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CIVIL EFFECTS EXERCISE

AEC GROUP SHELTER

AEC Facilities Division
Holmes & Narver, Inc.

Issuance Date: June 22, 1960

CIVIL EFFECTS TEST OPERATIONS
U.S. ATOMIC ENERGY COMMISSION

NOTICE

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AEC GROUP SHELTER

By

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Approved by: R. L. CORSBIE
Director
Civil Effects Test Operations

January 1960

FOREWORD

The Atomic Energy Commission is aware of its responsibility for taking a leading part in the protection of the people against nuclear attack or accident. As a result of atomic shelter tests and field experiments conducted by the United States Government over the past nine years, it has been conclusively shown, and agreed to by experts in the field, that shelters provide the only promising means of civilian protection in event of a nuclear war.

An analysis of the effects of multiple detonations of modern nuclear weapons shows that initial and residual effects are certain to produce casualties at an unacceptable rate among unprotected personnel. While the initial effects from a weapon yield of one megaton are hazardous in a zone measured in hundreds of square miles around the point of detonation, the residual radioactive fallout in casualty-producing quantities may be deposited over thousands of square miles. Shelters will protect the civilian population from this hazard.

A series of experiments culminating in the Operation Plumbbob series of tests at the Nevada Test Site in 1957 demonstrated that the blast loading produced on ground-level structures by a given explosion of known yield can be estimated. Response of simple structures to assumed blast loadings can be calculated with a fair degree of accuracy. It was found that blast pressures were greater on vertical aboveground structures than on below-ground structures because of the reflected overpressure and the drag pressure which affect surface structures. Aboveground structures can be designed to resist these overloads, but the cost of construction is prohibitive when compared to the underground or partially buried structure.

The final shelter tests were made at the Nevada Test Site in a project conducted by personnel of the U. S. Naval Radiological Defense Laboratory, the Atomic Energy Commission, and Atomic Energy Commission contractors as part of the program of the AEC-sponsored Civil Effects Test Group, Robert L. Corsbie, Director. During the tests the shelter was occupied by personnel at the time three nuclear devices were detonated, over a period of several weeks, atop 500-ft towers from about one to two miles away. The yield of each of the explosions was approximately 20 kt.

Results of the field tests showed that the shelter furnished almost 100 per cent protection against fallout radiation and that it withstood an exterior blast pressure of 576 lb/sq ft. Calculations made prior to the tests indicated that the shelter was capable of withstanding a blast pressure of 1440 lb/sq ft. For comparison, normal building design is based on an external pressure of 20 to 30 lb/sq ft to withstand high wind velocities.

The group shelter presented here combines outstanding protection against radioactive fallout with good protection against blast and, in addition, offers excellent protection against thermal radiation.

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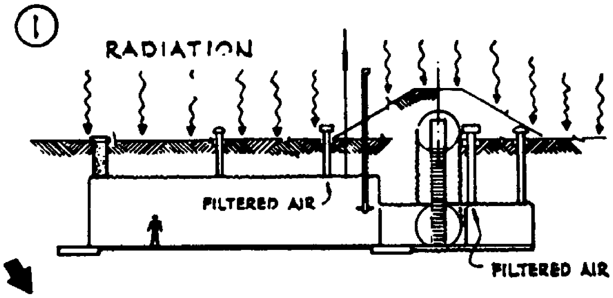
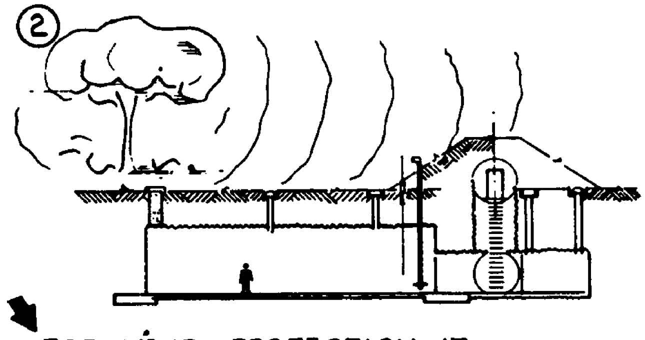
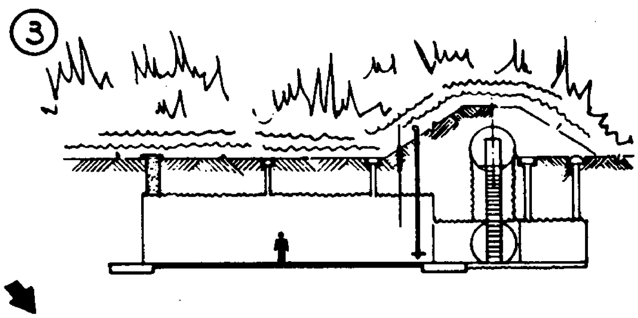


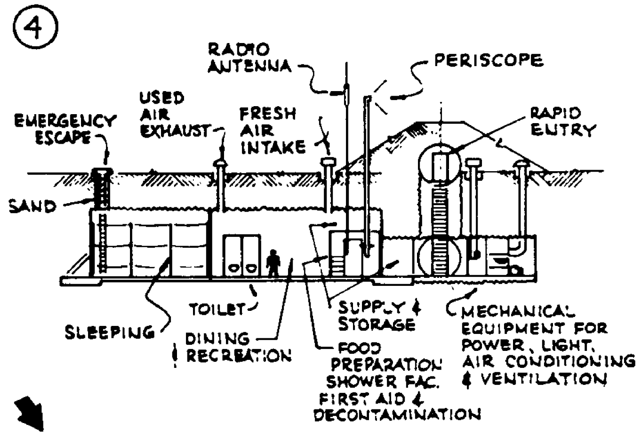
FOR YOUR PROTECTION IT REDUCES RADIATION HAZARDS TO ACCEPTABLE LEVELS



FOR YOUR PROTECTION IT RESISTS BLAST EFFECTS



FOR YOUR PROTECTION IT BLOCKS EXTREME HEAT AND FIRE STORM EFFECTS



AND IT PROVIDES THE NECESSITIES FOR SURVIVAL

AEC GROUP-SHELTER STUDY

1. INTRODUCTION

The engineering firm of Holmes & Narver, Inc., AEC Facilities Division, was engaged by the Division of Biology and Medicine, USAEC, Washington, D. C., to conduct an underground group-shelter study. Specifically, the shelter tested in Operation Plumbbob was to be refined and improved.

In addition to the refinement study, working plans, specifications, bills of materials, and a three-dimensional model were developed to enable the Atomic Energy Commission to obtain without delay realistic local cost estimates for construction of shelters of this type. Thus, technical information and details relative to a tested protective structure for both emergency and peacetime applications are made available.

Presented here is a group shelter of conceptual design and size for twofold use: (1) emergency shelter and (2) normal peacetime activities. The adaptability of the shelter to peacetime activities increases its attractiveness from an economic viewpoint. It also improves the emergency potential because the occupants will become familiar with the shelter and because a structure in regular use will have regular maintenance.

Figures 1 through 3 are plan views of the shelter; Figs. 4 through 7 are photographs of the shelter model.

Although this engineering study has been made to satisfy an Atomic Energy Commission responsibility, it is hoped that the results will be useful to other organizations and groups interested in protective structures.

2. GENERAL REQUIREMENTS

From the experience gained in the Operation Plumbbob shelter test, the Atomic Energy Commission developed the basic concepts and outlined the following minimum facility requirements for a group shelter:

1. To accommodate 100 persons of all age groups and both sexes (10 per cent of whom are casualties)
2. To allow 100 people to enter within a 5-min period
3. To withstand a blast pressure of 35 lb/sq in. (5040 lb/sq ft) and the thermonuclear explosion phenomena associated with that pressure region (with respect to blast resistance)
4. To reduce fallout radiation intensity by a factor of about 10,000 as compared to exposure on the surface
5. To have capability for complete "seal-up" for 3 hr during extreme and immediate radiation conditions and a maximum button-up for 1 week (using outside air intake)
6. To sustain 100 people for 14 days to one month, providing minimal accommodations as follows:
   (a) A dry, livable, fire-resistant and nontoxic interior
   (b) Beds, one for each two persons

(c) Dining facilities
(d) Food, with provisions for heating soup and milk (one hot meal per day)
(e) Medical supplies
(f) Storage for food and supplies
(g) Recreational facilities
(h) Control office for administration
(i) Emergency exit
(j) Water for drinking and sanitary use
(k) Decontamination and toilet facilities
(l) Waste disposal
(m) Air conditioned to prevent entrance of radiation particles, noxious fumes, and smoke
(n) Lighting and power

7. To provide for contact with aboveground area-control centers, etc., and for eventual evacuation by the following means:
   (a) Communications to control centers and nearby shelters*
   (b) Radiological instrumentation*
   (c) Visual contact with aboveground area during button-up period*
   (d) Facilities and equipment for outside decontamination parties

3. PERSONNEL ACCOMMODATIONS

3.1 First-aid and Medical Facilities

Facilities for decontamination and medical care are provided to handle the estimated 10 casualties (10 per cent of 100). A decontamination shower and wash sink are located near the shelter entrance door. Personnel found to have radioactive contamination will discard their clothing in the entry alcove and proceed through the decontamination shower.

A separate room containing nine beds has been provided for the care of sick and injured for whom full-time bed rest is necessary. The extent of medical care is necessarily limited, but routine first aid will be possible, with extra blankets, medical supplies, and drugs provided. Supplies of this nature will be stored in the loft or office area under the direct jurisdiction of the shelter leader. One doctor or first aid expert should be assigned to each shelter.

3.2 Decontamination, Cleanliness, and Toilet Facilities

Special clothing and equipment are provided for outside working parties. Decontamination of working personnel reentering the shelter will be accomplished in the manner described above. The decontamination shower and the wash sink will have dual functions since they can also serve as general personnel facilities.

Toilet facilities are designed for privacy and accessibility. There are four toilets in four separate rooms, each room being ventilated to the atmosphere by exhaust fans. The toilets are centrally located and convenient to the sleeping and isolation areas as well as to the dining and recreation area. A separate urinal is provided adjacent to the shower and wash sink.

A sewage ejector system is provided to dispose of all waste from toilets, urinal, sinks, and shower to the surface. This permits normal water flushing for maximum cleanliness.

3.3 Food Preparation and Eating

For practical reasons, food may consist of the equivalent of the standard Army "C" ration, which includes canned meats, vegetables, powdered milk, etc. Facilities are provided for controlling and dispensing food and for heating soup, coffee, and baby bottles.

The food supply will be highly satisfactory for 14 days and may be made to suffice for a longer period if the effects of detonations necessitate an extended residence in the shelter. A

*Antenna, periscopes, instrumentation, etc., are retractable.

sink is provided in the kitchen area for use in the preparation of meals and for washing utensils and equipment.

The dining and recreation area is furnished with tables and benches, which may also be used for playing games of various kinds. This furniture can be folded to provide additional floor space. The size of the dining area requires a staggered eating schedule, but all occupants can be accommodated within a reasonably short time.

3.4 Sleeping

Bunks for 66 people are provided in the sleeping area. Nine of these bunks are separated from the others by a solid wall, forming an isolation ward. Since the 100 shelter inhabitants will be required to perform duties on a shift basis 24 hr a day, the 66 bunks will provide sufficient sleeping facilities. Bunks are made of fire-resistant canvas stretched over rigid frames, which can be folded to provide additional floor space in an emergency. Only one blanket will be issued to each person since the temperature in the shelter is expected to remain relatively uniform at the comfort level.

3.5 Recreation

A recreation area, which also serves for dining, is provided to maintain morale. Various games can be played, but, since physical exertion would raise the body-heat output and increase the shelter temperature unnecessarily, games should be limited to those requiring little or no physical exertion. Group participation games, cards, reading material, and hobby craft can be utilized to occupy and relax the inhabitants.

3.6 Supply and Storage

Storage areas that can be locked and controlled have been provided for general and accountable supplies. Control of supplies is important since rationing may become necessary. A loft or attic area is provided in one end of the shelter (see Figs. 1 and 2). This area is accessible only from the office and the food-issue room and can be locked. The office and commissary area may also be used for accountable supplies and general storage. Accountable items would include such things as medical package units, drugs, and food.

Two areas are provided in the passageway for storage of nonaccountable items, i.e., excess clothing and rad-safe clothing.

Supplies should be furnished in quantities based on a 100-person occupancy for 14 days, plus a margin for safety.

4. DESIGN

4.1 Criteria For Selection of Materials

Construction materials for the shelter were selected on the basis of economy, availability, and proven performance. The predominant consideration was to make it possible for any public agency or civilian group to obtain protective structures easily and readily at a reasonable price, regardless of location.

In general, materials selected for the interior of the shelter are fire resistant, where practical and reasonable in cost, and nontoxic in nature to reduce personnel hazard.

4.2 Structural Features

The shelter structure is a multiplate corrugated-steel arch set on a concrete slab, a type commonly used for large culverts or other below-ground applications. End walls consist of bridge plate sheathing over a standard steel channel frame, braced to the concrete slab to prevent collapse from earth compression caused by blast pressures on the surface above. An escape hatch, intake- and exhaust-air vents, periscope sleeve, and antenna sleeve are constructed of pipe and are welded to the structure. Interior partitioning and furniture are wood. All plumbing and lighting fixtures are standard low-cost items.

Attached to one end of the structure is a multiplate corrugated-steel pipe large enough in diameter to provide a passageway and a mechanical-equipment room. An access passageway of corrugated-steel pipe is attached at right angles to the main passageway. This access passageway has a stairway to the earth surface, where a blast-resistant door is provided. The entire shelter, including the main passageway and mechanical-equipment room, is buried below the surface. The portion of the access passageway located at the aboveground entrance is mounded over with earth for blast protection. The extent of earth cover is shown in Fig. 3; the room layout and general orientation are shown in Figs. 1 and 2.

4.3 Entrance, Exit, and Interior Doors

The entrance door and exit-hatch cover are designed to be weatherproof and to withstand the effects of a thermonuclear explosion that produces not more than 35 lb/sq in. of blast pressure at the shelter.

The entrance and stairway are designed to allow the safe passage of 100 people into the shelter within a 5-min period. The shelter entrance door, which is quite heavy and opens out, should be kept in an open position to permit ready access when use of the shelter becomes necessary. A weatherproof wood door may be installed to prevent unauthorized entrance at other times.

Interior doors are designed for economy and function. The doors to the mechanical-equipment room and the main passageway entrance are steel to provide fire protection. Toilet-room, shower-room, and office doors are wood to provide privacy or security. All other openings where only semiprivacy is necessary, are provided with inexpensive canvas curtains, treated for fire resistance.

4.4 Ventilation and Air Conditioning

Ventilation and air conditioning of the entire shelter is provided by an automatic system, thermostatically controlled.

Normal operation of the air conditioning system draws 100 per cent fresh air from the outside into the system, conditions it to proper temperature and humidity, and exhausts the used air back to atmosphere. Filters in the fresh-air ducts remove radioactive particles, smoke, and fumes so that pure air is provided. During blast or emergency periods, the intake ducts and exhaust vents can be sealed; at such time the air within the shelter is recirculated. An oxygen bleed system is provided to add oxygen to the air when needed for human consumption during the period when outside air cannot be admitted. The toilet-room exhaust fans are manually controlled, and the exhaust vents have the same provisions for sealing as the main air-conditioning vents. Under extreme emergency conditions the shelter, occupied by 100 persons, can be closed to all outside air for a period of approximately $3\frac{1}{2}$ hr. After this period of time, fresh air must be drawn in to prevent suffocation.

A comparatively simple air-conditioning system that removes carbon dioxide and adds oxygen to the air in the shelter can be provided at additional cost. Such a system would allow complete closure to outside air for a period of approximately 24 hr, thus adapting the shelter to extreme fire-storm conditions. This is recommended where the shelter is built in cities or areas where a conflagration is a possibility.

4.5 Power and Lighting

Normal electric power will be provided by connection to a public utility system. Emergency power will be provided by a gasoline-engine-driven generator. Air intake to, and exhaust gases from, the engine will be conducted through pipes to the outside atmosphere.

The electrical system is designed for safety and practicability. Explosion-proof fixtures and equipment are used in the mechanical-equipment room and in the immediate area of the oxygen bleed system. Otherwise all fixtures and equipment are standard items. Circuits are protected by circuit breakers.

Lighting is provided by both fluorescent and incandescent fixtures, the type selected being the one most suitable for proper illumination of each of the different areas within the shelter. In case of complete power failure and for initial entrance into the shelter, emergency lighting in the form of battery flashlamps is provided. A permanent type battery system would be needed for power and lighting if the shelter were to be adapted to a fire-storm condition, i.e., complete seal-up from outside air for 24 hr.

4.6 Communications, Instrumentations, and Exterior Measurement Stations

Communications between any shelter, which may become isolated, and control centers or other shelters in the area is required. The type of communication system used is dependent upon local conditions. For widely separated shelters located in a rural area, two-way radio would be advisable; whereas, for shelters comparatively close to each other, field telephones would be more economical and practical.

The design of the shelter can accommodate various methods of communication. It includes a retractable antenna for radio communication; no special provisions are required for telephone systems.

Each shelter will be instrumented with a monitoring system for continuous reading of radiation intensity in the aboveground vicinity. The monitoring system consists of five permanently emplaced remote counter units spaced as shown on Fig. 3. Readings at these stations can be observed on the monitor control unit, which is located in the office and connected to each monitor by direct wire. These permanent stations will be supplemented by portable counters and air samplers, which are provided as part of the shelter supplies. These can be used to determine the radiation hazard without leaving the shelter. The portable counters also would be used by the first work parties leaving the shelter.

4.7 Other Features

The shelter provides protective features and facilities to meet general requirements. It is designed to provide a reasonable degree of protection and can be constructed in most areas that have no extreme climatic or subsurface conditions. Its basic design can be modified or expanded to suit specific conditions resulting from location or to provide more conveniences. It can be made more austere, or more elaborate, to suit local requirements and the amount of funds available. At the option of the agency or group planning to construct a group shelter, additional features such as the following might be provided:

1. For fire-storm protection in an area in close proximity to an industrial center with many buildings, a 24-hr complete seal-up of the shelter may be deemed necessary. For this type protection a complete carbon dioxide absorbing unit and oxygen-introduction system should be added to the existing air-conditioning system.
2. In extremely cold climates the addition of a heating system and wall insulation might be necessary.
3. In prime target areas a higher degree of blast-pressure resistance may be necessary.
4. In isolated areas a complete battery system for power may be necessary.
5. In populated or heavy-traffic areas asphalt paving might be provided aboveground for parking or other purposes.
6. In wet areas subsurface drainage and a sump pump may be necessary.

5. SITE CONSIDERATIONS

5.1 Buried vs. Aboveground Shelters

Local ground conditions must be investigated to determine whether the shelter should be build above or below ground. It may be built in one of three ways:

1. Aboveground, completely covered with earth mound.
2. Partially buried, covered with earth mound.
3. Completely buried, covered with earth backfill.

Each of these methods has advantages and disadvantages. The aboveground and partially aboveground shelters are subject to more extreme blast effects and therefore require more earth cover. The below-ground shelters may be affected by ground-water conditions, which, if excessive, would require waterproofing. The most economical shelter would be below ground in ordinary earth (not rock), unless a high water table or saturated earth condition exists. In rock or where a high water table exists, the partially buried or aboveground methods are more acceptable from a cost standpoint. Least acceptable on the basis of cost is the aboveground shelter. This type should be used only where hard rock is close to the surface or where there is an extremely high water table.

5.2 Use of Revetments, Barriers, Etc.

Barriers and revetments can be used for added protection of the various shelters. For example, entrance openings can be provided with barriers to reduce radiation shine and blast pressures on the access passageway. Barriers can be used to reduce thermal and blast effects on aboveground shelters. An example of this would be to locate a shelter on the opposite side of a mountain from the expected blast area, although convenience of access for the occupants must be the motivating consideration.

Revetments can be used to strengthen door-opening areas where doors are vertical and subject to reflected pressures.

5.3 Drainage

It is imperative that proper and complete surface and subsurface drainage be provided to prevent water intrusion into the shelter, even though a shelter may be located in a comparatively dry earth stratum. Because the cost of waterproofing a shelter of this size and type would not ordinarily be warranted, it is important to provide for drainage. This becomes more of a problem with a completely buried shelter, but the problem can be minimized by good site selection and sound construction. However, in all cases and regardless of local soil conditions, concrete floor slabs should be cast on a gravel fill and waterproofed to eliminate saturation and seepage.

A careful study should be made of ground-water statistics before an area is selected for shelter construction to avoid unusual conditions that would unduly increase the cost of the shelter.

6. UTILITIES

Basic utilities for a group shelter consist of (1) water, (2) power, and (3) waste disposal.

6.1 Water System

Water for shelter use should be potable (drinkable) since most of the water used will be for human consumption. A 5000-gal buried storage tank will provide water for all uses. The system is a gravity-flow design with a tank line extending to the earth surface for filling to avoid possible contamination. The tank should *not* be connected to the city water supply; however, during nonemergency occupancy in some localities a convenient piping arrangement permitting direct city-water service might be feasible.

The refrigeration system is equipped with an automatic pump that supplies water under pressure to the condensing unit for additional cooling, if needed. From the condenser the water is returned to the storage tank, where it loses its heat to the surrounding water and earth. Piping between the tank, the shelter, and the surface is designed to withstand some earth displacement without breakage. The water should be slightly over-chlorinated to inhibit algae growth, and the tank should be drained and refilled at intervals by maintenance personnel to keep the water fresh.

6.2 Power

Electric power should be supplied to the shelter by an underground concrete-encased cable from a source that is fairly well protected.

Fuel for the emergency generator will be contained in a 550-gal underground tank located adjacent to the machine room.

6.3 Waste Disposal

All sanitary waste will be removed by a sewage ejector system that is completely automatic, once energized. The ejector system consists of a vented, enclosed system that disposes of waste and prevents the escape of odors. The major components include a collector tank and an ejector pump. Collector lines receive waste from the sinks, shower, urinal, and toilets, and transport them to the collector tank. A float-operated switch starts the ejector pump when the level rises to a predetermined point; the waste material is then pumped to an outfall area above the earth surface. The pump shuts off when the tank is emptied.

Rubbish is stored in the storage area until it becomes possible for working parties to leave the shelter and utilize established disposal areas.

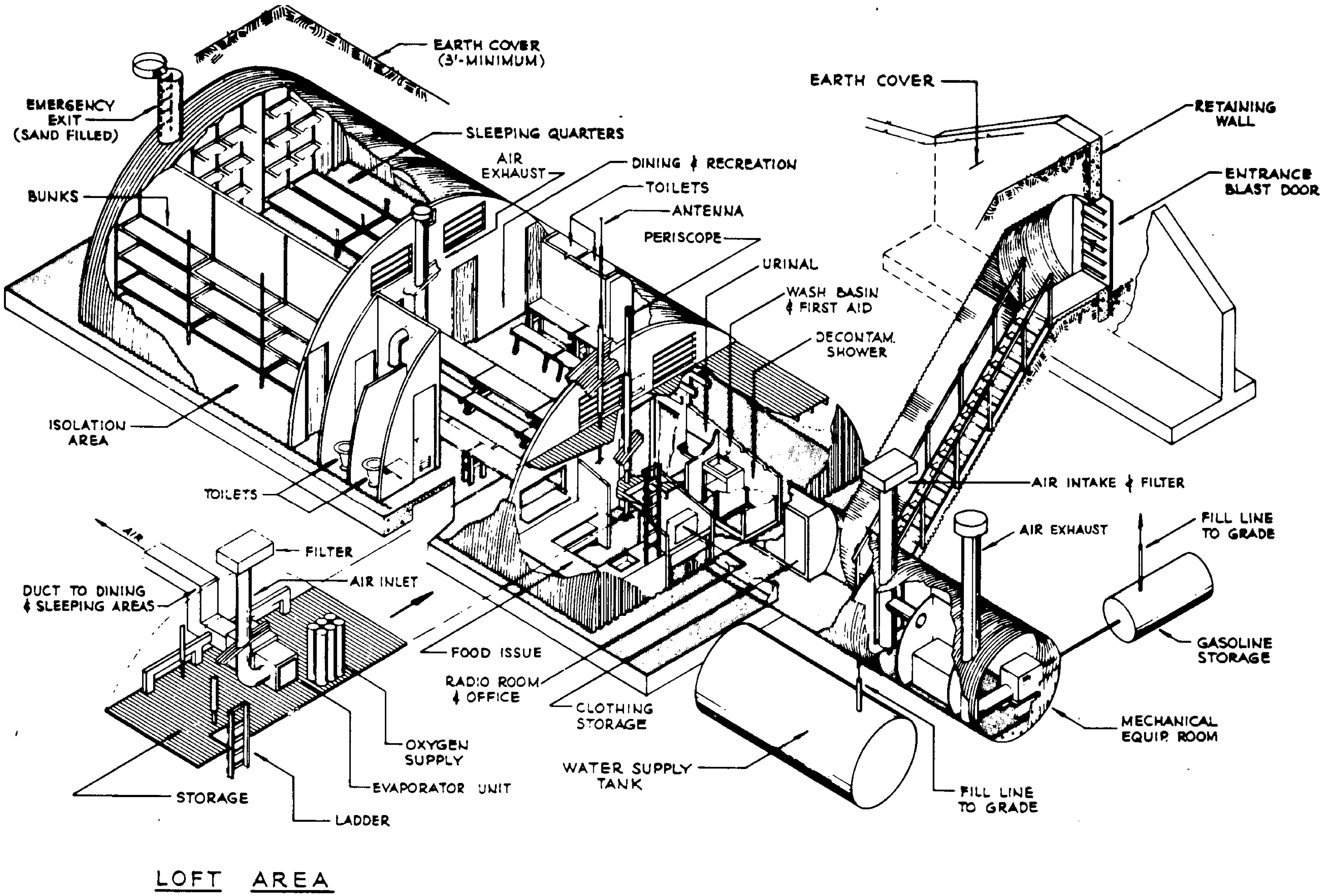


Fig. 1—Cutaway view of group shelter.

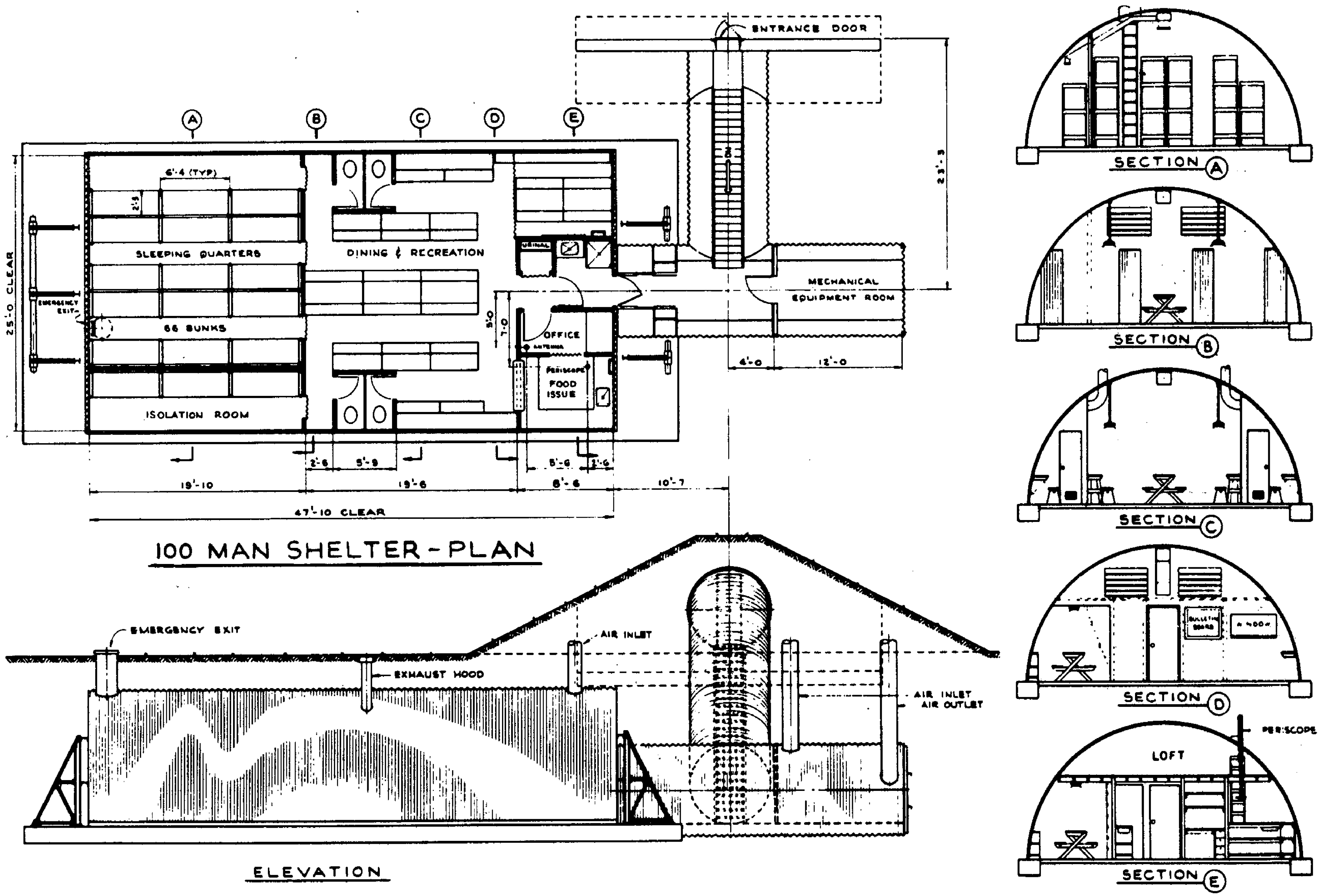


Fig. 2 —Plan and elevation of group shelter.

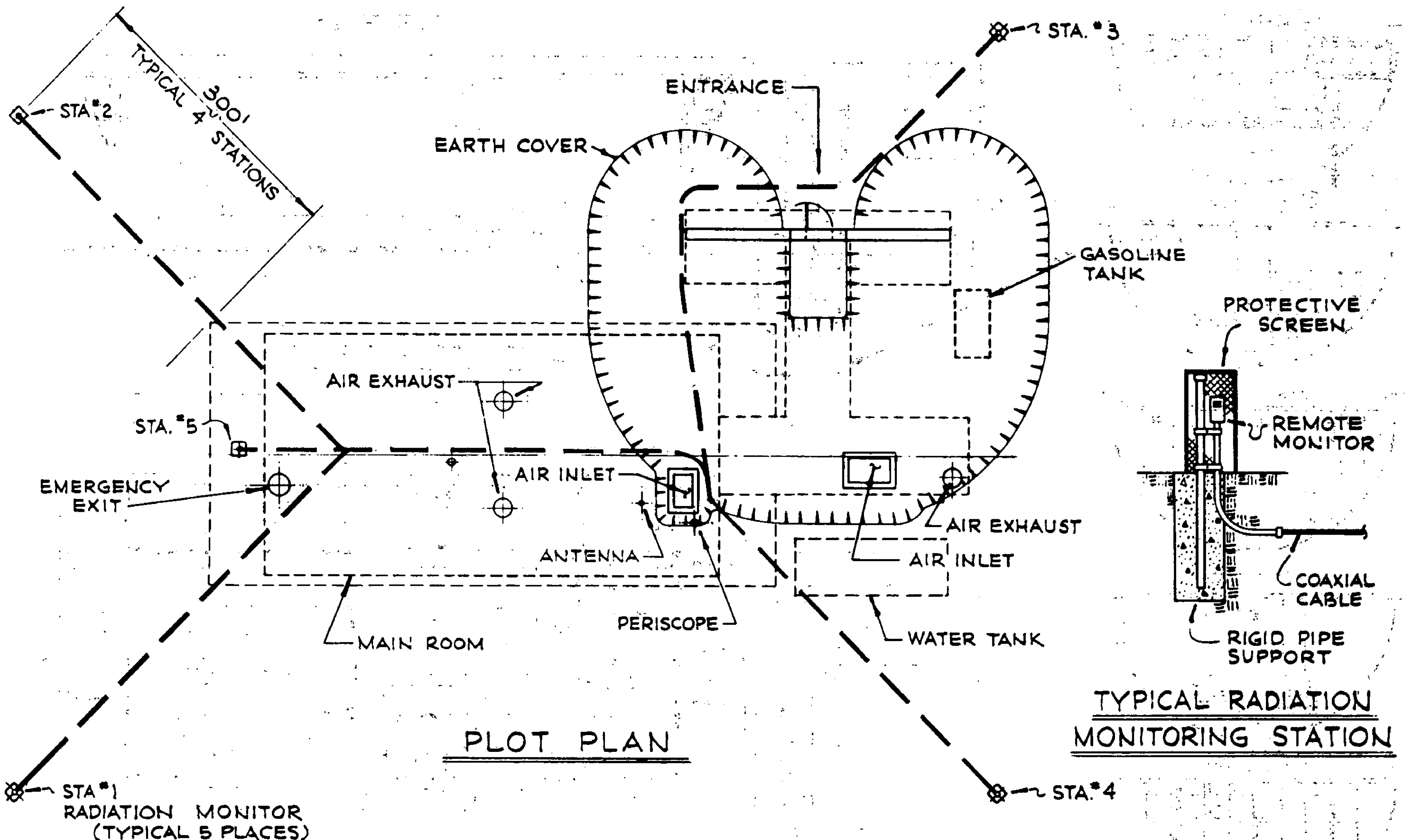


Fig. 3—Plot plan, showing position of monitoring stations.

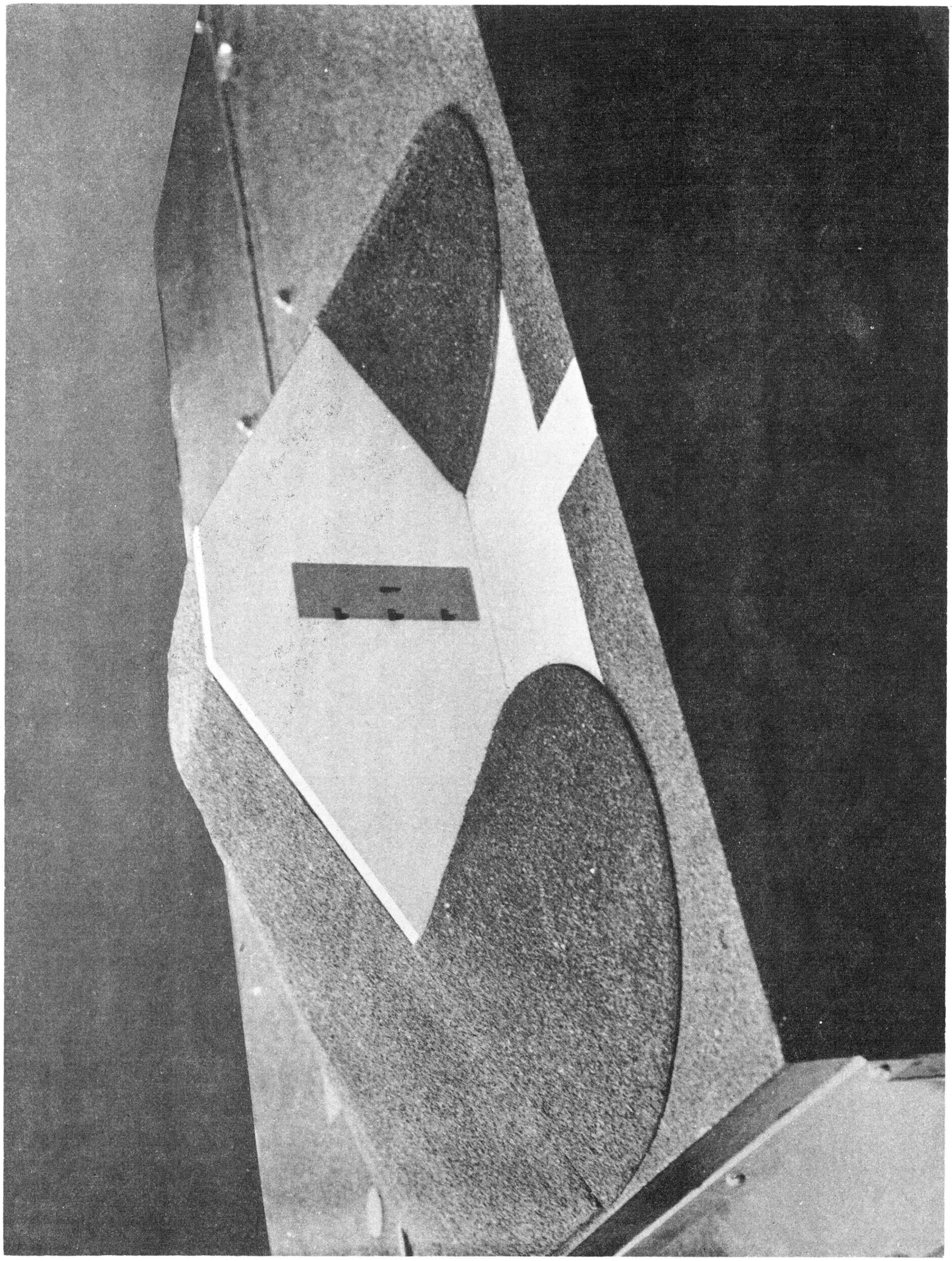


Fig. 4 — Photograph of shelter model, cover in place.

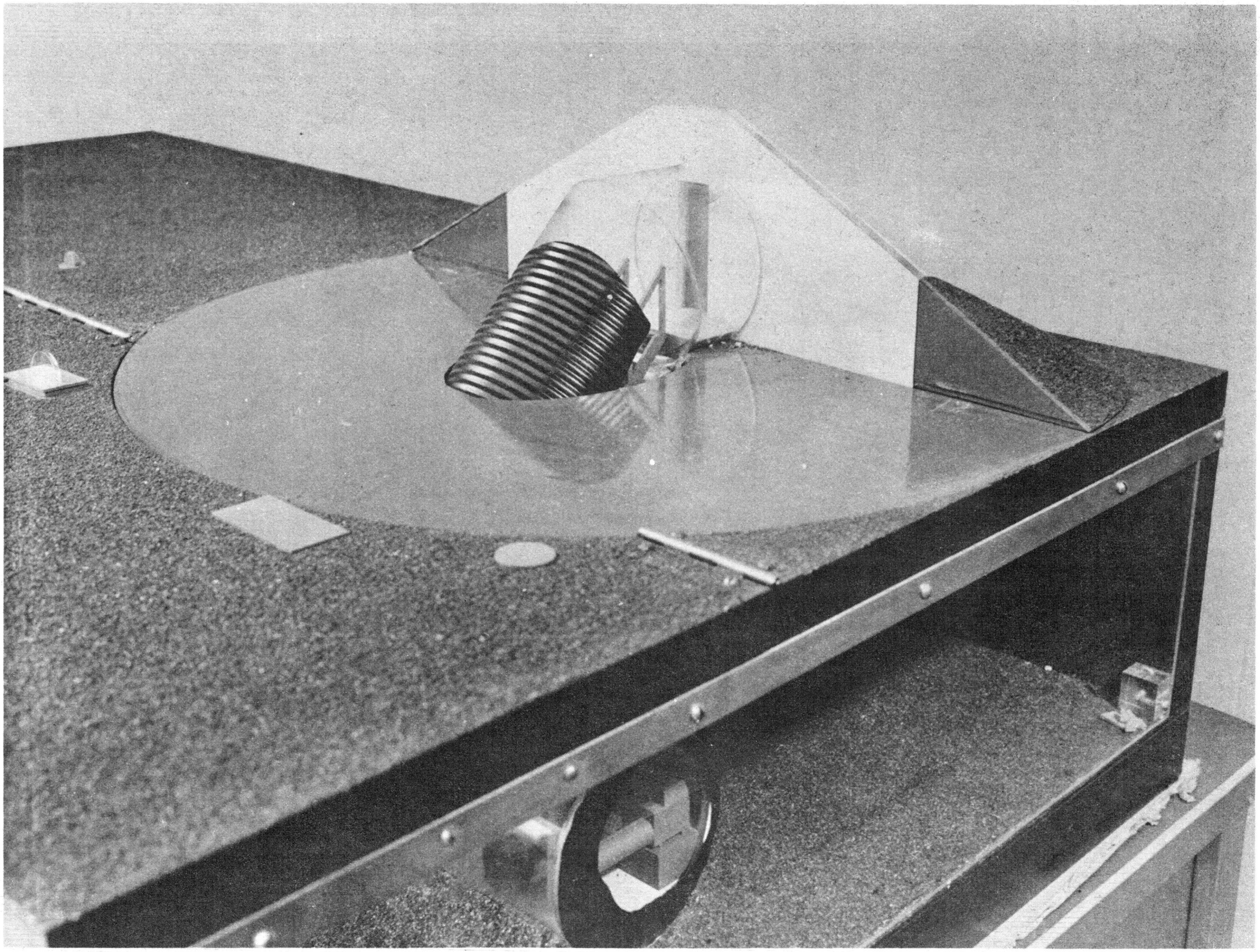


Fig. 5 — Photograph of shelter model, part of cover removed.

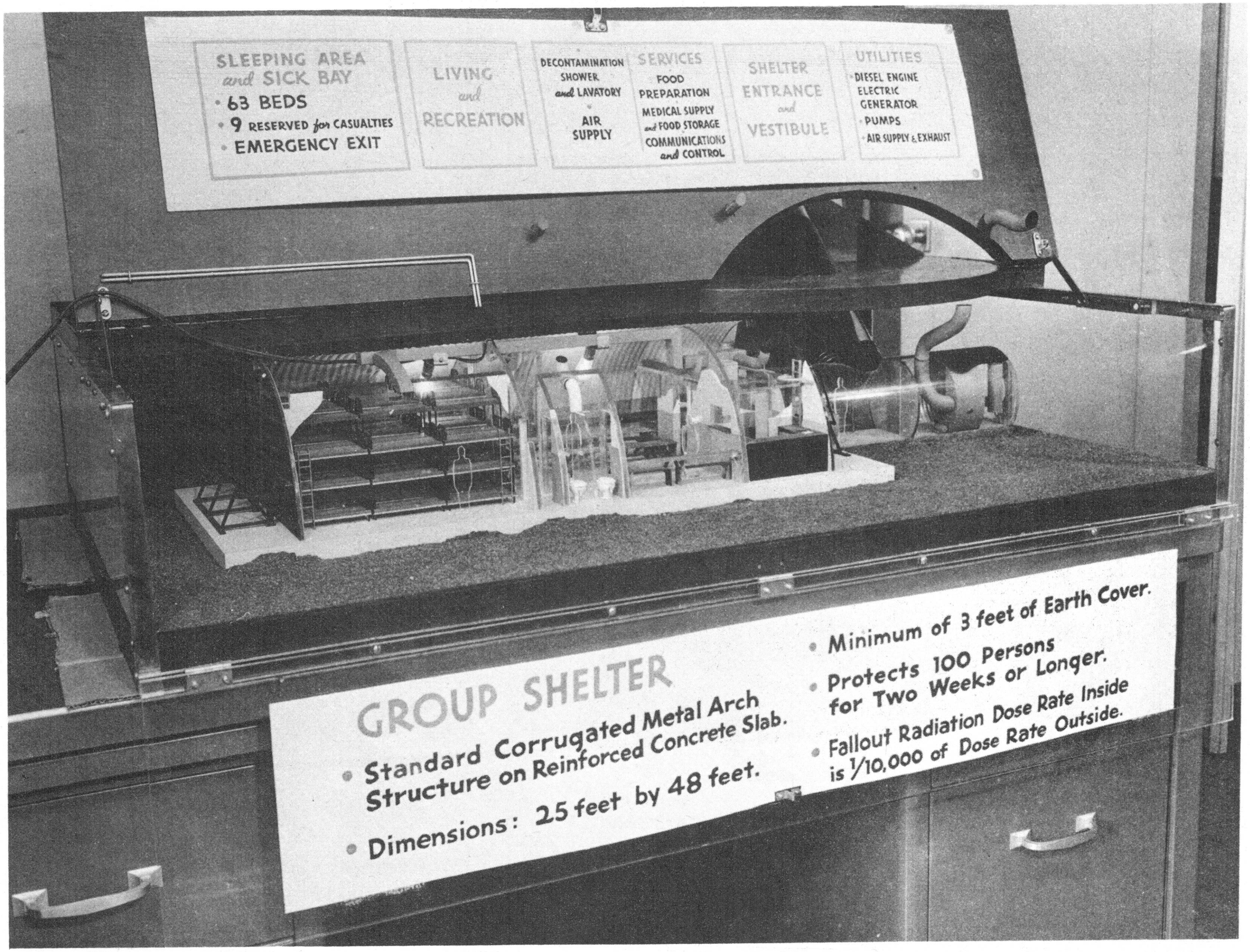


Fig. 6 — Photograph of shelter model, cover removed.

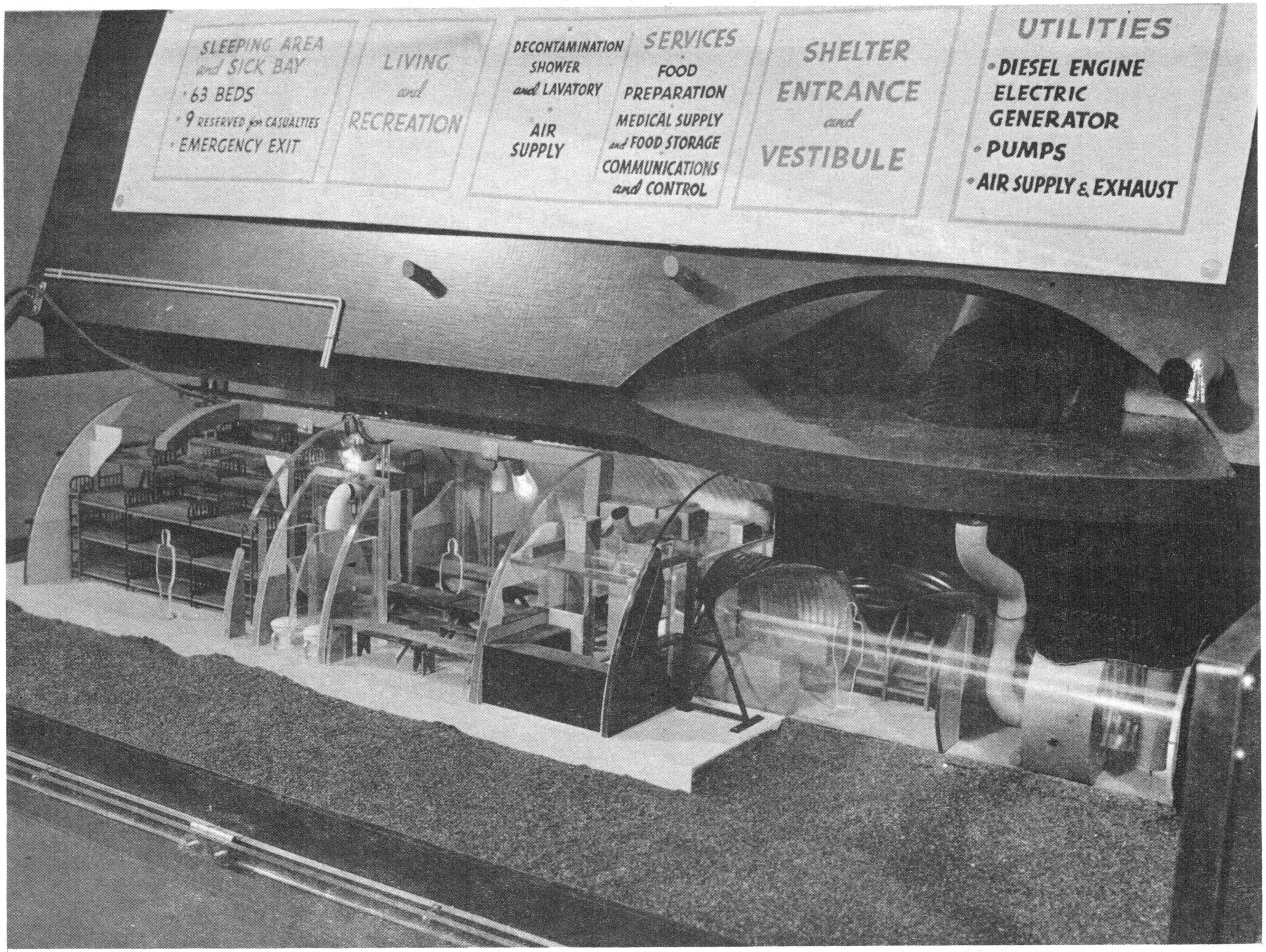


Fig. 7 — Photograph of shelter model, cover removed.

Part II

OPERATING MANUAL

OPERATING MANUAL

1. GENERAL OPERATING PROCEDURE

This is a shelter designed to provide for the protection of 100 persons in the event of a nuclear bomb attack. If the actual number of occupants is greater than this number, the rationing of supplies and the use of equipment will have to be adjusted to suit the larger number, with increased hardship for all. If the number of occupants is less than 100, the situation can be correspondingly eased. The absolute maximum number of personnel that can be sheltered, owing to limitations of the oxygen equipment, is 120. Exceeding this number will result in the risk of suffocation of all occupants.

Immediately upon entering the shelter, the vital services and supplies must be checked:

1. The electric power system in the shelter is connected to the public power system, with an engine-driven generator provided for use in case of public power failure. Upon entering the shelter, turn the main power switch at the entrance to the ON position, and test the lights with the wall switch for the entrance light. If it lights, the power system is still intact and the other lights in the shelter can be turned on at once. *If the lights do not work, see instructions below for starting the engine generator.*
2. A 5000-gal underground water tank, and a 550-gal underground gasoline tank are provided. Level gauges for these tanks are located on the wall in the office; they should be checked at once.
3. Medical supplies, food, and bedding (secured under lock-and-key) are stored in the office, commissary cabinets, and in the overhead loft, which is reached from the office.
4. Oxygen bottles and carbon dioxide absorption equipment are located in the loft over the shower room across from the office. There should be seven full oxygen bottles.

Values of supplies, bearing on condition of occupancy and decisions relating to tolerable environmental criteria, are, in this order:

1. Oxygen: If there is no oxygen and CO_2 equipment, the air in a buttoned-up shelter will be depleted in a few hours.
2. Water: Except in the case of the wounded or the sick, humans can go without water for a day or two before casualties will occur.
3. Food: People in good original health can exist perhaps a week without food, longer in some cases.
4. Fuel: A fuel supply is essential to the operation of the emergency power source. If the public power source escapes unscathed from the attack, there will be no need for the fuel supply. On the other hand, without a fuel supply, there will be no light, no air conditioning, and no means of oxygen dispersal to the occupied area. The lack of lighting or air conditioning might conceivably be tolerable; however, during a 24-hr button-up period, there is a strong possibility that atmospheric conditions in the shelter will eventually exceed the endurance limit of human beings and cause some casualties. Existence for a two-week period without any light might be possible, but it would be extremely difficult. Oxygen dispersal is a more serious matter; during the button-up period, oxygen must be added to the air as a prime requirement. Without power to

drive the ventilating fan, there must be some means of dispersing the oxygen through the living space. If ventilating equipment cannot be operated, the oxygen bottles should be moved from the loft to various dispersal locations in the shelter.

It is anticipated that during a nuclear attack the shelter must provide protection against two phases of hazard: (1) the initial blast, intense radiation, and firestorm and (2) the waiting period for the fallout to decay. The shelter is designed to permit complete closure to the outside for a period of 24 hr, and supplies are sufficient for a subsequent waiting period up to two weeks. For this to be possible, however, the occupants must submit to some degree of regimentation, and a group leader must be selected who will have complete authority over the operation of equipment and rationing of supplies.

As the people are admitted and the living community is organized, the group leader should consider the following sociological aspects affecting human behavior which may require action.

1. Weapons: During an extended period of living under the difficult conditions unavoidably present, there are likely to be psychological upsets among the occupants. Possession of weapons of any sort could be dangerous and perhaps disastrous.
2. Beverages: Alcoholic beverages under some conditions are perhaps beneficial and unobjectionable. In the circumstances of living in close confines, care would certainly have to be exercised in the dispensing of alcoholic beverages. Even nonalcoholic beverages present a problem because of limited storage space. Acceptability and control methods should be established at the outset.
3. Matches and smoking: Again, the regulation of these items may depend in large degree upon the composition of the community. It is pointed out, however, that for reasons discussed below there is no fire-fighting equipment included among the shelter provisions, and the fire hazard must be given serious consideration.
4. Money and valuables: People entering the shelter can be expected to have brought whatever of their money and valuables they could salvage. Locked storages are provided in the shelter for use at the group leader's discretion.

2. GENERATOR START-UP PROCEDURE

It is desirable to draw on the public power supply as long as possible; therefore, the generator should not be used until the public supply fails. Since this may come without warning, a battery-operated automatic light is furnished in the office area and another in the recreation area. These will serve until the generator can be started.

After checking, if there is no light, return the main switch to the OFF position and proceed to start the emergency system as follows (a flashlight may be used for working light until the generator is operating):

1. The engine room is at the bottom of the stairs, left. The generator set is at the back wall of the engine room.
2. Open the valve in the gasoline line from the tank to the engine.
3. Set the transfer switch (on the wall in the office) in the UTILITY position.
4. Be sure all switches on the panel in the office are in the OFF position, except switch No. 1, "Lights-Entrance and Machine Room" which should be ON.
5. Open the air supply and exhaust vents in the engine room by hand crank.*
6. Prime the carburetor with the hand lever on the fuel pump, close the choke, and turn the engine over by hand a few times to draw gasoline into the cylinders.
7. Open the choke part way, and spin the engine over. When it starts, ease the choke open until the engine is running smoothly on open choke: *Note: If the engine does not start,*

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*These vents can be left open during the attack without danger to the shelter occupants. However, should such be the case, it must be borne in mind that the engine room and contents may be rendered radioactive, and subsequent maintenance work may be dangerous.

check the ignition and fuel systems as shown in the instruction manual attached to the generating units. When systems are in proper condition, repeat items 6 and 7, above.

8. Reset the transfer switch to the GENERATOR position. This should put power on all circuits in the shelter, and the panel board in the office becomes operative.

3. BUTTON-UP PROCEDURE

When the full complement of shelter occupants has been admitted, the outside blast door must be closed and *locked* by a simple turn of the lock handle in the direction indicated. This is the first line of defense against blast and radiation; *failure to lock the door could be disastrous.*

In the second step of preparation, two items should be undertaken simultaneously, one group should be assigned to close outside openings; and a second group, to start the engine generator if it is not already in operation. Start-up procedure for the generator has already been described.

The following openings to the outside must be checked and closed:

1. Toilet-room exhausts (2). Lower by hand crank.
2. Sewage ejector pipe (1). Close valve in vertical pipe in center of building just inside sleeping quarters.
3. Sewer vent pipe (1). Close valve in vertical pipe in center of building just inside sleeping quarters.
4. Air-conditioning intake (1). Located in the loft over the office entrance; lower by hand crank.
5. Retract radio antenna in office and periscope in commissary.

The engine-room supply and exhaust ventilators must be left *open* if the generator is in operation.

For safeguarding and maintaining the breathing qualities of the air in the shelter, an oxygen system and carbon dioxide absorption material are provided. On the wall of the living space is the Oxygen Deficiency meter containing a small lamp, which *must* be lighted when the shelter is occupied, and adjusted to burn with a steady flame. The CO_2 absorption material is in drums in the loft above the office. Using the drum covers as pannikins, this material should be exposed liberally in thin layers throughout the living area and replenished as required. Unless the build-up of CO_2 in the atmosphere is controlled, the occupants will suffer from excessive water accumulation in the lungs and may actually suffocate.

With all outside openings closed, the engine-room door is closed and locked, and the underground entrance door to the shelter is closed and locked.

The shelter is now operable to withstand adverse conditions.

4. DURING ATTACK

Advice concerning the progress of the attack, general area instructions, and information can be received over the radio in the office. The simple operating instructions for the radio will be found on the instrument.

For operating the mechanical equipment during the button-up period and subsequently, it may be necessary for a person to cross the entrance area to the equipment room. In this event, he should first put on rad-safe clothing and survey the passage with detection equipment. Experience has shown that under some circumstances this area can be at least temporarily radiologically unsafe. If unsafe radiation levels are found, he must follow rad-safe procedures of protection and decontamination. (See below for protection, survey, and decontamination instructions.)

Previous instructions called for starting the emergency generator as a part of the buttoning-up operation. This is a precautionary measure so that in the event of a public power failure during the attack the generator will not have to be started in total darkness. If, after radio information indicates the attack has passed and the public power supply is found still operative, the emergency generator can be shut off. Availability of public power can be tested by switching the main switch in the office from GENERATOR to UTILITY and observing the result.

4.1 Air Conditioning

During the button-up period, the temperature and humidity of the atmosphere will increase. Keeping the people calm and physically at rest as much as possible will reduce the rate of temperature rise, but the air will inevitably become oppressive. When the room air temperature indicated by the thermostat in the living space on the wall next to the office goes above 85°, the air-conditioning equipment must be started.

To put the air conditioning equipment in operation, first make sure that the switches on the panel in the office, labelled "Supply Fan," "A-C Water Pump," and "A-C Compressor" are turned to ON, and that the air intake to the condenser in the engine room is open. Then proceed to the individual push buttons on the opposite wall of the office and push all three to START, the sequence of starting is not important. This will start all the mechanical equipment. Then check the room thermostat and set the control point at 85°. Proceed to the damper in the duct work in the loft back of the fan and set the damper to 100% RETURN AIR.

In the event the equipment fails to operate, recourse must be had to the manufacturer's detailed instructions filed in the office. If the air-conditioning equipment is not operated, the condition in the shelter will go beyond the limit of human endurance and may result in some casualties before it becomes radiologically safe to open the shelter to outside ventilation.

4.2 Oxygen

After about the sixth hour of complete closure with 100 occupants, the oxygen supply will become seriously depleted, and corrective steps must be taken.

The oxygen content of the air in the living space is indicated by the small lamp in the Oxygen Deficiency meter on the wall. This lamp must be observed periodically during the period of button-up. When the flame begins to die down (approximately 6 hr after button-up with 100 occupants), feeding of oxygen to the space must be begun from the tanks in the loft. The seven tanks are manifolded into a single outlet header, which, in turn, is controlled by a pressure regulator and a demand regulator. The pressure regulator has two gauges above it and a handle in the middle. The needle of the gauge reading the high number (about 2000) indicates the pressure of the oxygen supply remaining in the tanks (2200 lb when full). The other gauge, which reads from 0 to 150, shows the pressure of the oxygen being delivered from the tanks; this can be changed by screwing the center handle, turning this handle clockwise increases the pressure. This needle should be set at about 10 lb/sq in. The demand regulator is set by adjusting the control handle provided; it controls the rate of supply of oxygen at a fixed rate. Adjustment of this feed rate is a cut-and-try proposition requiring judgment and observation by the operator, i.e., try a valve setting and observe the result. If the meter flame picks up markedly and the occupants begin to show signs of exhilaration, the feed rate is too high. If the flame does not return to normal condition, the feed rate is too slow. Enough time should be allowed after each valve setting (3 or 4 min) for the oxygen change to become effective. When once set properly, the valve is automatic, and the only requirement is an occasional check-reading of the deficiency meter in the living space to be sure it does not indicate a waning oxygen supply.

4.3 Water and Sanitary Facilities

The entire water supply is contained in the 5000-gal tank. This supply must serve for drinking, washing, toilets, decontamination shower, and possibly for the air-conditioning equipment if outside weather is hot. Simple calculation shows that if the supply is to last 14 days for 100 people, the average use for all purposes cannot exceed $3\frac{1}{2}$ gal per person per day. A primary responsibility of the group leader is to see that this ration is not exceeded under any provocation; the penalty of failure is extreme and irrevocable. A ration of 1 gal per person per day for drinking will maintain reasonable personal comfort. Use for toilet flushing is the greatest single source of waste. Civilized sensibilities and morale of the people require that some water be used for this purpose. No means of regulating this use is provided, but strong admonition should be delivered to the occupants to use it sparingly, with a statement of the inevitable outcome of wasteful practices. Use for decontamination and personal cleanliness cannot be prescribed in advance but must depend on circumstances and the status of the water supply remaining.

The water supply that might be required for the air-conditioning system need not be of primary concern. Its most likely need will be during the button-up period when water is still adequate, and water thus used is returned to the tank and does not represent any actual diminishing of the total supply.

4.4 Food and Food Preparation

Food supplies have been stored in the commissary and in the loft area under lock and key to permit rationing control by the group leader. Supplies are sufficient to maintain 100 people in reasonable comfort for a period of 14 days. Provisions have been made in the commissary back of the office for infant feeding and for providing all occupants with one hot meal per day. Instructions in this bulletin cannot replace the judgment and ingenuity of the group leader in this department. Eating facilities have been provided based on group feeding in staggered schedules. As in the case of the water supply, the total store is adequate but not luxurious. Appetites may have to be curbed and rationing imposed, although the consequences of mismanagement in this instance are not so drastic.

4.5 Food Wastes and Contaminated Trash

Disposal of food wastes, contaminated clothing, and general trash is to be accomplished through use of the plastic bags provided for that purpose and stored in the cabinets in the passage to the engine room. Ultimate disposal outside the shelter cannot be accomplished until after the shelter is evacuated, and for that reason secure wrapping is recommended to reduce odor.

4.6 Bedding

A total of 66 beds is provided; 9 are isolated from the general area by a full-height partition. These are intended to be used, in case of need, for isolation of communicable diseases or for seriously wounded occupants. The balance of 57 spaces is expected to be used in shifts by the shelter occupants. Only one blanket per space is provided since the shelter atmosphere is expected to be generally warm and protection from cold is not a problem. If the shelter is in a cold area and experience and tests demonstrate the need for more blankets, they must, of course, be provided.

4.7 Medical Supplies

The first aid kit is stored under lock and key in the office to be administered by the group leader or his appointee. As the name implies, this is intended for first aid only, to care for minor wounds, and to alleviate the normal minor illnesses of a group of 100 people.

4.8 Fire Protection

No provision has been made, as such, for extinguishing fire in the furnishings of the shelter. All construction and furnishings have been made fire resistant, and sources of fire due to equipment have been eliminated. Fire can result only from personal carelessness of the occupants and only among their effects. Should such a fire occur, the only recourse is to smother it, beat it out, or use the precious water supply as sparingly as possible to extinguish it. Provision of chemical extinguishers would have presented a greater hazard than the fire owing to the toxic chemical products evolved during their use.

4.9 Periscope

A retractable periscope is provided in the commissary for visual observation of outside conditions. During the periods when attacks are imminent, the periscope must be used with caution. It will be damaged if not in the retracted position at the time the blast arrives.

4.10 Communications

All shelters are provided with two-way radio; in some cases, telephone communication is provided. Where phones are installed and they survive the attack, the phone will be the prime source of information pertinent to the occupants of the shelter. In all other cases, radio is the sole connection with the outside world. A retractable antenna in the office serves the radio and must be retracted during attack to prevent damage. To use the radio, you must run up the antenna and follow the instructions provided with the radio instrument to establish radio communication.

4.11 Rad-Safe Equipment

A permanent remote area-monitoring system is installed, with the instrument in the office. Instructions for operation are with the instrument. This unit will maintain a continuing survey of radiological conditions aboveground in the immediate shelter area and will indicate when conditions are safe for relaxing the buttoned-up condition and using outside air for ventilation. In those cases where all outside communications have broken down, this equipment will also have to serve as a basis for the decision of when to emerge from the shelter.

Supplementing the monitoring system, there is provided in the office a portable radiation scanning device. This unit is to be used for scanning the passage to the engine room, as required during the period of underground living, and for surveying conditions outside the shelter when the decision is being considered to evacuate the shelter. Instructions for use of the instrument are included in the case.

For the protection of reconnaissance or working parties that go outside, the radiological safety equipment includes personnel dosimeters (and a charger) for measuring the accumulated radiation doses and hand-carried meters for measuring dose rates. If there is sufficient time for last-minute preparations before occupying the shelter, it is to be expected that the rad-safe equipment in the shelter would be supplemented by instruments brought by the inhabitants, such as combination radio-radiation detection instruments that are the personal property of the occupants.

Disposable clothing is stored in the cabinets outside the office. On each occasion before venturing into possibly contaminated areas, it should be put on, and, if contamination is encountered in *any* degree, it should be taken off before reentering the shelter living area and disposed of in the plastic bags mentioned under "Wastes" above.

5. TERMINATION OF BUTTON-UP PROCEDURE

When the need for button-up status has passed, as advised over the communications system by an outside authority or, in extreme cases, as decided by the group leader on the basis of information derived from the equipment available, changes can be made, principally in the ventilating system, to improve comfort conditions within the shelter. The following steps should be undertaken, approximately in the order given here, although the exact sequence is not of vital importance.

1. Toilet ventilation: Toilet ventilation by positive exhaust equipment can be started. The toilet exhaust vents should be lifted to extreme high position by means of the hand cranks provided, and the ventilating exhaust fans started by turning on the two switches in the office, labelled Toilet Exhaust Fan.
2. Sewage ejector: The sewage ejector can be put into automatic operation to remove accumulated sewage. Open the handwheel valve in the horizontal sewage pipe and the lever valve in the vertical vent pipe, both located in the center of the building in the

sleeping quarters. After the valves have been opened, the pump can be started by turning on the switch on the office panel labelled Pump and pressing the start button on the opposite wall of the office labelled "Sump Pump." Operation of the ejector pump will thereafter be automatic, and it will require no further attention.

3. Oxygen feed system: The oxygen feed system can be turned off. The pressure-regulating handle should be turned to bring the needle to zero pressure, and, in addition, the individual valves at the top of each tank should be turned off to eliminate the unnecessary hazard of possible oxygen leaks.
4. Air-conditioning system: The air-conditioning system can be put on outside air. Outside air for the main shelter area can be provided by raising the main air-intake vent, accessible from the loft, and resetting the return-air damper at the foot of this vent in the ductwork to 100% OUTSIDE AIR.

   When the old air in the shelter has been fully exchanged for outside air (in a half-hour or so), the air damper should be reset to about 80% OUTSIDE AIR. This will provide adequate ventilation and reduce the cooling load on the air-conditioning equipment. Any time that the outdoor air temperature drops to 70° or below (as indicated by the air-temperature thermometer on the office wall), the air-conditioning equipment can be shut down entirely, except for the supply fan, which will continue to cool the space with outdoor air.

When these steps have been taken, the shelter is secured for normal living for the duration of the underground requirement. Personal comfort should be greatly improved by the increased ventilation, and there should be marked improvement in morale. However, the need for rationing of water and other supplies has not been diminished, and precautions should be taken against a wholesale let down of discipline in this respect. The natural impulse of the occupants to rush outside to freedom with the first relaxation of restriction should also be guarded against since there is every expectation that at this point after an attack the level of outside radiation, unseen and unseeable, will be highly lethal.

Instructions to evacuate the shelter will normally issue from an authoritative source via the communications system. In isolated sites or where there has been a communications breakdown, the decision will necessarily devolve upon the group leader.

When the time comes to leave the shelter, it may be discovered that the main entrance is blocked or otherwise unusable. To provide for this contingency, there is an emergency escape hatch through the roof at the back end of the sleeping quarters. It is reached by the ladder up the wall. The hatch is filled with sand, which should be spilled on the floor below. The hinged steel-plate cover is heavy but not more than one man can lift. It can be released by unfastening the simple hasp on the wall.