tight, about perpendicular to the charging-wire, and about 114 inch away from the end of the charging-wire, promptly move both hands and the tape to the right rather slowly taking about 2 seconds to move about 8 inches. The electrostatic charge on the unwound tape "jumps" the spark gaps from the tape to the upper end of the charging-wire and from the lower end of the charging-wire to the aluminum leaves, and charges the aluminum leaves. Be sure neither leaf is touching a stop-thread.

Try to charge the leaves enough to spread them far enough apart to give a reading of at least 15 mm, but no more than 20 mm after the KFM has been gently bumped or shaken to remove any unstable part of the charge.

e. Pull down on an insulating adjustment-thread to raise the lower end of the charging-wire. If the charging-wire has been held in charging position by its sticky-ended adjustment-thread being stuck to the top of the clear plastic cover, it is best first to pull down a little on the bare-ended adjustment-thread, and then to move, pull down on, and secure the sticky-ended adjustment-thread to the side of the can so that the lower part of the charging-wire is close to the underside of the clear plastic cover.
Do not touch the charging-wire.

f. Rewind the tape tight on its roll, for future use when other tape may not be available.

(Illustration) Transferring charge



Testing Your KFM to Learn if it Can Accurately Measure Low Dose Rates:

Put fresh drying agent in your KFM and then charge and test the KFM in a location where it is not exposed to abnormal radiation. Take an initial reading. If after 3 hours its reading has decreased by 1 mm, or less, this means that its leaf-suspending threads are good insulators and that your KFM can reliably measure dose rates as low as 0.03 roentgens per hour (30 milliroentgens per hour). By post-attack standards, 30 mR/hr is a low dose rate. In a whole month of continuous exposure (an impossibility, because fallout decays). 30 mR/hr would result in a dose of 21.9 roentgens - not enough to incapacitate. Warning: In heavy fallout areas, for the first few days after fallout deposition the dose rates inside even most good shelters will be higher than 0.03 R/hr.

Trouble Shooting:

If charging does not separate the two leaves sufficiently, take these corrective actions:

1. Be sure the pieces of anhydrite in the bottom of the ionization chamber (the can) are in a single layer, with no piece on top of another and the top of no piece more than 112 inch above the bottom of the can.
2. Check to be sure that the threads suspending the leaves are not crossed; then try to charge the KFM again.
3. If the KFM still cannot be charged, replace the used anhydrite with fresh anhydrite.
4. If you cannot charge a K FM when the air is very humid, charge it inside its dry-bucket.
5. If you cannot charge the KFM while in an area of heavy fallout, take it to the place affording the best protection against radiation, and try to charge it there. (A dose rate of several hundred R hr will neutralize the charges on both the charging device and the instrument so rapidly that a K FM cannot be charged.)

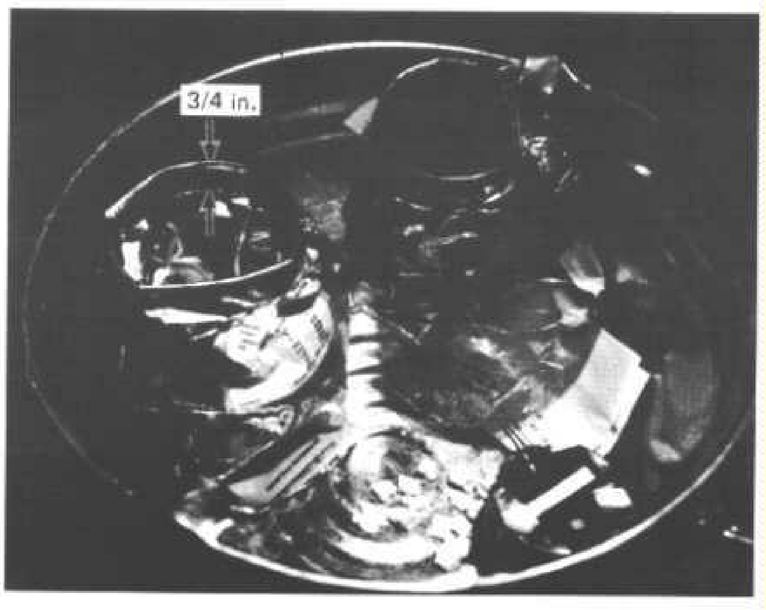
If a KFM or other radiation measuring instrument gives unexpectedly high readings inside a good shelter, wipe all dust off the outside of the instrument and repeat the radiation-measurements. Especially when exposing a fallout meter outdoors where there is fresh fallout, keep the instrument in a lidded pot, plastic bag, or other covering to avoid the possibility of having it contaminated with fallout particles and afterwards getting erroneously high radiation measurements.

XIV. Make and Use a Dry-Bucket:

By charging a KFM while it is inside a dry-bucket with a transparent plastic cover (see illustration), this fallout meter can be charged and used even if the relative humidity is 100% outside the dry-bucket. The air inside the dry-bucket is, kept very dry by a drying agent placed on its bottom.

About a cupful of anhydrite serves very well. The pieces of this dehydrated gypsum need not be as uniform in size as is best for use inside a KFM, but do not use powdered anhydrite.

Fig. 231a (Bucket with Anhydrite)

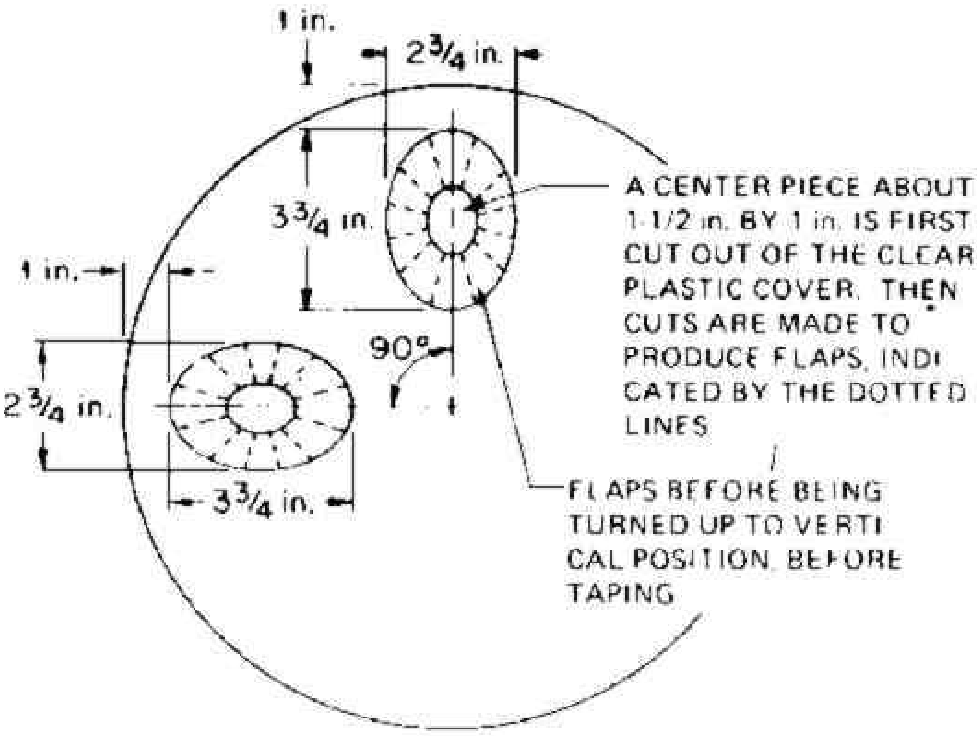


A dry-bucket can be readily made in about an hour by proceeding as follows:

1. Remove the handle of a large bucket, pot, or can preferably with a top diameter of at least 11 inches. A 4-gallon bucket having a top diameter of about 14 inches and a depth of about 9 inches is ideal. A plastic tub approximately this size is satisfactory. If the handle-supports interfere with stretching a piece of clear plastic film across the top of the bucket, remove them, being sure no sharp points remain.
2. Cut out a circular piece of clear plastic with a diameter about 5 inches larger than the diameter of the top of the bucket. Clear vinyl 4 mils thick, used for storm windows, etc., is best. Stretch the plastic smooth across the top of the bucket, and tie it in place, preferably with strong rubber bands looped together to form a circle.
3. Make a plastic top that fits snugly but is easily removable, by taping over and around the plastic just below the top of the bucket. One-inch-wide cloth duct tape, or one-inch-wide glass-reinforced strapping tape, serves well. When taping, do not permit the lower edge of the tape to be pulled inward below the rim of the bucket.

Fig. 231a (Bucket with Anhydrite - Enlarged View)

(Illustration) Cutting the clear plastic cover.



4. Cut two small holes (about 1 inch by 2 inches) in the plastic cover, as illustrated. Then make the radial cuts (shown by dotted lines) outward from the small holes, out to the solid-line outlines of the 3 inch by 4 inch hand-holes, so as to form small flaps.
5. Fold the small flaps upward, so they are vertical. Then tape them on their outer sides, so they form a vertical "wall" about 3/4 inch high around each hand-hole.
6. Reduce the length of two ordinary plastic bread bags (or similar plastic bags) to a length that is 5 inches greater than the height of the bucket. (Do not use rubber gloves in place of bags; gloves so used result in much more humid outside air being unintentionally pumped into a dry-bucket when it is being used while charging a KFM inside it.)
7. Insert a plastic bag into each hand-hole, and fold the edge of the plastic bag about 1/2 inch over the taped vertical "wall" around each hand-hole.
8. Strengthen the upper parts of the plastic bags by folding 2-inch pieces of tape over the top of the "wall" around each hand-hole.
9. Make about a quart of anhydrite by heating small pieces of wall-board gypsum, and keep this anhydrite dry in a Mason jar or other airtight container with a rubber or plastic sealer.
10. Make a circular aluminum-foil cover to place over the plastic cover when the dry-bucket is not being used for minutes to hours. Make this cover with a diameter about 4 inches greater than the diameter of the top of the bucket, and make it fit more snugly with an encircling loop of rubber bands, or with string. Though not essential, an aluminum-foil cover reduces the amount of water vapor that can reach and pass through the plastic cover, thus extending the life of the drying agent.
11. Charge a KFM inside a dry-bucket by:
    a. Taking off wrist watch and sharp-pointed rings that might tear the plastic bags.
    b. Placing inside the dry-bucket:
        (1) About a cup of anhydrite or silica gel;
        (2) the KFM, with its charging-wire adjusted in its charging position; and

(3) dry, folded paper and the electrostatic charging device, best a 5-inch-long piece of Plexiglas with smoothed edges, to be rubbed between dry paper folded about 4 inches square and about 20 sheets thick. (Unrolling a roll of tape inside a dry-bucket is an impractical charging method.)

c. Replacing the plastic cover, that is best held in place with a loop of rubber bands.

d. Charging the KFM with your hands inside the plastic bags, operating the charging device. Have another person illuminate the KFM with a flashlight. When adjusting the charging-wire, move your hands very slowly. See the dry-bucket photos.

12. Expose the KFM to fallout radiation either by:

a. Leaving the KFM inside the dry-bucket while exposing it to fallout radiation for one of the listed time intervals, and reading the KFM before and after the exposure while it remains inside the dry-bucket. (The reading eye should be a measured 12 inches above the SEAT of the KFM, and a flashlight or other light should be used.)

b. Taking the charged KFM out of the dry-bucket to read it, expose it, and read it after the exposure. (If this is done repeatedly, especially in a humid shelter, the drying agent will not be effective for many KFM charges, and will have to be replaced.)

XV. How to Use a KFM alter a Nuclear ATTACK:

A. Background Information:

If during a rapidly worsening crisis threatening nuclear war you are in the place where you plan to take shelter, postpone studying the instructions following this sentence until after you have:

(1) built or improved a high-protection-factor shelter (if possible, a shelter covered with 2 or 3 ft of earth and separate from flammable buildings), and

(2) made a KAP (homemade shelter-ventilating pump) if you have the instructions and materials, and

(3) stored at least 15 gallons of water for each shelter occupant if you can obtain containers.

Having a KFM or any other dependable fallout meter and knowing how to operate it will enable you to minimize radiation injuries and possible fatalities, especially by skillfully using a high-protection-factor fallout shelter to control and limit exposures to radiation. By studying this section you first will learn how to measure radiation dose rates (roentgens per hour = R/hr), how to calculate doses [It] received in different time intervals, and how to determine time intervals (hours and/or minutes) in which specified doses would be received. Then this section lists the sizes of doses (number of R) that the average person can tolerate without being sickened, that he is likely to survive, and that he is likely to be killed by.

Most fortunately for the future of all living things, the decay of radioactivity causes the sandlike fallout particles to become less and less dangerous with the passage of time. Each fallout particle acts much like a tiny X-ray machine would if it were made so that its rays, shooting out from it like invisible light, became weaker and weaker with time.

Contrary to exaggerated accounts of fallout dangers, the radiation dose rate from fallout particles when they reach the ground in the areas of the heaviest fallout will decrease quite rapidly. For example, consider the decay of fallout from a relatively nearby, large surface burst, at a place where the fallout particles are deposited on the ground one hour after the explosion. At this time one hour after the explosion, assume that the radiation dose rate (the best measure of radiation danger at a particular time) measures 2,000 roentgens per hour (2,000 R/hr) outdoors. Seven hours later the dose rate is reduced to 200 R/hr by normal radioactive decay. Two days after the explosion, the dose rate outdoors is reduced by radioactive decay to 20 R/hr. After two weeks, the dose rate is less than 2 R/hr. When the dose rate is 2 R/hr, people can go out of a good shelter and work outdoors for 3 hours a day, receiving a daily dose of 6 roentgens, without being sickened.

In places where fallout arrives several hours after the explosion, the radioactivity of the fallout will have gone through its time period of most rapid decay while the fallout particles were still airborne. If you are in a location so distant from the explosion that fallout arrives 8 hours after the explosion, two days must pass before the initial dose rate measured at your location will decay to 1/10 its initial intensity.

B. Finding the Dose Rate:

1. Reread Section IV, "What a KFM Is and How it Works." Also reread Section XIII, "Two Ways to Charge a KFM," and actually do each step immediately after reading it.

2. Charge the KFM so that it reads at least 15 mm. Next raise the lower end of the charging wire. Then gently bump or shake the KFM to remove any unstable part of the charge. Read the apparent separation of the lower edges of the leaves while the KFM rests on an approximately horizontal surface. If the reading is larger than 20 mm, bleed off enough charge to reduce the initial reading to 20 mm or slightly less, for maximum accuracy. Never take a reading while a leaf is touching a stop-thread.

3. To prevent possible contamination of a KFM (or of any other fallout meter) with fallout particles, keep it inside a plastic bag or other covering when there is risk of fallout particles being deposited or blown onto it. An instrument contaminated with fallout particles can give too high readings, especially of the low dose-rate measurements made inside a good shelter.

4. Expose the KFM to fallout radiation for one of the time intervals shown in the vertical columns of the table attached to the KFM - (Study the following table.) If the dose rate is not known even approximately, first expose the fully charged KFM for one minute. For dependable measurements outdoors, expose the charged KFM about 3 feet above the ground. The longer outdoor exposures usually are best made by attaching the KFM with 2 strong rubber hands to a stick or pole, being careful never to tilt the KFM too much.

5. Read the KFM after the exposure, while the KFM rests on an approximately horizontal surface.

6. Find the time interval that gives a dependable reading by exposing the fully charged K FM for one or more of the listed time intervals until the reading after the exposure is;

   (a) Not less than 5 mm.

   (b) At least 2 mm less than the reading before the exposure.

7. Calculate by simple subtraction the difference in the apparent separation of the lower edges of the leaves before the exposure and after the exposure. An example: If the reading before the exposure is 18 mm and the reading after the exposure is 6 mm, the difference in readings is 18 mm - 6 mm 12 mm.

8. If an exposure results in a difference in readings of less than 2 mm, recharge the KFM and expose it again for one of the longer time intervals listed. (If there appears to be no difference in the readings taken before and after an exposure for one minute, this does not prove there is absolutely no fallout danger. Take a longer reading.)

9. If an exposure results in the reading after the exposure being less than 5 mm, recharge the KFM and expose it again for one of the shorter time intervals listed.

10. Use the table attached to the KFM to find the dose rate (R/hr) during the time of exposure. The dose rate (R/hr) is found at the intersection of the vertical column of numbers under the time interval used and of the horizontal line of numbers that lists the calculated difference in readings at its left end.

    An example: If the time interval of the exposure was 1 MIN. and the difference in the readings was 12 mm, the table shows that the dose rate during the time interval of the exposure was 9.2 R/HR (9.2 roentgens per hour).

Another example: If the time interval of the exposure was 15 SEC. and the difference in readings was 11 mm, the table shows that the dose rate during the exposure was halfway between 31 R/hr and 37 R/hr; that is, the dose rate was 34 R/hr.

11. Note in the table that if an exposure for one of the listed time intervals causes the difference in readings to be 2 mm or 3 mm, then an exposure 4 times as long reveals the same dose rate. An example: If a 1- min. exposure results in a difference in readings of 2 mm, the table shows the dose rate was 1.6 R/hr; then if the KFM is exposed for 4 minutes at this same dose rate of 1.6 R/hr, the table shows that the resultant difference in readings is 8 mm. The longer exposure results in a more accurate determination of the dose rate.

12. If the dose rate is found to be greater than 0.2 R/hr and time is available, recharge the KFM and repeat the dose-rate measurement -- to avoid possible mistakes.

C. Calculating the Dose Received:

The dose of fallout radiation -- that is, the amount of fallout radiation received -- determines the harmful effects on men and animals. Being exposed to a high dose rate is not always dangerous -- provided the exposure is short enough to result in only a small dose being received. For example, if the dose rate outside an excellent fallout shelter is 1200 R/hr and a shelter occupant goes outside for 30 seconds, he would be exposed for 1/2 of 1 minute, or 1/2 of 1/60 of an hour, which equals 1/120 hour. Therefore, since the dose he would receive if he stayed outside for 1 hour would be 1200 R, in 30 seconds he would receive 1/120 of 1200, which equals 10 R (1200 R divided by 120 = 10 R). A total daily dose of 10 R (10 roentgens) will not cause any symptoms if it is not repeated day after day for a week or more.

In contrast, if the average dose rate of an area were found to be 12 R/hr and if a person remained exposed in that particular area for 24 hours, he would receive a dose of 288 R (12 R/hr x 24 hr = 288 R). Even assuming that this person had been exposed previously to very little radiation, there would still be a serious risk that this 288 R dose would be fatal under the difficult conditions that would follow a heavy nuclear attack.

Another example: Assume that three days after an attack the occupants of a dry, hot cave giving almost complete protection against fallout are in desperate need of water. The dose rate outside is found to be 20 R/hr. To backpack water from a source 3 miles away is estimated to take 2-1/2 hours. The cave occupants estimate that the water backpackers will receive' a dose in 2-1/2 hours of 50 R (2.5 hr x 20 R/hr = 50 R). A dose of 50 R will cause only mild symptoms (nausea in about 10% of persons receiving a 50 R dose) for persons who previously have received only very small doses. Therefore, one of the cave occupants makes a rapid radiation survey for about 1-1/2 miles along the proposed route, stopping to charge and read a KFM about every quarter of a mile. He finds no dose rates much higher than 20 R/hr.

So, the cave occupants decide the risk is small enough to justify some of them leaving shelter for about 2-1/2 hours to get water.

D. Estimating the Dangers from Different Radiation Doses:

Fortunately, the human body -- if given enough time -- can repair most of the damage caused by radiation. An historic example: A healthy man accidentally received a daily dose of 9.3 R (or somewhat more) of fallout-type radiation each day for a period of 106 days. His total accumulated dose was at least 1000 R. A dose of one thousand roentgens, if received in a few days, is almost three times the dose likely to kill the average man if he receives the whole dose in a few days and after a nuclear attack cannot get medical treatment, adequate rest, etc. However, the only symptom this man noted was serious fatigue.

The occupants of a high-protection-factor shelter (such as a trench shelter covered with 2 or 3 feet of earth and having crawlway entrances) would receive less than 1/200 of the radiation dose they would receive outside. Even in most areas of very heavy fallout, persons who remain continuously in such a shelter would receive a total accumulated dose of less than 25 R in the first day after the attack, and less than 100 R in the first two weeks. At the end of the first two weeks, such shelter occupants could start working outside for an increasing length of time each day, receiving a dally dose of no more than 6 R for up to two months without being sickened.

To control radiation exposure in this way, each shelter must have a fallout meter, and a daily record must be kept of the approximate total dose received each day by every shelter occupant - both while inside and outside the shelter. The long- term penalty which would result from a dose of 100 R received within a few weeks is much less than many Americans fear. If 100 average persons received an external dose of 100 R during and shortly after a nuclear attack, the studies of the Japanese A-bomb survivors indicate that no more than one of them is likely to die during the following 30 years as a result of this 100 R radiation dose. These delayed radiation deaths would be due to leukemia and other cancers. In the desperate crisis period following a major nuclear attack, such a relatively small shortening of life expectancy during the following 30 years should not keep people from starting recovery work to save themselves and their fellow citizens from death due to lack of food and other essentials.

A healthy person who previously has received a total accumulated dose of no more than 100 R distributed over a 2-week period should realize that:

(a) 100 R, even if all received in a day or less, is unlikely to require medical care - provided during the next 2 weeks a total additional dose of no more than a few R is received.

(b) 350 R received in a few days or less results in a 50-50 chance of being fatal after a large nuclear attack when few survivors could get medical care, sanitary surroundings, a well-balanced diet, or adequate rest.

(c) 600 R received in a few days or less is almost certain to cause death within a few days.

E. Finding the Protection Factor of a Shelter

To avoid the necessity of repeatedly going outside a shelter to determine the changing dose rates outside, find the shelter's protection factor (PF) by measuring the dose rate inside the shelter as soon as it becomes high enough to be reliably measured. Then promptly measure the dose rate outside. The uncontaminated shelter's PF = Dose Rate Inside/Dose Rate Inside.

An example: If the dose rate inside is found to be 0.2 R/hr and the dose rate outside is 31 R/hr, the shelter's PF = 31 R/hr / 0.2 R/hr = 155.

Then at future times the approximate dose rate outside can be found by measuring the dose rate inside and multiplying it by 155. Approximate Dose Rate Outside = Dose Rate Inside x PF.

F. Using a KFM to Reduce Radiation Doses Received:

If a charged KFM is discharged and reads zero within a second or two after being taken outside a good shelter, this means that the dose rate outside is hundreds of roentgens per hour. Get back inside! Also remember that a 15-second reading is not as accurate as are readings made in longer specified exposure times.

Inside most shelters, the dose received by an occupant varies considerably, depending on the occupant's location. For example, inside an expedient covered-trench shelter the dose rate is higher near the entrance than in the middle of the trench. In a typical basement shelter the best protection is found in one corner. Especially during the first several hours after the arrival of fallout, when the dose rates and doses received are highest, shelter occupants should use their fallout meters to determine where to place themselves to minimize the doses they receive.

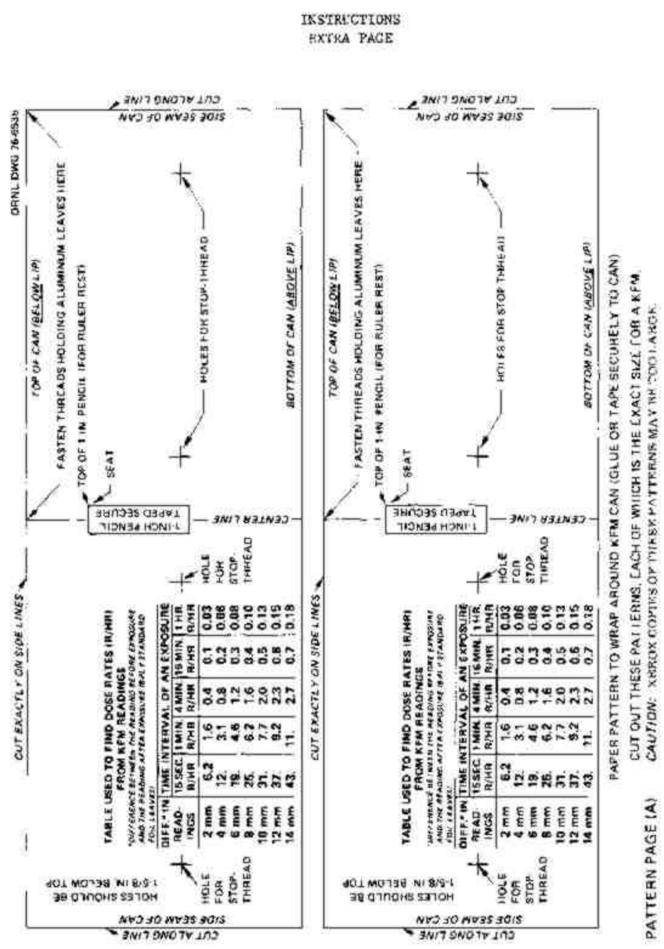
They should use available tools and materials to reduce the doses they receive, especially during the first day, by digging deeper (if practical) and reducing the size of openings by partially blocking them with earth, water containers, etc. -- while maintaining adequate ventilation. To greatly reduce the slight risk of fallout particles entering the body through nose or mouth, shelter occupants should cover nose and mouth with a towel or other cloth while the fallout is being deposited outside their shelter, if at the same time ventilating air is being blown or pumped through their shelter.

The air inside an occupied shelter often becomes very humid. If a good flow of outdoor air is flowing into a shelter--especially if pumped by briefly operating a KAP or other ventilating pump - a KFM usually can be charged at the air intake of the shelter room without putting it inside a dry-bucket; however, if the air to which a KFM is exposed has a relative humidity of 90% or higher, the instrument cannot be charged, even by quickly unrolling a roll of tape.

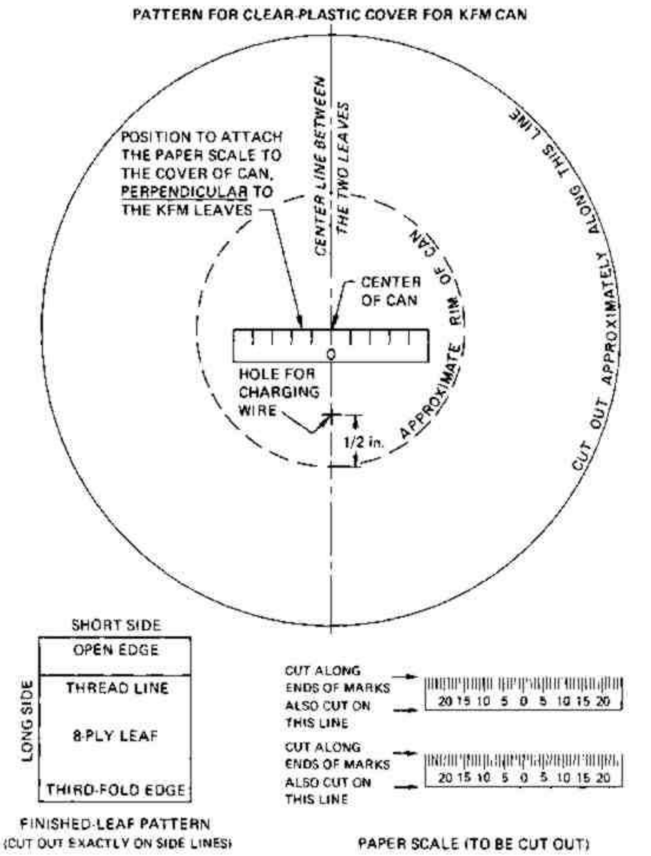
In extensive areas of heavy fallout, the occupants of most home basements, that provide inadequate shielding against heavy fallout radiation, would be in deadly danger. By using a dependable fallout meter, occupants would find that persons lying on the floor in certain locations would receive the smallest doses, and that, if they improvise additional shielding in these locations, the doses received could be greatly reduced. Additional shielding can be provided by making a very small shelter inside the basement where the dose rate is found to be lowest. Furniture, boxes, etc. can be used for walls, doors for the roof, and water containers, books, and other heavy objects for shielding -- especially on the roof. Or, if tools are available, breaking through the basement floor and digging a shelter trench will greatly increase available protection against radiation. If a second expedient ventilating pump, a KAP, (or a small Directional Fan), is made and used as a fan, such an extremely cramped shelter inside a shelter usually can be occupied by several times as many persons as can occupy it without forced ventilation.

END OF INSTRUCTIONS

PATTERN (A)



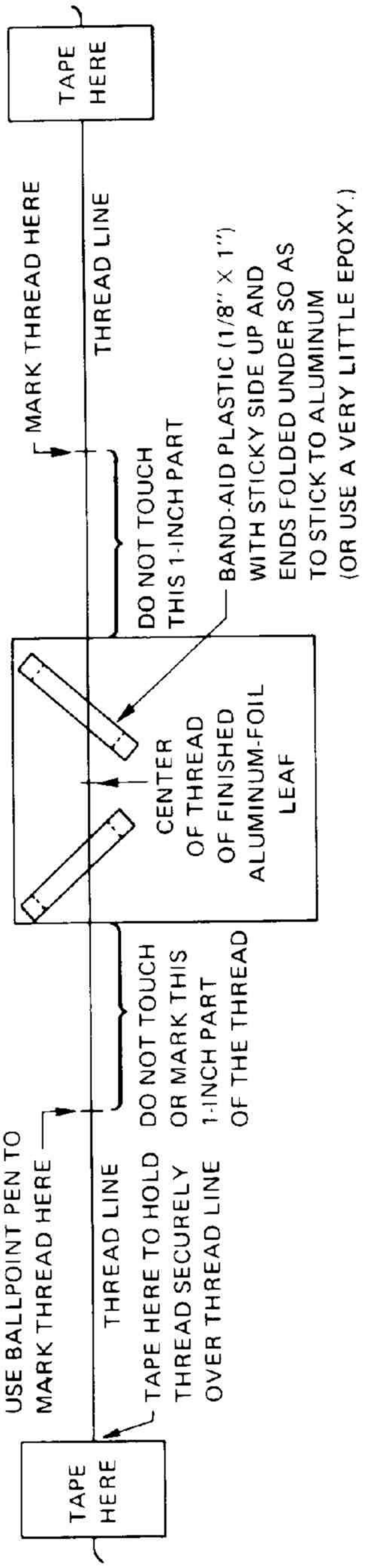
PATTERN (B)



PATTERN PAGE (B)

CAUTION: XEROX COPIES OF THE FINISHED-LEAF AND THE SCALE PATTERNS MAY BE SLIGHTLY TOO LARGE

(Cut out this guide along its border lines and tape to the top of a work table.)



REMINDERS FOR OPERATORS

The drying agent inside a KFM is O.K. if, when the charged KFM is not exposed to radiation, its readings decrease by 1 mm or less in 3 hours.

Reading: With the reading eye 12 inches vertically above the seat. note on the tom scale the separation of the lower edges of the leaves. If the right leaf is at 10 mm and the left leaf is at 3 mm. the KFM reads 10 mm. Never take a reading while a leaf is touching a stop-thread. Never use a reading that is less than 5 mm.

Finding a dose rate: If before exposure a KFM reads 17 mm and if after a l-minute exposure it reads 5 mm. the difference in readings is 12 mm the attached table shows the dose rate was 9.6 R hr during the exposure.

Finding a dose: If a person works outside for 3 hours where the dose rate is 2 R hr. what is his radiation dose? Answer: 3 hr x 2 R hr = 6 R.

Finding how long it takes to get a certain R dose: If the dose rate is 1.6 R hr outside and a person is willing to take a 6 R dose, how long can he remain outside? Answer: 6 R /1.6 R/hr 3.75 hr = 3 hours and 45 minutes.

Fallout radiation guides for a healthy person not previously exposed to a total radiation dose of more than 100 R during a 2-week period:

6 R per day can be tolerated for up to two months without losing the ability to work.

100 R in a week or less is not likely to seriously sicken.

350 R in a few days results in a 50-50 chance of dying, under post-attack conditions.

600 R in a week or less is almost certain to cause death within a few weeks.

REMINDERS FOR OPERATORS

The drying agent inside a KFM is O.K. if, when the charged KFM is not exposed to radiation, its readings decrease by 1 mm or less in 3 hours.

Reading: With the reading eye 12 inches vertically above the seat. note on the tom scale the separation of the lower edges of the leaves. If the right leaf is at 10 mm and the left leaf is at 3 mm. the KFM reads 10 mm. Never take a reading while a leaf is touching a stop-thread. Never use a reading that is less than 5 mm.

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Finding how long it takes to get a certain R dose: If the dose rate is 1.6 R hr outside and a person is willing to take a 6 R dose, how long can he remain outside? Answer: 6 R /1.6 R/hr 3.75 hr = 3 hours and 45 minutes.

Fallout radiation guides for a healthy person not previously exposed to a total radiation dose of more than 100 R during a 2-week period:

6 R per day can be tolerated for up to two months without losing the ability to work.

100 R in a week or less is not likely to seriously sicken.

350 R in a few days results in a 50-50 chance of dying, under post-attack conditions.

600 R in a week or less is almost certain to cause death within a few weeks.

WARNING:

The parts of the thread that will be inside the can and on which the leaf will be suspended must serve to insulate the high-voltage electrical charges to be placed on the leaf Therefore, the suspended parts Of the thread must be kept very clean.

Instructions:

(A) INSTRUCTIONS FOR PERSONS CONCERNED WITH REPRODUCING THE K.F.M. INSTRUCTIONS:

The KFM instruction pages are printed so that they can be readily cut out and pasted up (using the "LAYOUT FOR 12-PAGE TABLOID" given on page 242) to expedite rapid reproduction preparatory to mass distribution. No authorization is required to reproduce this survival information.

All of the paste-ups should be photo-reduced to fit your size newspaper, EXCEPT four cut-outs [paste-ups (15), (18), (21) and (24)] and one drawing [paste-up (26)] SHOULD REMAIN AT 100%.

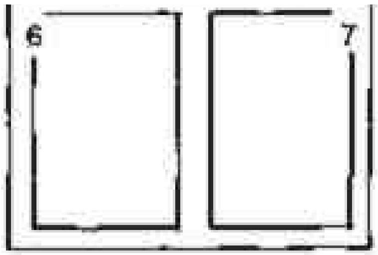
To make the instruction pages fully camera-ready for paste-up and photographing, it is necessary: (1) To cut off each page's title and number (such as "INSTRUCTIONS, Page 2" and "2I4"); (2) To use a camera-invisible blue pencil to copy the numbers on the back of each page onto the front of that page, writing them in a blank space nearest to the approximate original position of the numbers; (3) To cut out each of the 40 paste-ups.

On the back of each paste-up are the number of the tabloid page to which the paste-up is to be attached and (in parentheses) the number of the paste-up itself. For example, on the back of "INSTRUCTIONS, Page 2" are printed the following: "Pg 1- (2)" and "Pg 1- (3)." Thus, this page contains two paste-ups, both of which should be attached to page 1 of the tabloid paste-up. The positions in which they should be attached to page 1 are shown in the layout sketch on page 242.

Timed field tests by two newspapers have shown that less than 40 minutes is required to begin printing a KFM tabloid. Each test began when the newspaper was given only written instructions like this page and the following layout page, along with KFM instructions like those in this book except that the index numbers were already printed in camera-invisible blue on each half page of the instructions.

The camera-ready copy is for use with a straight lens (100%, horizontal and 100% vertical reproduction).

Fig. Pg. 241 TABLOID LAYOUT SHEET and CENTER FOLD OF A 12-PAGE TABLOID, INDICATING TABLOID Page 6 AND Page 7.



CENTER FOLD OF A 12-PAGE TABLOID, INDICATING TABLOID Page 6 AND Page 7.

All photographs are 85-line screen.

The following layout sketch for a 12-page tabloid indicates where each of the numbered paste-ups [(1), (2),... (40)] should be pasted-up and what spaces should be left blank. This positioning of the paste-ups is necessary to permit a KFM-maker to cut out the patterns without destroying any instructions printed on opposite sides of the 12 tabloid pages.

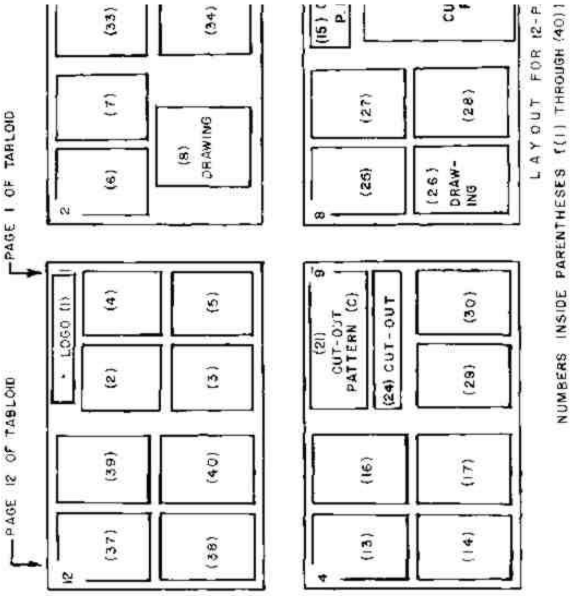


Fig. Pg. 232 INSTRUCTIONS (B) FOR PHOTOGRAPHER – PRINTER

Appendix D: Expedient Blast Shelters

I. INCREASING IMPORTANCE:

The majority of urban and suburban Americans would need blast shelters to avoid death or injury if they did not evacuate before an all-out nuclear attack. As nuclear arsenals continue to grow, an increasing majority would need the protection of blast shelters. In an attack on militarily relevant targets, as much as 5% of the total area of the 48 states could be subjected to blast damage severe enough to destroy or damage homes depending on the number of warheads assigned to each hard target, weapon reliability, etc. If blast shelters affording protection up to the 15-pounds-per-square-inch (15 psi) overpressure range were available to everybody and were occupied at the time of attack, the great majority of the occupants would survive all blast, fire, and radiation effects in the blast areas subjected to less than 15-psi blast effects.

Fifteen-psi blast shelters will survive as close as about 1.5 miles from ground zero of a 1-megaton surface burst, and about 2.3 miles from ground zero or a 1-megaton air burst. Except in high-density urban areas where the air supply openings and exits of shelters are all too likely to be covered with blast-hurled debris, the area in which people inside good earth- covered 15-psi blast shelters would be killed would be only about 1/6th as large as the area in which most people sheltered in typical American homes probably would die from blast and fire effects alone.

Blast tests have indicated that the Small Pole Shelter (the most blast-resistant of the earth-covered expedient shelters described in Appendix A) should enable its occupants to survive up to the 50-psi overpressure range - if built with the blast-resistant and radiation- protective features described in following sections, and if located outside an urban area. Calculations show that this earth-covered expedient blast shelter also would give adequate protection at the 50-psi blast overpressure range against the intense initial nuclear radiation that is emitted from the fireball of a 1-megaton explosion. However, to make this shelter (see page 258) provide adequate protection against the even more intense initial nuclear radiation that would reach the 50-psi overpressure range from the fireball of a 500-kiloton or smaller explosion, it should have at least 6 feet of earth cover and additional cans of water should be kept ready to be placed in the horizontal parts of the entryways promptly after the shelter is occupied.

The life-saving potential of well designed, well built blast shelters is a demonstrated fact. Millions of Americans living in high-risk areas would be able to build expedient blast shelters within only a few days provided they were given field-tested instructions, had made some preparations before the crisis arose, had a few days of recognized warning, and during the crisis were motivated by the President. The following information is given in the hope of encouraging more Americans to make preparations for blast protection.

Also, it may serve to increase the number who realize the need for permanent blast shelters in high-risk blast areas.

Some informed citizens particularly those who live near large cities or in their outer suburbs may choose to build earth-covered expedient blast shelters in their backyards, rather than to evacuate. Going into a strange area and trying to build or find good shelter and other essentials of life would entail risks that many people might hesitate to take, particularly if they live outside the probable areas of severe blast damage. For such citizens, the best decision might be to stay at home, build earth-covered expedient blast shelters, supply them with the essentials for long occupancy, and remain with their possessions.

The following descriptions of the characteristics and components of expedient blast shelters should enable many readers to use locally available materials to provide at least 15-psi blast protection. Pre-crisis preparations are essential, as well as the ability to work very hard for two to four days. (Field-tested instructions are not yet available; to date only workers who were supervised have built expedient blast shelters.5)

II. PRACTICALITY OF EXPEDIENT BLAST SHELTERS:

At Hiroshima and Nagasaki, simple wood-framed shelters with about 3 feet of earth over wooden roofs were undamaged by blast effects in areas where substantial buildings were demolished.4

Figure D.1 shows a Hiroshima shelter that people with hand tools could build in a day, if poles or timber were available. This shelter withstood blast and fire at an overpressure range of about 65 psi. Its narrow room and a 3-foot-thick earth cover brought about effective earth arching; this kept its yielding wooden frame from being broken.

Fig. D. 1. A small, earth-covered backyard shelter with a crude wooden frame-undamaged, although only 300 yards from ground zero at Hiroshima.

Although the shelter itself was undamaged, its occupants would have been fatally injured because the shelter had no blast door. The combined effect of blast waves, excessive pressure, blast wind, and burns from extremely hot dust blown into the shelter (the pop-corning effect) and from the heated air would have killed the occupants. For people to survive in areas of severe blast, their shelters must have strong blast doors.

In nuclear weapons tests in the Nevada desert, box-like shelters built of lumber and covered with sandy earth were structurally undamaged by 10- to 15-psi blast effects. However, none had blast doors, so occupants of these open shelters would have been injured by blast effects and burned as a result of the pop-corning effect. Furthermore, blast winds blew away much of the dry, sandy earth mounded over the shelters for shielding; this resulted in inadequate protection against fallout radiation.

Twelve different types of expedient shelters were blast-tested by Oak Ridge National Laboratory during three of Defense Nuclear Agency's blast tests.5 Two of these tests each involved the detonation of a million pounds or more of conventional explosive; air-blast effects equivalent to those from a 1-kiloton nuclear surface burst were produced by these chemical explosions.

Several of these shelters had expedient blast doors which were closed during the tests. Figure D.2 shows the undamaged interior of the best expedient blast shelter tested prior to 1978, an improved version of the Small-Pole Shelter described in Appendix A. Its two heavy plywood blast doors excluded practically all blast effects; the pressure inside rose only to 1.5 psi an overpressure not nearly high enough to break eardrums. The only damage was to the expedient shelter-ventilating pump (a KAP) in the stoop-in entryway. Two men worked about 5 minutes to replace the 4 flap-valves that were blown loose.

Fig. D.2. Undamaged interior of a Small-Pole Shelter after blast testing at the 53-psi overpressure range. Large buildings would have been completely demolished.

When blast-tested at 5-psi overpressure, not even the weakest covered-trench shelters with unsupported earth walls (described in Appendix A) were damaged structurally. However, if the covering earth were sandy and dry and if it were exposed to the blast winds of a megaton explosion at the 5-psi overpressure range, so much earth would be blown away that the shelter would give insufficient protection against fallout radiation. Much of the dry, shielding earth mounded over some of the above- ground shelters was, in fact, removed by the blast winds of these relatively small test explosions, even at the lower overpressure ranges at which homes would be wrecked.

In contrast, in blast tests where the steeply mounded earth was damp, little blast-wind erosion resulted. (The reader should remember that even if shelters without blast doors are undamaged, the occupants are likely to suffer injuries.)

II. CONSTRUCTION PRINCIPLES:

Millions of Americans if given good instructions, strong motivation, and several days to work should be able to build blast shelters with materials found in many rural areas and suburban neighborhoods. During a crisis, yard trees could be cut down for poles and sticks, and a garage or part of a house could be torn down for lumber. Many average citizens could build expedient blast shelters if they learn to:

- Utilize earth arching by making a yielding shelter. The remarkable protection that earth arching gives to those parts of a shelter designed to use

Fig. D.3. Effective earth arching in the earth covering of this 4-ft-wide Pole-Covered Trench Shelter prevented a single pole from being broken by blast forces that exerted a downward force of 53 psi (over 3-1/2 tons per square foot) on the overlying earth.

This picture shows the unbroken roof of a 4- foot-wide Pole-Covered Trench Shelter that was built in rock-like soil and blast tested where the blast pressure outside was 53 psi. Its strong blast doors prevented the blast wave from entering. Without the protection of earth arching that developed in the 5 feet of earth cover over the yielding roof poles, the poles would have been broken like straws. In contrast, the ground shock and earth pressure produced by 1-kiloton blast effects almost completely collapsed the unsupported, rock-like earth walls.

Fig. D.4. Post-blast interior of an Above- ground, Door-Covered Shelter that survived 1-kiloton blast effects at the 5.8-psi overpressure range. The shelter walls were made of bed sheets containing earth, as described in Appendix A.

Figure D.4 also indicates the effectiveness of earth arching. This photo shows the roof of a small, earth-covered fallout shelter, as it appeared after surviving blast effects severe enough to demolish most homes. The roof was made of light, hollow-core, interior doors and looks as though it had been completely broken. In fact, only the lower sheets of 1/8-inch-thick veneer of the hollow-core interior doors were broken. (These breaks were caused by a faulty construction procedure a front- end loader had dumped several tons of earth onto the uncovered doors.) The upper 1/8-inch-thick sheets of veneer were bowed downward, unbroken, until an earth arch formed in the 2-foot-thick earth covering and prevented the thin sheets from being broken. Earth arching also prevented this roof from being smashed in by blast overpressure that exerted a pressure of 5.8 psi (835 pounds per square foot) on the surface of the earth mounded over this open shelter. (See Appendix A for details of construction.)

- Make shelters with the minimum practical ceiling height and width. Most of the narrow covered-trench shelters used by tens of thousands of Londoners during the World War II blitz were built with only 4-1/2 foot ceilings, to maximize blast protection and minimize high water-table problems. These shelters were found to be among the safest for protection against nearby explosions. The Chinese also have a good understanding of this 'design principle and skillfully utilize the protection provided by earth arching. A Chinese civil defense handbook states: '. .. the height and width of tunnel shelters should be kept to the minimum required to accommodate the sheltering requirements," and 'The thicker the protective layer of earth, the greater the ability to resist blast waves." 21
- Shore earth walls to prevent their caving in as a result of ground shock and earth pressure. Most un-shored (that is, unsupported) earth walls are partially collapsed by ground shock at much lower blast overpressures than those at which a flexible roof protected by earth arching is damaged. Figure D.5 is a picture of a seated dummy taken by a high-speed movie camera mounted inside an un-shored, Pole- Covered Trench Shelter of the Russian type tested at the 20-psi range. (A second dummy was obscured by blast-torn curtains made of blankets.) The shelter had an open stairway entryway, positioned at right angles to the stand-up-height trench and facing away from the targeted "city" so as to minimize the entry of blast waves and blast wind.

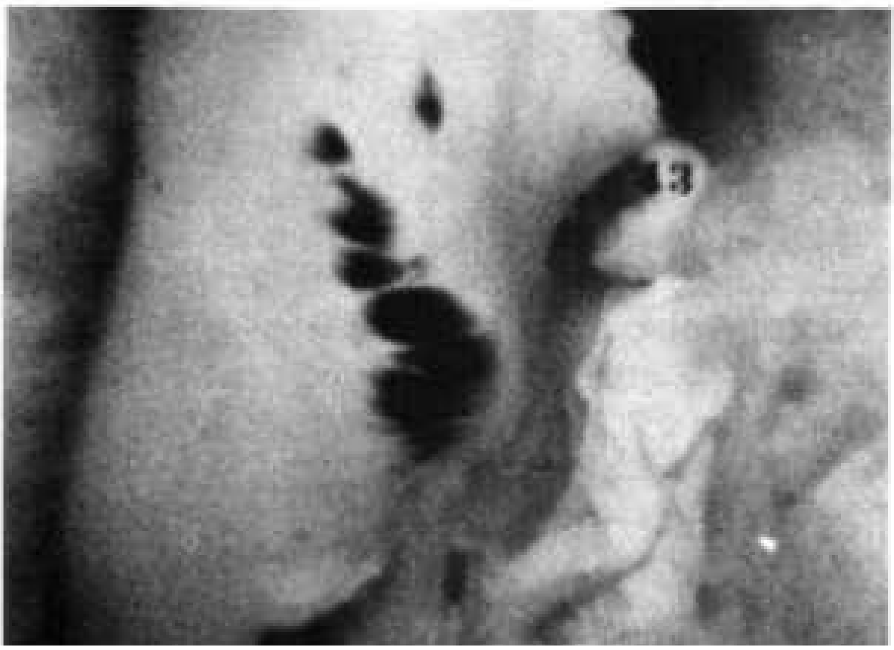


Fig. D.5. A dummy in an un-shored Pole-Covered Trench Shelter as it is struck by collapsing rock-like earth walls. The photo also shows the shelter's blanket-curtains as they are torn and blown into the shelter by the 180-mph blast wind. (Immediately after this photo was taken, the dummies were hit by the airborne blast wave and blast wind. Outside, the blast wind peaked at about 490 mph.)

Figure D.6 is a post-blast view of the essentially undamaged earth-covered roof poles and the disastrously collapsed, un-shored shelter walls of the Russian shelter tested at 20 psi.21 Russian civil defense books state that un-shored fallout shelters do not survive closer to the blast than the 7-psi overpressure range. This limitation was confirmed by an identical shelter tested at 7 psi; parts of its un-shored walls were quite badly collapsed by the ground shock from an explosion producing merely 1-kiloton blast effects.

Fig. D.6. Dummies after ground shock from 1-kiloton blast effects at the 20-psi range had collapsed the rock-like walls of a hardened desert soil called caliche. The dummies' steel "bones" and "'joints" prevented them from being knocked down and buried. The fallen caliche all around them kept them from being blown over by the air blast wave and 180-mph blast wind that followed.

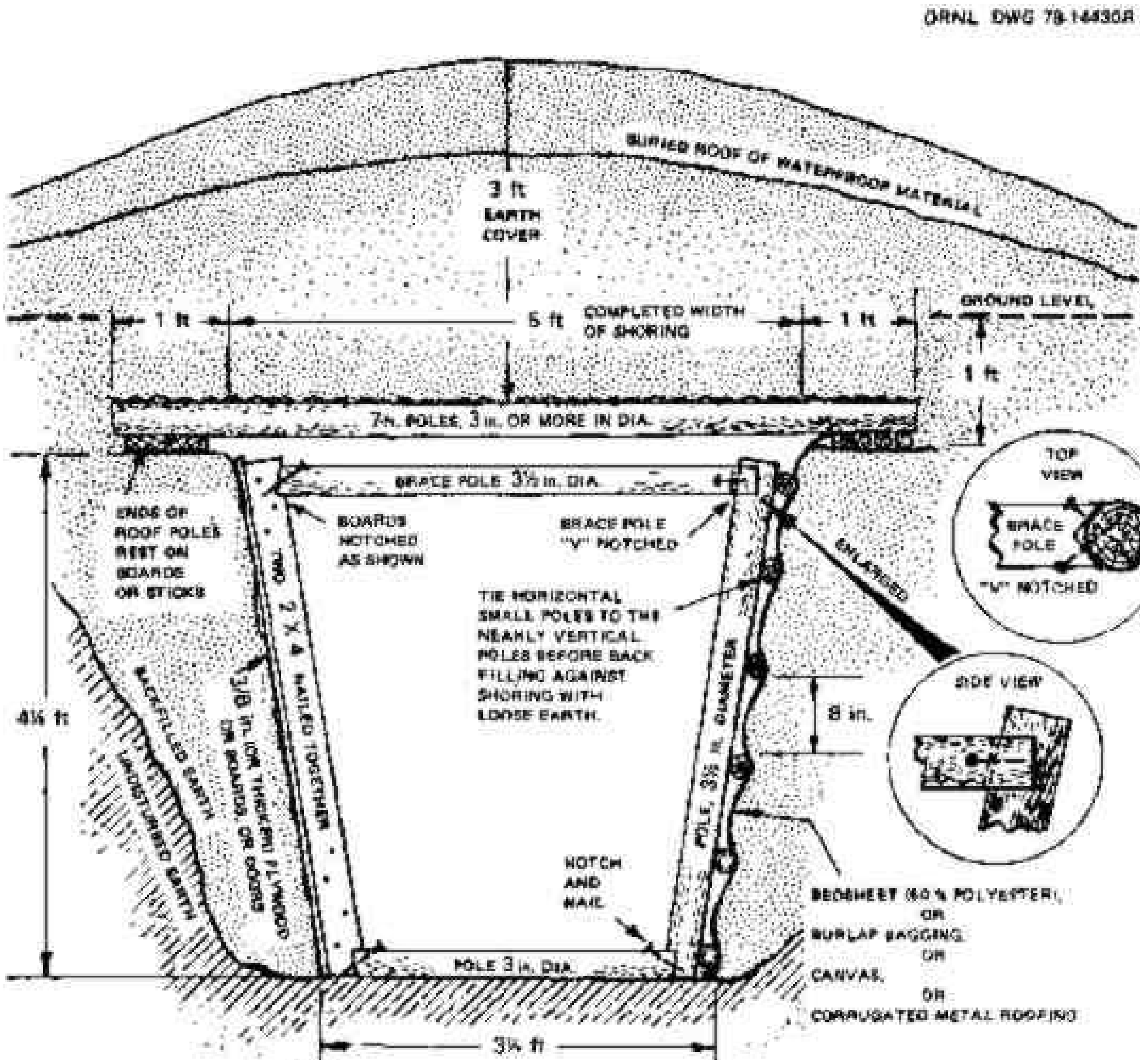


Fig. D.7. An illustration of several ways to shore a trench in unstable earth, using various materials. A 4-piece frame (consisting of 4 poles, or 4 boards, installed as shown above) should be installed every 2-1/2 feet along the length of the trench, including the horizontal parts of the entryways. All parts of the shoring should be at least 2 inches below the roof poles, so that the downward forces on the roof will press only on the earth. (ORNL-DWG 78-14430R)

Unsupported earth walls should be sloped as much as practical. The length and strength of available roofing material should be considered and, in order to attain effective earth arching, the thickness of the earth cover should be at least half as great as the distance between the edges of the trench. The stability of the earth determines the proper method for shoring the walls of a trench, shelter.

Methods for shoring both loose, unstable earth and firm, stable earth are described below:

* In loose, unstable earth such as sand, the walls of all underground shelters must be shored. First, an oversized trench must be dug with gently sloping sides. Next, the shoring is built, often as a freestanding, roofless structure. Then earth must be backfilled around the shoring to a level a few inches higher than the uppermost parts of the shoring, as in Fig. D.7. Finally, the roof poles or planks must be placed so that they are supported only by the backfilled earth. Blast tests have indicated that a Pole-Covered Trench Shelter thus proportioned and lightly shored should protect its occupants against disastrous collapse of its walls at overpressure ranges up to 15 psi.
* In firm, stable earth, it is best first to dig a trench a few inches wider than 7 feet (the length of the roof poles) and 1 foot deep. Next, dig the part to be shored, down the center of this shallow trench, using the dimensions given for the shoring in Fig. D.7. The trench walls should be sloped and smoothed quite accurately, so that the shoring can be tightened against the earth. If the shoring does not press tightly against the trench walls, large wedges of earth may be jarred loose, hit the shoring, and cause it to collapse.

  A different, comparatively simple way to tighten shoring is indicated by Fig. D.8. This sketch shows a 4-pole frame designed to be installed every 2-1/2 feet along a trench in stable earth and to be tightened against trench-wall shoring with the same dimensions as those shown in Fig. D.7. Note that the two horizontal brace poles have shallow "V" notches sawed in both ends.

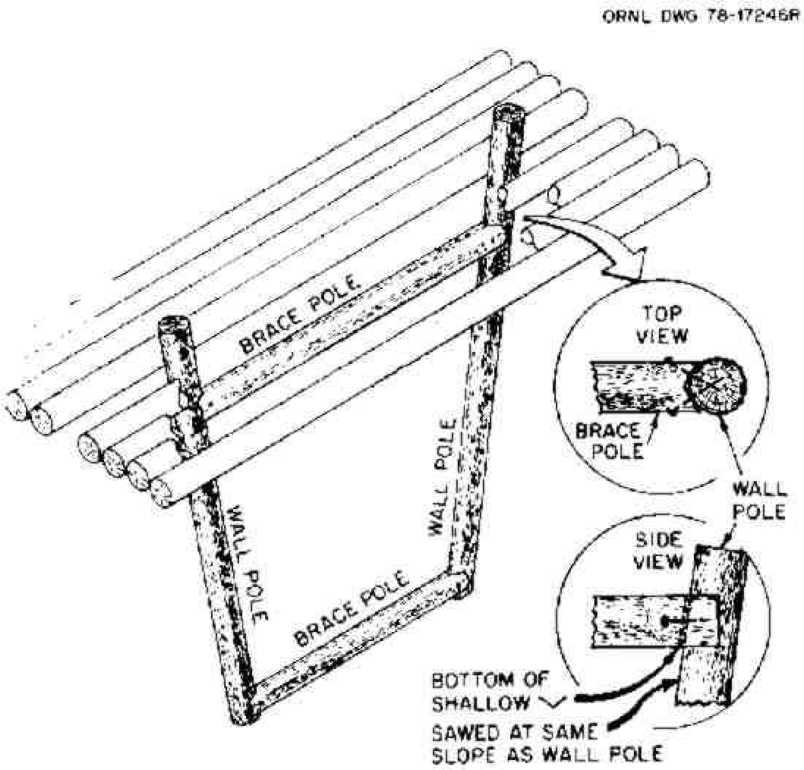


Fig. D.8. A 4-pole frame designed so that it can be tightened against the shoring materials that must press firmly against the walls of a trench dug in stable earth. (In this sketch, the middle sections of three poles have been removed, so that the upper brace pole may be seen more clearly.) (ORNL DWG 78-17246R)

If these brace poles are driven downward when positioned as shown, the two wall poles are forced outward against the shoring materials placed between them and the earth walls. An upper brace pole should be cut to the length needed to make it approximately the same height as the roof poles on each side of it (no higher) after the shoring is tightened. Finally, each "V"-notched end should be nailed to its wall pole.

Light, yielding poles can serve simultaneously both to roof and to shore a shelter. A good example is the Chinese "Man" Shelter illustrated in Fig. D.9, requiring comparatively few poles to build.21 This shelter is too cramped for long occupancy, and its un-shored, lower earth walls can be squeezed in by blast pressure. Therefore, it is not recommended if sufficient materials are available for building a well- shored, covered-trench shelter. It is described here primarily to help the reader understand the construction of similarly designed entryways, outlined later in this appendix. The room and the horizontal entryway of the model tested were made of 6-1/2-foot poles averaging only 3 inches in diameter. It had two vertical, triangular entries of ORNL design. Each was protected by an expedient triangular blast door made of poles. In Fig. D.9, note the two small horizontal poles at the top of the triangle, one tied inside and the other tied outside the triangle, to hold the wall poles together. Before covering this shelter with earth, a 6-inch-thick covering of small limbs was placed horizontally across the approximately 3-inch wide spaces between the 6-1/2-foot wall poles; the limbs were then covered with bed sheets.

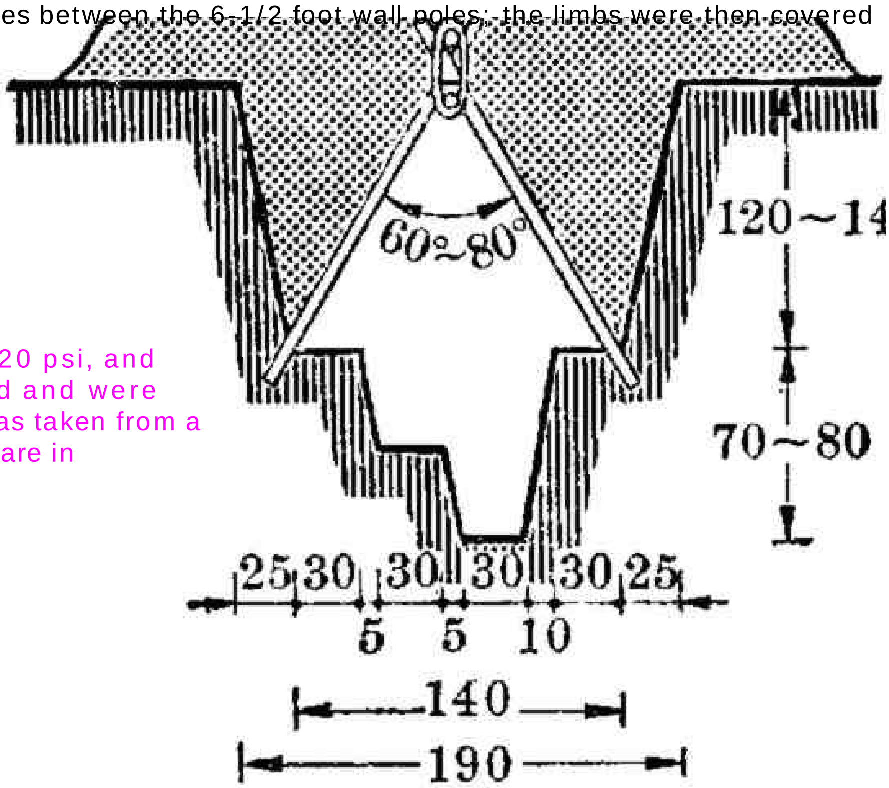


图 3-107 人字形骨架避弹所

Fig. D.9. Chinese "Man" Shelter tested at 20 psi, and undamaged because the thin poles yielded and were protected by earth arching. This drawing was taken from a Chinese civil defense manual. The dimensions are in centimeters.

When blast-tested in loose, unstable soil, the unsupported earth walls of the trench below the wall poles were squeezed in. The 12-inch width of the foot trench was reduced to as little as 4 inches by the short- duration forces produced by 0.2-kiloton blast effects at 50 psi. The much longer duration forces of a megaton explosion would be far more damaging to the shelter at lower overpressure ranges, due to destabilizing and squeezing-in un-shored earth at depths many feet below ground level.

Calculations based on blast-test findings indicate that the unsupported earth walls of a shelter are likely to fail if the aboveground maximum overpressure is greater than 5 to 7 psi and this overpressure is caused by an explosion that is a megaton or more.

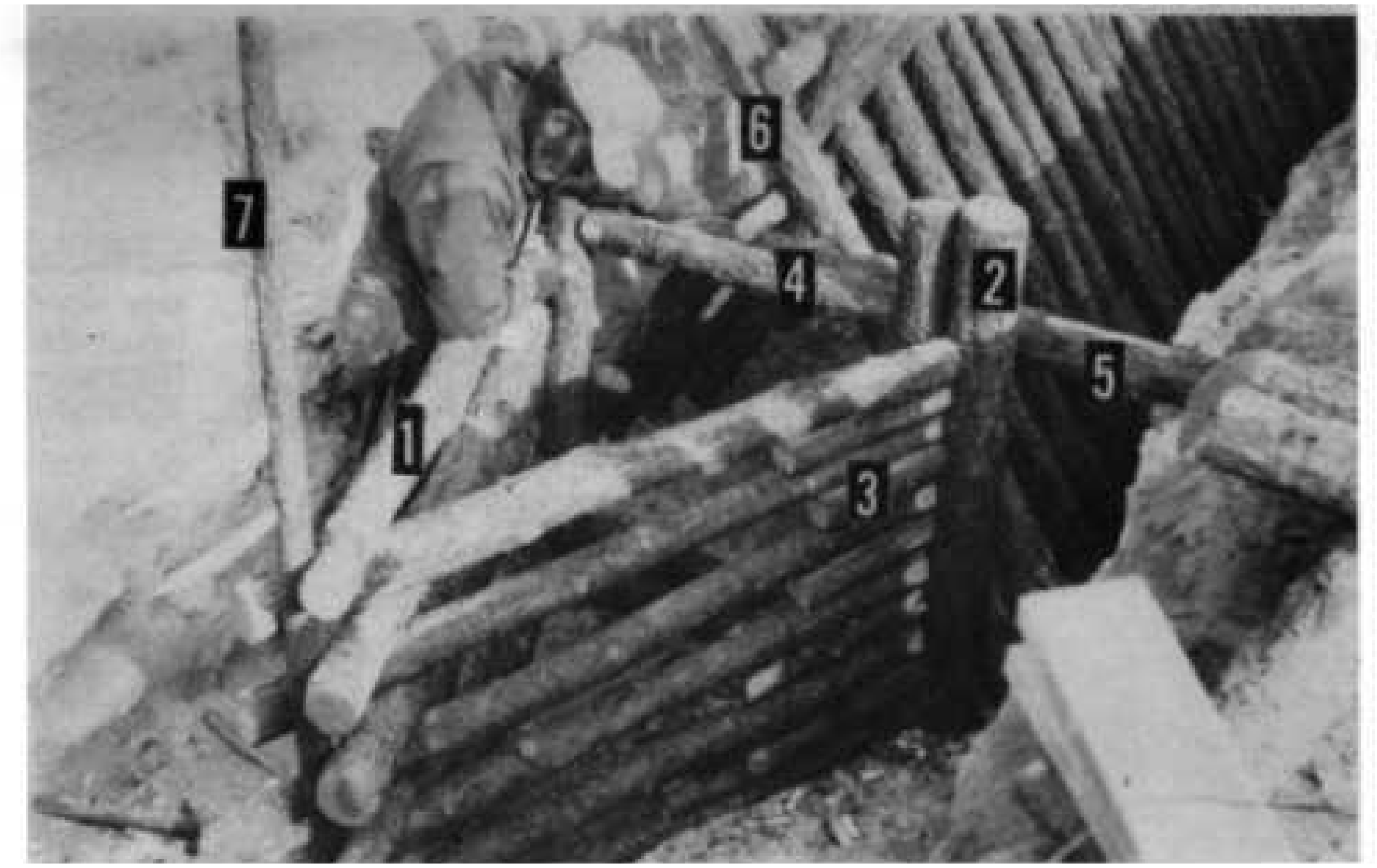
(Most homes would be severely damaged by the 3-psi blast effects from a 1-megaton or larger weapon. This damage would result one mile closer to ground zero of a 1-megaton surface burst than the distance at which the un-shored earth walls of some shelters would be collapsed. For a 20-megaton surface burst, the corresponding reduction in distance would be about 2.7 miles.)

° Build sufficiently long and strong entryways.

Blast shelters need longer horizontal entryways, taller vertical entryways, and thicker earth cover than do most fallout shelters; these are needed primarily for increased protection against high levels of initial nuclear radiation. The entryways of the Small-Pole Shelter described in Appendix A.3 (with the improvements for increased blast protection outlined in the following section of this appendix) afford protection against both blast and radiation up to the 50-psi overpressure range. However, these entryways require straight poles 14 feet long; these may be difficult to find or transport.

In contrast, both the horizontal and the vertical parts of the triangular entry pictured in Figs. D.10, D.11, and D.12 require only small-diameter, short poles. Triangular entries of this type were undamaged by 1-kiloton blast effects at the 20-psi overpressure range5 and by 0.2-kiloton blast effects at 50 psi. This type of entry and its blast door (also triangular and made of short poles) can be used with a wide variety of expedient blast shelters and should withstand megaton blast effects at 25 psi. Therefore, their construction is described in considerable detail.

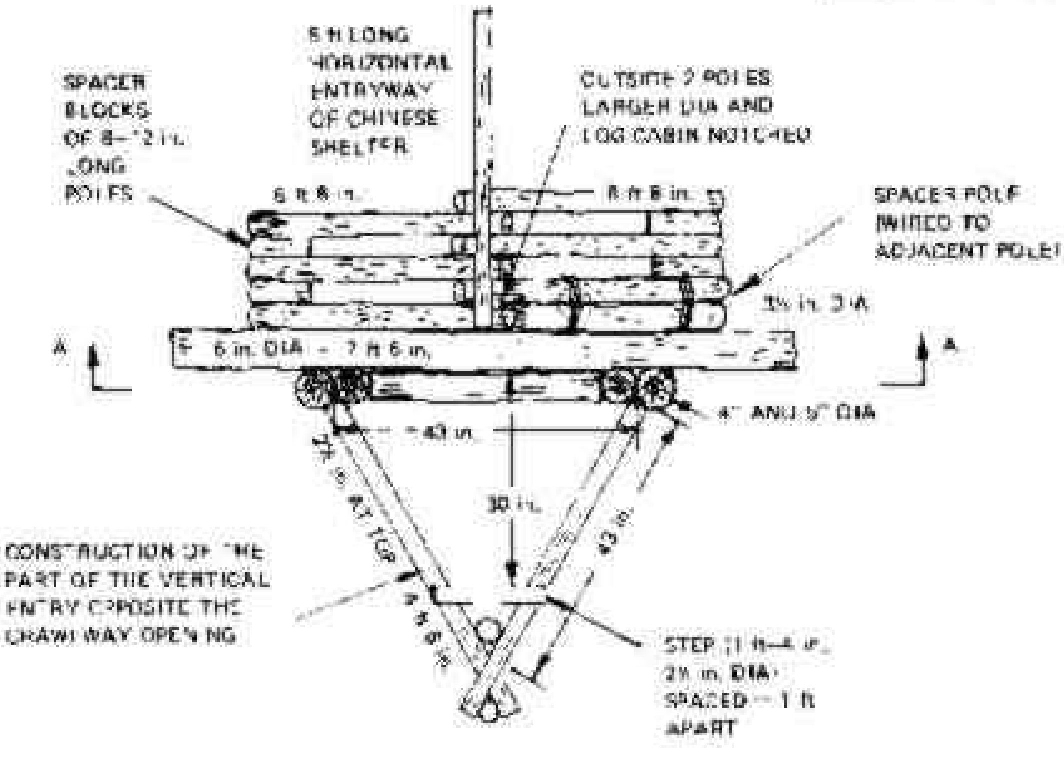
Fig. D. 10. Uncompleted lower section of a vertical triangular entry. (Photo 2954-77R)



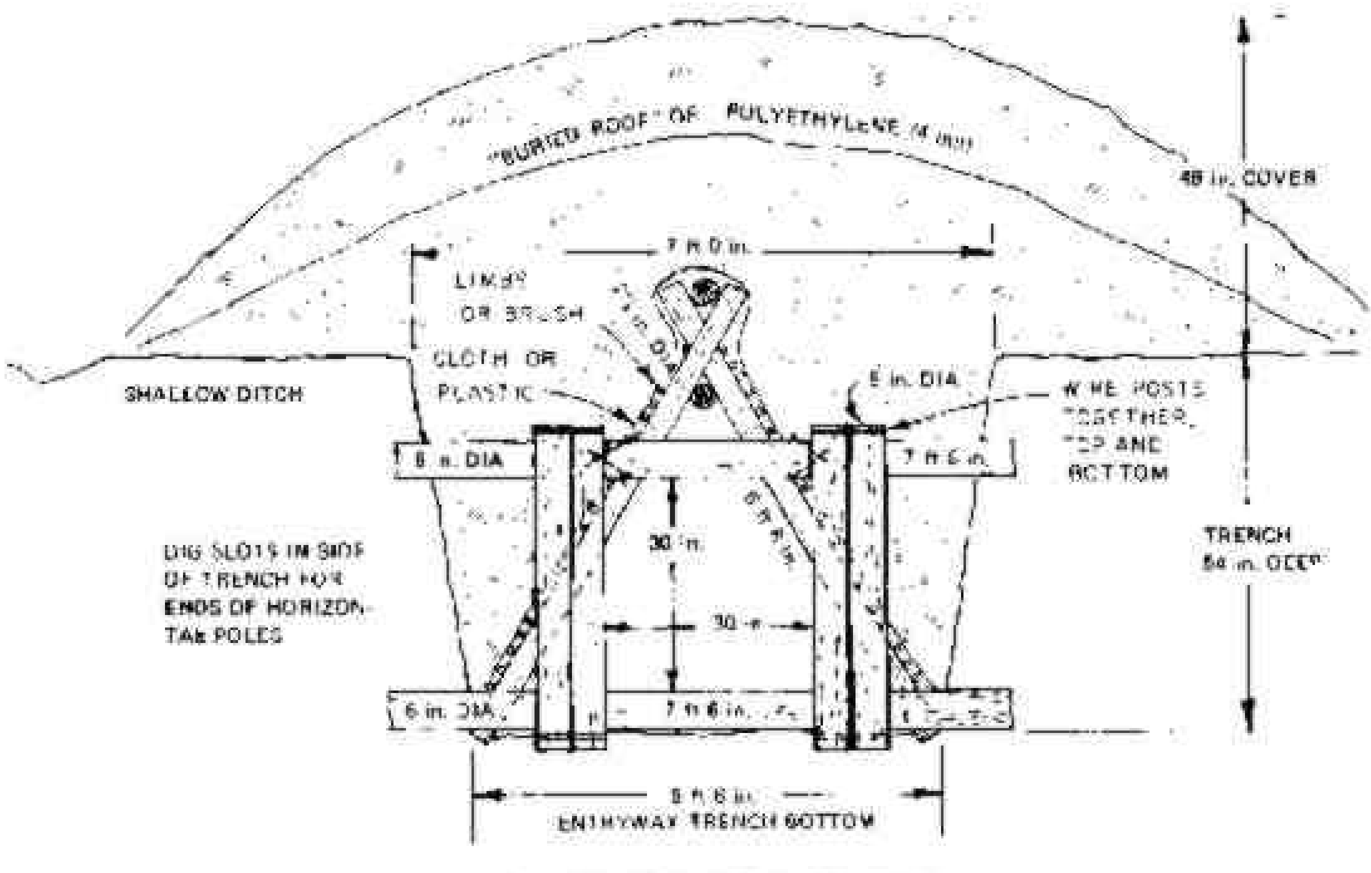
o The horizontal part of a triangular entry:

If the Chinese Man" Shelter shown in Fig. D.9 is made without excavating the un-shored lower trench that forms its earth seats, it will serve as a horizontal, shored crawlway-entry affording blast protection up to at least the 25-psi overpressure range. Two horizontal entries, one at each end of the shelter, should be provided. Each entry should be 10 feet long. This length is needed to reduce the amount of initial nuclear radiation reaching the blast shelter room while assuring

ORNL DWG 78 14675



TOP VIEW



VIEW LOOKING INTO SHELTER FROM A–A

Fig. D. 12. Completed frame of Chinese "Man" Shelter showing its two ORNL-designed entryways (one at each end) and triangular blast doors made of poles. Before covering the triangular vertical entries with earth, tree branches were placed vertically over the sides; the branches then were covered with bed sheets. Horizontal branches, also covered with bed sheets, were laid over the rest of the shelter frame. After being covered with earth, this shelter was subjected to 1-kiloton blast effects. Multiple earth arching over and around this yielding structure prevented both the small poles and the bed sheets from being damaged at 20 psi.

Each pair of vertical posts (2) was securely wired together at top and bottom. The two pairs were held apart at top and bottom by two horizontal brace- poles toe-nailed in place to frame the rectangular 30- X 30-inch crawlway "doorway" between the vertical entry and the horizontal entry. Only the upper pole (4) of these two 30-inch-long horizontal brace-poles is shown.

The two pairs of vertical posts (2) were positioned so that they pressed against two 7-1/2-foot horizontal poles (5); only the uppermost is shown. These in turn pressed against the outermost two poles (6) of the horizontal entry and against the earth in two slot-trenches dug in the sidewalls of the excavation. These two 7-1/2-foot poles (5) should be at least 6 inches in diameter.

Additional details of the lower section of this vertical triangular entry are given in Fig. D.11. If horizontal poles considerably larger in diameter than those illustrated are used, fewer poles are required and strength is increased. However, the space inside the entry is decreased unless the larger-diameter horizontal poles that form the "V" are made longer than 4-1/2 ft.

As shown on the left in Fig. D.10, a small, vertical pole (7) was placed in the small "V" between the outer ends of the horizontal poles that form the lower section of the vertical entry. After this photo was taken, a second small, vertical pole was positioned in the adjacent large "V", inside the entry. These two poles (7) were then tightly wired together so as to make a strong, somewhat yielding, outer- corner connection of the horizontal poles (1) in the same way that the tops of the side-wall poles of the Chinese "Man" Shelter are bound together.

The upper section of the vertical part of this entry (the section above the tops of the two pairs of vertical posts shown in Fig. D.10 and Fig. D.11) is made by overlapping the ends of its nearly horizontal poles (Fig. D.12). These poles [marked with a (1) in Fig. D.10] were each 4 feet 6 inches long and varied uniformly in diameter from about 2-1/2 inches just above the two pairs of wired-together posts, to 4-inch diameters just below the triangular door frame of poles. The triangular-shaped blast door was hinged to and closed against this door frame. The hinges were strips cut from worn auto tires, to be described shortly.

The upper section is formed by laying poles in a triangular pattern, ends crossing at the angles, with large ends and small ends placed so that the poles are as nearly horizontal as is practical. Each of its three corners is held together by strong wires that tightly bind an outside and an inside small vertical pole, in the same manner as the top of the Chinese "Man" Shelter (shown in Fig. D.9) is secured. (Instead of No. 9 soft steel wire, rope or twisted strips of strong fabric could be used.)

Before starting to install the upper section of a vertical triangular entry, the three outermost of the six small vertical poles that will hold the three corners together should be connected temporarily with three small horizontal poles. Connect them at the height of the door frame planned for the triangular blast door, and space them so as to be the same size as this door frame.

Next, all the horizontal poles should be laid out on the ground in the order of their increasing diameters. The triangular entry then should be started with the smallest poles at the base, with increasingly large-diameter poles used toward the top so that the three pairs of small vertical poles will press securely against all the horizontal side poles of the entry.

To prevent the negative overpressure ("suction") phase of the blast from yanking out and carrying away the blast door and the upper part of the vertical entry to which it is hinged, the uppermost 4 or 5 horizontal poles of each of the three sides of the vertical entry should be wired or tied securely together. Rope or strips of strong cloth can be used if strong wire is not available.

Before placing earth around this lightly constructed blast-protective entry, the vertical walls must be covered to a thickness of about 6 inches with a yielding, crushable covering of limbs, brush, or innerspring mattresses. Limbs or brush should be placed in three layers, with the innermost layer at right angles to the underlying poles. The yielding thickness then is covered with strong cloth, such as 50% Dacron bed sheets, or two thicknesses of 4-mil polyethylene film. This outermost covering keeps loose earth or sand from filling spaces inside the yielding layer or running into the entry. Thus protected, this vertical entry should be undamaged by 25-psi blast effects of megaton weapons.

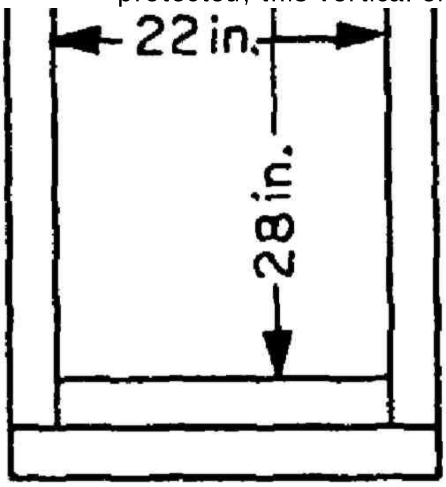


Fig. Pg. 252 A vertical blast -protective entry. 22 in. x 28 in.

A vertical blast-protective entry can also be made like a strong box, using 2-inch-thick boards. Such entries afford blast protection up to 50 psi if made as small as shown here and protected with yielding materials such as a 6-inch-thick layer of brush covered with strong cloth.

° Install blast doors to keep out airborne blast waves, blast wind, overpressure, blast-borne debris, burning-hot dust and air, and fallout.

A fast-rising overpressure of as little as 5 psi will break some people's eardrums. At overpressures of 15 to 20 psi, 50% of the people who are exposed will have their eardrums broken. However, persons near a shelter wall may have their eardrums broken by somewhat less than half of these un-reflected overpressures. (Any wall may reflect blast waves and greatly increase overpressures near it.) Broken eardrums are not serious in normal times, but after a nuclear attack this injury is likely to be far more dangerous to persons in crowded shelters without effective medical treatment. Lung damage, that can result from overpressures as low as 10 to 12 psi, would also be more serious under post-attack conditions.

A blast door must withstand blast waves and overpressure. Not only must the door itself be sufficiently strong to withstand forces at least as great as those which the shelter will survive, but in addition the door frame and the entranceway walls must be equally as strong. The expedient blast door pictured in Fig. D. 13 was made of rough boards, each a full 2 inches thick. It had a continuous row of hinges made of 18-inch-long strips cut from the treads of worn car tires.

Fig. D.13. Blast door surrounded by 4 blast-protector logs that were notched and nailed together. The wet, mounded soil had been compacted by the blast but not blown away.

The strips were nailed to the vertical poles on one side of the vertical entry. These and other details of construction are shown in Fig. D. 14. Although the two center boards were badly cracked by the shock wave and overpressure at the 17-psi range, the door pictured in Fig. D.13 afforded good protection against all blast effects from a surface explosion of a million pounds of TNT. In Fig. D.14,note the *essential,* strong tie-down attachment of the wires at the bottom of the vertical entry, to prevent the blast door from being yanked open by the negative pressure ("suction") that follows the overpressure.

Blast doors must be protected against reflected pressures from blast waves that could strike an edge of an unprotected door and tear it off its hinges. Note the blast-protector logs installed around the door pictured in Fig. D. 14. When the door was closed, the tops of these four logs were about 2 inches higher than the door, thus protecting its edges on all sides.

The closed door must be prevented from rebounding like a spring and opening a fraction of a second after being bowed down by overpressure, or from being opened and perhaps torn off its hinges by the partial vacuum ("suction") that follows the overpressure phase. Figure D. 14 gives the details of such a hold-down system for a blast door. Note that near the bottom of the vertical entry the 6 strong wires must encircle a horizontal pole that is flattened on one side and nailed to the vertical wall poles with at least a dozen 6-inch (60-penny) nails. Blast tests up to the 53-psi overpressure range have proved that this hold-down system works.5

Fig. D.14. Expedient blast door that can be closed and secured in 4 seconds. Four seconds would be too little time if the shelter is at the 15-psi overpressure range from a 550-kiloton or smaller warhead - typical of the 1987 Soviet ICBM arsenal. (See the last paragraph on page 255.) However, this door [illegible] 1063)

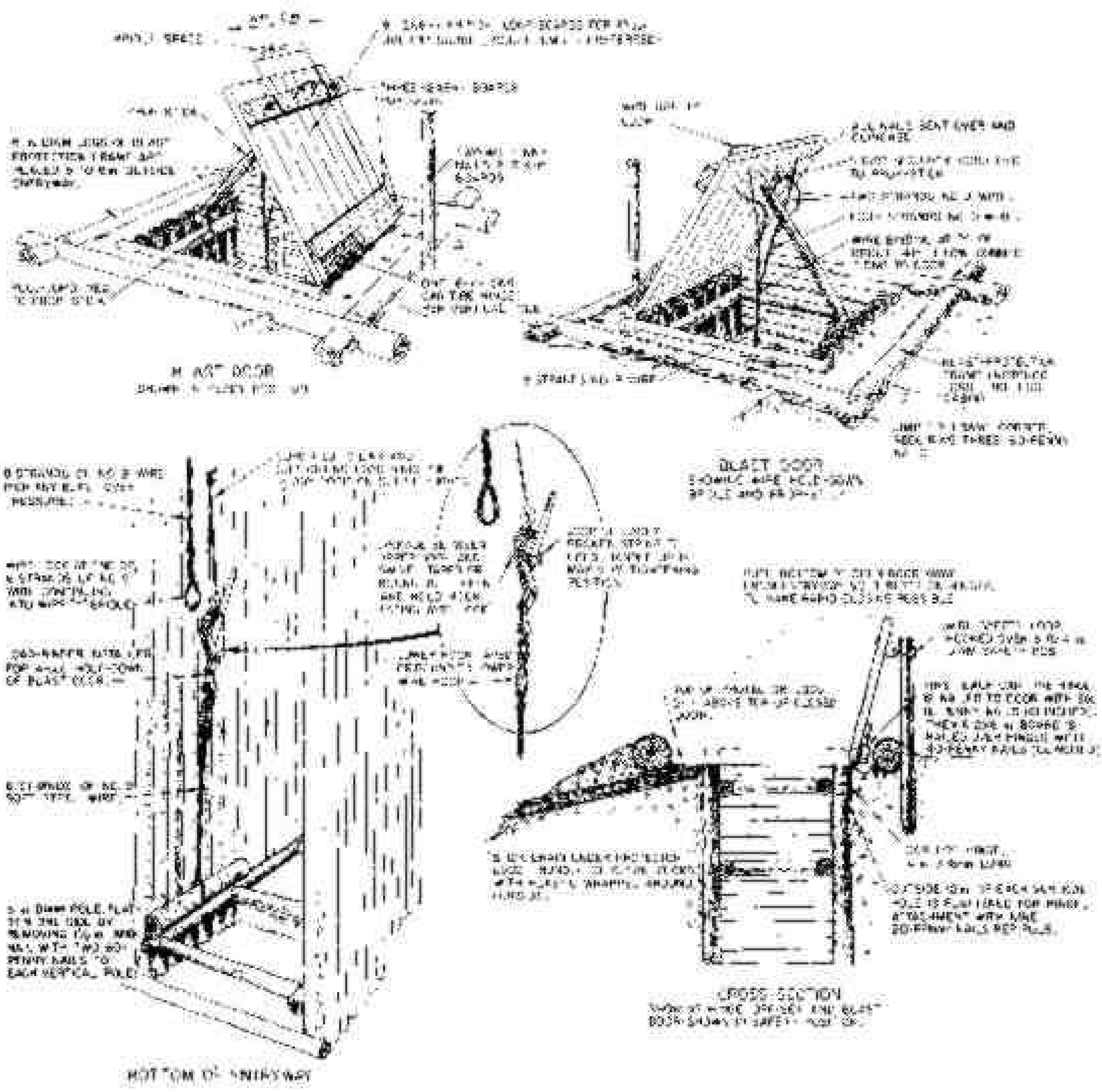


Figure D. 15 shows a blast door made of 5 thicknesses of 3/4-inch exterior plywood, well glued and nailed together with 4-1/2-in. nails at 4-in. spacing. This door was protected by 4 blast protector logs, each 8 feet long and about 8 inches in diameter. The logs were notched, nailed together, and surrounded with earth. For protection against ignition by the thermal pulse from an explosion, exposed wood and rubber should be coated with thick whitewash (slaked lime) or mud, or covered with aluminum foil.

An equally strong blast door and the door base upon which it closes can be made of poles. If poles are fresh-cut, they are easy to work with ax and saw. Figure D.16 shows the best blast-tested design. This door also had a continuous row of hinges made from worn auto tire treads. The pole to which the hinges were attached was 7 inches in diameter after peeling and had been flattened on its top and outer sides. The two other poles of the equal-sided triangle were 8 inches in diameter and had been flattened with an ax on the bottom, top, and inner sides. The three poles were each 55 inches long. They were notched and spiked together with 60-penny nails so that the door would close snugly on its similarly constructed base made of three stout poles. Other poles, at least 7 inches in diameter before being hewn so that they would fit together snugly, were nailed side-by-side on top of the three outer poles.

Many Americans have axes and would be able to cut poles, but not many know how to use an ax to hew flat, square sides on a pole or log. This easily acquired skill is illustrated by Fig. D.17. The worker should first fasten the pole down by nailing two small poles to it and to other logs on the ground. Figure D.17 shows a pole thus secured. When hewing a flat side, the worker stands with his legs spread far apart, and repeatedly moves his feet so that he can look almost straight down at where his ax head strikes. First, vertical cuts with a *sharp* ax are made about 3 or 4 inches apart and at angles of about 45 degrees to the surface of the pole, for the length of the pole. These multiple cuts should be made almost as deep as is needed to produce a flat side of the desired width. Then the worker, again beginning at the starting end, should cut off long strips, producing a flat side.

Fig. D.15. Tire-strip hinges nailed to an expedient, 4-inch-thick blast door made of plywood, designed to withstand 50-psi blast effects of very large weapons and undamaged by blast at the 53-psi range.

Fig. D.16. Blast-tested triangular blast door made of hand-hewn pine poles, notched and nailed together. This door closed on a triangular pole base that is concealed in this photo by two of the three blast-protector logs that also withstood 53-psi blast effects.

Fig. D.17. Hewing flat sides on a pole with a sharp ax.

To hew a second flat side at right angles to the first side, rotate the pole 900, secure it again, and repeat as pictured in Fig. D.17.

° Provide blast closures for an adequate ventilation system. The following two expedient closure systems permit adequate volumes of ventilating air to be pumped through a shelter:

1. Install two blast doors, one on each end of the shelter, designed to be left open until the extremely bright light from a large blast is seen. Figure D. 14 shows a door held open by a prop-stick that can be yanked away by the attached pull-cord. While propped open, one blast door serves as an extremely low-resistance air-intake opening, and the other serves as an air-exhaust opening. A large KAP can pump air at the rate of several thousand cubic feet per minute through such open doors.

   When an attack is expected, each pull-cord should be held by a shelter occupant who stays ready at all times to yank out the prop-stick as soon as he sees the light of an explosion. After the door has fallen closed, the loop at the end of its wire bridle is close to the upper hook of the load-binder and at the same height (Fig. D.14). The person who closes the door should quickly hook the upper hook of the load- binder into the wire loop and pull down on the handle of the load-binder. The door will then be tightly shut. (Sources during an emergency would be the millions of load-binders owned by truckers and farmers.)

   At distances from a large explosion where blast wave and overpressure effects are not destructive enough to smash most good expedient blast shelters, there is enough time between the instant the light of the explosion is seen and the arrival of its blast wave for an alert person to shut and securely fasten a well- designed blast door. The smaller the explosion and the greater the overpressure range, the shorter the warning time. Thus at

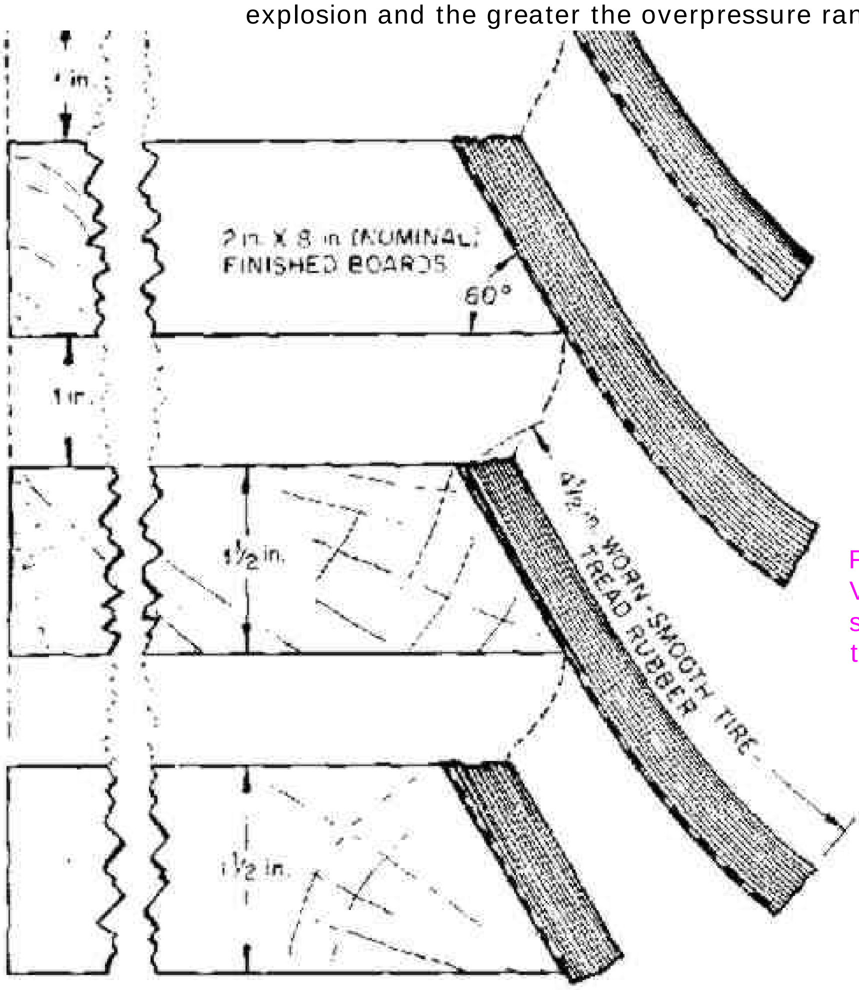
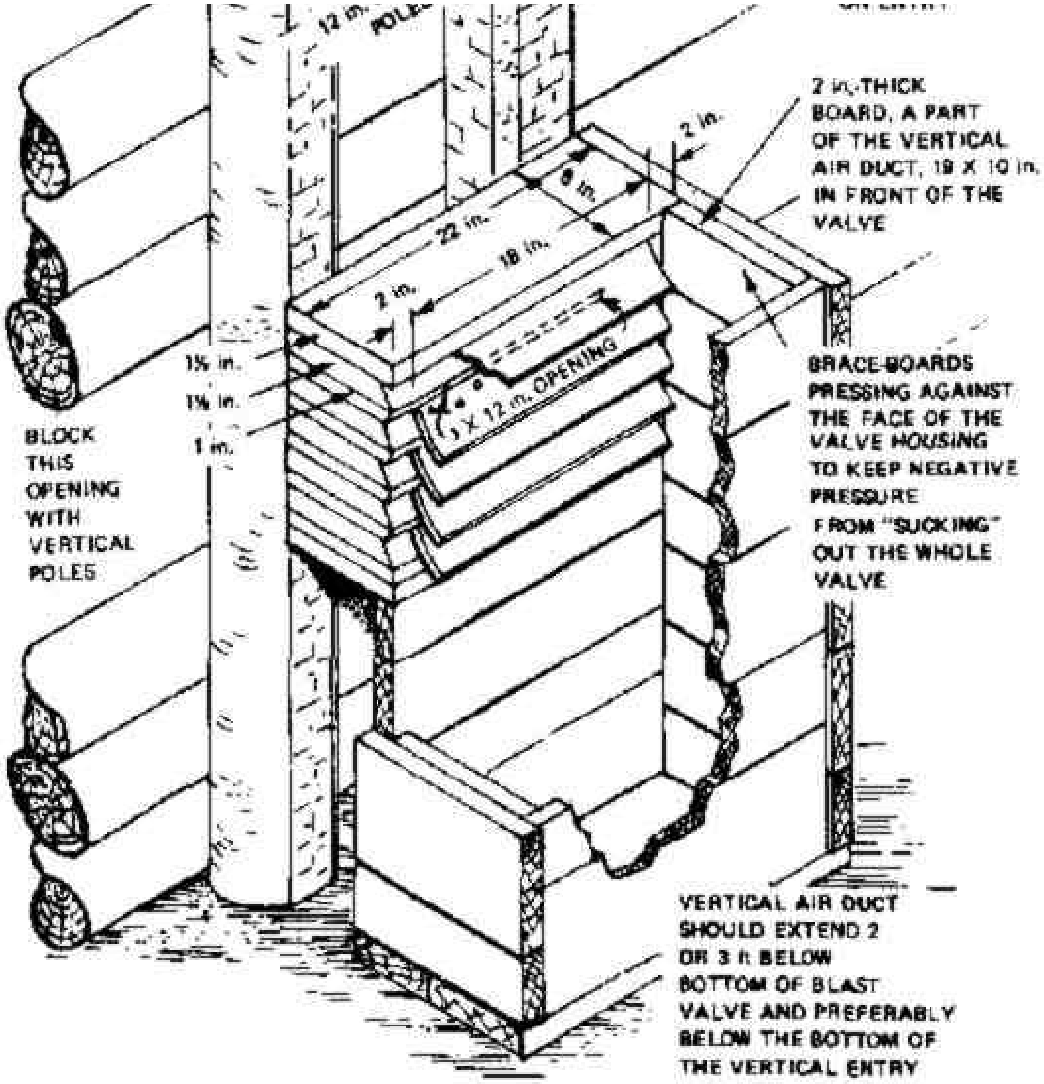


Fig. D.18. Overlapping-Flaps Blast Valve, made of boards, plywood, and strips cut from the treads of worn car tires. (ORNL DWG 73-2229A) the 15-psi overpressure range from a 1-megaton surface burst (1.5 miles), the blast wave arrives about 2.8 seconds after the light; whereas at the 10-psi overpressure range from a 1- megaton surface burst (1.9 miles), the blast wave arrives about 4.5 seconds after the light. For a 20- megaton surface burst, the warning time at the 15-psi range is about 8 seconds, and at the 30-psi over- pressure range, about 4 seconds. Experiments have shown that even people who react quite slowly can close and secure this door within 4 seconds after seeing a spotlight shine on the door without warning.

2. Build a vertical air shaft next to the outermost side of each vertical entry, with an Overlapping-Flaps Blast Valve (see Fig. D. 18) connecting each entry to its air shaft, as shown in Fig. D. 19. These air shafts and blast valves permit forced ventilation to be maintained when the two blast doors are closed. Figure D. 18 illustrates the construction of a fast-closing expedient blast valve, a design that was undamaged by the 65-psi shock wave and other effects produced by the explosion of a million pounds of TNT. When blast- tested in a shock- tube at 100-psi, the flaps were undamaged; they closed in 6/1000 of a second (0.006 sec.). This is as fast as the best factory-made blast valves close.

Fig. D.19. Installation of a 50-psi Overlapping- Flaps Blast Valve in such a way that it will not be blown into a shelter by the blast overpressure, nor pulled out by the following negative



To withstand 50 psi, the load-bearing "2-inch" boards (actually 1-1/2inches thick) of the valve should be at least 6 inches wide, if the 1-in.-high air openings are each made 12 in.

wide, measured between two vertical poles of a shelter entry. See Fig. D.19, that gives the dimensions of a valve that has been blast tested.5 Note that there are 5 inches of solid wood at each end of each 1-in.-high air opening. If there are 5 such air openings to a valve, a properly installed KAP (Appendix B) can pump air at about 125 cubic feet per minute (125 cfm) through a shelter equipped with such valves. This ventilation rate is ample for at least 40 people in cold weather. Except in hot and humid weather, a constant air supply of about 10 cfm per shelter occupant is enough to maintain tolerable conditions during continuous shelter occupancy for many days.

If a factory-made blower capable of pumping more than 100 cfm is available, use it. Such a hand-operated blower can pump against much higher air flow resistances than a KAP can. It can pump its full-rated volume of outdoor air through a shelter equipped with two Overlapping-Flaps Blast Valves, one at each end of the shelter and each with only 2 air openings-providing a total of 24 square inches of openings per valve. Equally or more effective is a home makeable Plywood Double- Action Piston Pump, made and operated as described in Appendix E.

Remember that a pressure of 7200 pounds pushes against each square foot of the exposed face of a blast valve when it is subjected to a 50-psi blast overpressure. Also keep in mind that the "suction" that follows can exert an outwardly directed force of up to 700 pounds per square foot on the valve face and can yank it out of position unless it is securely installed. Figure D. 19 shows how to securely install a blast valve. (Merely nailing a blast valve in its opening will not enable it to withstand severe blast forces.)

Note in Figure D.19 that an opening is shown between the back edge of the uppermost board of the Overlapping-Flaps Blast Valve and the adjacent horizontal pole of the vertical entry. Both this opening and the similar opening next to the lowermost board of the Blast Valve should be closed off with a stout board, to prevent blast from going through these openings and on into a vertical entry and the shelter room.

The top of an air shaft should be a few inches higher than the earth piled around it, as are the tops of the vertical entries of the Small-Pole Shelter illustrated in Figure A.3.1 on page 174. To minimize the amount of rain that may fall into an air shaft, a shed-like, open-sided miniature roof should be placed over it, a few inches above its top. The roof can be lightly constructed, since it will be blown away by a severe blast.

° Minimize aboveground construction and the mounding of shielding earth.

At high overpressure ranges, the shock wave and the blast-wind drag can wreck an aboveground shelter entry. For example, the 5-ft-high earth mound over a shelter built with its pole roof at ground level was moved enough by 1-kiloton air-blast effects at the 53-psi overpressure range to break one of the poles of a blast-door frame. The forces of a 1-megaton explosion at the same overpressure range would have operated 10 times as long, and probably would have smashed the vertical entryways of this shelter. Whenever practical, a blast shelter should be built far enough belowground so that the top of its shielding earth cover is at ground level. Avoiding above- ground construction and earth mounds also greatly reduces the chances of damage from blast-hurled, heavy debris, such as tree trunks and pieces of buildings.

Dry earth, steeply mounded over a shelter which is subjected to blast winds from a big explosion, will be mostly blown away. However, blast-wind "scouring" of wet earth is negligible. The blast winds from a 1-kiloton explosion at the 31-psi overpressure range scoured away 17 inches of dry, sandy soil mounded at a slope of 32 degrees.

If it is impractical to build a blast shelter with its roof belowground, good projection can be attained by mounding even dry earth at slopes not steeper than 10 degrees.

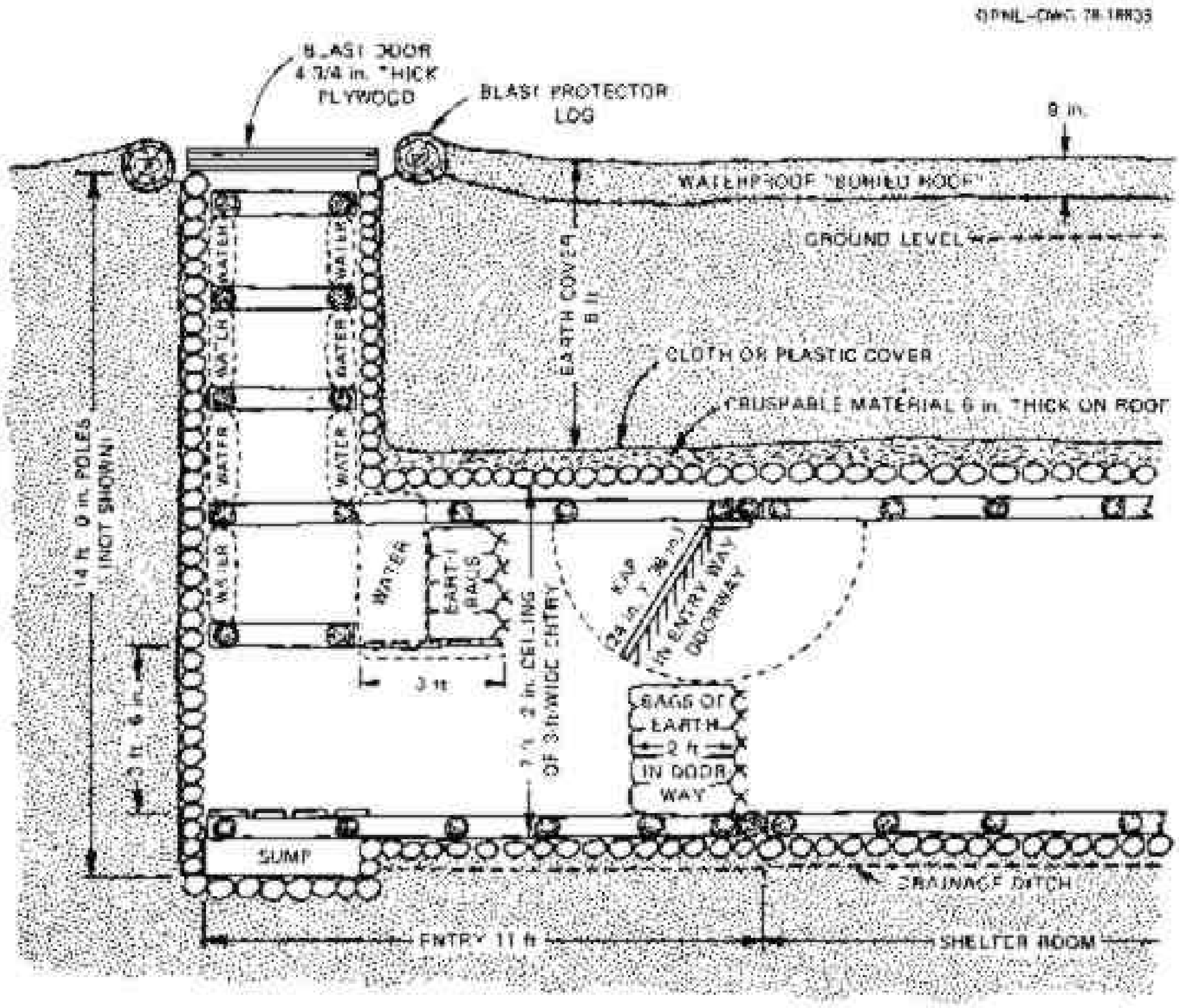
° Provide adequate shielding against initial nuclear radiation.

Good expedient blast shelters require a greater thickness of earth cover than is needed on good fallout shelters, for these reasons:

* Blast shelters should also protect against initial nuclear radiation emitted by the fireball. This radiation is reduced by half when it penetrates about 5 inches of packed earth (as compared to a halving-thickness of only about 3-1/2 inches of earth against radiation from fallout).
* The initial radiation, in some areas where good blast shelters will survive, can be much greater than the fallout radiation is likely to be.
* Initial nuclear radiation that comes through entryways is more difficult to attenuate (reduce) than fallout radiation. Therefore, longer entry- ways or additional right-angle turns must be provided.

For these reasons, good blast shelters should be covered with at least 4 ft of well-packed, average-weight earth, or 5 ft of unpacked or light earth. (A 3-ft thickness gives excellent protection against radiation from fallout.)

Fig. D.20. Entryway of Small-Pole Blast Shelter shielded against initial nuclear radiation. This sketch is a simplified vertical section through the centerline of one end of the shelter.



III. A 50-PSI SMALL-POLE SHELTER:

This expedient blast shelter is described in detail to enable the reader to build this model. The details will help him better understand the design principles of other expedient blast shelters that are capable of preventing injuries from blast effects severe enough to destroy all ordinary buildings and kill the occupants. Blast tests and calculations have indicated that the Small-Pole Shelter described and illustrated in Appendix A.3 will afford protection against all weapon effects at overpressure ranges up to 50 psi that are produced by an explosion of 1 megaton, or *larger,* provided the shelter is:

- ° Made with horizontal entryways each with ceilings no higher than 7 ft, 2 in., no wider than 3 ft, and each at least 10 ft long to lessen the radiation coming through the entries (see Fig. D.20). Lower and narrower entryways would give better protection but would increase the time required for entry.
- ° Constructed with a floor of poles that are 4 in. or more in diameter, laid side-by-side, with the wall poles resting on the floor poles. The ground shock and earth pressures at a depth of 10 ft or more resulting from an overpressure on the surface of more than about 35 psi, if caused by a large explosion, may destabilize and squeeze earth upward into the shelter through an unprotected earth floor. The Small-Pole Shelter described in Appendix A.3 has an earth floor.
- ° Installed in an excavation about 13 feet deep, with the shelter's vertical entrances appropriately increased in height so that the blast doors are only about one foot above the original ground level.

To prevent possibly life-endangering cave- in of the 13-foot-deep trench that was dug for the blast testing of this model shelter, the trench walls were sloped about 45 degrees. The shelter was built as a braced, free-standing structure, and then covered. During a crisis it would be impractical to safely excavate a deep trench with steeply sloping walls and then safely build a shelter in it. A 13-foot-deep trench is usually too deep to dig by hand-especially since to dig it with safely sloping walls requires the removal of a large amount of earth.

- ° Made with 4 rectangular horizontal braces in each vertical entry, in addition to the ends of the two long, ladder-like braces. The detailed drawings in Appendix A show' such braces. The lowest rectangular brace should be positioned 3-1/2 feet above the flooring at the bottom of the vertical entry (see Fig. D.20).
- ° Equipped with blast doors each made of 5 sheets of 3/4-inch exterior plywood (see Fig. D.15) bonded with resin glue and nailed together with 4-1/2 in. nails. The nails should be driven on 4-in. spacing and their protruding ends should be clinched (bent over). The blast doors must be secured against being yanked open by negative pressure ("suction") by securing them with a strong wire bridle (see Fig.-D.14), and with the lower, fixed wire strongly connected near the bottom of the entry to all of the vertical poles on one side, as shown in Fig. D.14.
- ° Provided with an adequate ventilation pump and with ventilation openings protected against blast by expedient blast-valves (Fig. D.18) installed in the vertical entries as shown in Fig. D. 19, to protect the air-intake and the air-exhaust openings. (Ventilation openings should be as far as practical from buildings and combustible materials. Manually closed ventilation openings are NOT effective at the 50-psi overpressure range of most weapons, because there is insufficient time to close them between the arrival of the warning light from the explosion and the arrival of the blast wave.)
- ° Made with the roof poles covered by a yielding layer of brush or limbs about 6 inches thick, or of innerspring mattresses. This yielding layer in turn should be covered with bed sheets or other strong cloth, to increase the effectiveness of protective earth arching. Brush or limbs should be laid in 3 layers with sticks of the middle layer perpendicular to those of the other two layers.
- ° Covered with 5 feet of earth, sloped no steeper than 10 degrees.
- ° Provided with additional shielding materials in the entryways, as shown in Fig. D.20. Such shielding would be needed to prevent occupants from receiving possibly incapacitating or fatal

doses of initial nuclear radiation through the entryways at the 50-psi overpressure range, if the shelter is subjected to the effects of a weapon that is one megaton, o*r larger,* in explosive yield.

Damp earth serves better for neutron shielding material than dry earth and can be substituted for water as shielding material if sufficient water containers are not available. (At the 50-psi over-pressure range from explosions *smaller* than one megaton, the entry and shielding shown in Fig. D.20 may not provide adequate protection against initial nuclear radiation.)

When the shelter is readied for rapid occupancy, the shelter-ventilating KAP is secured against the ceiling, and the bags of earth in the doorway (under the KAP) are removed. Persons entering the shelter would stoop to go under the platform adjacent to the vertical entry. This platform is attached to vertical wall-poles of the horizontal entry and supports shielding water and earth. When all except the person who will shut and secure the blast door are inside the shelter room, occupants should quickly begin to place bags of earth in the doorway. When the attack has begun, the whole doorway can be closed with bags of earth or other dense objects until ventilation is necessary.

The entries of other types of blast shelters can be shielded in similar ways.

° Protected against fire by being built sufficiently distant from buildings and flammable vegetation and by having its exposed wood covered. For maximum expedient protection against ignition by the thermal radiation from a large explosion, all exposed wood should be free of bark, coated with wet mud or damp slaked lime (whitewash), and covered with aluminum sheet metal or foil to reflect heat. (Most of the thermal radiation from an explosion that was 1 megaton or larger would reach the 50-psi over- pressure range after the blast wave had arrived and had torn the expedient protective coverings from the wood. However, as has been observed in megaton nuclear weapon tests, the dust cloud first produced by the pop-corning effect and later by the blast winds would screen solid wood near the ground so effectively against thermal radiation that it would not be ignited, provided it had been initially protected as described above.)

IV. PRECAUTIONS FOR OCCUPANTS OF BLAST SHELTERS:

Although a well constructed blast shelter may be undamaged at quite high overpressure ranges, its occupants may be injured or killed as a result of rapid ground motions that move the whole shelter several inches in a few thousandths of a second. Rapid ground motions are not likely to cause serious injuries unless the shelter is in an area subjected to 30- psi or greater blast effects. To prevent possible injury, when the occupants of high-protection blast shelters are expecting attack they should avoid:

° Having their heads close to the ceiling. The 'air slap" of the air-blast wave may push down the earth and an undamaged shelter much more rapidly than a person can fall. If one's head were to be only a few inches from the ceiling, a fractured skull could result.

° Leaning against a wall, because it may move very rapidly, horizontally as well as vertically.

° Sitting or standing on the floor, because ground shock may cause the whole shelter (including the floor) to rise very fast and injure persons sitting or standing on the floor. The safest thing to do is to sit or lie in a securely suspended, strong hammock or chair, or on thick foam rubber such as that of a mattress, or on a pile of small branches.

In dry areas or in a dry expedient shelter, ground shock may produce choking dust. Therefore, shelter occupants should be prepared to cover their faces with towels or other cloth, or put on a mask. If an attack is expected, they should keep such protective items within easy reach.

Appendix E: How to Make a Homemade Piston Pump

How to Make and Use a Homemade Plywood Double-Action Piston Pump

THE NEED:

Ventilating pumps-mostly centrifugal blowers capable of operating against quite high resistance to airflow-are used to force outdoor air through most high-protection-factor fallout shelters and through almost all permanent blast shelters. Low-pressure ventilating devices, including ordinary bladed fans and homemade air pumps such as KAPs and Directional Fans, cannot force enough air through a permanent shelter's usual air-supply system consisting of pipes, or of pipes with a blast valve, a filter, and the valves needed to maintain a positive pressure within the shelter.

Manually cranked centrifugal blowers, or blowers that can either be powered by an electric motor or be hand-cranked, are the preferred means of ventilating permanent shelters from Switzerland to China. The main disadvantages of efficient centrifugal blowers are:

1. They are quite expensive. For example, in 1985 a good American hand-cranked blower, that pumps only about 50 cubic feet per minute (50 cfm) through a shelter's pipes, blast valve and filter, retails for around $250. An excellent foreign blower that enables one man to pump somewhat larger volumes sells for about twice as much.
2. Not enough centrifugal blowers could be manufactured quickly enough to equip all shelters likely to be built during a recognized crisis threatening nuclear attack, and lasting for weeks to several months.

Therefore, there is need for an efficient, manually operated, low- cost ventilating pump that:

3. Can pump adequate volumes of outdoor air through shelter- ventilating systems that have quite high resistances-up to several inches water gauge pressure differential.
4. Will be serviceable after at least several weeks of continuous use.
5. Can be built at low cost in home workshops by many Americans, using only materials available in most towns.
6. Could be made by the millions in thousands of shops all over the U.S., for mass production during a recognized prolonged crisis, using only plywood and other widely available materials.

To produce such a shelter ventilating pump, during the past 20 years I have worked intermittently designing and building several types of homemade air pumps. However, until I was traveling in China as an official guest in October 1982 and saw a wooden double- action piston pump being used, I did not conceive or come across a design that I was able to develop into a shelter-ventilating pump that meets all of the requirements outlined above. Now I have made and tested a simple homemade Plywood Double-Action Piston Pump, described below, that satisfies these requirements. Three other persons have used successively improved versions of these instructions to make this model, and several others have contributed improvements.

HOW A PLYWOOD DOUBLE-ACTION PISTON PUMP WORKS:

Fig. 1 pictures the box-like test model described in these instructions.

Fig. 1. Plywood Double-Action Piston Pump, with manometer attached for tests.

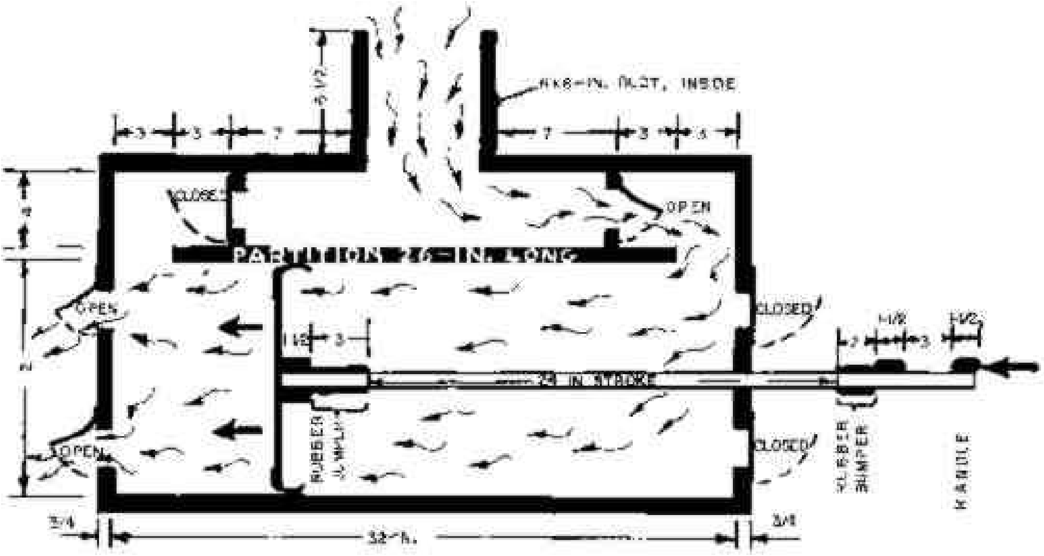
Fig. 2 illustrates a vertical section through a slightly improved model, and shows the 12x12-in. plywood piston being pushed from right to left, causing air from the outdoors to be "sucked" down the open air-supply duct in the top of the pump, then down to the right through the open valve in the airtight frame (that is above and near the right end of the PARTITION), and on down into the lower- pressure area behind the leftward-moving piston.

Because the air to the right of the leftward-moving piston is at a lower pressure than the air in the shelter room, the exhaust valves in the front end (the handle end) of the pump are held closed.

During this half of the pumping cycle, the higher-pressure air in the part of the pump's square "cylinder" to the left of the leftward-moving piston opens the air-exhaust valves in the back end of the pump, and fresh air is forced out into the shelter room, The higher-pressure air to the left of the valve in the airtight frame (that is above the left end of the PARTITION) keeps this valve closed, while the lower-pressure air to the right of this valve helps keep it closed.

When the piston is pulled to the right, all of the valves shown closed are quickly opened, and all shown open are quickly closed. Then fresh air is forced into the shelter room through the opened exhaust valves in the front end of the pump.

Fig. 2. Vertical Section of the Double-Action Piston Pump showing its square piston being pushed to the left.



PERFORMANCE TESTS:

The volumetric and durability tests summarized below are proof that this homemade Plywood Double-Action Piston Pump is better than most hand-cranked centrifugal blowers for supplying a shelter with outdoor air through typical air-intake and exhaust pipes- especially when the ventilation system contains a filter and/or blast valves. The filters that give the best protection, Chemical Biological Radiological (CBR) Filters, have quite high resistance to airflow, as do commercial blast valves that close quickly enough to protect filters.

1. Volumetric tests:

   Because the rapidly pulsating airflows into and out of a piston pump are very hard to measure accurately with an air velocity meter, I made an inflatable cylindrical bag of 2-mil (0.002 inch) polyethylene film; the fully inflated volume of this bag was 256 cubic feet. The bag was suspended on a horizontal strong cord running through its length. A short tube 62 inches in circumference connected the back end of the pump (that is opposite the operator's end) to the suspended bag. Bag and pump were in a below ground shelter that normally has essentially motionless air. See Fig. 1.

   Since this type of pump exhausts equal volumes of air from each of its two ends, the total cubic feet per minute (cfm) that it pumps equals twice the cfm that it exhausts into the shelter from one of its ends. See Fig. 1, that shows the pump attached with "C" clamps to a small steel table and being used to pump air into the 256 cubic foot suspended bag.

   I measured the pressure differences against which the pump was operated. In a shelter these differences typically are caused by the resistance to airflow in pipes, valves, and a filter. I measured pressure differences in inches water gauge (1 in. w.g. 0.036 psi) with the small-tube manometer attached to the side of the pump. To produce various pressure differences for several tests, I nailed a piece of plywood over the top of the air-intake duct, so as to produce different sized openings: in most tests I placed different layers of filter materials in a filter box that was fitted airtight over the 6 x 6-in. air-supply duct on the top of the pump. See Fig. 3. (This low-resistance filter removes practically all fallout particles of wartime concern, and also most infective aerosols that may be used in biological warfare. See "Making and Using a Homemade Filter Box and Filter", by Cresson H. Kearny, October 1985.

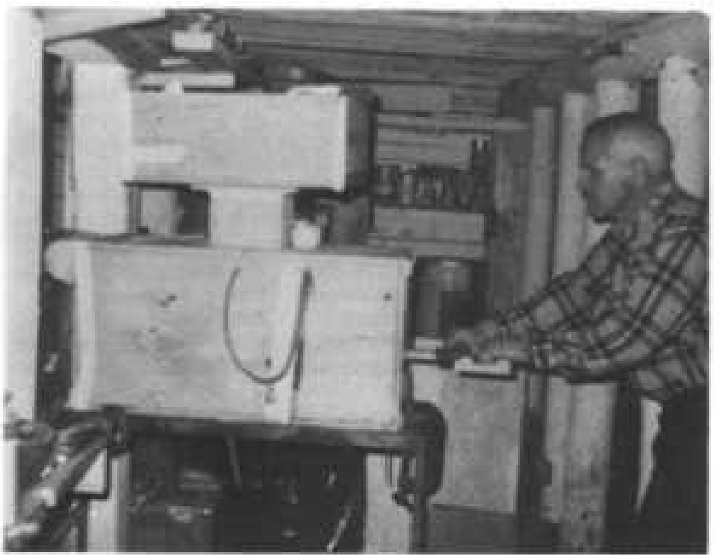


Fig. 3. Pump with Homemade Filter (20 x 20 x 8-inches inside dimensions) connected airtight on top of the pump's 6 x 6-inch air-intake duct.

The best centrifugal blowers that I have seen or heard about are those manufactured by a Finnish company, Temet Oy. (I cranked a Temet Oy blower in an Israeli shelter used for testing ventilation equipment: the Finnish centrifugal blower was better than Swiss, German and captured Russian blowers also undergoing tests.) Therefore, in Table 1 a few of the volumetric tests of my best model Plywood Double-Action Piston Pump (powered by one and two men) are compared with performance data furnished by Temet Oy for its centrifugal blower when cranked by two men. I have converted Temet Oy's metric units into the common American units.

In Table 1 the pressure difference of 4.3 inches water gauge is the resistance to airflow that Temet Oy realistically gives as typical of a well designed shelter ventilation system of pipes, valves and blower plus a Chemical Biological Radiological (CBR) filter. Temet Oy gives 2.0 inches water gauge as typical of the same ventilation system with only a low resistance dust filter. The much larger volume pumped by the Double-Action Piston Pump when a CBR filter is used (as compared to the cfm pumped by this very good centrifugal blower) is typical of the reduced effectiveness of even the best centrifugal blowers at high pressure differences.

In areas devastated by a nuclear explosion, the typical very dusty conditions are likely to result in filters soon becoming dirty and higher in resistance to airflow. Then the greater effectiveness of a piston pump for ventilating a shelter with a high-resistance air-supply system will be even more important than when its filter is clean.

Table 1. Comparison of Plywood Double-Action Piston Pump with Temet Oy Centrifugal Blower.

TYPE OF PUMP	PRES. DIFF (in. w.g.)	CUBIC FEET PER MINUTE	HORSE-POWER
Double-Action Piston Pump			
one man	4.9	134	?
two men	4.3	182	?
Temet Oy Centrifugal Blower			
two men	4.3	90	0.15
Double-Action Piston Pump			
one man	2.3	172	?
two men	2.3	208	?
Temet Oy Centrifugal Blower			
two men	2	300	0.18

The horsepower requirements of my pump have not yet been measured. However, based on the calculated air pressure on the 12 x 12-in. piston of 22.3 lbs. when the pressure difference was 4.3 in. w.g. (0.155 psi), when two pumpers were making 52 strokes (cycles) per minute while pumping 182 cfm, the horsepower delivered was about 0.14 HP without allowing for friction and the losses of power due to reversals in the directions of piston movements. I estimate that the actual horsepower delivered by the two pumpers (I, a 69 year old with a stiff back in 1983, and a 15-year-old boy) was somewhat less than 0.2 HP. A man in good condition can work for hours delivering 0.1 HP.

When comparing machines powered by human muscles, what muscles are used and how they are used are often as important as are the horsepower requirements. Leg muscles are more efficient and are much stronger than arm muscles. Arm muscles are used much more in cranking a blower than in pushing and pulling the piston of a properly designed reciprocating piston pump back and forth horizontally. See Fig. 3. If this double-action piston pump is placed at a height above the floor so that its handle is approximately at the height of a standing operator's elbows, then the operator can do most of the work with his legs. See Fig. 3. He efficiently moves his body back and forth for over a foot, while moving his hands and forearms horizontally for slightly less than a foot relative to his body. To deliver the same horsepower by cranking a blower uses less efficient muscles inefficiently, and is much more tiring.

As shown in Table 2, the volumetric efficiency of my best model is good for a shelter-ventilating pump. The volumetric efficiency of a piston pump (a positive displacement pump) is found by dividing the cfm actually pumped by the theoretical maximum cfm at the same pumping rate and the same pressure difference, assuming all piston strokes are full length, that all valves open and close instantaneously, and that there is no leakage. Table 2 shows that the greater the pressure difference, the lower the efficiency- as one would expect, because of increased leakage.

PRES. DIFF (in. w.g.)	STROKES PER MINUTE	cfm	EFFICIENCY
4	36	122	84.0%
2.6	45	160	89.0%
0.7	51	188	92.0%
0.4	54	202	94.0%
0.2	55	208	94.5%

Table 2. Volumetric Efficiencies of Double-Action Piston Pump Operated by One Man.

2. Durability tests:

Finding a home-makeable method to seal the moving piston so as to assure at least one month of continuous efficient pumping was the most difficult problem. Various rubber seals attached to the edges of the piston were unsatisfactory, and aluminum sheet metal strips (shaped and attached like the galvanized steel sheet metal strips used in this model) wore out in less than a week, even when oiled every 24 hours.

To save money during weeks of continuous durability testing, the pump was operated by an electric motor that powered a pulley drive that turned a 2-foot-diameter pulley having an attached 40-in.-long steel pitman with a hinged connection to a horizontally- sliding bar connected to the handle of the pump's wooden piston rod. See Fig. 4.

After pumping for 380 hours (15.83 days) at 44 strokes per minute against a pressure difference of 2.3 in. w.g., the worst worn spot on any of the 30-gauge steel sheet metal sealing strips on the piston was reduced in thickness from its original 0.0155 in. to 0.0145 in. This worst-spot wear of 0.001 in. is only about a 6% reduction in thickness. The flap valves functioned as well as when new, and appeared unworn.

I conclude that this pump would be serviceable after several months of continuous use-provided it is lubricated after every 24 hours of actual use, as in this durability test. In this test I lubricated the piston, its "cylinder's" four walls, and its rod with Lubri-plate Ne. 105, "the original whito grease". This non-sticky "grease-type lubricant" is used extensively, especially to lubricate internal combustion engines before first starting up. Another builder of this model pump found Siloo White Lube, an all-purpose lithium grease, the best of the lubricants that he tested. Judging from my' prior durability' tests, a very' light oil applied daily serves reasonably well. Ordinary bearing grease is unsatisfactory.

Needed Materials:

The following materials (that cost about $65. retail in 1985) are needed to make and operate the best model of this pump:

- Plywood, 3/4-in. exterior: one 4 x 8-ft. sheet (finished on one side, un-warped).
- Plywood, 3/8-in. exterior: 1/4th of a 4 x 8-ft. sheet (finished on one side, un-warped). (Second choice: 1/4-in. exterior plywood).
- Oak board, 3/4 x 1-3/4 in., straight, well seasoned, 4 ft. long, to make the piston rod. (If oak or other very' strong wood is not available, use a straight fir or pine board.)
- Fir or pine board, about 3/4 x 1-3/4 in., 8 ft. long, to make the piston-rod handle, etc.
- 28-gauge or lighter galvanized-steel flashing (sold by lumber yards for roofers), no thicker than 0.016 in.: or galvanized steel or flashing no thinner than 0.012 in. Or 30 gauge galvanized steel sheetmetal available in some sheet metal shops. (Sheet- metal thicker than 0.016 is not springy enough for making this pump's near-equivalent of piston rings.) Best to go to a sheet- metal shop and have 3 strips cut, each 3 in. wide and about 30 in. long.
- Screws, round-headed, zinc-plated wood screws:
- 22 each of No. 12 (2-in. long, 12/32 in. dia.), with flat washers 10 each of No. 10 (1-1/2 in. long, with flat washers)
- 15 each of No. 6 (3/4 in. long, with flat washers)
- Nails, 4-penny (1-1/2 in.), best cement-coated: 1/4 lb. Nails, 3-penny (1-1/4 in:), galvanized: 1/4 lb.
- Staples (if an oak board for the piston rod is not available), No. 17, 3/4-in., galvanized): 1/4 lb.
- Tacks, No. 6 upholstery, (1/2-in. long): a small container. Tacks, No. 3 upholstery (3/8-in. long): a small container. Felt, weather stripping, 5/8-hi. wide: 10 ft.
- Tape, silver duct tape, 2-in. wide: a small roll.
- Tape, masking tape, 3/4-in. wide: a small roll.
- Adhesive, waterproof: "Liquid Nails", or other all purpose construction adhesive: one approx. 11-oz. tube (for use in caulking gun).
- Epoxy, 5-minute: 2 tubes.
- Rubber cement: a small tube.
- Sealer (such as polyurethane clear finish, to reduce absorption of oil or other lubricant of the "cylinder"): 1/2 pint.
- Plastic film, transparent storm-window type (such as 4-mil Flexo-Glass, by Warp Bros.): 3 sq. ft.
- Grease-type lubricant, an all-purpose motor-break-in lithium grease such as "Siloo White Lube" or "Lubri-plate No. 5 Space Age Lubricant": two approx. 10 oz. tubes.
- Inner tube rubber, heavy truck or auto (cut from an old tube): 1 sq. ft.

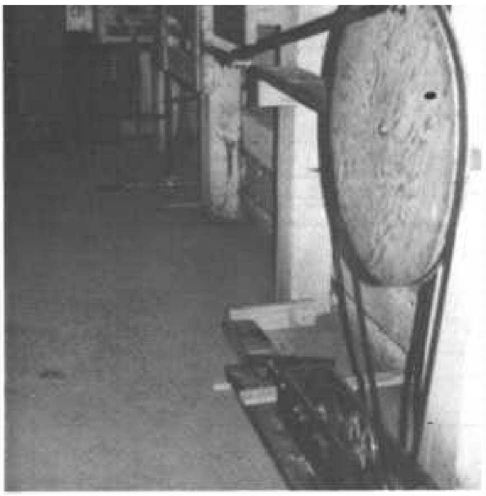


Fig. 4. Mechanized Drive Used in Weeks-Long Durability Tests.

FUNCTIONAL RELATIONS OF PARTS:

Look at Figs. 2, 5, and 6. In Figs. Sand 6, the lower, fixed part of the front end is pictured below the piston rod. The piston rod slides back and forth on the center of the fixed part of the front end (as indicated more clearly in Fig. 7), and in the notch in the removable part of the front end.

Fig. 5. Front End of the Durability Test Pump, showing the lower fixed part (below piston rod) and the upper removable part, which is held by 6 screws with flat washers. Felt weather-stripping makes the removable part airtight.

Fig. 6. Pump Built by Dale Huber, of Lake City, Florida in his home workshop, while guided only by the second draft of these repeatedly improved instructions. The removable part of the front end has been taken off, to insert the piston into the 12 x 12-in. "cylinder" under the PARTITION. The plastic flaps of this pump's flap valves are black: transparent plastic film is preferred.

Note that a single plastic-film flap covers each pair of 2 x 4-in. valve holes, and that, as shown in Fig. 2 (that gives a side view of all six flaps), all flaps open away from the vertical center-plane of the pump.

In Fig. 5 the removable (upper) part of the front end is shown in place, secured by six round-head screws with flat washers. In Fig. 7 note the pair of 2 x 4-in. flap- valve holes above the piston rod.

In Fig. 6. the removable part of the front end has been removed, exposing the 26-in.-long, horizontal PARTITION that serves as the top of the 12 x 12-in. "cylinder", in which the piston can make a 24-in.-maximum- length stroke. Also see Figs. 2 and 7. Fig. 6 also shows the piston while it is being removed and one of the two rubber bumpers (made of inner tube rubber) on its piston rod.

The back end of the "box" is made of one piece of plywood, as shown in Fig. 8. The two plastic flaps of its exhaust valves each cover two 2 x 4-in. valve holes, that are positioned the same as the four valve holes in the front end.

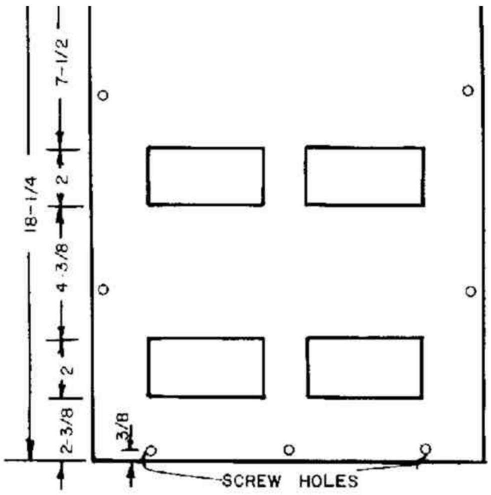


Fig. 7. Front End (Operator's End) of Plywood Double-Action Piston Pump. The two 4 x 12-in. valve frames are shown by dashed lines, as is the 12 x 26-in. PARTITION. (tioned the same as the four valve holes in the front end.

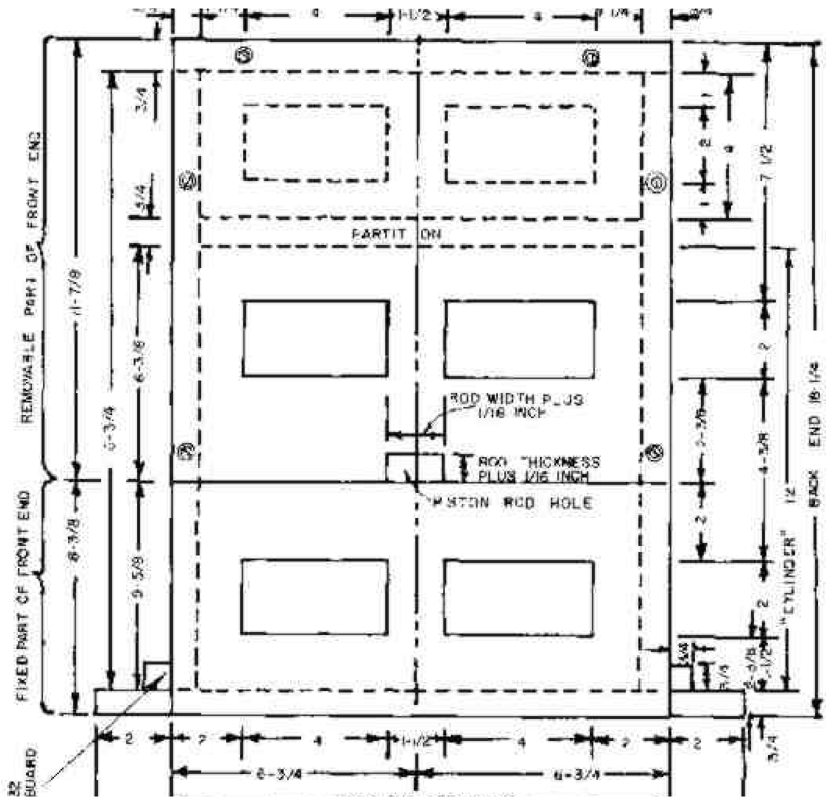


Fig. 8. Back End. Only the plywood is shown.

CUTTING OUT THE PLYWOOD PARTS:

1. The four parts of the "cylinder" (its bottom, two sides, and the PARTITION: see Fig. 7) should be made with the wood grain of the plywood running in the same direction as the lengths of these parts. This reduces piston friction.
2. Outline on a sheet of exterior 3/4-in. plywood all of the plywood parts-except for the 12 x 12-in. piston and the two 12 x 12-in. construction forms, which are made of 3/8-in. exterior plywood. (If

3/8-in. plywood is not available, use 1/4-in.) Do not assume that the corners of a sheet of plywood are truly square. Also check the width of the saw cut of the saw to be used, and allow for this width when drawing adjacent outlines of parts on the plywood. Be sure to make all corners square.

3. If you do not have a table saw that saws accurately, or a heavy- duty' saber saw, you will do well to pay a professional carpenter or cabinet maker to saw out the plywood parts-and also the piston rod if you are making it out of an oak board. A professional can accurately saw out all of the plywood parts and the 10 valve holes in about 2 hours, provided you have accurately outlined all saw lines.
4. Make the following plywood rectangles with tolerances of + or - 1/32 in.:
   - PARTITION, 12 x 26-in.
   - Two sides, each 16-3/4 x 32-in. (If your "3/4-in. plywood" actually is less than 11/16-in. thick, make the height of each of your sides 16-3/4-in. less the difference between 3/4-in. and the actual thickness of your plywood. See Fig. 7.)
   - Bottom, 17-1/2 x 32-in.
   - Top, 13-1/2 x 32-in.
   - Two valve frames, each 4 x 12-in.
   - Piston, 12 x 12-in. (of 3/8-in. plywood).
   - Two construction forms, each 12 x 12-in. (of 3/8-in. plywood).
5. Make the following plywood rectangles with tolerances of + or - 1/16 in.:
   - Back end, 13-1/2 x 17-1/4-in. (See Fig. 8.)
   - Removable (upper) part of front end, 13-1/2 x 10-7/8 in. (See Figs. 7 and 9.)
   - Fixed (lower) part of front end, 13-1/2 x 6-3/8-in. (See Figs. 7 and 10.) The four parts of the air-intake duct: two each 6-1/2 x 6-in.; two each 6-1/2 x 7-1/2-in.
   - Two spacers (to be nailed to the bottom) each 3/4 x 3/4 x 32-in.
6. Saw out the 10 valve holes; a tolerance of + or - 1/8 in. is good enough. (See Figs. 7, 8, 9, and 10.)
7. Saw a square 6 x 6-in. hole in the center of the top, as shown in Fig. 2 - if you are going to install the homemade filter (described in separate instructions) directly on top of your pump. (To connect your pump to a round air-intake pipe, cut an appropriate round hole in the top.)
8. Sandpaper the finished sides of the PARTITION, the two sides, and the bottom, to reduce friction on the reciprocating piston. Use fine sandpaper.
9. [illegible] omplete the flap valves, that are the lowest resistance,

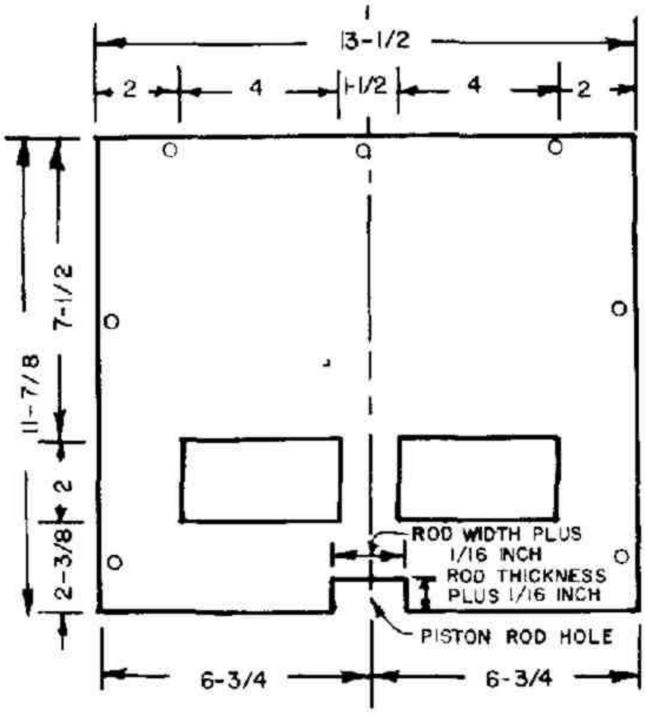
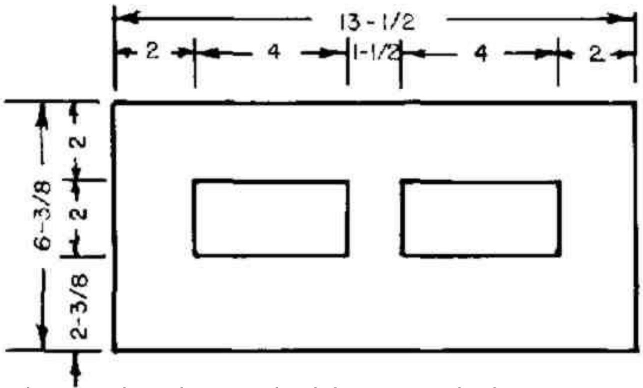


Fig. 9. Removable Part of Front End, Unfinished. Only the plywood is shown.

a. Make a 3-3/4 x 5-3/4-in. cardboard TEMPLATE, using carbon paper to transfer lines of Fig. 11 to cardboard. (See Fig. 11 on page 7, and note that this TEMPLATE outlines the right half of the 3-3/4 x 11-1/2-in. plastic-film flap.) Also transfer the dashed tack-line and mark the ends of the 4 horizontal stop-string lines. Drill 8 small holes through the cardboard at the ends of the 4 stop-string lines, so that you can use a pencil to mark these points on plywood.

b. Use your TEMPLATE to mark around the 2 x 4-in. valve holes in plywood parts: (1) the positions of the ends of each hole's H stop- strings, (2) the right side-edge and the bottom-edge of each flap after it is attached, and (3) the tack-lines.

Fig. 10. Fixed Part of Front End, Unfinished. Only the plywood is shown.



c. Drill a 1/16-in. diameter hole through the plywood at each point marked for an end of a stop-string.

d. With nylon kite string (or other nylon string about 1/16-in. in diameter, such as 50-lb-test nylon fishing line) and a big enough needle, string the "four" stop-strings across each 2 x 4-in. hole. (Use a string long enough to make "four" uncut stop-strings.) Start on the unfinished, back side of the plywood, on the opposite side from the future valve flap. To secure the starting end, wrap the string around a half-driven tack, and then drive it in. Keep pulling the string tight as you thread it through the holes and as you wrap its finishing end around a half-driven tack. Finally epoxy the string in all of the holes, on the back side of the plywood. (An equally strong nylon string can be made by twisting together 4 pieces of waxed nylon dental floss.)
(Stop-strings also can be positioned by using No. 3 upholstery tacks in place of the 1/16-in. diameter holes. Drive a tack partly' in, wind the string around it while pulling the string tight, and drive the tack completely in, to hold the string securely. Finally, coat the tack heads and the adjacent plywood with a smooth covering of adhesive, to provide a smooth seat for the valve flap.)

e. Cut out 6 plastic flaps of transparent 4-mil plastic film (each 3-3/4 x 11-1/2 in.). The easiest way to accurately' cut a flap of thin plastic film is to make a cardboard template 3-3/4 x 11-1/2-in.. place it on the film, and cut around it with a very sharp knife.

f. In preparation for attaching a flap over each pair of 2 x 4-in. valve holes, cover the plywood above each pair of holes with masking tape, up to the straight "tack line" that you already have drawn 1/2 in. above each hole. Use your cardboard TEMPLATE. The masking tape will prevent the adhesive (that will be used to attach each valve flap) from being applied too near the 2 x 4-in. holes, where adhesive would keep a flap from opening fully.

g. Position each of the 6 flaps properly' in its closed position, with its lower edge on the line that you already have used the TEMPLATE to draw 3/4 in. below each flap's pair of 2 x 4-in. holes. Position its right side-edge on the line already drawn 1 in. from the right side of the right hole of each pair of 2 x 4-in. holes. Then put masking tape over the lower edge of each flap and the adjacent plywood, to hold the flap temporarily' in its closed position.

h. Gently fold down the upper part of each flap, so that the plywood above its pair of 2 x 4-in. holes is uncovered (except where you have placed the protective tape), and place small pieces of masking tape so as to hold each flap temporarily in this folded-down position.

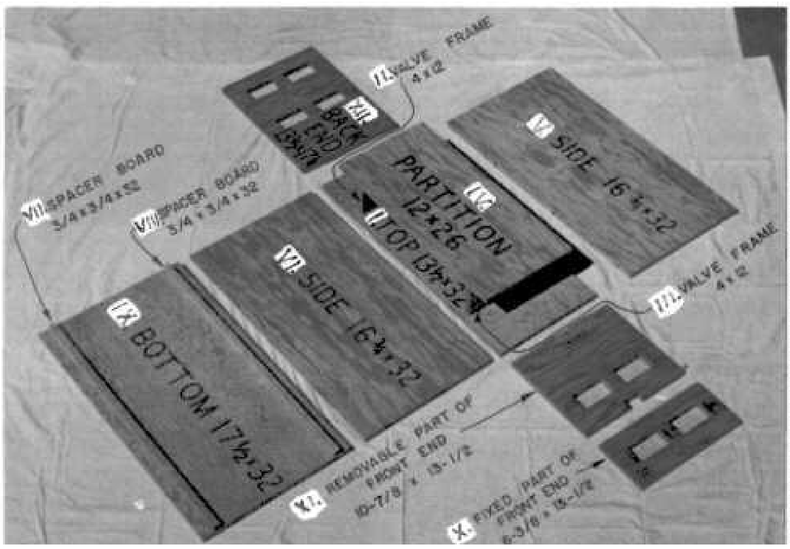
i. Quickly apply a thin coat of all-purpose construction adhesive (such as Liquid Nails) to a 1/2-in.-wide plywood area above the protective masking tape that covers the plywood up to the "tack line" 1/2 in. above each pair of 2 x 4-in. valve holes. Then promptly' detach the small pieces of masking tape holding the flap in its folded-down position, and turn the flap (the lower part of which is still being held in its proper closed position by masking tape) into the whole flap's closed position. Press the upper part firmly' against the approximately 1/2- in.-wide coating of adhesive, to secure the valve in its proper closed position. Allow several hours for the adhesive to harden before removing the tape and using the valve.

j. rive small tacks (No. 3: 3/8 in.) on the "tack line" (see TEMPLATE), to make sure the flap stays securely attached after long use. (Very small tacks are easily driven if held with tweezers or needle-nosed pliers.)

PUTTING THE PUMP "BOX" TOGETHER:

1. The following procedure is the best tested construction method for persons who lack experience in putting parts together so that all corners are exactly square, or who do not have the big clamps and other gluing equipment used by cabinet makers. This procedure is best carried out by two persons working together.
2. On the finished side of the top, draw two parallel lines exactly 12 in. apart and parallel to the top's 32-in.-long edges. Each of these lines will be 3/4-in. from an edge. Also draw a line 6 in. from and parallel to each end of the top, to mark the positions of the two valve frames. See Fig. 2.
3. Build the pump's "box" upside down; start by placing its top on the floor, as indicated by Fig. 12.

Fig. 12. Parts of the Pump "Box", with Dimensions in Inches. The Roman numbers give the best tested order for attaching these parts to each other.



4. Attach the two valve frames II and III to the top I with construction adhesive, positioning each of them 6 in. from an end of the top I. Make sure that each frame's flap valve is upside down and facing away from the center of the pump. Remove any adhesive that is on the top beyond the ends of the valve frames.
   (When using construction adhesive to make this pump, it is best to apply a rather thin coat to only one of the two plywood surfaces to be joined. Then promptly rub one plywood part slightly back and forth against the other, while pressing them together-thus making sure that both surfaces are coated and in close contact. Wait until the adhesive sets and bonds adequately before attaching more parts.)
5. Draw two parallel lines on the unfinished side of the PARTITION, each 3 inches from one of its ends. Adhere the two 12-in.-long unattached edges of the valve frames to the PARTITION on these two lines, as illustrated by Figs. 2, 7 and 12. Allow time for the adhesive to set.
6. Before permanently attaching side V, position it vertically with a long edge resting on the top, and with a side-edge of the PARTITION and ends of the two valve frames I and II in contact with the finished side of side V. See Fig, 7. On the unfinished (outer) side of side V draw lines showing the positions of the PARTITION and of the two valve frames in contact with the finished side of side V.
7. Preparatory to attaching side V to the PARTITION and to the two valve frames, drill 4 slightly oversize screw holes (for your 2-in. roundhead screws(through side V. Drill these holes so that a screw will go into an end of each valve frame about 1 in. from its adhered edge, and the other 2 screws will go into the side-edge of the PARTITION, at points above the valve frames. Next, with side V temporarily in its final position, drill with a smaller diameter drill through the 4 holes in side V, into the PARTITION and into the two valve frames. Then with the 4 screws temporarily connect side V, the PARTITION, and the two valve frames, and, while checking with a carpenter's square the squareness of the angle between the PARTITION and side V, adjust the two pairs of screws to attain squareness, Remove side V,
8. Apply adhesive to the 3/4-in.-wide area along the long edge of the top, and if necessary a thicker coating of adhesive than normal to unattached edges of the PARTITION and of the two valve frames. Then promptly position side V, and by again screwing in and adjusting the 4 screws, make the angle between the PARTITION and side V square. Allow the adhesive to set.
9. Use short pieces of duct tape to temporarily attach the two 12 x 12-in. construction forms to the PARTITION and to side V, (Before using these forms, drive 4 small nails into each form, near its corners, to serve as handles for removing them from the completed "cylinder".) Attach a construction form near each end of the PARTITION.
10. Adhere the finished side of side VI to the top, to the unattached side-edge of the PARTITION, and to end-edges of the valve frames, while keeping side VI pressed against the two square construction forms. To keep side VI pressed against the construction forms until the adhesive sets, use small nails to temporarily nail two small boards horizontally across the ends of the sides, at each end of the "box".
11. On the finished side of the bottom IX, draw two parallel lines 13- 1/2-in. apart, making each line 6-3/4-in. from the center line of the bottom, as shown in Fig, 7, Nail the two 3/4 x 3/4 x 32-in, spacer boards VII and VIII to the bottom, 13-1/2-in. apart.
12. To attach the bottom, first place it (with its finished side down) on the exposed long-edges of the sides, If you find that the bottom rests on the construction forms and is not in contact with the long-edges of the sides, in effect increase the heights of the sides by coating with adhesive both the edges of the sides and the 3/4-in.-wide area of the bottom to which the sides will be adhered, Then adhere the bottom onto the edges of the sides. Before the adhesive hardens, remove any that has been squeezed into the corner of the "cylinder".
13. Permanently attach the fixed part of the front end X (see Fig. 7, 10 and 12) with adhesive and small nails to the sides and to the bottom. Be sure that its flap valve is upside down and is facing away

from the center of the pump, and that a long edge of this part is level with the outer side of the bottom. Remove the construction forms.

14. Paint the interior of the "cylinder" with sealer-after removing all adhesive that may be in its corners.
15. After the sealer dries, sandpaper the interior of the "cylinder" with fine sandpaper, and paint it again with the final coat of sealer.
16. To attach the removable part of the front end XI, stand the "box" on its completely open end and drill slightly oversize screw holes (for your 2-in. screws) clear through the removable part of the front end, as indicated by Fig. 9. With the flap valve facing outward, temporarily attach this part with a few small nails to the end of the top and to ends of the two sides. Then with a smaller-diameter bit, drill the screw holes deep enough into the top and the sides so that the 7 screws will hold securely.
17. So that it will be unnecessary to tightly screw on the removable part of the front end in order to make its repeated temporary attachments airtight, tack felt weather-stripping (best 1/8-in. thick and 5/8-in. wide), or strips made of two thicknesses of flannel, to the contact edges of the top and the sides. No. 3 (3/8-in.) carpet tacks serve well. Then with a razor blade carefully cut the felt covering the screw holes in the edges, and remove these small pieces of covering felt.
18. Attach with screws the removable part of the front end.
19. To prevent damage to the front-end valve flaps when you stand the pump on its front end, epoxy a small piece of 3/8-in. plywood to the front end, near each of its four corners, as pictured in Figs. 3 and 5. Before standing the pump on its front end, use small pieces of masking tape to temporarily secure its valve flaps in their closed positions.
20. Attach the back end XII, using only screws. See Fig. 8. (For repairs, the back end may have to be removed.) To make the attachment of the back end airtight, coat its attachment "crack" only with rubber cement.

MAKING THE PISTON, THE PISTON ROD, AND ITS HANDLE:

1. Have a sheet metal shop cut three 3-ft.-long, 3-in.-wide strips of galvanized steel sheet metal that is no more than 0.016-in., thick and no less than 0.012-in. thick. (Most galvanized steel valley flashing used by roofers and sold by many lumber yards is less than 0.016-in. thick; 30-gauge galvanized sheet metal sold by some sheet metal shops is about 0.015-in. thick.) Steel sheet metal thicker than about 0.016 in. is not springy enough and is unsatisfactory.
2. With a tolerance of + or - 1/32-in., cut from these strips two strips each 11-13/16-in. long, and two strips each 11-3/4-in. long. (These four strips first must be bent and then tacked to the four sides of the plywood piston; these piston-sealing strips serve rather like piston rings, by making close, sliding, low-friction contact with the sides of the plywood "cylinder". Steel strips resist wear and if properly lubricated make the pump serviceable for months of continuous use.)
3. Preparing the four sheet metal sealing strips:
    a. Since the strips to be tacked to the top and the bottom of the piston must be bent differently from the strips to be tacked to its two sides, mark "T or B" on each of he two strips that are 11-13/16 in. long, and mark "8" on each of the two strips that are 11-3/4 in. long.
    b. On each of the two strips marked "T or B", draw an ink line along which to make the approximately 30 degree bend, and another line for the approximately 90 degree bend. (See the left half of Fig. 13 for the distances from the edges of these two "T or B" strips to their bends.) Also draw two ink lines along which to drive tacks, spaced as shown in the left half of Fig. 13. Likewise draw four lines on each of the two strips marked "8", as specified in the right half of Fig. 13, noting that some of these lines are spaced differently than corresponding lines on the strips marked "Tor B"

c. Using a small sharpened nail for a punch and placing one strip of sheet metal at a time on a smooth board, punch 2 rows of tack holes in each strip. The tack holes should be about 1-1/2 in. apart.

d. From a nominal 1 x 2-in. straight board, make two boards each about 3/4 x 7/8 x 12-1/4 in., for use in bending the sealing strips.

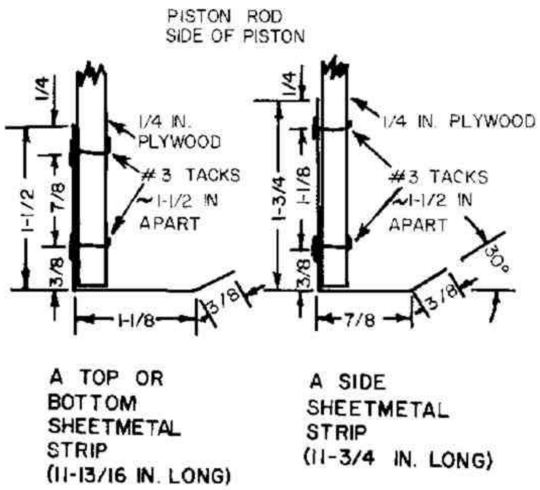
e. Securely sandwich a "T or B" strip of sheet metal between the two 12-1/4-in.-long boards placed exactly on top of each other, by tightening two "C" clamps on the ends of the two boards, so that the bending line 3/8-in, from one side of the strip is just visible along the straight edge of a board. Then hold the two clamped boards in a vise so that the 3/8-in.-wide part of the sheet metal strip is uppermost and vertical.

f. Bend the exposed part of the strip about 30 degrees off the vertical, away from the side of the strip where the holes have been indented by the punch. To bend evenly, hammer gently and repeatedly on a 3/4 x 3/4 x 18-in. board held against the exposed 3/8-in.-wide part of the strip.

g. With the sheet metal strip held sandwiched between the two 12-1/4-in.-long boards by the two "C" clamps and the vise, so that the bending line for the almost 90-degree bend is barely visible, bend the exposed part of the strip 90 degrees, in the same direction that the 3/8-in.-wide part was bent. See Figs. 13 and 14.

h. Bend the other "T or B" strip, and similarly bend each of the two "8" strips.

Fig. 13.Piston Sealing Strips, each made of a springy sheet metal strip 3 in. wide.



4. Attach the four sheet metal sealing strips to the plywood piston with No. 6 tacks (1/2-in. long). Place on a solid metal surface the part of the plywood piston opposite the spot to which part of a strip is being tacked, so that when a tack is hammered in its point is clinched (bent over) on the far side of the 3/8-in.-thick plywood piston, by being hammered against the solid metal surface.

a. First tack a "T or B" sheet metal strip to the top of the piston, and a "T or B" strip to its bottom.

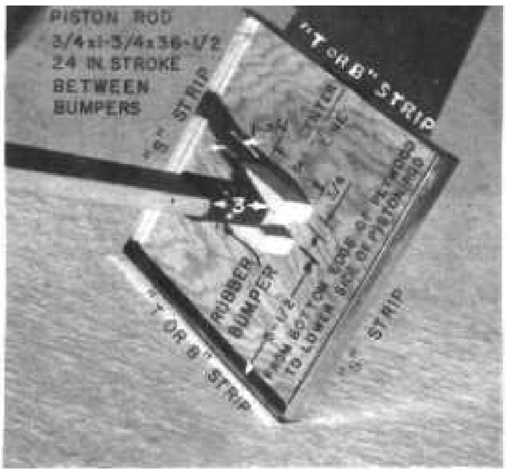


Fig. 14. Plywood Piston with Sheet metal Sealing Strips Attached.

b. Then tack the two "8" strips to its sides. The strips should fit together so as to make square corners. If adjacent ends of two strips do not fit neatly together, cut bit by bit a very little off the end(s) of a strip(s) so that the two adjacent ends fit together neatly at their

c. To prevent air leakage between the ends of the sealing strips, put rubber cement in the four corner "cracks" between strips. (This was not done on the test pump's piston.)

5. For the piston rod, saw from a straight, well-seasoned oak board a 3/4 x 1-3/4 x 36-1/2-in. board. Sandpaper it smooth. (A piston rod made of well-seasoned oak is less likely to break if abused, but necessitates using screws, in place of nails and staples, for attachments. Piston rods made of nominal 1 x 2-in. fir boards were undamaged in the tests.)

6. To complete the piston rod:

a. For the handle, use 4 pieces of a nominal 1 x 2-in. board cut to the lengths shown in Fig. 15. Also see Fig. 16. Round all edges and corners, to minimize the chances of the operators' blistering their hands.

b. Paint the piston rod and its handle with sealer. When dry, sandpaper. Then apply a final coat of sealer.

c. Use adhesive, screws, and nails (or adhesive and nails if your piston rod is of soft wood) in making the handle illustrated by Fig. 15

Fig. 16. The Pump Handle of the Durability-Test Pump, showing how one man best holds it when two men are pumping.

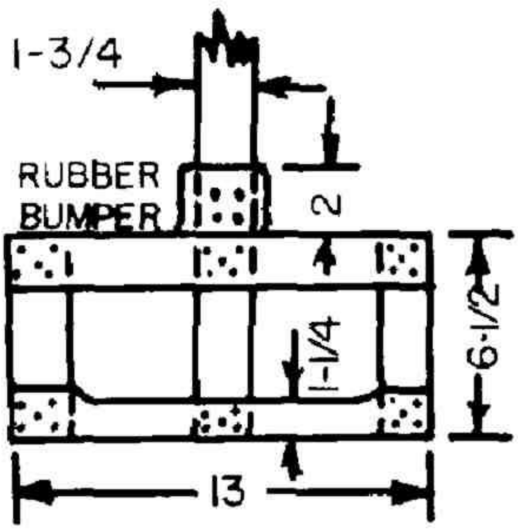


Fig. 15. Piston Rod Handle Made of 3/4 x 1-3/4-inch boards.

d. To reduce friction on the piston rod and resultant enlargement of the piston-rod hole with long use, coat with epoxy all four sides of the piston-rod hole. See Figs. 7 and 16. Be sure that the piston rod slides snugly yet freely in its hole when the removable part of the front end is screwed in place.

e. From a piece of thick truck-tire inner-tube rubber, cut a 2-in.- wide strip 12-in. long. To make the 2-in.-wide rubber bumper (see Figs. 15 and 16), connect one end of this rubber strip to the center of a 3/4-in.-wide side of the piston rod. Do not place any screw or staple in the strip closer than 1 in. from the strip's forward edge, that may repeatedly bump into the front end. Wrap and attach the strip quite tightly around the piston rod next to the handle. (If you have only a piece of passenger-car inner-tube rubber, then to make a 2-in.-wide bumper use a 4-in.-wide strip of this thinner rubber folded double lengthwise.)

7. Attaching the piston rod to the piston:

a. On the back of the 12 x 12-in. plywood piston, mark lines to enable you to attach the piston rod as pictured in Fig. 14. Note that the lower side of the piston rod is exactly 5-1/2 in. above the lower edge of the plywood of the piston, and that the center line of the piston rod intersects the vertical center line of the plywood of the piston.

b. To the end of the piston rod (see Fig. 14) adhere and screw (or adhere and nail if your piston rod is not oak) two pieces of nominal 1 x 2-in. boards each 3 in. long. Each of these two small boards and the end of the piston rod are in contact with and securely connected to the plywood piston, and form a perfect "T" at the end of the piston rod.

c. Connect the piston rod to the piston, best with epoxy (or adhesive) and small screws. Make sure that: (1) the four piston sealing strips overlap the piston's plywood in the direction of the piston rod, (2) the 1-3/4-in.-wide sides of the piston rod are parallel to the top and bottom of the piston, and (3) the piston rod is perpendicular to the piston. See Figs. 2 and 14.

d. Make and attach to the piston rod a 3-in.-long rubber bumper, positioned close to the piston as shown in Fig. 2.

OPERATING THE PUMP:

1. Check to see that the four sheet metal strips on the four sides of the piston all make even contact with the walls of the "cylinder" when the piston is moved back and forth. If the piston does not slide back and forth quite easily even when not lubricated, carefully bend a strip or strips so that they press less against the "cylinder" walls. If while someone is shining a flashlight through a valve opening in the other end of the pump you observe that parts of a sheet metal strip do not make close contact with a "cylinder" wall, gently bend outward that part of the strip.

2. Lubricate all four walls of the "cylinder", the sheet metal strips that slide against the walls, and the piston rod. Use a very thin motor-breaking white lithium grease (not an ordinary bearing grease, that is too sticky). Or use a thin oil. The pump should be lubricated after no more than each 24 hours of use, and before being used again after days of disuse.

3. Install the pump at a height above the floor so that most of the persons who are going to pump can push and pull with their hands moving at about the same height that their elbows are when they are standing. See Fig. 3for an example of a pump-supporting table raised to an efficient height for operators who are the height of the pumper pictured.

4. To save work and to minimize wear on the pump, usually operate it with a length of stroke a little shorter than the distance between its two rubber bumpers. To save energy especially when pumping air through a high resistance ventilation system, move the piston back and forth by using mostly your leg and body muscles.

PROLONGED STORAGE:

Wipe off all grease and other lubricants if you do not plan to use this pump for months. All lubricants-especially those on wood-tend to become gummy with time. Keep your supply of pump lubricants taped to your pump.

REQUEST:

Suggestions for improving this pump and/or these instructions will be appreciated, and may contribute to improvements likely to save lives.

Cresson H. Kearny

FILTER BOX AND FILTER

PURPOSES:

The primary shelter ventilation requirement is to supply enough outdoor air to maintain endurable heat-humidity conditions.

To keep the concentration of respiratory carbon dioxide low enough for survival, very little fresh outdoor air is required. Even for an infant or an infirm person remaining in a crowded shelter for days, 3 cubic feet per minute (3 cfm) is adequate. For a healthy adult or child 1.5 cfm is enough. Too much carbon dioxide, not too little oxygen, is the initial cause of unendurable conditions in inadequately ventilated shelters in which the air does not get unendurably hot.

In contrast, up to 25 cfm of outdoor air per occupant may be needed to maintain endurable heat-humidity conditions inside a crowded shelter occupied for days during a heat wave in a hot, humid part of the U.S. Hence the need for a large-volume ventilating pump, best with a low-resistance filter.

If outdoor air flows into a shelter through a hood, gooseneck pipe, or other air-supply opening that causes all but tiny fallout particles to fall out before the air reaches shelter occupants, breathing this unfiltered air will not result in short-term radiation casualties. However, a very small fraction of the occupants of a shelter supplied with unfiltered air in an area of heavy fallout may contract cancer years later as a result of breathing shelter air containing tiny fallout particles, which a properly designed filter could have removed. Air that has been in contact with fallout particles before being filtered is not radioactive,

The homemade filter illustrated below, if used with an efficient "suction" pump such as the Plywood Double-Action Piston Pump described separately, will remove practically all fallout particles likely to cause casualties even decades later, This filter also will remove most infective aerosols, the air-borne tiny particles used in biological warfare - an unlikely type of attack on the United States. It will not remove poisonous gasses, an even less likely danger to Americans if all-out war befalls us.

CONSTRUCTION:

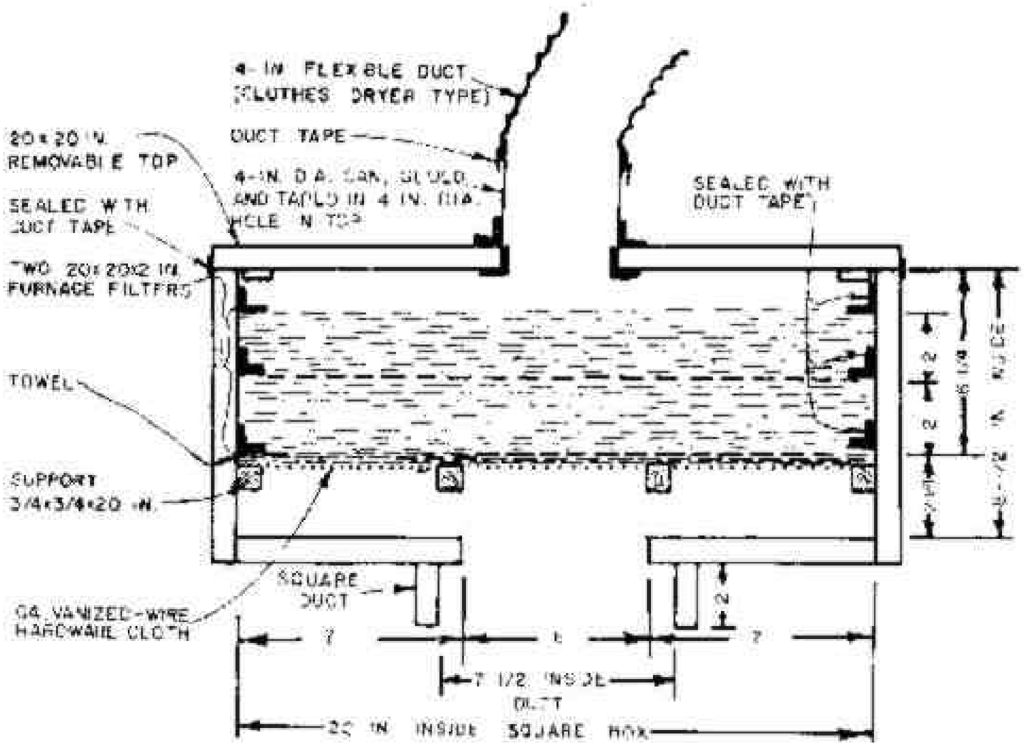
Filter Box:

If 20 x 20-inch furnace filters are available, use plywood or boards to build the filter box shown in the illustration. To make permanent connections airtight, first use waterproof construction adhesive or glue, and then tape. (If only smaller filters are available, reduce the horizontal dimensions of the box accordingly, except for the top and bottom openings.) Check to be sure that your filters will fit snugly in the box of the size you plan to build.

The square frame on the bottom of the filter box should fit snugly over the square air-intake duct on the top of your Plywood Double-Action Piston Pump. Tape the cracks to make the connection airtight and to permit easy removal of the filter box.

Make the illustrated 4 supports of the hardware cloth no thicker than 3/4 inch, thus providing enough space below the filter for low- resistance airflow. (Hardware cloth is a stiff, square-mesh, molten- dipped galvanized wire.)

(Figure p.270) Homemade Filter To Fit On Plywood Double-Action Piston Pump, and To Be Connected to a 4-Inch-Diameter Air-Intake Pipe.



Make the square top of the filter box so that it covers the upper edges of the box's sides and can be easily removed. Then cut in its center a round hole slightly smaller than 4 inches in diameter. File the hole's edges so that a 4-inch-diameter can (such as a coffee can with its top and bottom cut out) fits snugly in this hole. To connect the can securely and airtight, first use waterproof construction adhesive or epoxy, and then tape. (If construction adhesive or epoxy is not available, cut a 2-1/2-inch-diameter hole in the center of the bottom of the 4-inch-diameter can. Then make radial cuts spaced about one-half inch apart, out to the full diameter of the can. Bend these tabs outward 180 degrees, preparatory to tacking them with small tacks to the bottom of the filter box top. Tape airtight.)

So that the top of the filter box can be easily removed, tape it onto its box. A roll of duct tape should be kept with the filter box and pump at all times.

To connect the filter box to the shelter's air-intake pipe, the best widely available air duct is the inexpensive, 4-inch-diameter flexible duct used with clothes dryers.

Filter Materials:

Furnace or air-conditioner dust filters, those made of oiled fiberglass fibers, will remove practically all but the very smallest fallout particles. Filters that are sold in box-like housings can easily be installed so that all the pumped air will pass through them, by taping them to the inner sides of the filter box. The illustration shows two plain mats of furnace filter material, each taped around its edges. (If commercial dust filters are not available, bath towel cloth will serve. However, in very dusty areas a cloth filter may become overloaded, thus seriously reducing the rate of airflow much sooner than if an oiled fiber filter is used as a pre-filter.)

To filter out most of the tiny particles that may pass through one or more furnace filters, place two thicknesses of bath towel on top of the filter-support made of hardware cloth, and tape them around their edges to the box. See illustration.

Tests by U.S. Army specialists have shown that filtering air through two thicknesses of bath towel removes about 85 percent of even microscopic aerosols as small as 1 to 5 microns in diameter. (See "Emergency Respiratory Protection Against Radiological and Biological Aerosols", by II. G. Guyton et al., A.M.A. Archives of Industrial Health, Vol. 20, July through Dec. 1959.) This is the size of most infective aerosols used in biological warfare. In most of an area subjected to a biological attack, if 85 percent of this size-range of infective aerosols and practically all larger particles are removed, then most persons breathing this filtered air will not receive enough infective agents to infect and sicken them.

Persons who are especially desirous of protecting their shelter's occupants against biological warfare aerosols, but who can not afford or obtain expensive High Efficiency Particulate Air filters (HE PA filters), should consider using disposable pleated air filters that meet official ASHRAE standards. One 2-in. pleated air filter, measuring 19-1/2 x 19-1/2 in., will remove over 90 percent of particles in the 1.0-5.0 micron range, yet when clean its resistance to an airflow of 200 cfm is only about 0.2 in. water gauge (about 0.007 psi). Its cost is about twice that of a good ordinary furnace filter of the same size. However, it has approximately three times the life of a standard panel type filter before becoming overloaded. Disposable pleated air filters are available in larger cities.

USE:

The illustrated homemade filter has such low resistance to airflow that, when up to about 200 cfm is being pumped through it by a Plywood Double-Action Piston Pump, the air volume is decreased by only about 10 percent, as compared to the volume pumped with no filter in the ventilation system. With a homemade Plywood Double- Action Piston Pump, up to approximately 200 cfm can be pumped through this filter even when the total difference in air pressure (caused by the ventilation pipes, a dirty filter, etc. that restrict airflow) is high, about 5 inches water gauge (0.18 psi).

Even if the United States suffers an all-out Soviet attack, only a small part of its area will be subjected to blast effects severe enough to injure the occupants of fallout shelters. (Fallout shelters are not designed to withstand blast, but especially typical earth-covered ones afford consequential blast protection.) In contrast, an installed filter, unless protected by an efficient blast valve, will be wrecked by a quite low-pressure blast wave that comes down its open air-intake pipe -even if the small part of the blast wave that would enter the shelter room through its open ventilation pipes is not nearly powerful enough to injure the shelter occupants. Thus unprotected installed filters will be wrecked in an area several times as large as the area in which occupants of fallout shelters will be injured by blast.

To be sure of having a filter in good condition, you can:

1. Make and keep in your shelter an extra complete filter, ready to replace your installed filter if it is damaged, or if it becomes overloaded with dust and its resistance to airflow becomes too high. Furthermore, if your filter is installed in your shelter room and becomes so radioactive with retained fallout particles that it is delivering a consequential radiation dose to shelter occupants, it is advantageous to be able to remove it, pitch it out, and install a replacement filter. (To be able to supply your shelter with unfiltered air in peacetime or after the end of consequential fallout danger,

you should make and keep ready a duct with appropriate fittings to connect your pump directly to its air-intake pipe.)

2. If you have only one filter, do not install it before you need to filter the air supply. Connect your pump directly to the air-intake pipe, using an appropriate duct and fittings. Then before the attack and before the arrival of fallout (revealed by your fallout-monitoring instrument), keep your shelter well ventilated with unfiltered air. Whether or not your filter is installed, stop ventilating your shelter for a few hours while heavy fallout is being deposited outside - unless heat-humidity conditions become unbearable. If before shelter ventilation is stopped the shelter air does not contain an abnormally high concentration of carbon dioxide, then no outdoor air need be supplied for about 5 hours to prevent building up too high a concentration of respiratory carbon dioxide - provided there is about 70 cubic feet of shelter-room volume for each occupant.

AN ENCOURAGING REMINDER:

Persons making preparations to improve their chances of surviving an all-out attack should realize that if the United States is hit with warheads the sizes of those in the 1987 Soviet intercontinental arsenal, the fallout particles of critical concern will be much larger than the extremely small particles (1 to 5 microns in diameter) which are not completely removed by this filter. Fallout particles this small produced by large nuclear explosions do not fall to the ground for many days to months after the nuclear explosions, by which time they have become much less radioactive. Essentially all of the larger particles can be removed merely by filtering the air through a few thicknesses of bath towel cloth.

Appendix F: Providing Improved Ventilation and Light

THE NEED:

This is the means for providing improved natural ventilation and daylight to a shelter with an emergency exit. Survivors in areas of heavy fallout can greatly reduce the radiation doses that they will receive, and thus decrease their risks of contracting cancer, if they sleep and spend many of their non-outdoor-working hours inside good shelters during the first several months after an attack. (See Minimizing Excess Radiogenic Cancer Deaths After a Nuclear Attack, by Kathy S. Gant and Conrad V. Chester, Health Physics, September 1981.)

A permanent family shelter can serve quite well for months as a post-attack temporary home if it is designed to provide adequate natural ventilation most of the time, to have adequate and easy forced ventilation by a KAP when forced ventilation is needed, and to have daylight illumination, A shelter dependent on ventilation laboriously pumped through pipes and on artificial lights even during daytime is much less practical for use as a post-attack home.

The following instructions should enable a family having an earth-covered shelter with an emergency exit to make it much more livable for months-long occupancy. The means described below for providing improved ventilation and daylight illumination also will supply guidance to survivors who will build shelters post-attack to minimize continuing radiation exposures, especially to children and pregnant women,

BUILDING AND USING A MULTI-PURPOSE EMERGENCY EXIT HOUSING:

Build a multi-use emergency exit housing of the design pictured in Fig. F,1 and detailed in Fig. F.2, Size your exit housing to fit snugly over the top of your completed vertical exit shaft. This exit housing is made of 3/4-inch exterior plywood, four 2 x 2 x 36-inch boards, and four 16 x 16-inch window panes of 1/8-inch Plexiglas. Plated screws and waterproof adhesives are used to assure sturdiness and durability.

Fig. F.1, Multi-Use Emergency Exit Housing Installed Over the Square Emergency Exit Described by Figs. 17,1, 17.2, and 17.3. (Photograph)

The adjustable top of this exit housing measures 4 x 4 x 1 feet, and can be tilted to make different sized ventilation openings in any of four directions. The top also can be raised straight up to make various sized openings all the way around, or it can be completely closed - as explained by Fig. F.2 and the following descriptions of its uses.

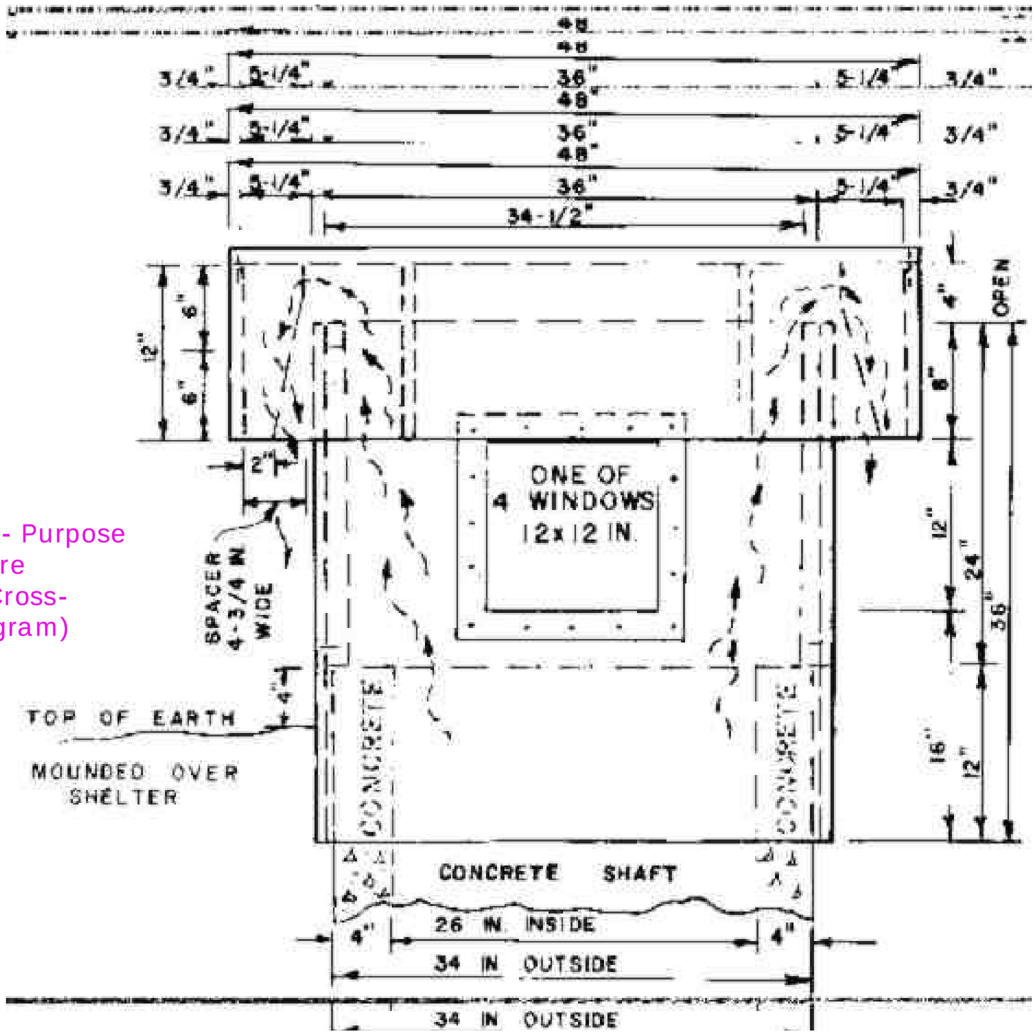


Fig. F.2. Plan and Side View of Multi- Purpose Emergency Exit Housing, on a Square Emergency Exit with 34 x 34-Inch Cross-Sectional Outside Dimensions. (Diagram)

Fig. F.3. The Top and Four Walls of the Multi-Purpose Emergency Exit Housing, Nested Together to Save Storage Space. (Photograph)

In Figs. F.2 and F.3, note the eight beveled plywood guides, two on the inside of each side of the top. These guides are needed so that the top can be tilted in the position desired, merely by using a stick to raise it from below. To hold the top in a tilted or raised position, spacer boards are placed between the raised top and the upper edges of a wall or walls, as illustrated by Fig. F.4.

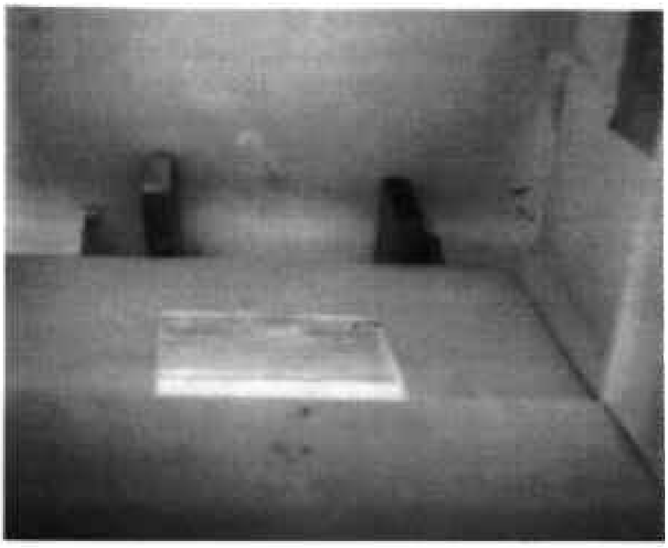


Fig. F.4. View from Below the Exit, Looking Up the Multi-Purpose Emergency Exit Housing. The top is shown supported in a tilted position by two 6-inch-wide boards placed between a wall and the top. (Photograph)

The illustrated housing over a vertical exit provides:

- o A means to regulate shelter ventilation, and to increase natural ventilation when the wind is blowing. If, for example, the shelter's opened exit is to the north of its opened entry and a north wind is blowing, shelter airflow will blow in through the exit and out through the entry. This natural ventilating airflow, often inadequate, is increased if the adjustable top of the exit housing is not simply raised 6 inches on all four sides, but is tilted as shown in Fig. F.1, with its south side closed and its north side tilted up 6 inches to provide a 6 x 26-inch ventilation opening between the upper edge of the entry housing's north wall and its top. Then a north wind striking the north wall produces increased air pressure over and above this wall, forcing more air into the exit and on through the shelter. In contrast, if a south wind is blowing, natural airflow will go in through the shelter's entry and out through its exit. And if the adjustable top still is tilted open to the north as illustrated, then reduced air pressure over and above the downwind north wall will "suck" an increased airflow out of the exit and through the shelter.
- o The measured increases in airflows through a small shelter resulting from the top of this exit housing being tilted were only 40-50 cfm when an 8-10 mph breeze was blowing. These rather small increases in airflow, however, often would make it unnecessary to supply forced ventilation to a family shelter by intermittently operating a KAP.
- o Exclusion of rain, snow, and larger dust and fallout particles. The four 12 x 48-inch vertical sides of the adjustable top overhang the exit housing's walls by 6 to 12 inches. Thus the top serves as a large ventilation hood over the exit, preventing rain, snow, and larger dust and fallout particles from entering while ventilation is continuing. (To prevent entry of flies and mosquitoes, an insect screen panel, made to fit over the bottom of the emergency exit, should be kept stored in the shelter until needed. A screen door for the inner entry doorway also should be stored. Remember that installing screens greatly reduces natural ventilation airflows.)
- o A reliable source of daylight. The four 12 x 12-inch' windows of this exit housing let enough daylight into the exit shaft, that is painted white, to permit a person on the shelter floor below to read, even for several minutes after sunset. See Fig. F.4.
- o A way to observe what is going on all around the shelter, without having to go outside, and with lessened exposure to fallout radiation.

- o Quick installation post-attack, after fallout decays sufficiently. In an installation test, dirt was dug away to expose the upper 12 inches of the emergency exit shaft. Then in just 8 minutes the author and a boy carried the 5 parts of this exit housing 80 feet, positioned its four walls around the already exposed upper 12 inches of the reinforced concrete emergency exit, nailed its walls together, and placed its adjustable top in the tilted position pictured in Fig. F.1.

BUILDING AND USING AN ENTRYWAY COVER THAT PROVIDES A LARGE, PROTECTED VENTILATION OPENING:

Build a shelter entryway cover that keeps out rain, snow, and the bigger dust and fallout particles while providing a large, protected ventilation opening both for natural ventilation and for easy forced ventilation by a KAP when needed.

For an example of one type of entryway cover, see Fig. F.5. This photo shows a 4-piece cover, that two men in a little less than 5 minutes carried out o
above the shelter's opened stairway doors.

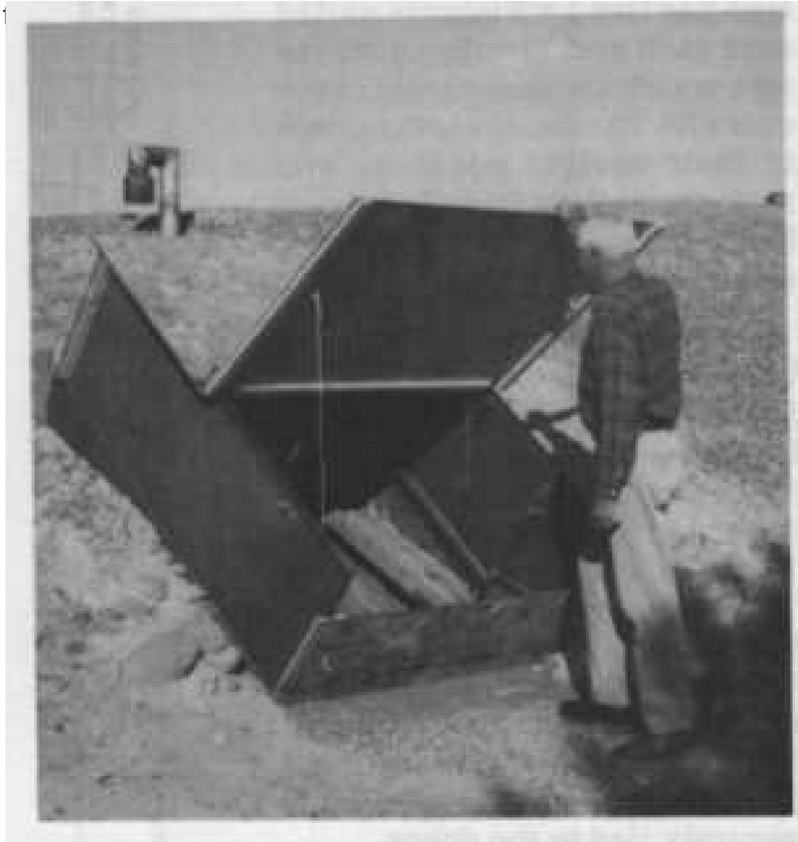


Fig. F.5. A Quickly Installable, 4-Piece Entryway Cover That Provides Easy Access and a Large, Protected Ventilation Opening.

This cover is made of 4 pieces of 1/4-inch chipboard, each 5 feet wide, and short lengths of nailed-on 1 x 2-inch boards. These 4 pieces can be tied quickly with their attached nylon cords to inner parts of the two 2 x 6-foot steel entryway doors, which are pictured in their opened, upright positions.

The lowermost of the 4 chipboard pieces has a groove near each end. The grooves are each made of 2 nailed-on lengths of 1 x 2 lumber spaced apart to fit the lower ends of the doors and hold them in their upright positions 4 feet apart. The upper edge of this lowermost piece is 8 inches below the lower raised corners of the doors, so that an 8 x 48-inch ventilation opening is assured when the lower of the two large covering pieces (pictured being held open) rests on the doors. (This step-over piece of chipboard illustrates a way to reduce the quantity of larger fallout particles that will be blown into many types of shelters, because most sand-like particles and coarse dust are blown along close to the ground. They are not blown upward and over a vertical obstruction by most winds. If an entryway has an inner, ordinary doorway, even more fallout particles can be kept out of the shelter room if an 18 x 18-inch ventilation hole is cut in the door near its top.

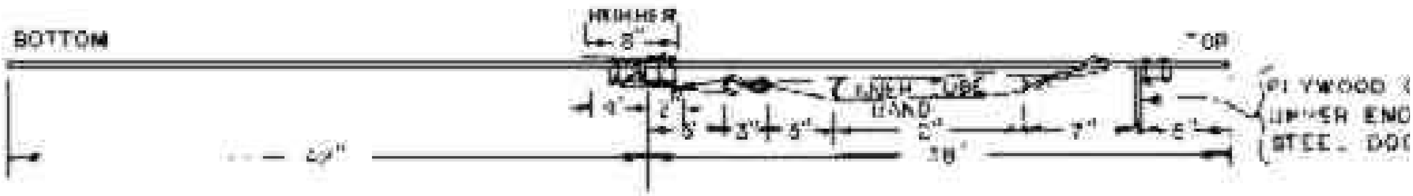
Then air entering the shelter room will have to rise at least 4 feet above the entryway floor, and most of the larger fallout particles will be deposited on the entryway floor.)

The chipboard piece attached to the upper ends of the doors also has two 1 x 2 boards nailed near each end, forming grooves into which the upper ends of the doors fit. The doors are thus held in their upright positions and rain, etc. is kept from falling or being blown through the upper end into the entryway.

The uppermost of the two large covering pieces of chipboard (or exterior plywood) rests on the opened doors and is kept from slipping down by a 1 x 2-inch board nailed 4 inches from its upper end. This small board "hooks" over the upper edge of the piece of chipboard (or plywood) attached to the upper ends of the steel doors. (See the drawing on the side of this column.) This large piece of chipboard is securely tied to the doors.

To keep the two large pieces from moving sideways, one 1 x 2-inch board is nailed near each of their side edges, spaced so as to lie against the outside of each opened, upright steel door. To strengthen the hinge-line edge of the upper large covering piece, a ix 2-inch board is nailed along its lower edge.

Fig. Pg. 276.



The lower of the two large covering pieces also has a reinforcing 1 x 2 nailed near its hinged edge.

The most practical hinge that the author has devised is illustrated by the drawing. This flexible hinge is much less likely to be broken than are conventional hinges, and makes it easier to build the two large covering pieces to fit over the opened doors. Note that the upper edge of the lower large piece goes under the rain-proofing, 6-inch-wide rubber flap, which is nailed only along the lower edge of the upper large covering piece. Then the two large pieces are held and hinged together by first stretching each of 2 strong, 2-inch-wide rubber bands (or rustproof springs) attached by cords to the upper large covering piece, and then hooking its attached bent-wire hook onto a nylon cord loop connected to the lower large covering piece. Each strong rubber band (cut from a truck inner-tube) and its attached hook and nylon cords is 5 inches from an opened door. Thus hinged, the lower large piece can be easily raised to permit a person to step out of or into the stairway entry. When this hinged lower large piece is closed and tied down, a 2.7 square foot protected ventilation opening with a 10- -inch overhang results.

OTHER ENTRYWAY COVERS TO PROVIDE LARGE PROTECTED OPENINGS FOR NATURAL AND KAP VENTILATION:

The owner of a permanent shelter with an emergency exit may be able to improvise coverings over its entry and exit after fallout decays sufficiently to permit work outdoors - provided that he understands natural ventilation and low-pressure forced ventilation requirements, and has the boards, nails, pieces of chipboard or plywood or canvas, tools, etc. needed. But if you own a permanent shelter your pre-crisis preparations surely should include making and storing ready-to-install entryway and exit coverings of whatever designs you decide will best meet your anticipated needs for high-protection factor sleeping and living quarters during weeks or months following a nuclear attack.

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Selected Index

Definitions and explanations of terms are given on the listed pages. Because some terms are mentioned on up to 55 different pages, all pages on which some terms are listed are not included.

For broad categories of information, see the Contents page.

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First Aid Kit Checklist

The Caveats:

This List is Generalized for Remote Extended Outing Activities Specialize Further by Season, Location, and Activity Type
These items represent a mix of typical treatment aids based upon camping experience as well as treatment practicality. If starting fresh, it is usually more economical to purchase a "comprehensive kit" and add to it rather than build from scratch.

Some listed items may be availed via physician prescription only, if necessary discuss your plan and needs with your troop, group, family, or familiar physician.

Designate:

- [ ] Medical Treatment Person (usually most qualified)
- [ ] First Aid Kit Known & Identifiable to ALL
- [ ] First Aid Kit Location Known (in camp and on the move)
- [ ] Keep Inventory List (this page) in First Aid Kits

Medical Information Booklet:

- [ ] First Aid
- [ ] Emergency Wilderness Medicine
- [ ] Mental Status Test, Grading, & Procedures Sheet (Sports / Head Injury Type)

Medical Tools or Equipment:

- [ ] Note: Scalpels Carried ONLY by Certified Professionals, Scalpels are NOT normally carried in First Aid Kits, especially NOT for Scouts!
- [ ] Medical Case to Hold All of Medical Care Contents, Soft Side Is More Flexible, Clear Sides May Locate Contents Faster, Water Proof Containers Can Be Hard or Soft Sided, User Judgment.
- [ ] Resuscitation Mask / CPR Shield
- [ ] Splint Material (SAM, a soft padded aluminum splint material that can be trimmed with scissors, 36"x4" Is Best, Read Instructions, Comes Folded Small – in a pinch: fire shield, duct tape, alum foil, sticks)
- [ ] Lighter / Water Proof Matches & Striker
- [ ] Bite / Sting Suction, Extractor Device
- [ ] Tweezers, Pointed (removal of fine slivers, glass, dirt, ...)
- [ ] Tweezers / Pullers (ticks and larger items / shards)
- [ ] Thermometer (external)
- [ ] Medical Scissors & Good Medium Size Scissors
- [ ] Duct Tape (10 to 15 Feet, Either spool space is used for storage OR collapsed OR re-wrapped on small pencil sized spool)
- [ ] Gloves, Latex (Many / Box)
- [ ] Safety Pins and Straight Pins
- [ ] Paper, Note Pad / Book, Pen, Pencil & Eraser
- [ ] Infectious Waste Bag (Red, Marked or Sticker, Tie / Tape / Seal)
- [ ] Tiny or Mid Sized Flashlight, working with spare batteries
- [ ] Magnifying Glass

[ ] Tongue Depressor (used as applicator / small splint stick)

[ ] Curved / Straight Locking Jaw Forceps (scissor like clamp)

[ ] Gallon Size Plastic Zip Lock Bags (universally useful)

Wound Care:

[ ] Irrigation Syringe or Plastic Squeeze Wash Bottle with Spray Tube / Top

[ ] Medical Wash for Above Application System (Betadine)

[ ] Scrub Brush

[ ] Antibiotic Ointment

[ ] Disposable Sanitary Wipes

[ ] Moleskin & Molefoam

[ ] Ace Wraps (4" & 3" with Clips)

[ ] Dressing / Gauze, Non Stick, Non Scabbing

[ ] Gauzes: Assorted Pads and Sizes (Self Stick and Non-Scabbing, 1.5"x2" to 4"x4" (mix as desired /available)

[ ] Bandage Strips (small, medium, large)

[ ] Bandage Squares (small, medium, large) & Some Round

[ ] 2" Sterile Dressings

[ ] 2"x4" to 4"x4" Dressing Sponges

[ ] 4" Compress Bandage

[ ] Trauma Pads, approximately 10"x10" and 10"x5"

[ ] Cravats, Large

[ ] Eye Pad / Patch

[ ] Adhesive Tape, Reel, 1" wide, Plastic

[ ] Adhesive Tape, Reel, 1" wide, Surgical

[ ] Butterfly Bandages

[ ] Knuckle Bandages

[ ] Cotton Applicators / Swabs (Regular & Long)

[ ] Cold Packs

Medication & Treatments:

[ ] Aspirin

[ ] Tylenol (Acetaminophen)

[ ] Motrin or Advil (Ibuprofen)

[ ] Liquid Soap (Still the #1 Bacteria Killer)

[ ] Solarcaine (Gel or Lotion)

[ ] Phenergan (Suppository)

[ ] Lopermide (Anti-Diarrheal)

[ ] Hydrocortisone Cream

[ ] Vaseline (Petroleum Jelly)

[ ] Visine

[ ] Moisturizing Lotion (Eucerine, really good stuff)

[ ] Antihistamine

[ ] Mylanta / Maalox (Anti-Acid)

[ ] Lotromin AF / Tinactin (Anti Fungus Cream)

[ ] Sun Screen, Heavy Duty (Note: Waxy exterior of Aspen tree equals about SPF-8, hand rub tree then exposed skin)

[ ] Chap Stick with Sun Block

[ ] Sting / Itch Relief, Calamine

[ ] Feminine Hygiene: Pads, Tampons

[ ] Benadryl

[ ] H_2O_2 / Hydrogen Peroxide

[ ]

[ ]

OPTIONS, Created or Purchased (user judgment/location/season):

[ ] Dental Emergency Kit

[ ] Bicycling "Road Rash" First Aid Kit

[ ] Boating First Aid Kit

[ ] Tick Removal Kit

[ ] Bee Sting Kit

[ ] Allergy Response Kit, Atropine Injector

[ ] Snake Bite Kit (Note: Most Specialists think it improper to X-cut in the U.S. IF within 24 hours of medical treatment)

[ ] Communication Device

[ ] Gatorade Powder (electrolyte replenishment and re-hydration)

[ ]

[ ]

This manuscript is the first in a series that we want to create for our group, and we are looking for input from the members of the AZ Survivalism Meet-Up Group in order to complete this set of volumes. We would like this document to be the beginnings of what we hope to be a pretty complete Survival Reference Library. The goal of these documents is to provide a comprehensive approach to the subject of surviving a catastrophic event, no matter what it is. We hope to have these manuscripts include a wide variety of possibilities. Since this is one concerns the concept of nuclear threat, we would like to add various other categories, such as; Chemical, Biological, Economic Collapse, Government Abuse, Food Shortages, Drought Strategies, Petro-Resource Interruptions, Asteroid Impact, etc. We are not looking for a surface study, but rather, an in-depth treatise concerning the subject matter. We would like to see at least several different sources combined per subject in order to merge that info into a comprehensive study on the subject in question.

What we would like to find volunteers from among the members of the group to contribute to this tome by picking a topic and creating their own manual from existing material on the web, or any other place that it can be found. The web is the easiest place to farm for material, because it is already in an electronic format, and most easily melded together. Please feel free to contact us in reference to any questions that you might have concerning the Project.

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This is a possible list of necessary skill-sets needed to adequately maintain a viable community after surviving a catastrophic event. We are looking for additional input from the group as to others. Keep in mind that there may a whole lot more that we didn't

I. Medical:
1. Doctor: General Practitioner – Acting pharmacist, OBY, GYN, Surgeon, dentist, etc.
2. Nurse: Registered – Maybe has some background in anesthesiology, ER, etc.
3. EMT or Medic: Both are trained in triage cases, and a medic w/ acute trauma, battlefield medicine, etc.
4. Medical Records Clerk: Keeps the entire medical team organized (could double as Nurse), etc.
5. Veterinarian: Generalist – Pets, farm animals, wild animals, disease, etc.

II. Mechanical:
1. Mechanic (Vehicle): Both gas and diesel background preferred; helpful if can do vehicle electrics, etc.
2. HVAC/Plumber: Heat, air, water, and sewage are very essential things, etc.
3. Electrician: Exp in AC & DC Power w/ low voltage, as well as high voltage, wiring, insulation, etc.
4. Machinist: Drilling, milling, lathe, fabrication, bender, etc.
5. Carpenter: Construction generalist
6. Mason: Block, footers, and foundation; concrete
7. Welder/Fabricator: Foundry, welding, blacksmithing

III. Agricultural:
1. Farmer: Generalist – Grains, vegetables, soils, crop rotation, fertilization, etc.
2. Rancher: Generalist - animal husbandry/breeding, care & feeding of various breeds farm animals

IV. Security:
1. Officer: Military (high as we can get) – Tactics, strategy, planning, logistics, etc.
2. Officer: Military – Second in command – Tactics, strategy, planning, logistics, etc.
3. Pilot/Mechanic: Obvious
4. Technician: Electronic security installation, design, repair, CCTV, DVR, exterior beam, etc.
5. Gunsmith: Repair of firearms, reloading, armory, etc.
6. Fireman: Fire prevention, fire-fighting, supplies, equipment maintenance, etc.

V. Educational:
1. Teacher: Generalist
2. Librarian: Not only computer-savvy, but also can do manual card access, etc.
3. Spiritual Leader(s): Non-denominational, Pastor, Rabbi, Other, etc.
4. Physical: Exercise – Conditioning, well-being, trainer, sports injuries, etc.
5. PR/Communications: Community Newsletter, announcements, other settlements, negotiator, etc.

VI. Technological:

1. Engineer: Structural – Concrete, Wood, Earth, & Steel
2. Engineer: Electrical – Design, build, & Repair generators, solar, & wind, etc.
3. Engineer: Hydro – Water, hydroponics, irrigation, water quality, etc.
4. Computer: Network generalist, hardware repair background
5. Communications: Radio, cellular, electronics, etc.

VII. Scientific:

1. Biologist: Generalist
2. Botanist: Generalist
3. Chemist: Generalist
4. Meteorologist: Weather detection, prediction, weather station on site and off site, etc.

VIII. Domestic:

1. Seamstress/Tailor: Clothing – Weaving, loom, knitting, machine operation, cotton, wool, dying, etc.
2. Tanner/Cobbler: Leather clothing, shoes, and other articles
3. Hunter/Gatherer: Procures various wild meats, wild fruits & vegetables, mushrooms, greens, etc.
4. Cook/Nutritionist - Nutritional welfare of the group, prep, cook, kitchen, etc.
5. Janitorial: Maintenance of common areas inside and outside, cleaning supplies, etc.

The above categories designate 39 Individual with different skill-sets as essential; however, it is possible that there would be a lot of cross-over with some individuals having multiple skill-sets. I think that the tendency would be to try and eliminate, or cut back on the number of people in the settlement, but I think that would be a mistake. If we have multiple people with the same skill-sets then we have redundancy, which is the best scenario. In the event of death or disablement, that skill would continue on.