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VENTILATION

From 1999 edition of Nuclear War Survival Skills

CRITICAL IMPORTANCE

If high-protection-factor shelters or most other shelters that lack adequate forced ventilation were fully occupied for several days in warm or hot weather, they would become so hot and humid that the occupants would collapse from the heat if they were to remain inside. It is important to understand that the heat and water vapor given off by the bodies of people in a crowded, long-occupied shelter could be deadly if fallout prevents leaving the shelter.

When people enter an underground shelter or basement in the summertime, at first the air feels cool. However, if most shelters are fully occupied for a few days without adequate ventilation, the floors, walls, and ceilings, originally cool, will have absorbed about all the body heat of which they are capable. Some shelters will become dangerously hot in a few hours. Unless most of the occupants body heat and water vapor from sweat are removed by air circulated through a typical shelter, the heat-humidity conditions will become increasingly dangerous in warm or hot weather. One of the most important nuclear war survival skills people should learn is how to keep occupied shelters adequately ventilated in all seasons and cool enough for many days of occupancy in warm or hot weather. Methods for ventilating with homemade devices and for keeping ventilating air from carrying fallout particles into shelters are described in Appendices A and B. Instructions for Directional Fanning, the simplest means for forcing adequate volumes of air to flow through shelters, are given at the end of this chapter.

MAKING AND USING AN EXPEDIENT AIR PUMP

The best expedient way to maintain livable conditions in a shelter, especially in hot weather, is to make and use a large-volume shelter-ventilating pump. Field tests have proved that average Americans can build the expedient air pump described in Appendix B in a few hours, with inexpensive materials found in most households.

This simple pump was invented in 1962 by the author. 1 called it a Punkah-Pump, because its hand- pulled operation is somewhat like that of an ancient fan called a 'punkah", still used by some primitive peoples in hot countries. (Unlike the punkah, however, this air pump can force air to move in a desired direction and is a true pump.) It was named the Kearny Air Pump (KAP) by the Office of Civil Defense following tests of various models by

Stanford Research Institute, the Protective Structures Development Center, and General American Transportation Company. These tests confirmed findings first made at Oak Ridge National Laboratory regarding the advantages of the KAP both as a manually operated pump for forcing large volumes of outdoor air through shelters and as a device for distributing air within shelters and fanning the occupants. See Fig. 6.1.

The air pump instructions given in Appendix B are the result of having scores of families and pairs of untrained individuals, including children, build and use this air pump. They were guided by successively improved versions of these detailed, written instructions, that include many illustrations (see Appendix B). Some people who are experienced at building things will find these instructions unnecessarily long and detailed. However, shelter-building experiments have shown that the physically stronger individuals, usually the more experienced builders, should do more of the hard, manual work when shelters are built, and that those less experienced at building should do the lighter work including making shelter ventilating pumps. These detailed, step-by-step instructions have enabled people who never.

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(Photograph) Fig. 6.1. A 6 foot KAP tested for durability at Oak Ridge. After 1000 hours of operation during which it pumped air through a room at a rate of 4000 cubic feet per minute (4000 cfm), there were only minor tears in the plastic flaps.

(Photograph) Fig. 6.2. Behind the girl is the homemade air pump that made it possible for a family of six to live in a crowded trench shelter for more than three days. Outside the temperature rose to 930 F.

before had attempted to build a novel device of any kind to make serviceable air pumps.

(The air pump instructions given in Appendix B repeat some information in this chapter. This repetition is included both to help the reader when he starts to build an air pump and to increase the chances of the best available complete instructions being given to local newspapers during some future crisis. The instructions given in this book could be photographed, reproduced, and mass-distributed by newspapers.)

Figure 6.2 shows (behind the girl) a 20-inch-wide by 36-inch-high KAP installed in the entry trench of a trench shelter. The father of the Utah family described earlier had made this simple pump at home, using only materials and tools found in many homes as described in Appendix B. He carried the pump on top of his car to the shelter-building site. The pendulum-like, flap-valve pump was swung from two cabinet hinges (not shown) screwed onto a board. The board was nailed to roof poles of the narrow entry trench extending behind the girl in the photograph. The pull-cord was attached to the pump frame below its hinged top and extended along one trench wall for the whole length of the shelter. Any one of the six occupants could pull this cord and easily pump as much as 300 cubic feet per minute of outdoor air through the shelter and through the insect screens over both its entrances. (Without these screens, the numerous mosquitoes in this irrigated area would have made the family's shelter stay very unpleasant.)

During the 77 hours that the family continuously occupied their narrow, covered trench, the temperatures outside rose as high as 930 F. Without the air pump, the six occupants would have been driven from their shelter by unbearable temperature- humidity conditions during the day.8

The photo in Fig. 6.2 also shows how the air pump hung when not being operated, partially blocking the entry trench and causing a "chimney effect" flow of air at night. There was a 10-inch space between the air pump and the trench floor, and the resulting flow of air maintained adequate ventilation in the cool of the desert night, when outdoor temperatures dropped as low as 450 F. Cool outdoor air flowed down into the entry and under the motionless air pump, replacing the body-warmed air inside the shelter. The entering cool air continuously

forced the warm air out of the shelter room at ceiling height through the emergency crawlway-exhaust trench at the other end. When the weather is cool, a piece of plastic or tightly woven cloth could be hung inthe doorway of a well designed, narrow shelter, to cause a flow of fresh air in the same manner.

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Numerous shelter occupancy tests have proved that modern Americans can live for weeks in an adequately cooled shelter with only 10 square feet of floor space per person.13Other tests, such as one conducted by the Navy near Washington, D.C. during an abnormally cool two weeks in August, 1962, have shown that conditions can become difficult even when summertime outdoor air is being pumped through a long-occupied shelter at the rate of 12 cubic feet per minute, per person.14,15This is four times the minimum ventilation rate for each occupant specified by the Federal Emergency Management Agency (FEMA) for American shelters: 3 cubic feet per minute (3 cfm). Three cfm is about three times the supply of outdoor air needed to keep healthy people from having headaches as a result of exhaled carbon dioxide. In hot, humid weather, much more outdoor air than 12 cfm per person must be supplied to a crowded, long-occupied shelter, as will be described in the following section and in Appendix B.

MAINTAINING ENDURABLE SHELTER CONDITIONS IN HOT WEATHER

The Navy test mentioned above showed how much modern Americans who are accustomed to air conditioning could learn from jungle natives about keeping cool and healthy by skillfully using hot, humid, outdoor air. While working in jungles from the Amazon to Burma, I observed the methods used by the natives to avoid unhealthful conditions like those experienced in the Navy shelter, which was ventilated in a conventional American manner. These jungle methods include the first five of the six cooling methods listed in this section. During 24 years of civil defense research, my colleagues and 1 have improved upon the cooling methods of jungle people, primarily by the invention and thorough field-testing of the homemade KAP described in Appendix B, and of the Directional Fans covered by the instructions at the end of this chapter.

Even during a heat wave in a hot part of the United States, endurable conditions can be maintained in a fully occupied, belowground shelter with this simple pump, if the test-proven requirements listed below are ALL met.

Most basement shelters and many aboveground shelters also can be kept at livable temperatures in hot weather if the cooling methods listed below are ALL followed:

° Supply enough air to carry away all the shelter occupants' body heat without raising the "effective temperature ' of the air at the exhaust end of the shelter by more than 2 degrees F. The "effective temperature" of the air to which a person is exposed is equivalent to the temperature of air at 100% relative humidity that causes the same sensation of warmth or cold. "Effective temperature" combines the effects of the temperature of the air, its relative humidity, and its movement. An ordinary thermometer does not measure effective temperature. In occupancy tests of crowded shelters when the supply of outdoor air was hot and dry, shelter occupants have been surprised to find that they felt hottest at the air-exhaust end of their shelter, where the temperature reading was lower than at the air-intake end. Their sweaty bodies had acted as evaporative air coolers, but their body heat had raised the effective temperature, a reliable indicator of heat stress. If 40 cubic feet per minute (40 cfm) per person of outdoor air is supplied and properly distributed, then (even if the outdoor air is at a temperature which is typical of the hottest hours during a heat wave in a hot, humid area of the United States) the effective temperature of the shelter air will be increased no more than 2 degrees F by the shelter occupants' body heat and water vapor. Except for a relatively few sick people dependent on air conditioning, anyone could endure air that has an effective temperature only 2 degrees F higher than that of the air outdoors.
(There are exceptions to this ventilation requirement when the ceiling or walls of basement or aboveground shelters in buildings are heated by the sun to levels higher than skin temperature. In such shelters, more than 40 cfm of outdoor air per occupant must be supplied. However, if a shelter is covered by at least two feet of earth, it will be so well insulated that its ceiling and walls will not get hot enough to heat the occupants.)

° Move the air gently, so as not to raise its temperature. In the aforementioned Navy test, a high speed, electric ventilating pump and the frictional resistance of pipes and filters raised the temperature of the air supplied to the shelter by 3 degrees F. Under extreme heat wave conditions, an air supply 3 degrees F hotter than outdoor air could be disastrous especially if considerably less than 40 cfm per occupant is supplied, and body heat raises the air temperature several additional degrees.

° Distribute the air quite evenly throughout the shelter. In a trench shelter, where air is pumped in at one end and flows out the other, good distribution is assured.In larger shelters, such as basements, ventilating air will move from the air-supply opening straight to the air exhaust opening. Persons out of this air stream will not be adequately cooled. By using one or more additional, smaller KAPs (also described in Appendix B), fresh air can be distributed easily throughout large shelter rooms, and the occupants will be gently fanned.

° Provide occupants with adequate drinking water and salt. In extremely hot weather, this means 4 quarts of water per day per person and 1 tablespoon (10 grams) of salt, including the salt in food.

° Wear as few clothes as practical. When the skin is bare, moving air can evaporate sweat more efficiently for effective cooling. Air movement can keep bare skin drier, and therefore less susceptible to heat rash and skin infections. In the inadequately ventilated Navy test shelter, 34 of the 99 initially healthy young men had heat rash and 23 had more serious skin complaints at the end of their sweaty two-week confinement, although their overall physical condition had not deteriorated.15 However, at sick call every day all of these Navy test subjects with skin complaints were treated by medical corpsmen. In a nuclear war, very few shelter occupants would have medicines to treat skin diseases and infections, that if not taken care of usually worsen rapidly under continuously hot, humid conditions. Simple means for preventing skin diseases and infections-means proved very effective by jungle natives and by our best trained jungle infantrymen in World War II - are described in the Prevention of Skin Diseases section of Chapter 12.

° Keep pumping about 40 cfm of air per person through the shelter both day and night during hot weather, so that the occupants and the shelter itself will be cooled off at night. In the Navy test, the ventilation rate of 7 to 12 cfm was not high enough to give occupants the partial relief from heat and sweating that people normally get at night.15 In a National Academy of Sciences meeting on protective shelters, an authority stated: "Laboratory experiments and field investigations have shown that healthy persons at rest can tolerate daily exposures to ETs [effective temperatures] up to 900 F, provided they can get a good night's sleep in a cooler environment."14 An effective temperature 900 F is higher than the highest outdoor effective temperature during a heatwave in the South or in American deserts.

ADEQUATE VENTILATION IN COLD WEATHER

In freezing weather, a belowground shelter covered with damp earth may continue to absorb almost all of its occupants' body heat for many days and stay unpleasantly cold.

In one winter test of such a fully occupied shelter, the temperature of the humid air in the shelter remained around 50 degrees F.16 Under such conditions, shelter occupants should continue to ventilate their shelter adequately, to avoid the following conditions:

° A dangerous buildup of carbon dioxide from exhaled breath, the first symptoms of which are headaches and deeper breathing.

° Headaches from the carbon monoxide produced by smoking. When the ventilation rate is low, smoking should not be permitted, even near the exhaust opening.

° Headaches, collapse, or death due to carbon monoxide from open fires or gasoline lanterns that release gases into the shelter air.

NATURAL VENTILATION

Enough air usually will be blown through an aboveground shelter if sufficiently large openings are provided on opposite sides and if there is any breeze. But if the weather is warm and still and the shelter crowded, the temperature-humidity conditions soon can become unbearable.

Adequate natural ventilation for belowground shelters is more difficult. Even if there is a light breeze, not much air will make a right-angle turn and go down a vertical entry, make another right-angle turn, and then flow through a trench or other shelter partially obscured by people and supplies.

In cool weather, occupants body heat will warm the shelter air and make it lighter than the outdoor air. If a chimney-like opening or vent-duct is provided in the ceiling, the warmed, lighter air will flow upward and out of the shelter, provided an adequate air-intake vent is open near the floor. An Eskimo igloo is an excellent example of how very small ventilation openings, skillfully located in the ceiling and at floor level, make it possible in cold weather for chimney-type natural ventilation to supply the 1 cfm per person of outdoor air needed to prevent exhaled carbon dioxide from becoming dangerously concentrated.

In warm weather, chimney-type natural ventilation usually is inadequate for most high-protection factor shelters that are fully occupied for days. And in hot weather, when as much as 40 cfm per occupant is required, body-warmed shelter air is no lighter than the outdoor air. Chimney-type ventilation fails completely under these conditions.

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SHELTER VENTILATION WITHOUT FILTERS

Numerous tests have shown that the hazards from fallout particles carried into shelters by unfiltered ventilating air are minor compared to the dangers from inadequate ventilation. A 1962 summary of the official standards for ventilating systems of fallout shelters stated: "Air filters are not essential for small (family size) shelters..."17 More recent findings have led to the same conclusion for large fallout shelters. A 1973 report by the Subcommittee on Fallout of the National Academy of Sciences on the radioiodine inhalation problem stated this conclusion: "The opinion of the Subcommittee is that inhalation is far less of a threat than ingestion [eating or drinking], and does not justify countermeasures such as filters in the ventilating systems of shelters."18

Recommendations such as those above realistically face the fact that, if we suffer a nuclear attack, the vast majority of Americans will have only the fallout protection given by buildings and some expedient shelters. Consequently, how best to use available resources must be the primary consideration when planning for protection against the worst dangers of a nuclear attack; relatively minor hazards may have to be accepted. For unprepared people, inhalation of fallout particles would be a minor danger compared to being forced out of a shelter because of dangerously inadequate ventilation.

The most dangerous fallout particles are those deposited on the ground within the first few hours after the explosion that produces them. Typically, these 'hot" particles would be so large and fast-falling that they would not be carried into expedient shelters equipped with low-velocity air intake openings, such as those described in this book. Nor would these most dangerous '"hot" fallout particles be "sucked" into gooseneck air-intake pipes, or other properly designed air-intake openings of a permanent shelter.

For most shelters built or improved hurriedly during a crisis it will be impractical to provide filtered air. The Car-Over-Trench Shelter pictured in Fig. 6.3 points up the overriding need for pumped air for occupants of crowded shelters during warm or hot weather. This simple shelter provides fallout protection about four times as effective as that given by a typical home basement. After the car was driven over the trench, earth was shoveled into the car and its trunk and on top of its hood. At one end was a combined crawlway entrance/air intake opening, at the other end, a 1-foot-square air exhaust opening. Each opening was covered by a small awning. To keep loose shielding earth from running under the car and into the trench, the upper edges of 5-foot-wide strips of polyethylene film first were attached with duct tape to the sides and ends of the car, about 2 feet above the ground. Then earth was piled onto the parts of the film strips that were lying on the ground, to secure them. Finally, earth was piled against the vertical parts of the attached film strips.

Fig. 6.3. Pulling a Small. Stick-Frame KAP to Keep Temperatures Endurable for Occupants of a Car- Over-Trench Shelter in Warm Weather. Enough air also can be

supplied with a small Directional Fan, although more laboriously.

(Placing earth rolls - see page 150 - around the sides of an earth-loaded car provides better, more secure side shielding, but requires more materials and work.)

INHALATION DANGERS

Only extremely small fallout particles can reach the lungs. The human nose and other air passages can filter out almost all particles 10 micrometers [10 microns] [or larger] in diameter, and about 95 percent of those exceeding 5 micrometers." (See reference 6, page 599.) Five micrometers equal 5 millionths of a meter, or 5 thousandths of a millimeter.

Using a dust mask or breathing through cloth would be helpful to keep from inhaling larger 'hot" fallout particles which may cause beta burns in noses, sinuses, and bronchial tubes. Many such retained particles may be swallowed when cleared from one's air passageways by the body's natural protective processes.

As shown below in Fig. 6.4, a relatively "large" particle - 40 microns (40 *u* m) in diameter, spherical, and with the sand-like density of most fallout particles - falls about 1300 feet in 8 hours. (A dark-colored particle 40 microns in diameter is about as small a speck as most people can see with the naked eye.) Most 40- *u* m-diameter fallout particles would take a

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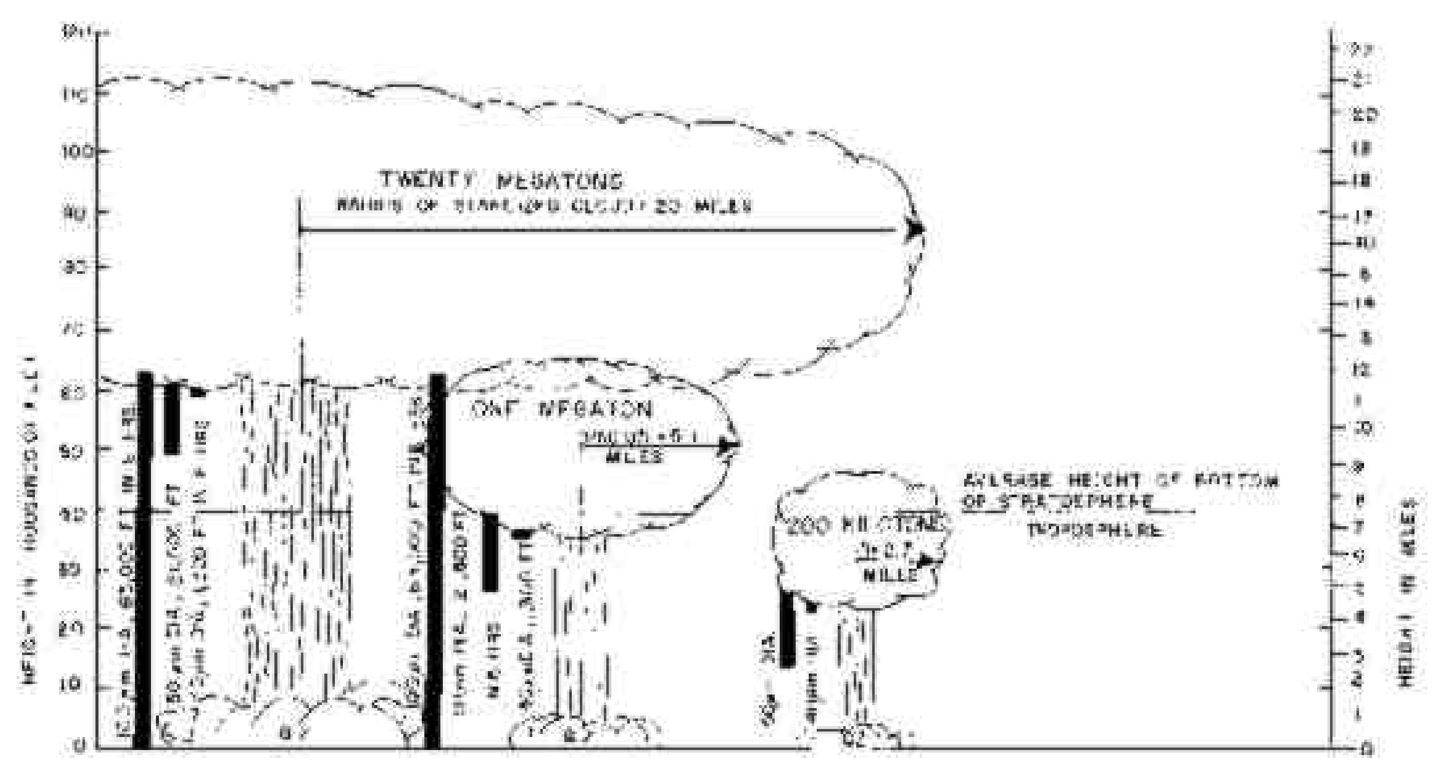
(Illustration) Fig. 6.4. Stabilized Radioactive Fallout Clouds Shown a Few Minutes After the Explosions, with distances that spherical fallout particles having diameters of 40, 50, and 100 microns fall in 8 hours.6



few days to fall from the cloud of a one-megaton explosion down far enough into the troposphere to be occasionally scavenged and promptly brought to earth by rain or snow while still very radioactive. In 1987, however, most of the thousands of deployed Soviet ICBM warheads are 550 kilotons or smaller. (See *Jane's Weapon Systems, 1987-88.)* The stabilized clouds of such explosions would be mostly in the troposphere, and some of even the tiniest particles - those small enough to be breathed into one's lungs - would be promptly scavenged and deposited in scattered "hot spots." Fortunately, most of the very small and tiniest fallout particles would not be deposited for days to months, by which time radioactive decay would have made them much less dangerous. Breathing tiny radioactive particles into one's lungs would constitute a minor health hazard compared to other dangers that would afflict an unprepared people subjected to a large scale nuclear attack.

SCAVENGING OF RADIOACTIVE PARTICLES

Scavenging is most effective below about 30,000 feet, the maximum height of most rain and snow clouds. See Fig. 6.4. Because the Soviets have deployed thousands of ICBMs with warheads of "only" 100 to 550 kilotons, Americans face increased dangers from very radioactive particles scavenged by rain-outs or snow-outs. The resultant "hot spots" of fallout heavy enough to kill unsheltered people in a few weeks could be scattered even hundreds of miles downwind from areas of multiple explosions, especially missile fields. Prudent Americans, even those living several hundred miles from important targets, whenever practical should equip their shelters with adequate ventilating pumps and dust filters.

This potential danger from extremely small fallout particles will be worsened if the United States deploys mobile ICBMs such as Midget- man, probably on large military reservations in the West. (The Soviet Union already has mobile ICBMs in its nuclear forces.) In the event of a Soviet attack, our hard-to-target mobile missiles probably would be subjected to a barrage of relatively small warheads air-bursted so as to blanket their deployment areas. The resultant large clouds of extremely small radioactive particles in the troposphere usually would be blown eastward, and resultant life-endangering "hot spots" from rain-outs and/or snow-outs could be scattered clear to the Atlantic coast.

Fortunately, even in many expedient shelters completed in a few days, filtered air can be provided by using a homemade KAP to pump air through furnace or air-conditioner filters, as described in the last section of Appendix B. To learn how you can supply a shelter at low cost with air so well filtered that essentially all extremely small fallout particles and infective aerosols are removed, see Appendix E, How To Make a Homemade Plywood Double-Action Piston Pump and Filter.

These worsening potential dangers from extremely small "hot" fallout particles brought promptly to earth by scavenging are not likely to endanger nearly as many Americans' lives as would 24-hour fallout of much larger particles from surface and near-surface explosions. Providing enough outdoor air to shelters, rather than filtered air, will continue to deserve first priority.

STOPPING OR RESTRICTING SHELTER VENTILATION

When instrument readings or observations show that heavy fallout has begun to be deposited, shelter occupants should decide whether to restrict or stop ventilation. If it is windy outside, even some sand-like fallout particles may be blown into a shelter with large ventilation openings. However, ventilation should not be restricted long enough to cause weaker occupants to be on the verge of collapse from overheating, or to result in headaches from exhaled carbon dioxide.

If a house is burning dangerously close to a separate, earth covered shelter, closing the shelter's ventilation openings for an hour or two usually will prevent the entry of dangerous concentrations of carbon monoxide, carbon dioxide, or smoke. (Most houses will burn to the ground in less than two hours.)

When an attack is expected, a shelter, occupied or soon to be occupied, should be kept as cool as practical by pumping large volumes of outdoor air through it when the outdoor air is cooler than the shelter air. This also will assure that the air is fresh and low in exhaled carbon dioxide. Then, if a need arises to stop or restrict ventilation, the shelter can be closed for longer than could be done safely otherwise.

VENTILATION/COOLING OF PERMANENT SHELTERS

A permanent family fallout shelter, built at moderate cost before a crisis, should have a ventilation system that can supply adequate volumes of either filtered or unfiltered air, pumped in through an air-intake pipe and out through an air-exhaust pipe. Provision also should be made for the grim possibility that fallout could be so heavy that a shelter might have to be occupied for weeks, or even part-time for months. A small or medium-sized permanent shelter should be designed so that most of the time after an attack it can have adequate natural ventilation through its entryway and emergency exit. During hot spells, forced ventilation through these same large air passageways should be provided by using a homemade KAP. This manual air pump, described in Appendix B, can force large volumes of air through low- resistance openings with minimum effort.

Ways to ventilate and cool permanent shelters are described in Chapter 17, "Permanent Family Fallout Shelters for Dual Use," and in Appendix E, "How to Make and Use a Homemade Plywood Double-Action Piston Pump and Filter."

WARNING: MANY OFFICIAL INSTRUCTIONS FOR BUILDING AND VENTILATING SHELTERS ARE LIFE-ENDANGERING

The reader is advised not to read this section if pressed for time during a crisis, unless he is considering building an expedient or permanent shelter described in an official civil defense publication.

Because of the worldwide extreme fear of radiation, civil defense specialists who prepare official self-help instructions for building shelters have made radiation protection their overriding objective. Apparently the men in Moscow and Washington who decide what shelter-building and shelter-ventilating instructions their fellow citizens receive -

especially instructions for building and improving expedient shelters-do not understand the ventilation requirements for maintaining endurable temperature/humidity conditions in crowded shelters. It must be remembered that shelters may have to be occupied continuously for days in warm or hot weather.

Russian small expedient shelters are even more dangerously under-ventilated than are most of their American counterparts, and can serve to illustrate similar ventilation deficiencies of American shelters. Figure 6.5 is a Russian drawing (with its caption translated) of a "Wood - Earth Shelter" in a Soviet self-help civil defense booklet, "Anti-Radiation Shelters in Rural Areas." This booklet, published in a 200,000- copy edition, includes illustrated instructions for building 20 different types of expedient shelters. All 20 of these shelters have dangerously inadequate natural ventilation, and none of them have air pumps. Note that this high- protection-factor, covered-trench shelter depends on air flowing down through its "Dust Filter with Straw Packing (hay)" and out through its small "Exhaust Duct with Damper."

As part of Oak Ridge National Laboratory's participation in Defense Nuclear Agency's "Dice Throw" 1978 blast test, I built two Russian Pole- Covered Trench Shelters. These were like the shelter shown in Fig. 6.5, except that each lacked a trapdoor and filter. As anticipated, so little air flowed through these essentially dead-ended test shelters that temperatures soon became unbearable.

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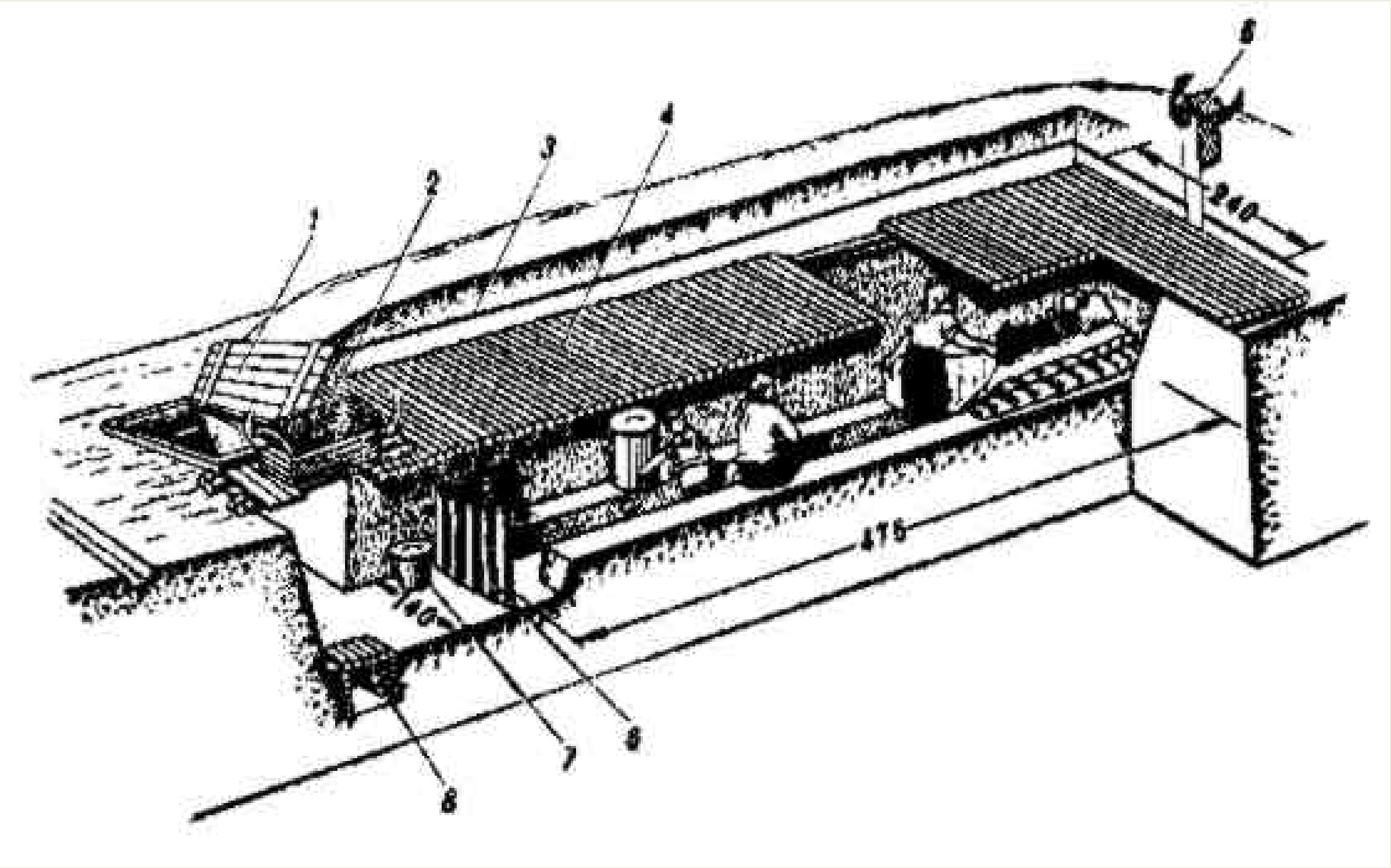
> **(Illustration) Fig. 6.5. [Figure 20.] Wood-Earth Shelter without Lining of the Walls for Clay Soils, 10 Occupants: 1 - Trap Door; 2 - Dust Filter with a Straw Packing (hay); 3 - Earth Cover 60-80 cm thick; 4 - Roofing made of Poles; 5-Exhaust Duct with Damper; 6 - Curtain made of Tightly Woven Cloth; 7 - Removable Container for Wastes; 8- Water Collecting Sump.**
>
> **NOTE: Bill of materials is: Rough Lumber, 2.7 cubic meters; Nails, 0.12 kilogram; Wire, 0.64 kilogram; Work Requirement, 90-110 man-hours; Shielding Coefficient, 250-300.**



Russian earth-covered expedient fallout shelters are based on military dugouts designed for brief occupancy during a conventional attack. Subsequently, they were improved for fallout protection but were made much less habitable by Soviet civil defense specialists. Apparently these specialists were ignorant of ventilation requirements, and almost certainly they did not field-test small expedient fallout shelters for habitability. Tens of millions of Russians have been taught to build such shelters.

Once any bureaucracy issues dangerously faulty equipment or instructions, it rarely corrects them except under pressure. I have experienced this reluctance even during wartime, when trying to improve faulty combat equipment that was causing American soldiers to lose their lives. Continuing proofs of such bureaucratic reluctance to correct dangerous errors are hundreds of thousands of potentially life- endangering civil defense pamphlets and booklets - especially the several editions of *In Time of Emergency* - kept nationwide in hundreds of communities, primarily for crisis distribution.

Some American official instructions for building expedient shelters have been slowly improved over the decades; the best are given in the June 1985 edition of *Protection in the Nuclear Age,* one of the Federal Emergency Management Agency's widely available free booklets. Yet even in this improved edition no mention is made of the crucial need for forced ventilation during warm weather, nor for expedient, simple means for providing pumped air. Also, in the June 1985 edition of *Protection in the Nuclear Age,* the second crawlway entry/exit of the Above- Ground, Door-Covered Shelter (see Appendix A.4) is

replaced by a "4-6" DIA. "PIPE FOR VENTILATION," which makes this very small shelter essentially dead-ended and thereby eliminates adequate ventilation in warm weather. With only a 6-inch-diameter air-exhaust opening, not nearly enough air can flow naturally in warm weather through this crowded shelter's room (only about 39 inches wide by 34 inches high). As proved by habitability tests in Florida and elsewhere, a KAP or Directional Fan must be used, even with two crawlway entry/exits.

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The essential second crawlway entry/exit of the Aboveground Door-Covered Shelter was eliminated as the result of a recommendation by a contractor for FEMA charged with field testing and evaluating expedient shelters, and improving abbreviated shelter-building instructions. No habitability tests were required. So the contractor concluded in his 1978 report to FEMA that the second entry/exit should be eliminated because "The building of entries is time consuming and with this small a shelter a second entry is really not justified."

In peacetime, bureaucracies of all nations tend to divide up responsibilities between specialists and to promote means by which non- prestigious wartime problems can apparently be solved with the least expense and work.

DIRECTIONAL FANNING TO VENTILATE SHELTERS

The Directional Fanning instructions on the following two pages may save more lives than any other instructions given in this book for a homemakeable survival item. I regret that no one rediscovered this premechanization, simple, yet effective way of manually pumping air until after the original *Nuclear War Survival Skills* was published.

In 1980, Dr. William Olsen, a NASA research engineer long concerned with improving self-help civil defense, rediscovered one kind of Directional Fanning. Since then, with the assistance of able Americans and others, I have designed and tested several types of Directional Fans. I have field-tested and repeatedly improved the instructions to enable average people to quickly learn how to make and use such fans effectively.

The great advantage of Directional Fanning is that almost anyone who is given the field-tested instructions can quickly make and use one of these simple fans. Only very widely available materials are needed. The main disadvantage is that Directional Fanning is a more laborious way to ventilate a shelter than using KAPs, as described in detail in Appendix B.

Americans are not likely to receive Directional Fanning instructions from the Federal Emergency Management Agency. FEMA's predecessors, the Office of Civil Defense and the Defense Civil Preparedness Agency, were unable to get the millions of dollars

necessary to buy factory-made KAPs and other manual air pumps to ventilate officially designated fallout shelters, and FEMA has avoided shelter ventilating controversies. No widely available official American publication includes instructions for making and using any expedient airpumping device.

Thanks to Congressman Ike Skelton, Democrat of Missouri and strong civil defense advocate, in 1981 I was able to demonstrate Directional Fanning to Louis Giuffrida, at that time the Director of FEMA. I gave Directional Fans to the FEMA specialists concerned with shelter ventilation, all of whom have since left FEMA. To date, although Directional Fanning instructions have been reproduced in three private civil defense publications, and some 600 copies of a metric version of the instructions were distributed to British civil defense professionals at the 1984 Annual Study of Civil Defense and Emergency Planning Officers, FEMA has not even evaluated Directional Fanning.

In contrast, in 1981 I gave copies of instructions for both KAPs and Directional Fans to Dr. Yin Zhi-shu, the Director of the People's Republic of China's National Research and Design Institute of Civil Defense - and the next day he started evaluating these simple devices. (At that time I was traveling extensively in China as an official guest, exchanging civil defense information.) Dr. Yin, who heads all Chinese civil defense research and development, went with his top ventilation and shelter design specialists to a furniture factory in Beijing. There I watched workmen quickly build both a large and a small KAP, and also Directional Fans. Then Dr. Yin and his specialists began using their air-velocity meters to measure the volumes of air that these simple devices could pump. On the following days I participated in more ventilation tests using KAPs and Directional Fans in tunnel blast shelters in Beijing and in the port city of Dalien.

While watching these top Chinese civil defense professionals make and test KAPs and Directional Fans, I kept thinking: 'This is the way Thomas Edison and Henry Ford would have evaluated simple devices of possible great importance to millions."

The reader is urged to keep the following two pages of Directional Fanning instructions ready for reproduction in a crisis. The sections on the small 2-handled Directional Fan and the large 1-Man Fan will be the most useful to unprepared people. Ventilation by pairs of men using Bedsheet Fans is an effective method for forcing very large volumes of outdoor air through tunnels, corridors and mines with ceilings at least 9 feet high - provided they have two large openings. However, this method requires organization and discipline.

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DIRECTIONAL FANNING TO VENTILATE SHELTERS

Directional Fanning is the simplest way to force enough outdoor air through typical

basement, trench, and other expedient shelters to maintain endurable conditions, even in extremely hot, humid weather.

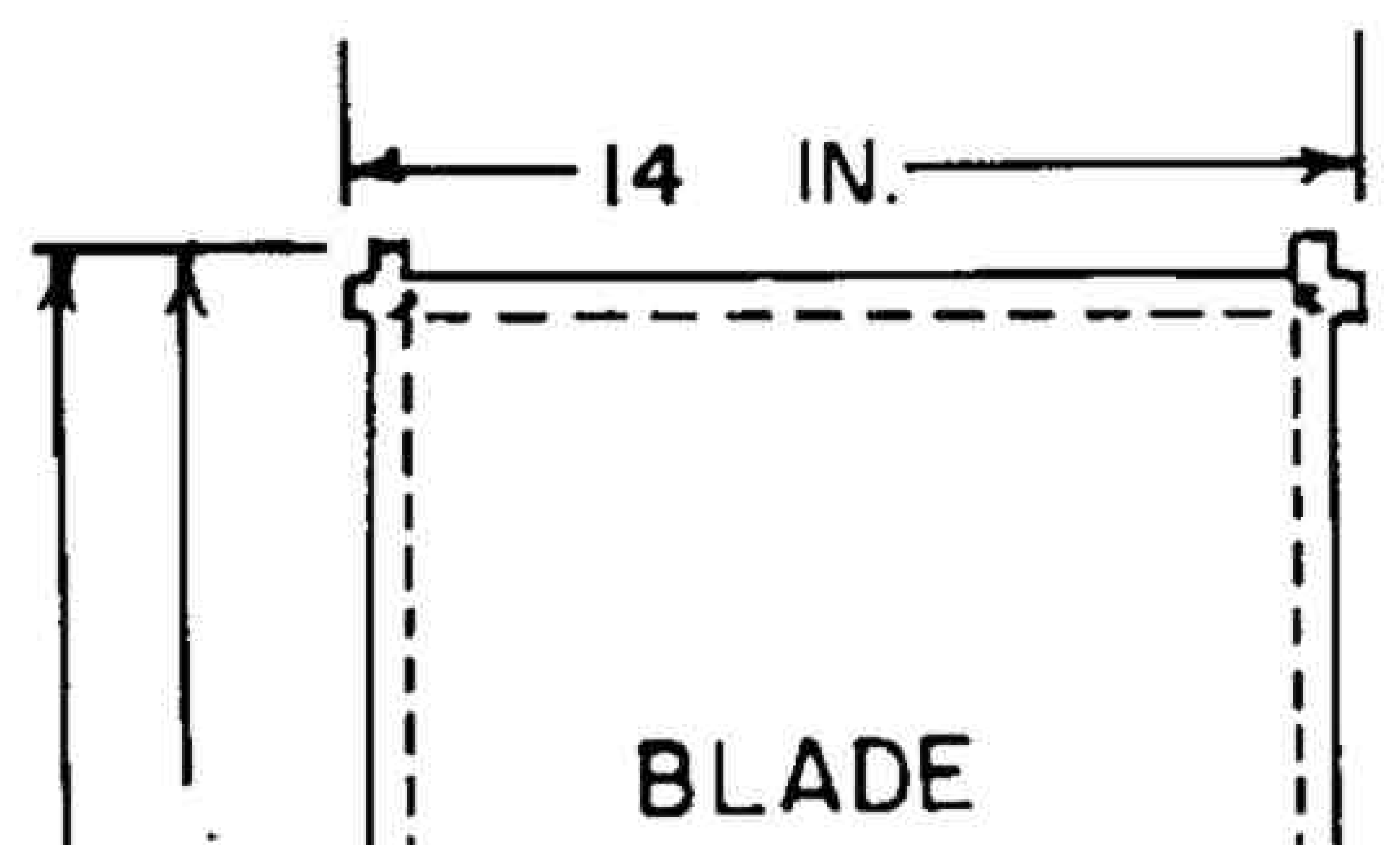
During a worsening nuclear crisis most unprepared citizens probably will not have the time and/or materials needed to make a KAP or other efficient shelter-ventilating pump - even if they have the instructions. In contrast, tests with average citizens have indicated that if they have instructions for making and using Directional Fans and if there are a few hours of warning time before the attack, then the majority will be able to ventilate all of their expedient shelters, except some of the largest.

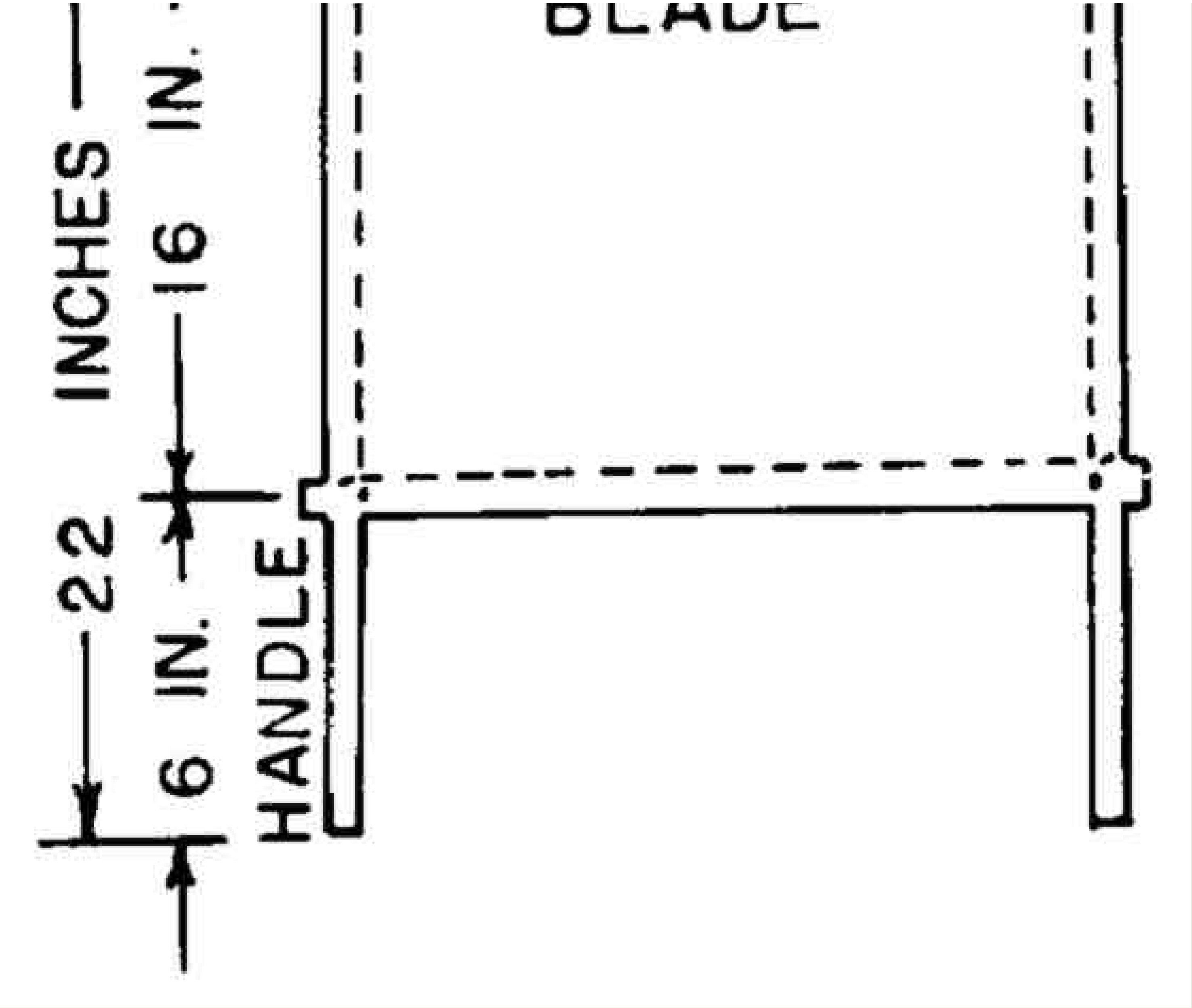
The principal disadvantage of Directional Fans is that they are more laborious to operate than are KAPs, that are manually powered, pendulum- like air pumps that conserve energy.

A. DIRECTIONAL FANNING TO VENTILATE AND COOL SMALLER SHELTERS

A 2-Handled Directional Fan of the size illustrated (14 in. x 16 in. with a 6 in. handle) is less tiring to use and requires less manual dexterity than does a 1-handled fan with the same size blade. With this small two handled fan you quite easily can force about 300 cubic feet per minute (300 cfm) of outdoor air through a crowded trench or basement shelter. This is enough air for up to 9 adults crowded into a small shelter in extremely hot humid weather, and enough for about 100 people in cold weather. By fanning vigorously, 500 to 600 cubic feet per minute have been forced through a small covered-trench shelter.

Fig 59a (Illustration)





To make a durable 2-handled fan, first make its frame out of 2 sticks each 14 inches long and 2 sticks each 22 inches long. See sketch. To strengthen the corners, overlap the sticks about one-half inch, as shown.

When using sticks cut from a tree, select ones with diameters of about 3' inch, and make shallow notches in all 4 sticks before tying together the 4 corners of the blade. If you do not have strong string, use 1/2 inch-wide strips of bedsheet cloth, or other strong cloth, slightly twisted.

If using sawed sticks, he sure to use none smaller than 3/4 inch in cross section. If you have very small nails or brads, use only one to connect each corner: then tie each corner securely. To prevent possible blistering of hands, wrap cloth around the fan handles, or wear gloves.

To cover the fan's blade, any strong, light fabric, such as bedsheet cloth, serves well If

you are going to sew on the cloth, first cuts 26 x 30-inch piece. Wrap the 30-inch width smoothly crosswise around the frame, after cutting 4 notches in the cloth's corners, so that the tied-together parts of the sticks will not he covered. Pin or tape the cloth to make a smooth blade: finally sew securely. (If waterproof construction adhesive is available, a smaller piece of cloth can be used and the blade can be covered in a very few minutes.)

If time and/or materials are very limited, make a fan with its blade merely a piece of cloth connecting two 22-inch-long sticks. This very simple fan is reasonably effective, although tiring to use.

Cardboard covering a blade is likely to become damp and fragile in the humid air of a crowded shelter, very light sheetmetal makes a good fan blade and requires only 2 sticks. A blade of 4-inch plywood is too heavy.

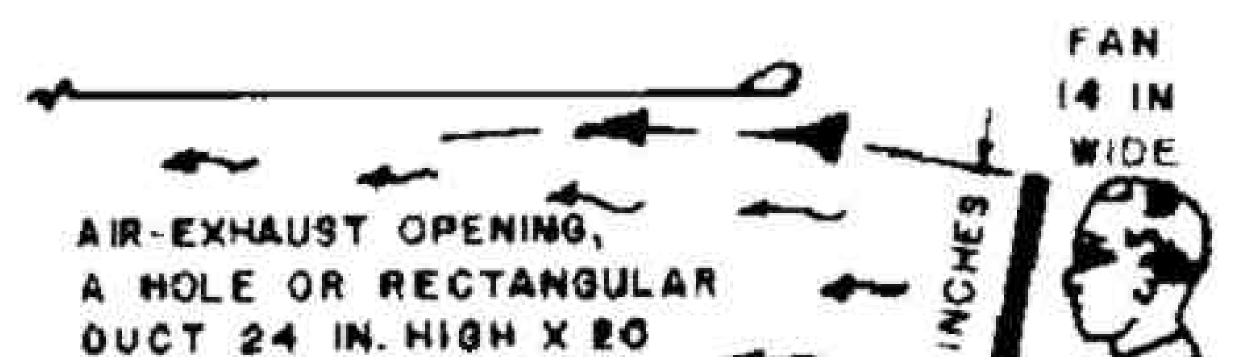
If no sticks are available, a double thickness of heavy, stiff cardboard 22 inches long by 14 inches wide will pump almost as much air if used as a handleless fan. The pieces should he securely tied or taped together. If waterproof tape is available, cover the parts that you will grip with sweaty hands, thus preventing dampening and softening the cardboard.

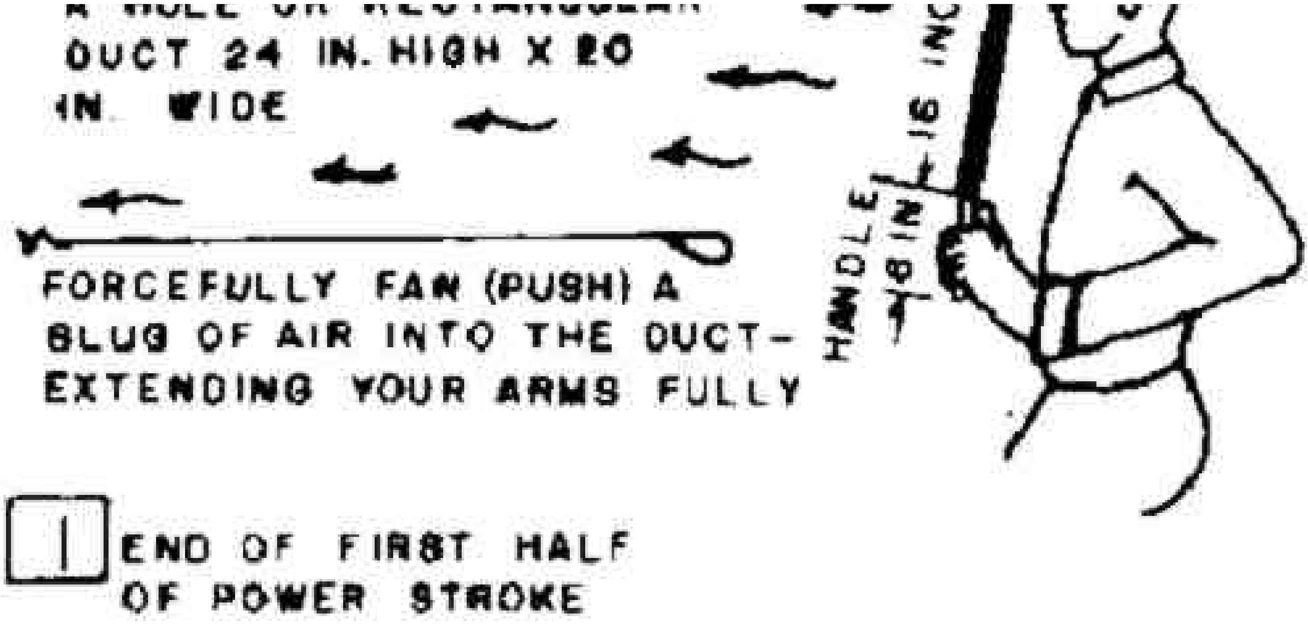
For maximum ventilation, the air-intake opening of a shelter should heat least as large as its air-exhaust opening. (If the air-exhaust opening of your small shelter is much larger than that shown in the sketches, block part of it off to reduce it to approximately this 24-inch-high by 20-inch-wide size, for more effective use with this fan.) The air should be fanned out of the shelter in the direction in which the air is naturally flowing. For maximum ventilation rate, fan about 40 strokes per minute.

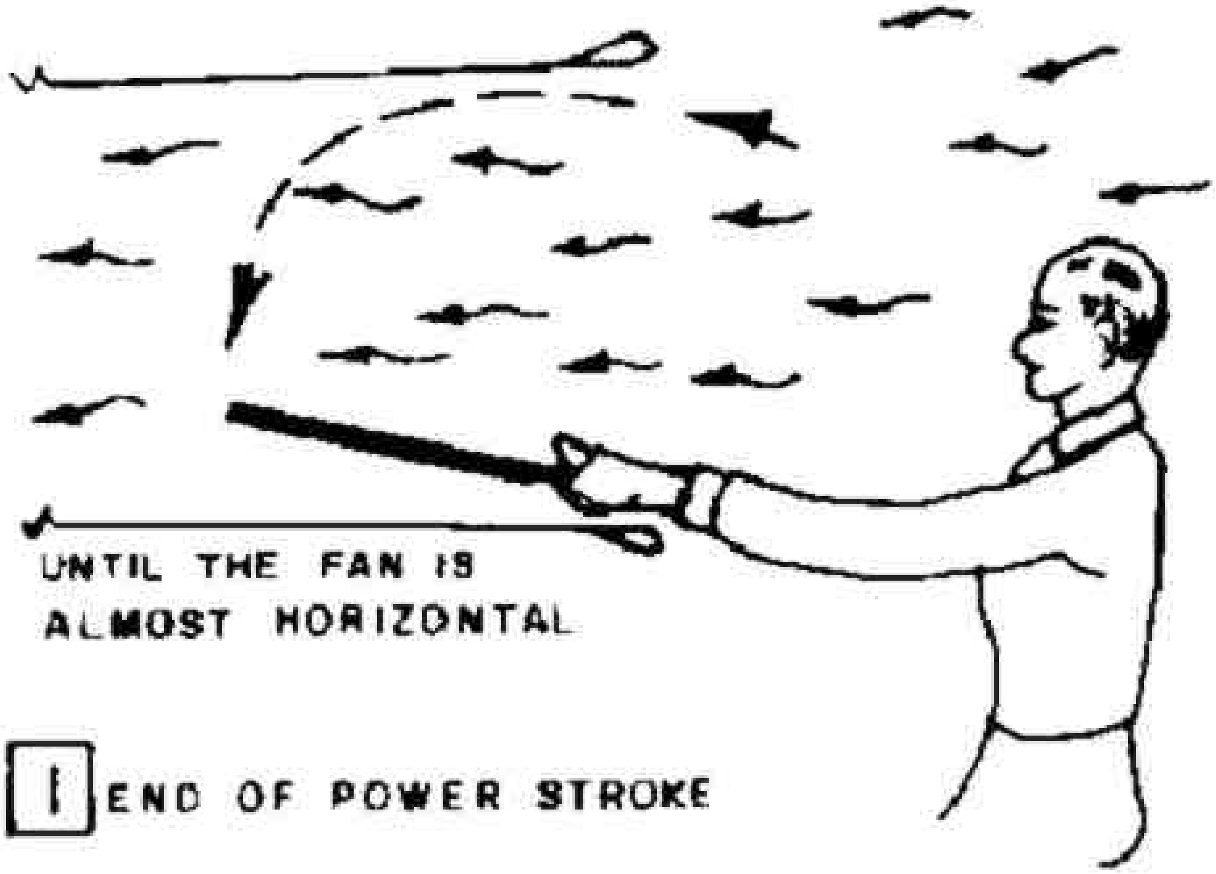
With one or more Directional Fans, air inside a shelter can be distributed effectively and the occupants cooled. Also, if during the time of maximum fallout dose rate the occupants get close together in the most protective part of the shelter, they often will get unbearably hot unless fanned.

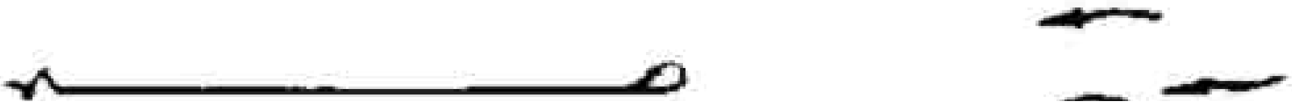
To fan air out through an air-exhaust opening, sit facing the opening with your elbows about 4 inches lower than the bottom of the opening. Then count 1, 2, 3 while you:

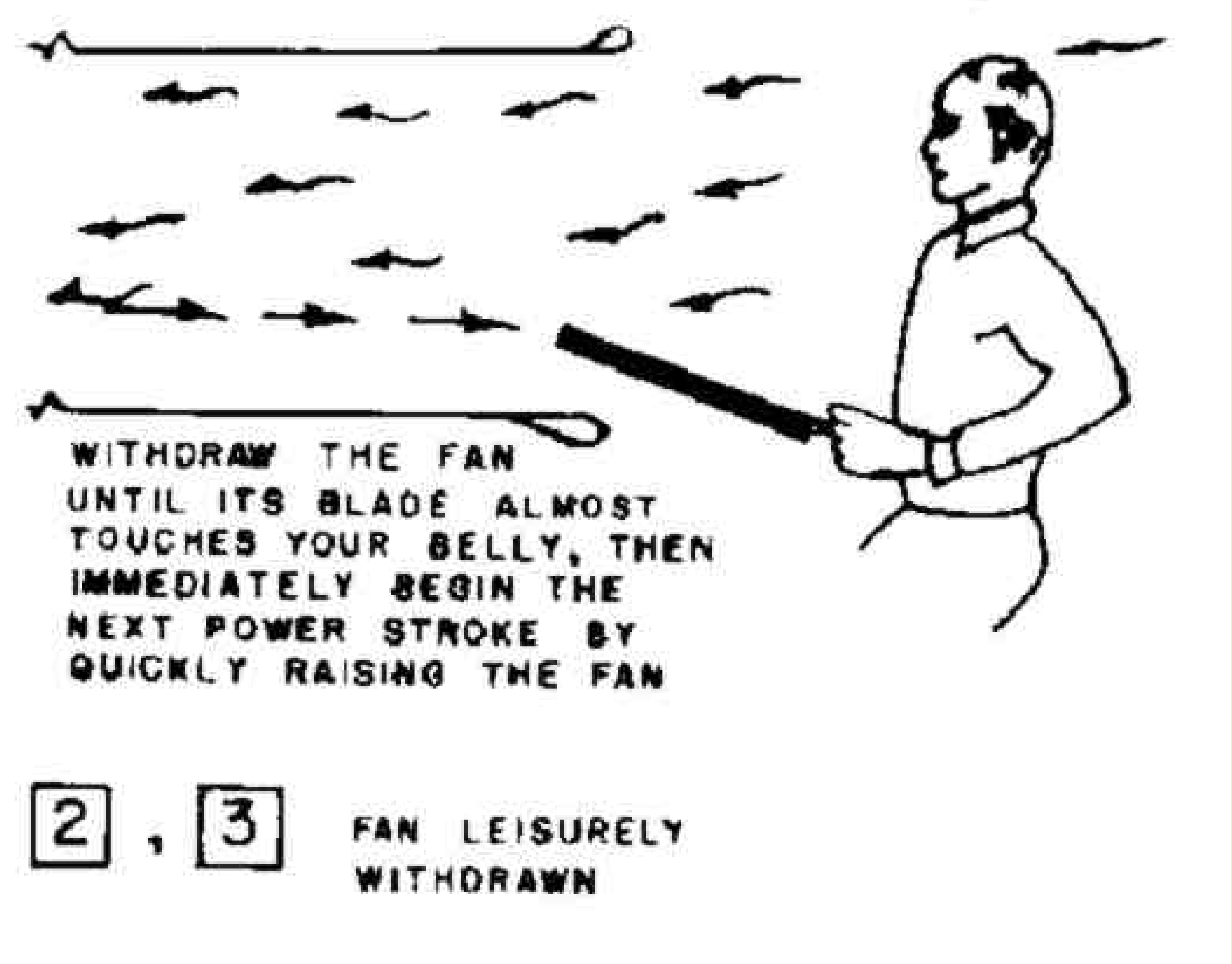
Fig. Pg 59b (Illustration)




A HOLE OR RECTANGULAR
DUCT 24 IN. HIGH X 20 IN. WIDE
16 INC
HANDLE 18 IN
FORCEFULLY FAN (PUSH) A SLUG OF AIR INTO THE DUCT- EXTENDING YOUR ARMS FULLY
1 END OF FIRST HALF OF POWER STROKE


UNTIL THE FAN IS ALMOST HORIZONTAL
1 END OF POWER STROKE





1) Quickly raise the fan to a vertical position close in front of your face and immediately fan (push) a slug of air into the opening - ending the power stroke with your arms fully extended and with the fan almost horizontal and out of the way of air that was "sucked" behind the fan and is still flowing out through the opening.

2), 3) After a slight pause, leisurely withdraw the almost horizontal fan until the bottom of its blade almost touches your stomach -- preparatory to the next power stroke.

To increase the flow of air through a shelter, while fanning the occupants:

Have two or more occupants sitting inside the shelter each use a fan of the size described above to fan the air so as to increase its velocity in the direction in which air already is flowing through the shelter. Such Directional Fanning is especially effective in increasing the air flow through small, narrow shelters.

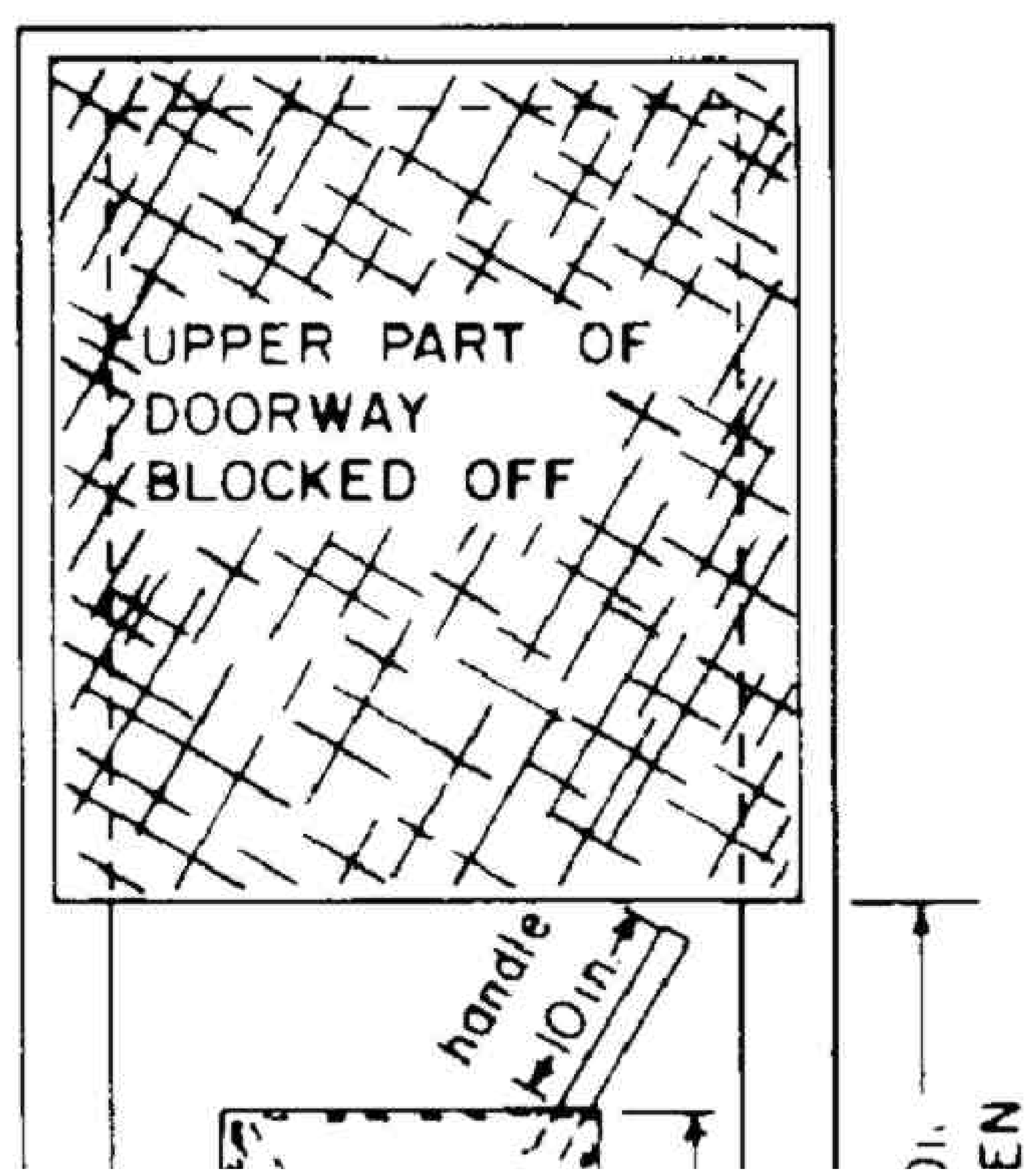
To avoid higher radiation exposures near openings, build an essentially airtight partition across the shelter room, with a 24-inch-high x 20-inch-wide hole in it through which to

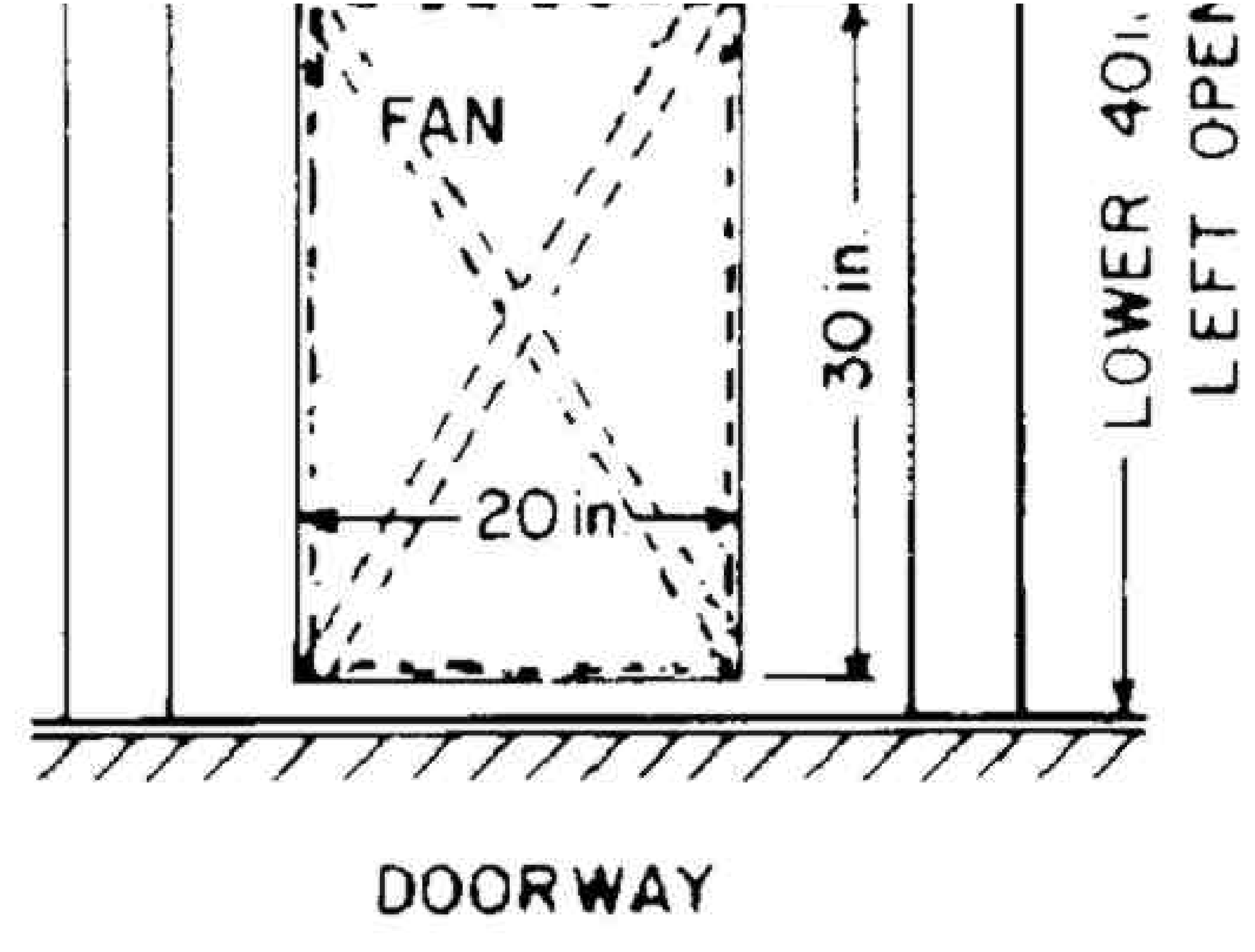
fan. By fanning through a 24 x 20-inch hole in a cardboard partition built across a doorway inside a U- shaped permanent trench shelter 76 feet long, the air flow was increased by an average of :327 cubic feet per minute.

B. DIRECTIONAL FANNING TO LARGER SHELTERS VENTILATE AND COOL LARGER SHELTERS

1. With a Large 1-Man Fan

Fig. Pg. 59c (Illustration)





To ventilate larger basements, big covered trenches, and other large shelters lacking adequate ventilation, use one or more large 1-man fans. See sketch. Note that the 20 x :30-inch fan blade is made like a 2-stick kite, and that the upper end of the longer diagonal stick serves ass 10-inch handle. The model illustrated is made of 2 nominal 1 x 2-inch boards, one 46 inches long and the other 35 inches long. These boards are connected at a point 17-1/2 inches from their lower ends, first with a single clinched nail, and then by being tied securely. The edges of the handle are rounded smooth

The blade frame is covered on both sides with strong bedsheet cloth, that is wrapped around and secured to the strong cords or wires tied to notches cut in the boards or sticks) near the 4 corners of the blade. (If cord or wire is not available. 4 2-inch-wide strips of strong cloth, slightly twisted, serve well.)

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A durable but laboriously heavy fan can be made in a few' minutes using a 20 x 30-inch piece of 1/4 inch plywood nailed to a single 46-inch-long. 1 x 2- inch hoard. Or use a single round stick about 1-1/4 inches in diameter, flattened on one side.

A fan with its blade made of two sheets of very heavy cardboard tied on both sides of a 1 x 2-inch board is decidedly effective when dry. However, typical cardboard will become soft and worthless in most crowded, long-occupied humid shelters.

To fan directionally, it is best to stand just outside and to one side of a doorway, so that your body does not obstruct the air flow. Preferably stand opposite and facing the open door, which should be secured open and perpendicular to its doorway. Hold the fan like a golf club and swing it with your arms extended. Then slowly count 1, 2 while you:

1. Make the power stroke with the fan blade broadside until the end of the stroke, when you quickly turn it 90 degrees.

2. Make the pendulum-like return stroke with the fan blade kept edgewise)" feathered") to the air flow until the end, when you quickly turn it 90 degrees, preparatory.' to making the next power stroke.

To pump more air, block off the upper part of the doorway with cloth, cardboard, plywood, etc.. to prevent air from flowing back in the wrong direction through the upper part of the doorway. See sketch on preceding page.

Whenever practical, directionally fan the air in the same direction that the air is naturally flowing through the shelter. More air usually can be pumped through a shelter if the fan is used to force air out through the air exhaust opening. This reduces the air pressure inside the shelter and causes fresh outdoor air to be "sucked" into the shelter through the air-intake doorway, or through other large air- intake openings. Thus with one fan 1,000 cubic feet per minute can he pumped through a fully occupied shelter. This is enough outdoor air - if it is properly distributed within the shelter - to maintain tolerable conditions for weeks for 25 occupants during extremely hot weather, and for up to about 300 occupants during cold weather.

To ventilate and cool a room having only one doorway and no other opening, do not block off any part of the doorway. If air is fanned into such a room through the lower part of its completely open doorway, then air will flow back out of the room through the upper part of the doorway. However, this pumps much less air than when a separate, large air-exhaust opening is provided.

To increase the flow of outdoor air through a tunnel-shelter, several fanners equally spaced along its length should each fan in the direction of the natural air flow. This procedure was first proved practical during a 1981 ventilation test that Cresson H. Kearny participated in with Chinese civil defense officials in the port city of Dalien. In this test 5 fanners, each with a fan of approximately the size illustrated, forced air from the outdoors through a 395-foot section between two opened entrances of a typical Chinese tunnel-shelter. The air flow was increased from a natural flow of 290 cubic feet per minute to

:3.680 cubic feet per minute. The 5 excellent Chinese fans each had a blade made of a piece of 3 mm (approx. 1/8th in.) plywood nailed to a single board.

2. With a Bedsheet Fan

Use a 2-man Bedsheet Fan to force thousands of cubic feet per minute of outdoor air through a tunnel or long corridor having at least a 9-foot ceiling and a large opening at each end. The most practical design tested was made from a strong double bedsheet cut down to 6-foot width, with the wide hem at its head-end left unchanged and with a similar-sized hem sewn in its opposite end, to give a finished length of 6 feet. A 6-foot-long, nominal 1 x 2-inch board (or an approximately 1-1/2 inch diameter stick) was secured inside each end hem of various models with waterproof construction adhesive, or with tacks, or by tying. Before a board was inserted, its edges were rounded. Round sticks were smoothed.

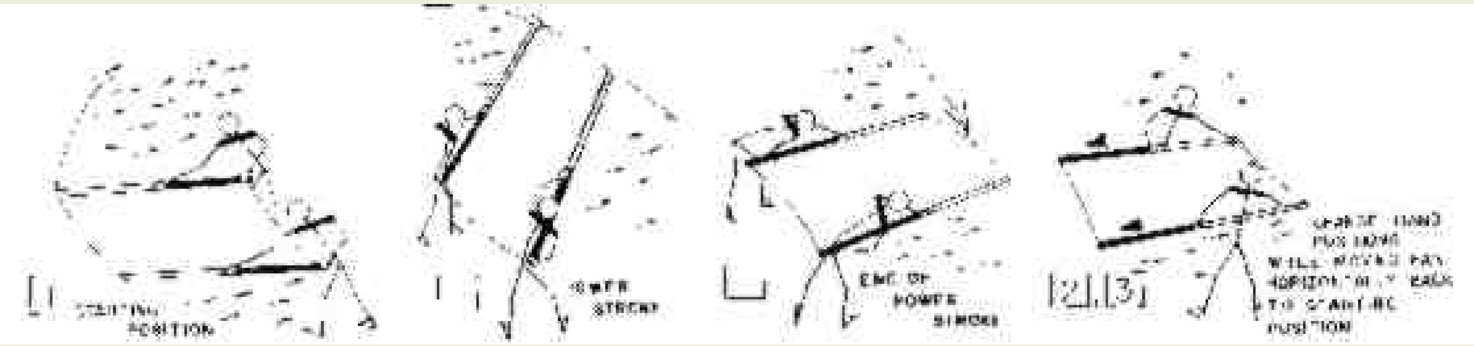
Two persons preparing to use a Bedsheet Fan see sketch) should stand facing each other, at right angles to the desired direction of air flow', with the cloth extended horizontally between them. Each fanner should grip his stick with one hand near its "downwind" end and with his other hand near its center.

A pair of Directional Fanners get ready to make a power stroke by leaning in the upwind direction, as illustrated. Then the pair of fanners should count 1, 2. :3 while they:

> **1. Make the power stroke by rapidly sweeping their sticks and the attached cloth in an arc, until they are leaning in the downwind direction and the sticks and cloth are again horizontal. See sketch.**
>
> **2,3. Hold the sticks and cloth horizontal (to permit air that was "sucked" behind the cloth to continue flowing in the desired direction) while leisurely moving the Bedsheet Fan back to the starting position. During this move the fanners change hands, as illustrated. Note that what was the upper side of the fan at the beginning of the power stroke now has become the lower side.)**

Two men thus fanning vigorously produced a net air flow of 5,500 cubic feet per minute through an empty school corridor that is 8 feet wide, has a 9- foot ceiling, and is 194 feet long. The doors at both ends were open. To adequately ventilate and cool people crowded into a long tunnel in hot weather, a pair of Bedsheet Fanners should be positioned about every 100 feet along its length.

> **Fig. Pg. 60 (Illustration)**



The practicality of using Bedsheet Fans to ventilate some very large mines or caves having 2 or more large openings was proved by tests with members of the Citizens Preparedness Group of Greater Kansas City. These tests were conducted in 1982 near Kansas City in a huge limestone mine that has a ceiling averaging about 17 feet high, corridors about 35 feet wide, columns of unexcavated rock about 15 feet square, and over 1,000,000 square feet of level, dry floor space. The air inside is "dead", remarkably still, because the only openings are two truck-sized portals on one side of the mine. Five pairs of Bedsheet Fanners, spaced about 75 feet apart down a corridor, after fanning for several minutes produced a measured air flow of approximately 100,000 cubic feet per minute through this part of this corridor!

With many more pairs of Bedsheet Fanners working, enough air for at least 10,000 occupants could be "sucked" into this mine through one of its 17 x 20-foot portals, fanned down a corridor to the far "dead end" of the mine, then fanned through across corridor, and finally fanned back out through the corridor that has the second truck-sized portal at its outer end.

A pair of pre-mechanization coal miners produced a directed airflow' by holding apiece of canvas vertically between them while they quickly walked a short ways in the direction of the desired airflow; they walked back with the canvas held horizontally between them. Then they repeated.

C. ADDITIONAL ADVANTAGES OF DIRECTIONAL FANS

1. No installation is needed, thus saving working time and materials for making habitable shelters hurriedly built or upgraded during a crisis.

2. Directional Fans enable shelter occupants to quickly reverse the direction of air flow through their shelter when outdoor wind changes cause the direction of natural air flow' to be reversed.

3. Four or more Directional Fans when used to circulate air within a shelter room can serve like air ducts, while simultaneously fanning occupants.

4. Directional Fans are very unlikely to be damaged by blast effects severe enough to wreck bladed fans or other fixed ventilation devices placed at or near air-intake or air-exhaust openings, but not severe enough to injure shelter occupants.

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