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## OPERATION OF THE CRREL PROTOTYPE AIR TRANSPORTABLE SHELTER

Stephen N. Flanders

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report describes the operation of the CRREL prototype air-transportable shelter which was designed specifically for use in cold regions. The operating instructions cover moving the shelter on its own wheels or skis, loading it onto a truck or military transport aircraft, slinging it from a helicopter or preparing it for shipment as an ISO container. The report details how to site the shelter and expand it to about double its transport size. The report also covers operation of the utility systems, including the on-board alternator set, the primary and auxiliary heating systems, the water system, and various safety systems.		



## PREFACE

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OPERATION OF THE CRREL PROTOTYPE  
AIR TRANSPORTABLE SHELTER

by  
Stephen N. Flanders

SECTION 1: INTRODUCTION

1.1 PURPOSE OF SHELTER

The U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) has designed an air transportable shelter that can house four to six people in extremely cold environments.

The shelter has the following features:

- (1) It efficiently provides heat, water, and electrical power.
- (2) It accommodates cooking, sleeping, eating, desk work, and storage.
- (3) It has an auxiliary tent that creates a protected entrance/work space on the porch and ample bivouac or storage space on the roof.
- (4) It can be transported by air, land, or sea and loaded without special equipment.
- (5) A crew of 2 to 6 wearing cold dry uniforms can rapidly expand or strike the shelter. Expanded, the hardwall portion has about double the floor area of the shelter in the transportation mode.
- (6) The shelter can provide the most important functions in (1) and (2) without expansion.

1.2 DESCRIPTION OF SHELTER

The shelter is a 6,000-lb box that serves as its own container during shipping and expands to provide additional area when occupied. An optional tent covers the expanded unit. Fully equipped, the shelter weighs 10,000 lb.

In the shipping mode the shelter is designed to conform with ISO air/sea/land container requirements for size (about 8 x 8 x 20 ft), fittings and strength. The shelter has a flat, reinforced underside that allows air transport by military 463L cargo handling systems without benefit of pallets (see Figure 1.2.1).



Figure 1.2.1. The shelter in shipping configuration being loaded into a USAF C-130. Legs mount wheels or skis to permit mobility to and from nearby sites. These legs are removed for transport.

The basic container becomes a shelter when a hinged porch panel swings down to provide access to the front door. All the essential facilities (power, heat, kitchen, and bunk room) are available in the 128-ft<sup>2</sup> core module. The shelter expands to an area of 265 ft<sup>2</sup> in two stages. First, the roof and three walls extend out from the core module as a rigid structural unit. A floor then swings down inside the extended unit to form 137 ft<sup>2</sup> of additional space (see Figure 1.2.2).

A nylon tent covers the entire expanded shelter, protecting the building, creating an "arctic entrance" through the porch, and permitting the 15 x 20-ft roof area to be used for storage or bivouac space (see Figure 1.2.3).

The shelter has removable, adjustable legs that elevate the building to help prevent snow drift accumulation. These legs permit a crew to load or unload the shelter on military aircraft and vehicles without special equipment. The legs can be mounted on skis or wheels to permit slow towing for short distances.



Figure 1.2.2. The expanded shelter. Roof, sidewall, and end walls roll back to the left as a rigid structural unit. The porch swings down to reveal the front door and engine compartment access (behind the step ladder). A frame supports the tent.



Figure 1.2.3. Tent over the shelter provides an "arctic entrance" and ample storage space.

The shelter roofs, walls and floors are foam core plywood panels. Aluminum, steel, and fiber-reinforced plastic (FRP) provide additional strength in areas subjected to additional loads during shipping.

The fixed portion of the shelter (see Fig. 1.2.4) contains a kitchen, a bunk room for four persons, a toilet, closets, an engine, and utility and snow melt compartments. There is a main entrance as well as an emergency exit from the bunk room.

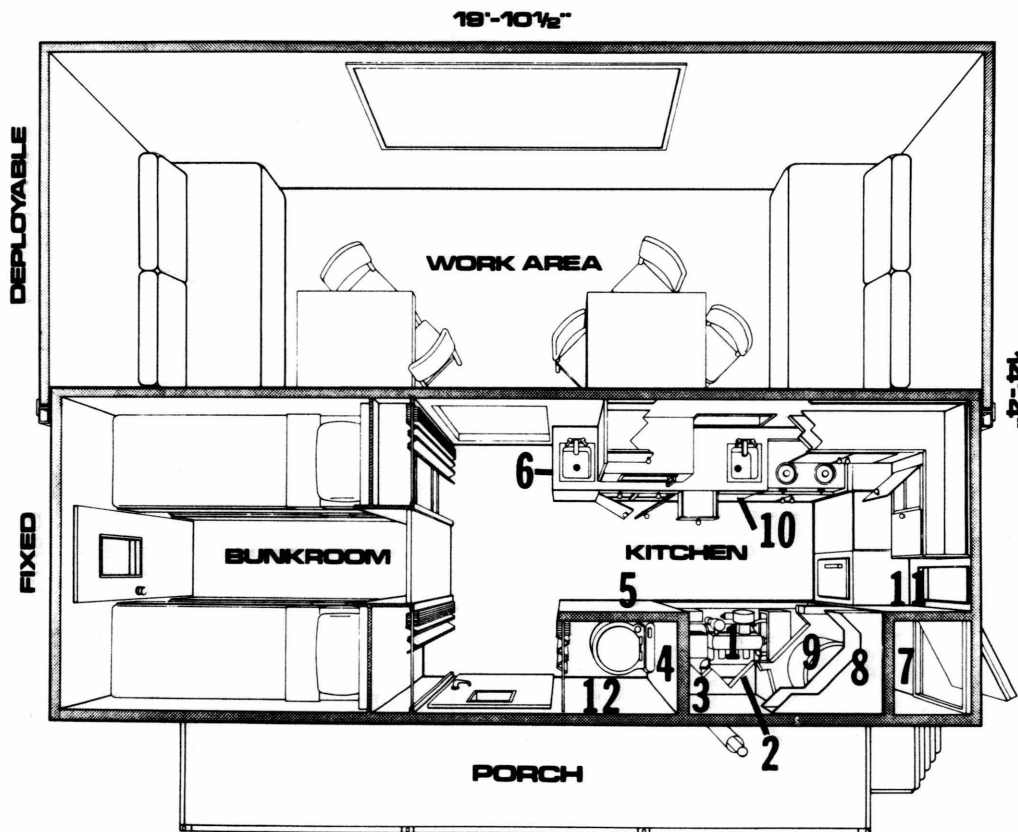


Figure 1.2.4. Equipment location.

- |                                  |                             |
|----------------------------------|-----------------------------|
| 1. Alternator                    | 7. Snowmelt/holding tank    |
| 2. Auxiliary heater              | 8. Gravity tank             |
| 3. Battery charger               | 9. Water heater             |
| 4. Electrical distribution panel | 10. Wastewater holding tank |
| 5. Remote start panel            | 11. Drinking water filter   |
| 6. Fan-coil space heater         | 12. Safety systems          |



An 8-kW liquid-cooled alternator set driven by a four cylinder gasoline engine provides heat and power. The power is single phase 125-250 V a. c.

Waste heat from the engine is used in a number of ways. Engine coolant from the block and exhaust manifold circulates through a heat exchanger located in the central part of the building. A blower forces warmed air through a distribution network. Waste engine heat is also used to heat water and melt snow.

The generator should run only at times of peak activity to provide direct electricity and to charge the 12-V d.c. batteries. The batteries power the 12-V lighting system, an auxiliary gasoline fired heater, and a carbon monoxide monitoring and alarm system.

Safety systems include an automatic 12-V d.c. fire extinguishing system for the engine and heater compartments and a heat/smoke alarm.

The shelter has a waterproof receptacle outside on the porch that will accept 250-V a.c. 20-A line service. All receptacles inside and outside the shelter are ground-fault interrupted (GFI), except as labeled.

Two kinds of fasteners, bolts and locking pins, connect parts after reconfiguration. Bolts are interchangeable, 1/2 in. coarse thread (13 threads/in.) and 1-1/2 in. long under the hex head. They are compatible with a 3/4-in. socket. A supply of stainless steel bolts comes with the shelter, but any machine shop or maintenance facility should be able to supply an equivalent bolt.

The locking pins have a 1/2-in. shank but are of varying lengths. A button on the handle releases a pair of steel balls in the tip that hold the pin in its hole. Because of their varying length and because of their expense, cable lanyards secure the locking pins near their intended place of use.

Figure 1.2.5 shows the standard bolt and a typical locking pin. A special apron stows bolts under the tool rack shown in Figure 1.2.6 when the bolts are not installed on the building.

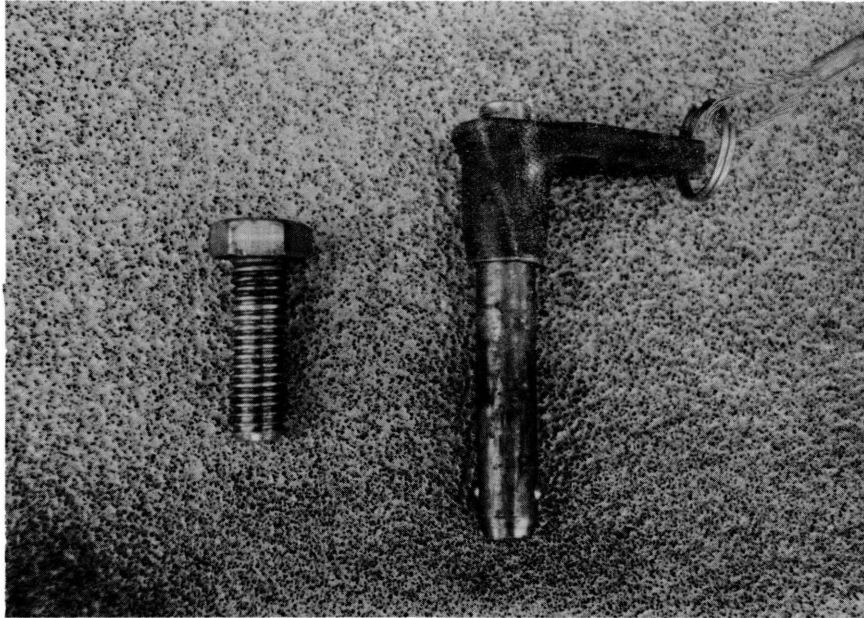


Figure 1.2.5. Typical field fasteners: a  $\frac{1}{2}$ -in. - 13 threads/in. bolt and a  $\frac{1}{2}$ -in. locking pin.

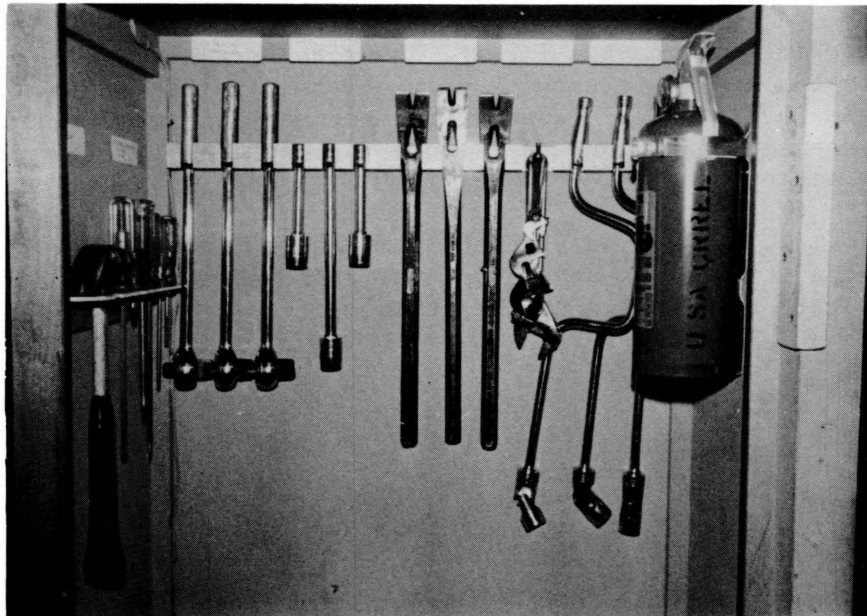


Figure 1.2.6. Tools are stowed on a special rack. Bolts are stowed beneath in the pockets of an apron (not pictured).

## SECTION 2: MOBILITY

### 2.1 MOBILITY CAPABILITIES

The CRREL shelter can be transported by air, sea, or land in its closed 8 x 8 x 20 ft container configuration. It loads on C-130 military transport aircraft without pallets and without special loading equipment. It follows ISO standards for 20-ft shipping containers so that it can be stacked with other modules on a container ship or travel on other ISO-adapted conveyances. It loads on a "low-boy" flatbed truck without crane or forklift. Skis or wheels, depending on ground cover, permit towing the shelter short distances at slow speeds.

### 2.2 MOBILITY HARDWARE

#### 2.2.1 Description of Mobility Hardware

Special structural elements and mechanical devices make the shelter self-reliant. The underside of the shelter is smooth and specially reinforced to permit loading on 463L aircraft roller systems. Each corner is reinforced by a column designed for a 100,800-lb vertical load. A forged steel ISO fitting at the top and the bottom of each column makes the shelter compatible with other ISO shipping containers.

The legs have two mobility functions: they mount skis and wheels for towing the shelter and they telescope to adjust the height of the shelter to the bed of a truck or aircraft. A towing assembly that mounts on either end of the shelter steers the wheels or skis via steering rods attached to the legs.

#### 2.2.2 Removal/Installation of Legs

During installation and removal of the legs, the shelter must rest on some intermediate support such as the bed of an aircraft or a truck or the auxiliary jack supplied with the shelter. The adjustable main legs each connect to a diagonal strut, a diagonal cable (both attached to the leg) and a cross-beam. The legs and diagonal struts attach to the shelter with seven standard bolts per leg.

##### 2.2.2.1. Removing the Legs

To remove each pair of legs, loosen the turnbuckles on the cross-cables, remove the locking pins on the cable yokes (shown in Fig. 2.2.1), remove the yokes, and restore the pins in the yoke. If the towing assembly is attached, remove it according to paragraph 2.3.1.2.

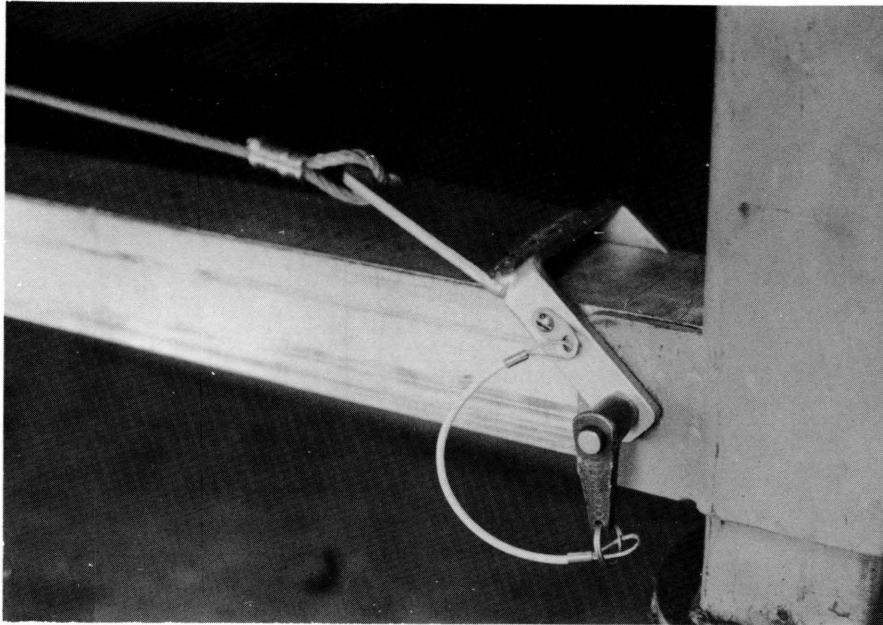


Figure 2.2.1. A pin secures the cross-cables and cross-beams to the legs.

To help support the leg's weight while removing it, adjust the leg by inserting a 3/4-in. drive in the end of the adjustment shaft (shown in Fig. 2.2.2) and turning it so the jack leg rests on the ground. Remove the four bolts holding each leg and the three holding each diagonal strut (see Fig. 2.2.2). Replace the bolts in the apron pocket.

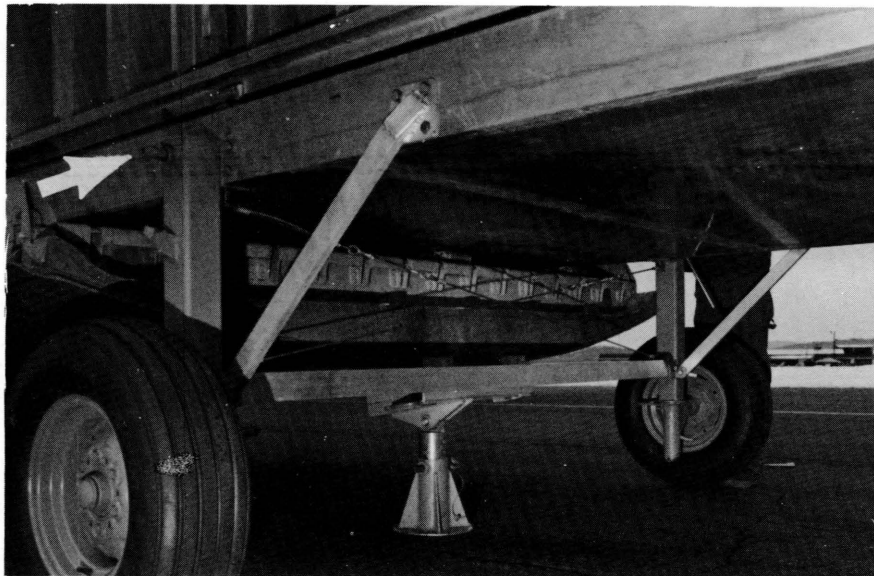


Figure 2.2.2. A socket drive handle fits the end of the adjustment shaft (arrow). Seven bolts secure the lag assembly to the base of the shelter.



#### 2.2.2.2 Installing the Legs

The building must be on some intermediate support high enough for the legs to assume the load after they are installed.

Follow the check list in Appendix VII.

Install legs in pairs. Match each leg/strut assembly with its color-coded location. Match the holes on the mounting plate of the leg with the corresponding holes on the base of the shelter. Rest the leg on the ground and extend it until it reaches the holes. To extend the leg, insert the socket drive into the end of the adjustment shaft on the jack and turn it. When the holes are aligned, loosely install at least one bolt through the mounting plate.

Align the mounting plate of the diagonal strut so that its holes correspond to those on the base of the shelter. Install the four bolts on the jack and the three bolts on the strut with light pressure. Do not tighten these bolts yet.

Adjust the legs so they are hanging from the building. Place the cross-beam in the pockets on the legs with the mid-span hole toward the middle of the shelter. Insert the pins through the cable yokes (see Fig. 2.2.1). Jack the legs until the shelter bears lightly on the ground. Tighten the turnbuckles. Tighten all bolts firmly. The legs may now completely support the weight of their end of the building.

### 2.3 MOBILITY METHODS

#### 2.3.1 Towing

##### 2.3.1.1 Installation of Running Gear

The shelter can ride on skis or wheels, depending the terrain. The wheels mount full time. The skis, which hold the wheels off the ground when installed, are solely for snow-covered terrain that cannot support a wheeled vehicle.

To install or remove the skis, each side of the shelter must be jacked up in turn. First, chock the wheels or skis on the side opposite the jack to prevent movement in either direction. Place the auxiliary jack in the center of the side that is to be filled.

When the side is lifted, install or remove the skis with the locking pin (see Fig. 2.3.1). When a ski is being used, the pin should be stored in the mounting holes on the ski.



Figure 2.3.1. Skis are secured to the bottom of the leg with a locking pin.

#### 2.3.1.2 Installation of Towing Assembly

The shelter tows from either end. Crank the legs to their minimum length, so the steering rods will reach. Attach the towing tongue to the beam between the legs using the locking pin (see Fig. 2.3.2). Align the tongue perpendicularly to the beam and swing the steering rods to the radius arms on the legs.

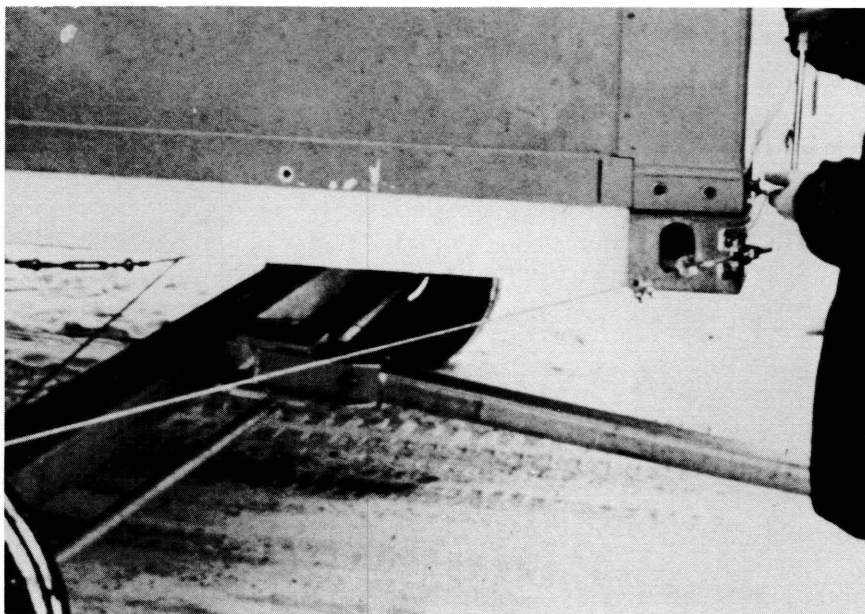


Figure 2.3.2. The towing tongue attached to the cross strut at either end of the shelter. The legs must be fully retracted for the steering rods to align properly.

Remove the locking pin on the leg's bearing plate (see Fig. 2.3.3). This pin inhibits steering. If necessary, relieve the weight from this leg to remove the pin. Align the end of the steering rod with the holes in the steering yoke. Place the pin through the holes in the steering yoke and through the end of the steering rod (see Fig. 2.3.3). To remove the towing assembly, reverse the procedure.

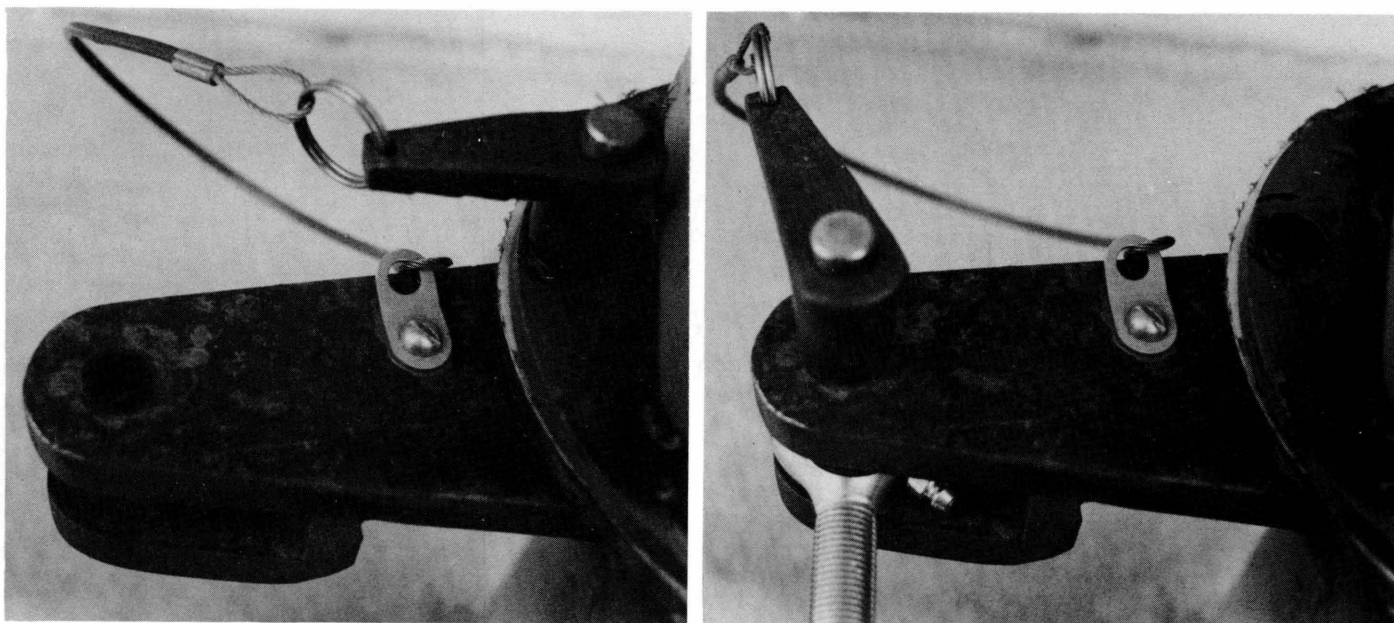


Figure 2.3.3. A pin locks a leg in place (left) or connects the steering linkage (right).

#### 2.3.1.3 Towing

The shelter should only be towed short distances at low speeds: 8 kph (5 mph) and 4 kph (2.5 mph) are the recommended maximum towing speeds for wheels and skis, respectively. The shelter has a limited turning radius. On sharp curves someone should advise the driver if the tires are about to rub the diagonal struts.

Avoid backing because it is difficult to steer the shelter backwards. When backing into tight places, disconnect, reposition the vehicle, and reconnect the tongue. Towing from the opposite end is the best method to reverse direction.

#### 2.3.1.4 Parking

The shelter has no parking brake. Chock the wheels when parking. During freeze-thaw conditions lay an expendable sheet of material under the skis to prevent freezing to the surface.

## 2.3.2 Conventional Truck Transport

### 2.3.2.1 Equipment Needed

The truck must have a flat bed between 36 and 55 in. high. If the bed is higher, a tilt bed or cribbing is required to raise the shelter. The bed must be at least 16 ft long. A pair of "come-along" hand-operated winches, five or six 8-ft lengths of 1-in. pipe for rollers, and the shelter's tool kit including its 3/4-in. sockets with ratchet and speeder handles are required.

### 2.3.2.2 Loading

Secure the shelter with winches or chocks so it will not roll during the loading procedure. Follow the check list in Appendix I.

Remove and store the auxiliary stub legs attached to the bottom of the ISO fittings (Figure 2.3.7). Align the end of the shelter marked "load to front" with the rear of the truck. Disconnect the steering rods. Jack up all four legs until the underside of the shelter is above the level of the pipe rollers placed on the truck bed. Back the truck or roll the shelter on its wheels until the part of the shelter just in front of the legs overlaps the first set of rollers (see Fig. 2.3.4).

Attach the "come-alongs" so that they prevent accidental movement of the shelter. Retract this first pair of legs so that the shelter rests on the first pipe placed across the truck bed. Remove the legs according to paragraph 2.2.2.2.

Roll the shelter further onto the truck bed. Add pipes at the front of the shelter and, after the center of the shelter is on the truck, at the back end of the bed. Adding pipe rollers at the back end requires jack adjustment so that the shelter rests on one pipe placed across the truck bed.

When the part of the shelter on the truck is just short of the diagonal struts of the second pair of legs (see Fig. 2.3.4), crank up these legs so the shelter rests completely on the bed. The legs should then be removed.

Pull the shelter the rest of the way onto the bed, adding rollers as necessary, and secure it through the ISO corner fittings. Stow the legs and struts on the bed of the truck if the shelter is to be unloaded without additional aids. If the shelter is to be shipped as an ISO container, stow the legs and tools inside the shelter.



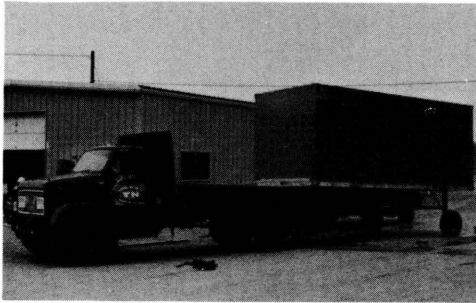
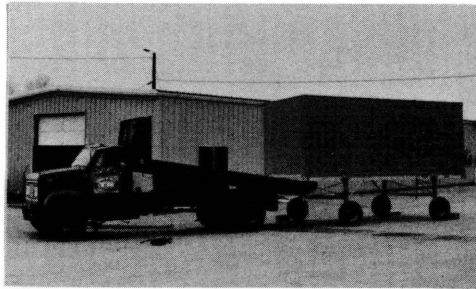


Figure 2.3.4. Loading sequence:

1. Rest edge of shelter on bed
2. Remove legs
3. Roll on and remove remaining legs

#### 2.3.2.3 Unloading

Secure the shelter with winches or chocks so it will not roll away during unloading. Follow the check list in Appendix II.

Unloading is the reverse of loading (2.3.2.2). Use "come-alongs" to extract the shelter and a safety snub line from the head board of the truck to the loop in the base beam to ensure that the shelter does not roll out of control.

### 2.3.3 C-130 Air Transport

#### 2.3.3.1 Equipment needed

A ramp support pedestal is essential for loading the shelter on an aircraft. The 3/4-in. socket drive available in the shelter's tool kit will be required. If the shelter is to be extracted on terrain in which it will not slide or roll easily and no vehicle is available for pulling, a snatch block can be used with the winch in the portable aircraft.

#### 2.3.3.2 Loading

Secure the shelter with winches or chocks so it will not roll away during loading. Follow the checklist in Appendix I.

Remove and store the auxiliary stub legs (Fig. 2.3.7) to make the underside smooth. Lower the aircraft tailgate until it is in line with the aircraft floor. Place the ramp support pedestal under the lowered tailgate.

Align the shelter with the end of the tailgate. Disconnect the steering linkage. Extend all four legs of the shelter until the underside is higher than the aircraft roller system.

Move the shelter so it overlaps the aircraft tailgate just short of the first set of legs (see Fig. 2.3.5). Use the aircraft winch to move the shelter, if necessary. Retract the front legs so the shelter rests on the roller system. Remove the legs according to paragraph 2.2.2.1.

Level the shelter with the aircraft floor by adjusting the two remaining legs. Move the shelter further into the aircraft to just short of the diagonal struts of the second pair of legs. Retract these legs so the shelter is resting completely on the rollers and then remove the legs.

Draw the shelter the rest of the way onto the aircraft and secure it between the ISO fittings and the aircraft tie-downs. Stow the legs, their attachments, and the tools on the aircraft tailgate.

#### 2.3.3.3 Unloading

Secure the shelter with winches or chocks so it will not roll away during unloading. Follow the check list in Appendix II.

Unloading is the reverse of loading. Starting by installing the ramp support pedestal. Next, lay out the legs on the ground in reverse order of removal. When extracting the shelter in cold weather on skis, cool the skis below freezing before placing them on the snow to prevent them from freezing to the snow.

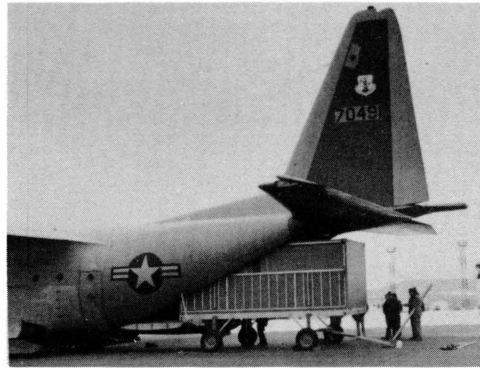


Figure 2.3.5. Aircraft loading sequence: Overlap shelter on tailgate and remove first set of legs. Roll onto aircraft and remove second set of legs. Roll on and secure in place.

If manpower or pulling vehicles are unavailable during unloading, use the aircraft winch with a snatch block placed on the aircraft tailgate or some fixed point on the ground. Snub the line inside the aircraft to prevent the shelter from rolling out accidentally.

Install the legs in pairs as the shelter is extracted, as outlined in the Appendix VII checklist. Tighten the cross cables before the legs carry a load. Once installed, crank each set of legs down so that they carry the entire weight of their end of the shelter.

#### 2.3.4 C-141 Air Transport

No procedure exists for the C-141. The C-141 is likely to land where a K-loader for direct unloading is available. If no such adjustable

ramp cargo trailer is available, the floor of the C-141 is above the maximum extension of the shelter legs. Loading would require an elevated ramp for the skis or wheels to proceed as described in paragraph 2.3.3.2.

### 2.3.5 Helicopter Air Transport

A helicopter that can carry 13,000-lb on the external sling hook is sufficient. The general procedures outlined in TM 55-450-8 apply. Transport the shelter with its jack-legs or auxiliary stub legs attached, since it is not designed to rest on its bottom skin. Chock the wheels.

Provide a ladder for the men on the roof who will attach the slings to the helicopter. Someone should prevent the ladder from blowing away in the rotor downwash.

The top ISO fittings are for vertical lifting only; therefore attach all rigging to the lower ISO fittings. Lift the shelter with slings at least 2 in. wide to prevent excessive compression loads from squeezing the roof panel. The slings must reach their apex at a point at least 7 ft above the roof.

The shelter has been successfully lifted using the rigging elements described in Table 1 and shown in Figure 2.3.6.

Table 1. Rigging elements for helicopter lift of shelter.

<u>Item</u>	<u>Number of each</u>	<u>Location</u>
Medium clevis	4	Lower ISO fittings.
Large clevis	2	Apex of slings and doughnut.
20-ft cargo slings 10,000-lb capacity	10	2 each from 4 lower ISO fittings and 2 each from the apex of the slings to the doughnut.
3-ft doughnut 10,000-lb capacity	2	Top of rig.
Ground rod and probe	1	Held by ground crew for lift-off to bleed static electricity from the helicopter.
16-ft Aluminum ladder	1	Held by ground crew for lift-off Preparation.

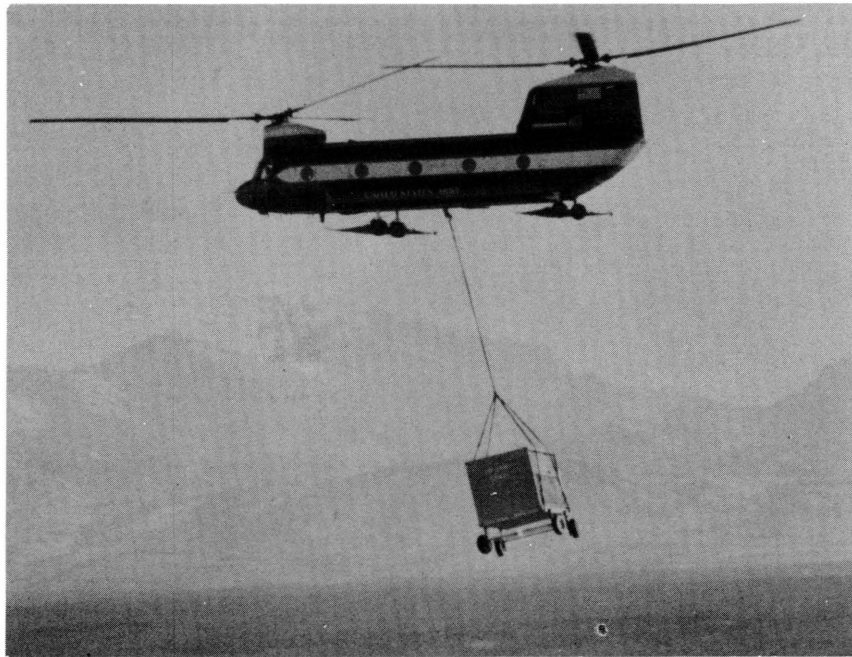


Figure 2.3.6. Rigging configuration for helicopter lift of shelter.

### 2.3.6 ISO Transport

#### 2.3.6.1 Introduction

The shelter can be transported as a modular, multimodal (ISO) shipping container. Its structure and fittings make it compatible with other ISO containers on specially equipped ships, trucks, and railroad cars.

#### 2.3.6.2 ISO Conversion

Converting the shelter into a shipping container requires removal of the legs as outlined in paragraph 2.2.2.1. The legs can be removed when the shelter is loaded onto a truck as described in paragraph 2.3.2. Everything must be stowed in the shelter as described in Section 3.7. Remove and stow the auxiliary stub legs which attach to the ISO fittings, Figure 2.3.7.

#### 2.3.6.3 ISO Handling

ISO handling requires a crane with suitable spreaders, or, if necessary, a forklift truck. When lifting by crane, there are three options:

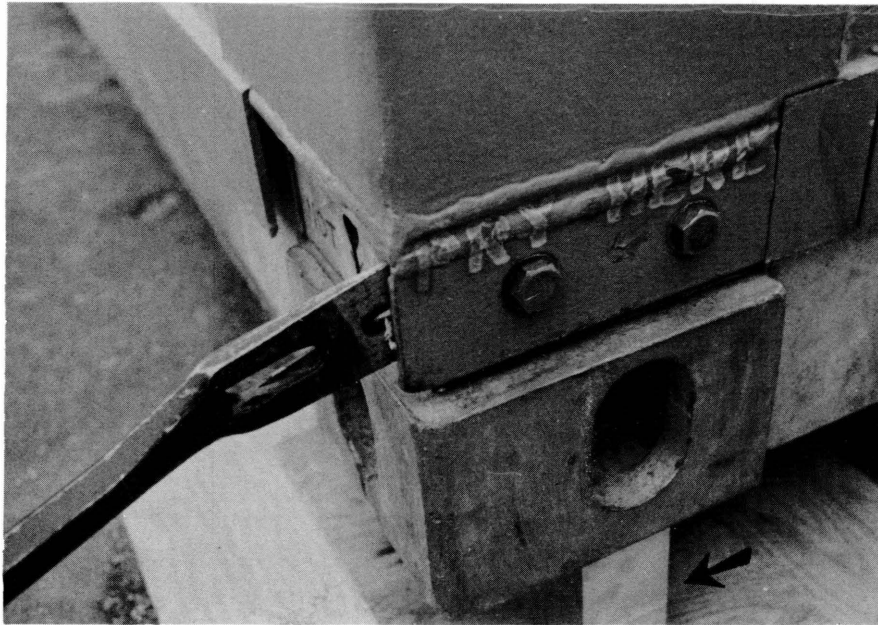


Figure 2.3.7. Auxiliary stub legs (arrow) attach to the bottom of the ISO fittings to facilitate handling with forklift trucks.

- (1) Use a frame attached to the top fittings (make sure the two bolts at the bottom of each column are secure).
- (2) Use a spreader bar about 8 ft wide that permits attaching slings to the bottom fittings without substantially squeezing the shelter.
- (3) As a least preferred option, lift the shelter with a sling attached to the ISO fittings arranged so that the sling apex is at least 7 ft above the shelter roof.

The shelter has no special provision for forklift truck handling because it is largely self-mobile. However, when a forklift truck is the only available means of manipulation, the standard legs or auxiliary stub legs should be in place. Cover each fork with a 2 x 6 plank to protect the aluminum underskin.

Caution: Avoid close contact of the backstop on the forklift platform with the shelter wall. Never lift on the bottom of the shelter with the ends of the forks.

## SECTION 3: Expansion/Striking

### 3.1 THE STAGES OF EXPANSION

Expansion should follow the check list in Appendix III. After the shelter is established on site, there are three basic configurations for use:

- (1) Unexpanded - use the basic core module with only the porch opened.
- (2) Expanded - open up the core module doubling the heated work space.
- (3) Expanded with tent - erect the tent to provide a vestibule on the porch and storage/bivouac space on the roof.

### 3.2 EXPANSION FEATURES

From its 8 x 8 x 20-ft shipping mode, the hardwall shelter expands in two directions. The porch swings down from one side, supported on the jack legs by knee braces. On the opposite side, a roof and three walls slide out on two beams to double the enclosed floor area of the shelter. A floor panel attached inside the deployable assembly swings down to complete the enclosure.

After expanding the hardwall assembly, the tent framework and fabric are set up to cover the entire structure. Furniture and appliances are unpacked and installed inside.

### 3.3 ESTABLISHING THE SHELTER ON SITE

#### 3.3.1 Orientation

Establish the shelter on fairly level terrain. Jacking the legs can level the shelter on uneven terrain with variations in excess of 18 in. within the maximum dimensions of the shelter.

First Priority: Orient the porch side of the shelter uphill and the bottom step from the porch side close to the ground.

Second Priority: Orient the porch side away from the prevailing wind. The porch has doors and step attachment points at both ends to facilitate this orientation.

However, if the snow melter is to be used, place the steps on the end of the shelter with the snow melter so that the access door is within reach. When the snow melter serves as a reservoir only, the steps can be placed on either end.

### 3.3.2 Placement of Footing Pads for Main Jack Legs

After orienting the shelter, prepare a foundation for it. The skis provide a firmer foundation than the wheels. See Section 3.4.1 for opening the porch to reach the tools and skis and Section 2.3.1.1 for installing skis.

With skis as footing pads, adhesion to the snow during freeze-thaw conditions can be avoided by placing disposable plastic or plywood between the skis and the ground.

### 3.3.3 Leveling the Shelter

With footing pads in place and all legs fully retracted, the shelter is ready for leveling with the 4-ft carpenter's square stored just inside the front door.

First, one person should prepare to crank the farthest downhill leg. Another person should go under the shelter, holding the carpenter's level against the underside so it is lined up with the farthest downhill leg and the uphill leg diagonally opposite (Fig. 3.3.1). Lines on the underside mark diagonals between legs.

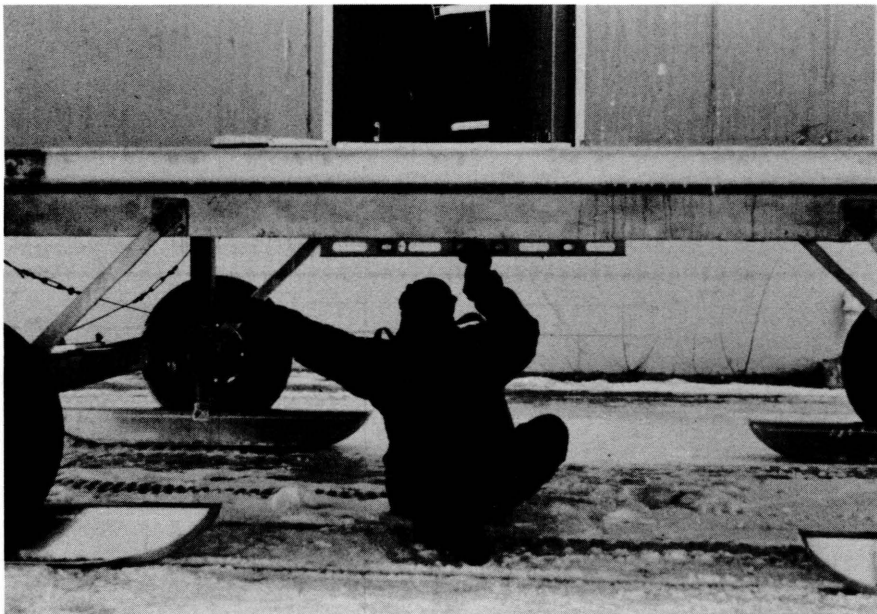


Figure 3.3.1. Initial leveling along diagonals between legs starts with the lowest leg.



Crank the downhill leg to extend it until the diagonal on the underside is level. The shelter will now rest on three points: the two legs on the leveled diagonal and the leg of the remaining two that has the greatest weight over it. Adjust this third leg with the level on the diagonal between it and the fourth leg that is not touching (this leg should be fully retracted).

When the building is level, crank the fourth leg down to the ground. Check if the four bottom edges of the perimeter are level.

### 3.4 HARD-WALL EXPANSION

#### 3.4.1 Opening the Porch

At least two people are needed to extend the porch safely. First, make sure that the knee braces swing freely by unpinning them as shown in Figure 3.4.1. Also make sure that the knee braces' travel is restrained by preventer cables. Next, release the porch catches that attach the porch to the corner columns. Someone should hold the porch upright while the catches are released.



Figure 3.4.1. Support arms. Be sure to unpin the bottom of the support arms, First, before fastening the porch latches, Second.

Now, with at least two people to restrain the descent of the floor, it may be lowered. As the porch is lowered, the knee braces should swing downward until the preventer cables stop them. The knee braces should guide themselves onto the chisel-shaped horns on the jack legs.

To prevent the wind from lifting the porch, insert locking pins through the holes provided, one on each knee brace.

Steps hook onto either end of the porch secured with locking pins (see Fig. 1.2.3). Drop the adjustable pedestals to the ground by squeezing the jam mechanisms holding them.

**IMPORTANT:** Never open the porch past the level position. Opening the porch too far can pull the hinges off. Use the auxiliary porch support legs to avoid opening the porch too far if the shelter is not mounted on its jack legs. The porch support legs are stored on the underside of the porch during shipment (Fig. 3.7.12) and slip onto the lower flange of the beam on the front edge of the porch.

### 3.4.2 Expanding the Roof-Wall-Floor Assembly

#### 3.4.2.1 Attaching the Expansion Beams

Two expansion beams form a railway on which the roof-wall-floor assembly rolls in the deployment/striking cycle. The beams stow inside the shelter on the kitchen floor (Fig. 3.7.10). Installing the beams requires a 3/4 in. socket on a speeder (crank) handle for every two people who will install the beams. Unpack the supply of standard bolts.

Remove the expansion beams from their stowed location. The beams are color-coded and should be attached with the color-coded mounting locations. The mounting locations are above each jack on the side of the shelter opposite from the porch.

One person should hold up the outboard end of the beam while his partner rests the flanged inboard end on the small aluminum block and bolts it in place as tightly as the speeder wrench will allow (Fig. 3.4.2).

Next, lay out the color coded beam jacks by the cantilevered ends of the beams. Place the rectangular insert in the end of the beam (Fig. 3.4.3) and the footing pads under the bases of the jacks.

Adjust the jacks until the outboard ends of the expansion beams are about 1/2 in. higher than level to allow for settlement. Insert the aluminum hook-like fittings on the ends of the attached cables into the end holes on the lower ISO fittings and tighten the cable by closing the attached levers as shown in Figure 3.4.4.



Figure 3.4.2. Installing the deployment beams. One person should hold up the free end while the other tightens bolts with an expansion wrench.



Figure 3.4.3. The expansion beam jacks should be about 1/2 in. above level or more to allow for settlement of the bearing surface.



Figure 3.4.4. A clamp on the hook-end of each cable tightens the cable system. A pin holds the expandable assembly in place after expansion (see also Fig. 3.4.6).

The jacks and the cables should now support and hold the beams in place as the shelter is expanded.

#### 3.4.2.2 Positioning the Expandable Assembly

The next step is to roll the deployable wall-roof-floor assembly into position along the deployment beams.

First, unbolt the expandable assembly from the fixed portion of the shelter. The bolts are located along the upright aluminum angle on each end of the porch wall and along the aluminum angle skirt on the bottom edge of the long wall of the expandable assembly. Store all bolts in the bolt and tool apron for later use. Remove the two bolts from the base of each ISO column.

Now, take the heavy-duty pry-bars supplied with the shelter and pry the ISO columns away from the base. Two people can now pull the expandable assembly away from the fixed portion of the shelter by grabbing the aluminum skirt near the expansion beams and walking backwards (Figure 3.4.5).

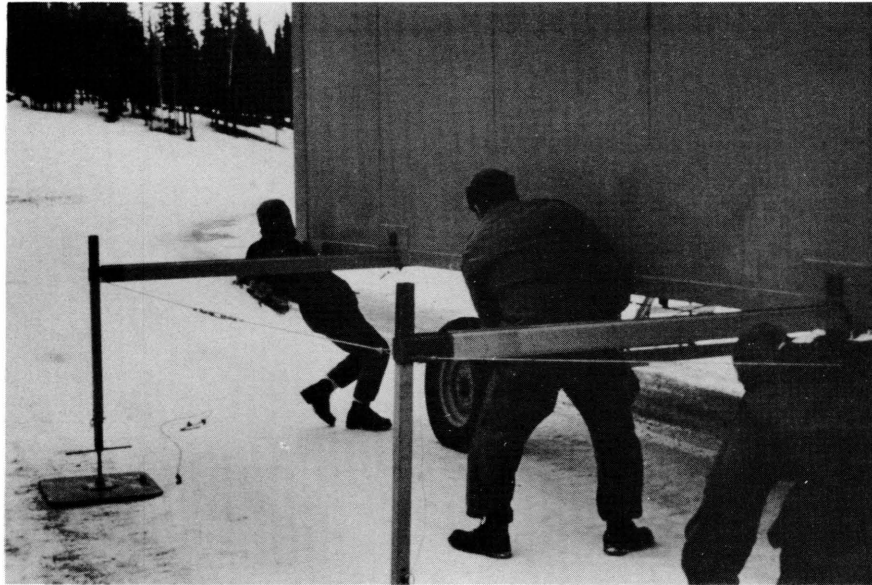


Figure 3.4.5. Expandable section moves by pulling it out on its rollers.

(Pushing on the ISO columns should be avoided since it is likely to cause the expandable assembly to swerve to one side and bind.) Roll the assembly back swiftly until it bumps solidly against a cleat on the roof.

To secure the expandable assembly to the core module portion, align the holes through the skirt on the short sides with corresponding holes on the sides of the lower ISO fittings. Insert the locking pins that are attached to the aluminum hooks on the cables that support the expansion beams (Fig. 3.4.6.).

#### 3.4.2.3 Lowering the Floor

Finally, lower the floor that is stowed along the long wall inside the deployable assembly. The floor is hinged at the bottom and latched with retaining hooks at the top.

**PERSONNEL SHOULD BE PREPARED TO MOVE CLEAR OF THIS HEAVY PANEL AT ANY TIME IN CASE IT DROPS ACCIDENTALLY.**

One person should take the line from its hook in the middle of the panel, snub it around his waist, and brace himself to carry the weight of the panel along the line as shown in Figure 3.4.7. The ropeman should wear gloves to protect himself from rope burn.

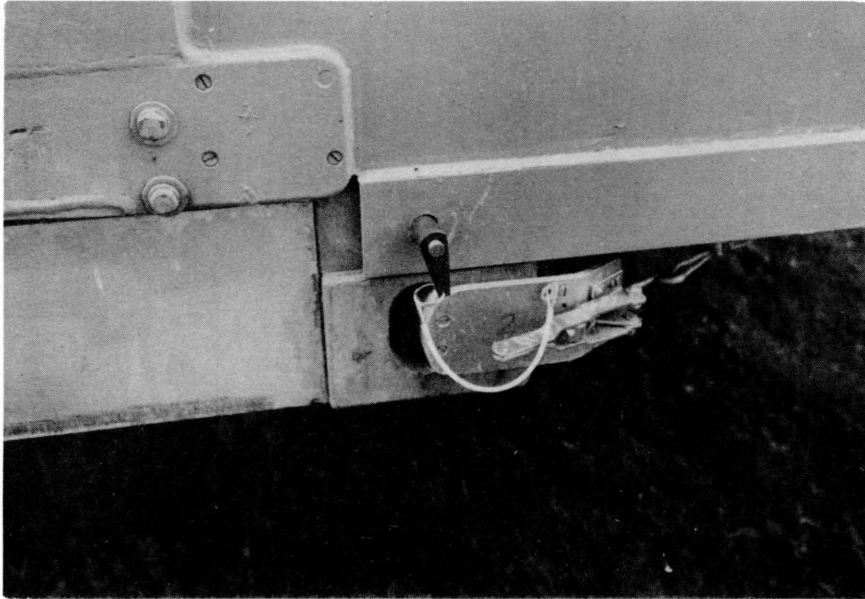


Figure 3.4.6. Locking pins position the expandable assembly before the floor is lowered.



Figure 3.4.7. Snubbing the line around the waist to control the floor.



A second person should walk along the deployment beams and release the hooks holding the panel (see Fig. 3.4.8).



Figure 3.4.8. Walking along the beams to unhook the floor.

Ease the freed panel gently to the horizontal position by having the ropeman let the rope out and slowly lower the floor. Detach the line at the bottom to get it out of the way. Replace the clevis on the pulley.

#### 3.4.2.4. Raising the Floor

At least two people are needed to raise the floor back into place.

First, reconnect the hoisting line to the bottom of the floor. The line should come out of the top of the top pulley toward the person who will be pulling it. The lines must travel from the top pulley to the bottom without crossing, as shown in Figure 3.4.9.



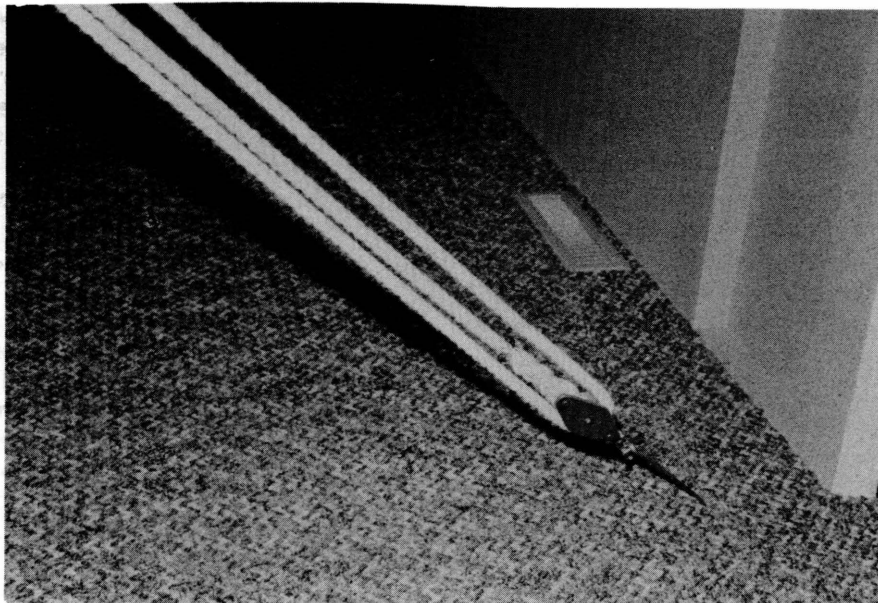


Figure 3.4.9. Lines should run from the top pulley to the bottom without crossing. When detaching the pulley, be sure to replace the clevis on it.

Two people should raise the floor by hauling on the rope. The rear man should snub the line around his waist. The floor requires a last push from someone on the deployment beam to seat it under the retaining hook on the wall. If the pulleys are misaligned, it is possible for them to foul as the floor approaches vertical. It may be necessary to shake the line to clear the pulley out of the path of the floor. If shaking the line does not work, lower the floor and realign the pulleys.

### 3.5 TENT ERECTION

#### 3.5.1 Deploying the Tent Hardware

##### 3.5.1.1. Description of Hardware

There are three types of hardware supplied with the tent: poles, cables, and attachment fittings. The poles and attachment fittings are color coded and numbered.

The attachment fittings connect to the ISO fittings on the roof and to the porch. The ISO attachment fittings consist of a collection of plates and eye-bolts with oversized wing nuts. The attachment fittings for the porch are four large clamps with sockets attached to the top.

The poles fit into sockets on the attachment fittings and support the cables. Each connecting part is numbered and color-coded to correspond with its mate. To erect the tent follow the check list in Appendix V. To strike the tent refer to Appendix VI.

### 3.5.1.2 The Color and Number Code for Layout

The color-coding and numbering facilitate placing the attachment fittings at the proper locations on the shelter. Figure 3.5.1 shows four imaginary lines along which attachments occur. Each line has its own color code.

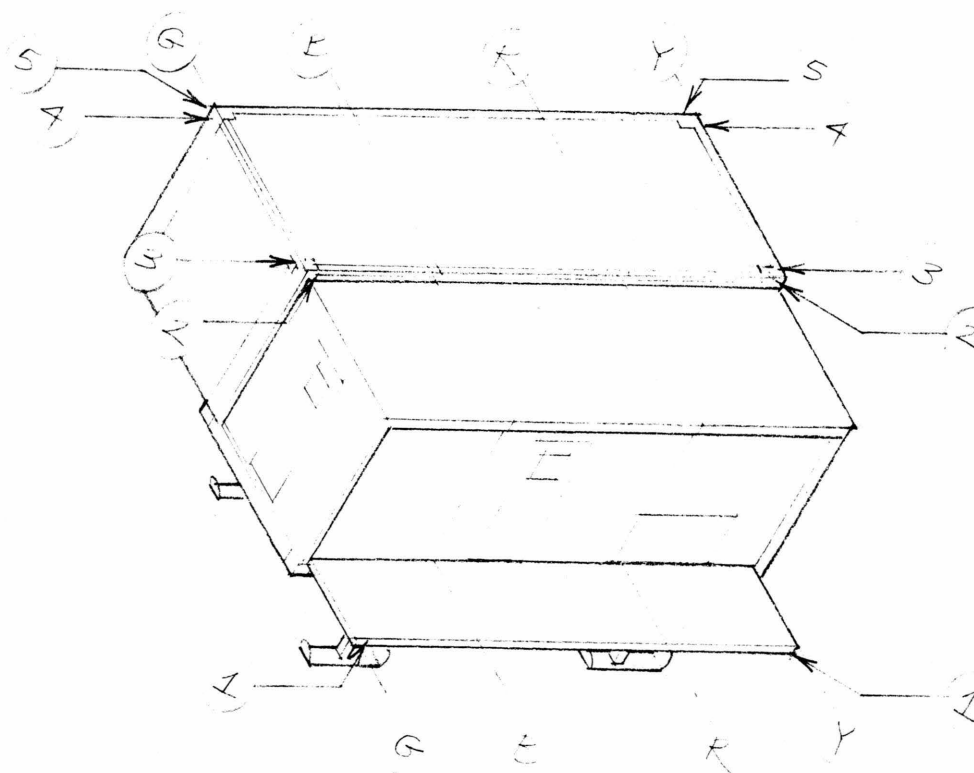


Figure 3.5.1. Color code for tent framework attachment: from left to right, G = green, B = black, R = red and Y = yellow are reference lines across the width of the shelter. Numbered reference lines run the length of the shelter.

The line on the far left end of the shelter is coded green. Working from left to right, the code continues black, red, and finally yellow on the far right-hand end of the shelter.

Working front to back along each color line there are five numbered stations: The first one is the front edge of the porch. The fittings that clamp onto this beam are numbered "1"; each is colored to correspond with a sectional line.

The joint between the fixed and deployable sections of the shelter is the site of stations #2 and #3 (horizontal and vertical connection points).

Station #2. Clamps on the black and red lines fasten onto the edge of the roof. Each clamp has a horizontally oriented socket, labeled "2"; this receives a horizontal aluminum pipe (Figure 3.5.2). At the green and yellow stations, #2 receives the butt-end of a horizontal rectangular strut.

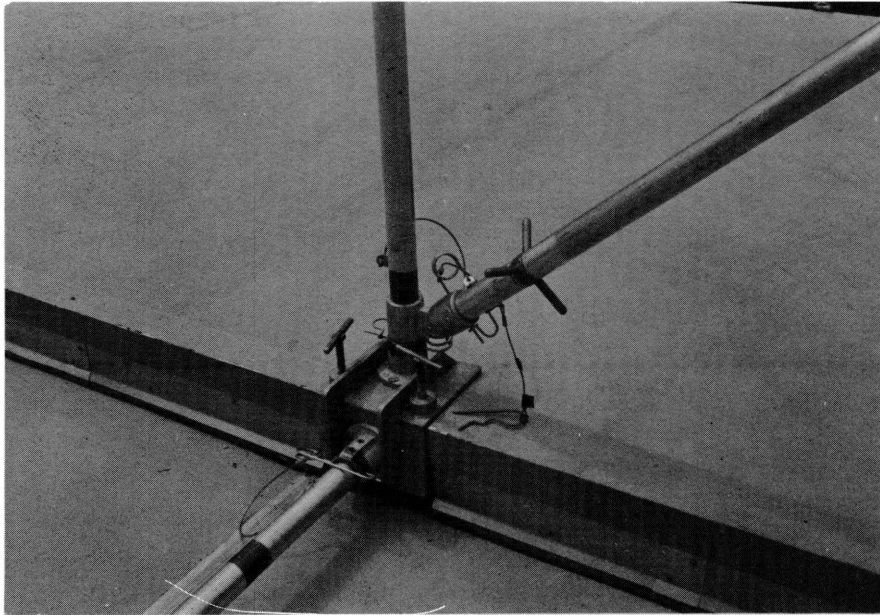


Figure 3.5.2. Clamps at the deployment joint (stations #2 and #3) support ridge poles, diagonal braces and horizontal struts on the black and red lines.

Station #3: The same black and red clamps have a vertically oriented socket, labeled "3," that receives the upright poles that form the ridge of the tent (see Fig. 3.5.2). The #3 locations on the ISO fittings (green and yellow) receive a vertical pole with a plate that bears on top of the fittings and a stud that connects through a hole on the narrow end of the fitting to a plate, also labeled "3" (see Fig. 3.5.3).

Station #4: This plate, labeled "4," works with a similar plate at the opposite ISO fitting to anchor and tighten the tent along the edge of the roof on the narrow end of the expandable action. There are no connections for station #4 on the red and black lines.

Station #5: This station is on the far edge of the roof away from the porch. The green and yellow #5 fittings are special plates that tighten the tent hem along the long dimension of the roof. The black and red #5 fittings attach to cable ends.

#### 3.5.1.3 Laying Out the Hardware

Lay out the coded fittings (shown in Figures 3.5.4-3.5.6) at their coded locations. Place the poles (shown in Figures 3.5.7-3.5.9) numbered "1" and "3" near their correct locations on the porch and roof.

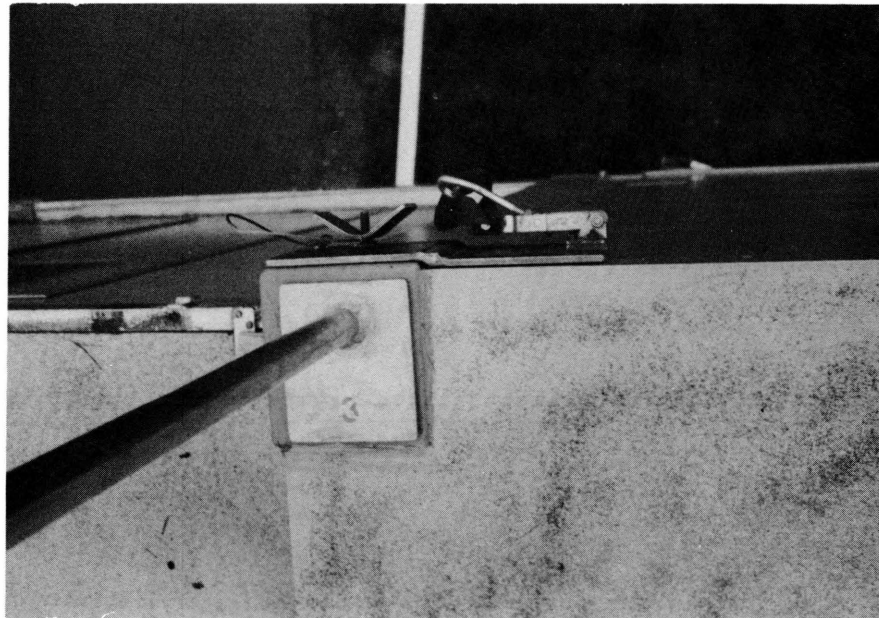


Figure 3.5.3. Ridge poles at station #3 on the yellow and green lines connect to plates on the ISO fittings.

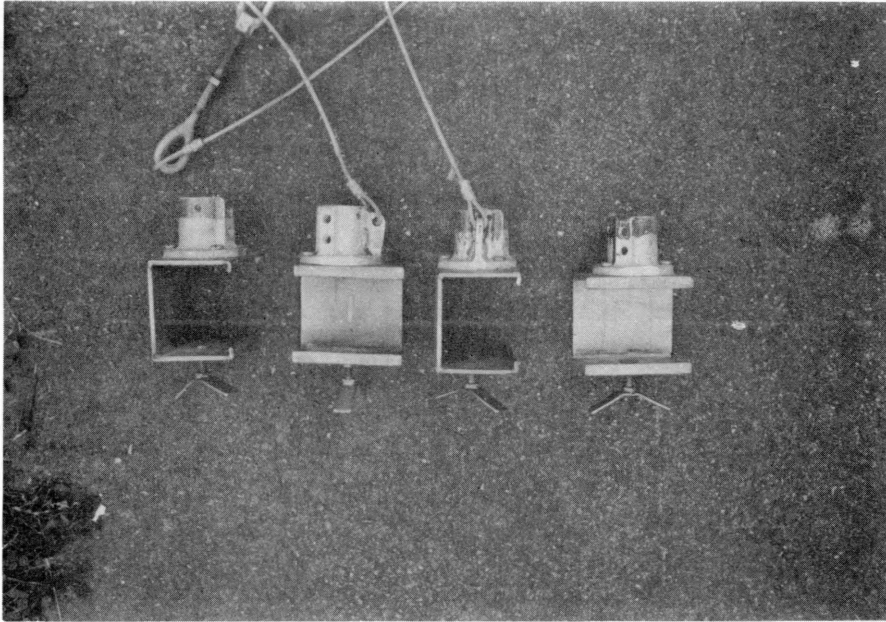


Figure 3.5.4. The porch attachment fittings (station #1: green, black, red and yellow).

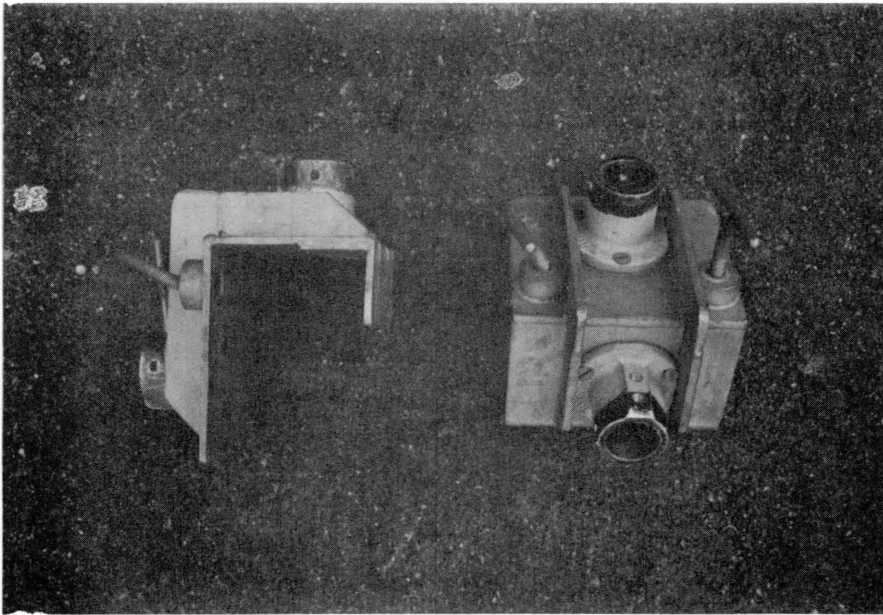


Figure 3.5.5. The ridge pole attachment fittings (stations #2 and #3: black and red).

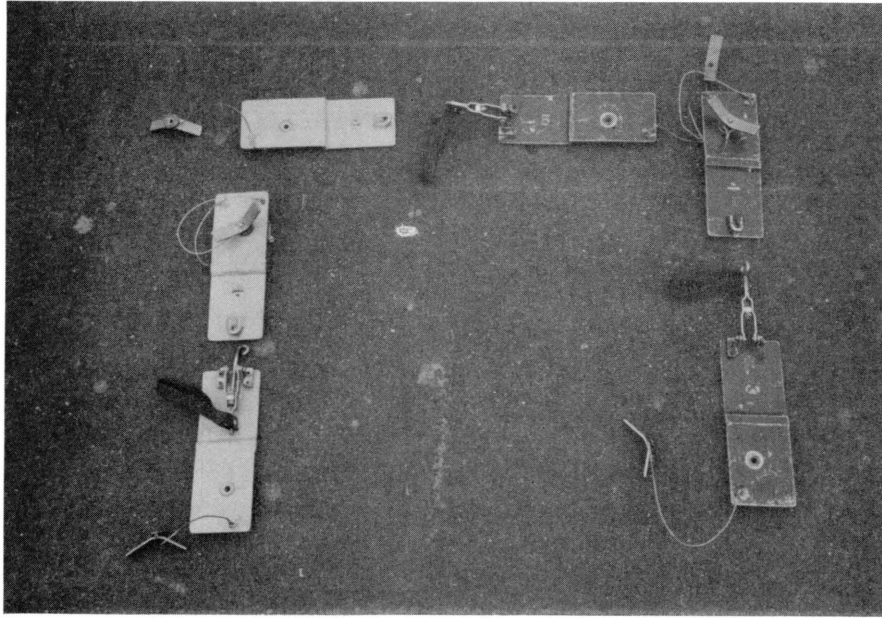


Figure 3.5.6. Fittings to anchor the tent hem for the green and yellow #3, #4 and #5 stations.

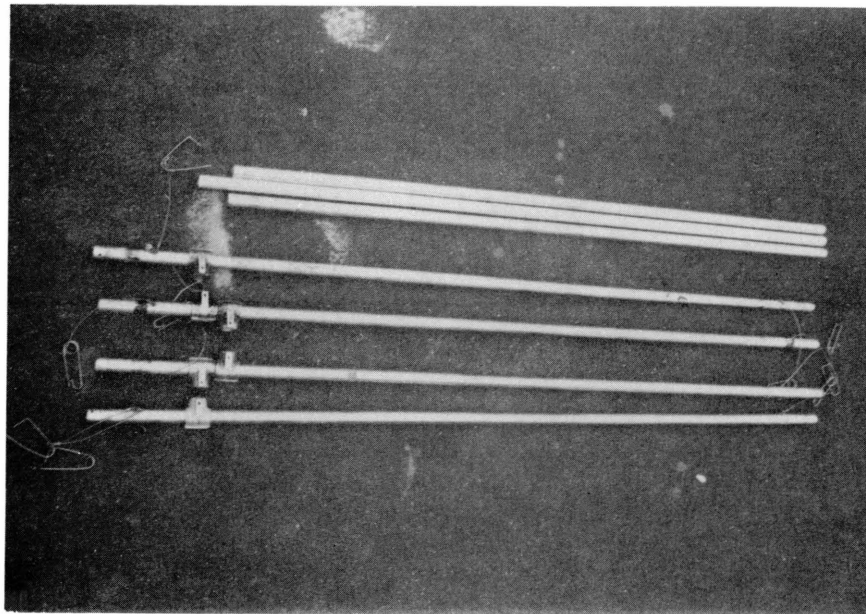


Figure 3.5.7. The porch poles (station #1: green, black, red and green).



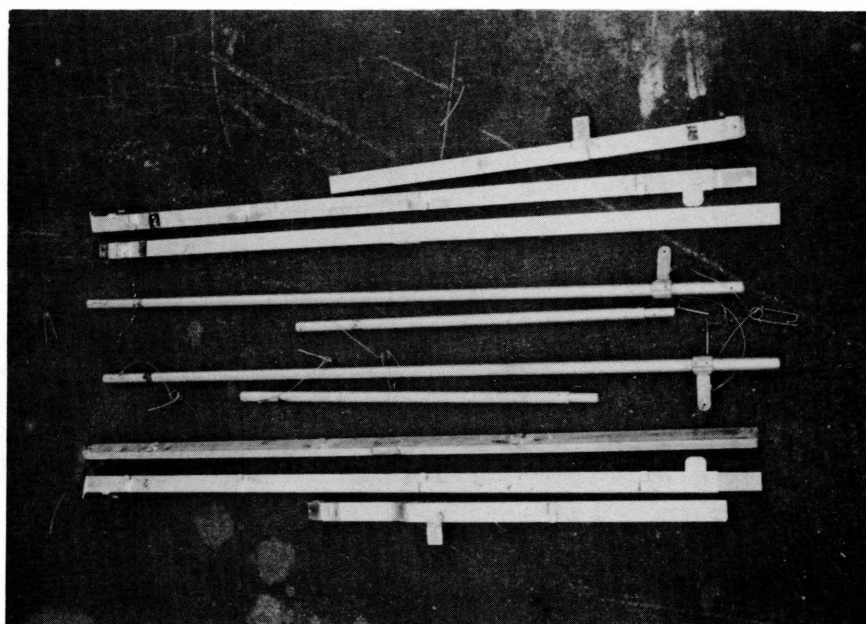


Figure 3.5.8. The horizontal struts and door jambs (station #1 and #2: green, black, red and yellow).

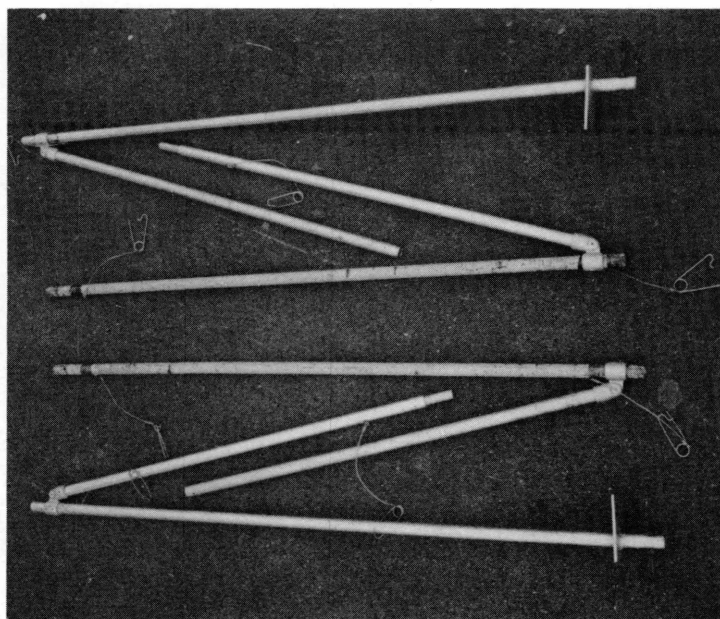


Figure 3.5.9. The ridge poles (station #3: green, black, red and yellow).



Arrange the cable system as a central spine, along station #3, with the longer cables (socket fittings numbered "1") oriented toward the porch and station #1, and the shorter cables with the I-bolts and small cross-shaped plates (numbered "5") oriented toward station 5.

#### 3.5.1.4. Attaching the Fittings

Slide the black and red #1 fittings from the end of the porch beam to the location marked by a stripe, followed by the green and yellow fittings. Screw down the wing nuts to clamp these in position.

Slide black and red #3 fittings into place as shown in Figure 3.5.2 and screw them down. The green and yellow #3 poles have studs at the bottom. Insert these into the tops of the ISO fittings so the stud protrudes through the hole on the narrow face. The green and yellow #3 fitting plates slide over these studs and are held in place with the captured wing nut (see Fig. 3.5.3).

The green and yellow #4 fitting plates attach to their ISO fittings much like the #3 plate, except the stud is attached to a separate plate (see Fig. 3.5.10).

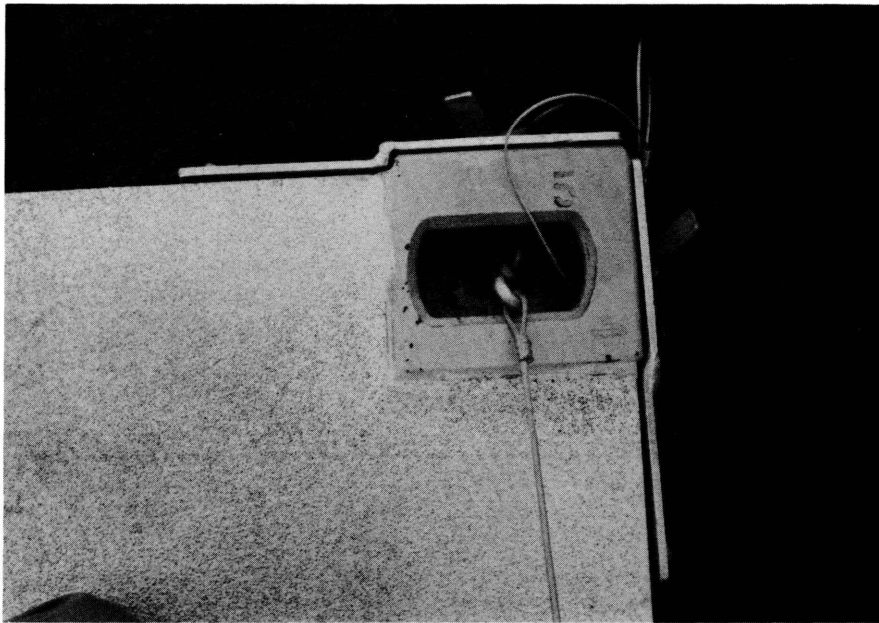


Figure 3.5.10. The yellow and green #4 fitting plates are attached to the ISO fitting with their own captured studs and wing nuts. The yellow and green #5 fitting plates are attached to the end of the cable system on the gable ends of the tent.

Attach the green and yellow #5 fitting plates to the long side of ISO fittings with the I-bolt on the end of the cable and the wing nut. Slide the black and red #5 fittings up under the special pairs of clips on the aluminum edge strip along the roof.

#### 3.5.1.5. Erecting the Poles

Place each pole in its socket and insert the captured "safety pin" through both the socket and the pole. Secure the upright poles on the porch and roof with the double band of color in the down position.

Join and secure the diagonal pieces on the end and central poles as shown in Figure 3.5.11.

Secure the rectangular door jambs on each end of the porch. The horizontal struts that run from station #3 on the edge of the expandable section's roof to station #1 on the porch come apart in the center for storage. Assemble the two rectangular and two tubular horizontal struts.

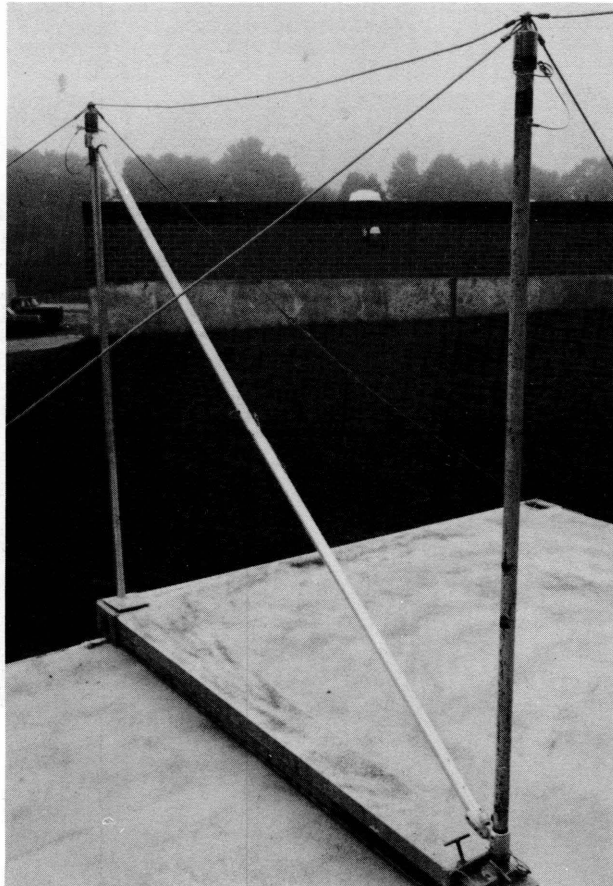


Figure 3.5.11. Half of a diagonal strut is captured on a pair of ridge poles on each end of the roof.

The rectangular green and yellow horizontal struts hook into a fitting on the fixed roof, slide past the vertical angle on the corner between end and side walls, and have tabs that drop down into the top of the door jambs. The end is secured to the porch upright as shown in Figure 3.5.12 with the end of the pin pointed inwards.

The horizontal struts at the red and black locations attach to the roof fittings as shown in Figure 3.5.2 and pin to the wall as shown in Figure 3.5.13.

Install the horizontal poles that hold the porch uprights apart with the longest pole in the center span as in Figure 3.5.14.

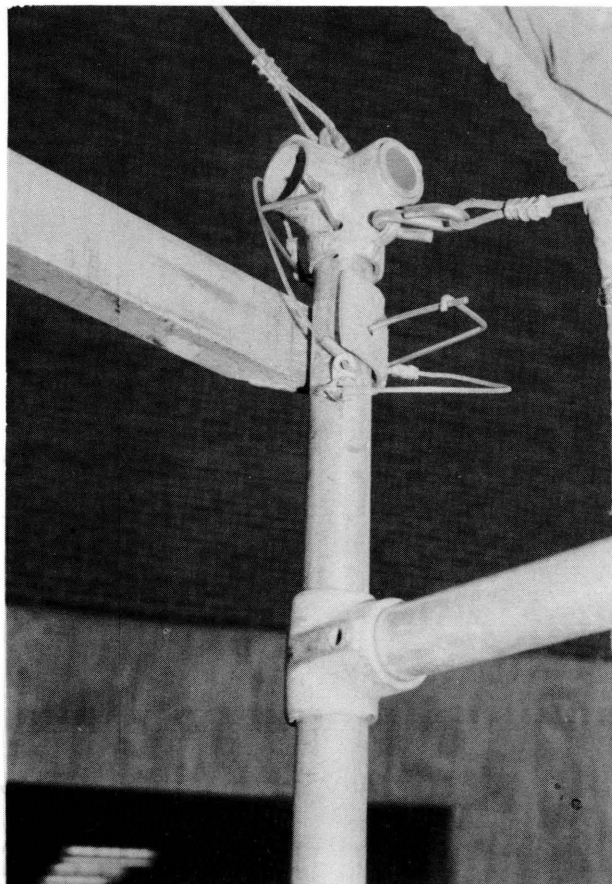


Figure 3.5.12. The yellow and green porch corners have rectangular struts coming along the end of the shelter and tubular spacers along the length joining into them.

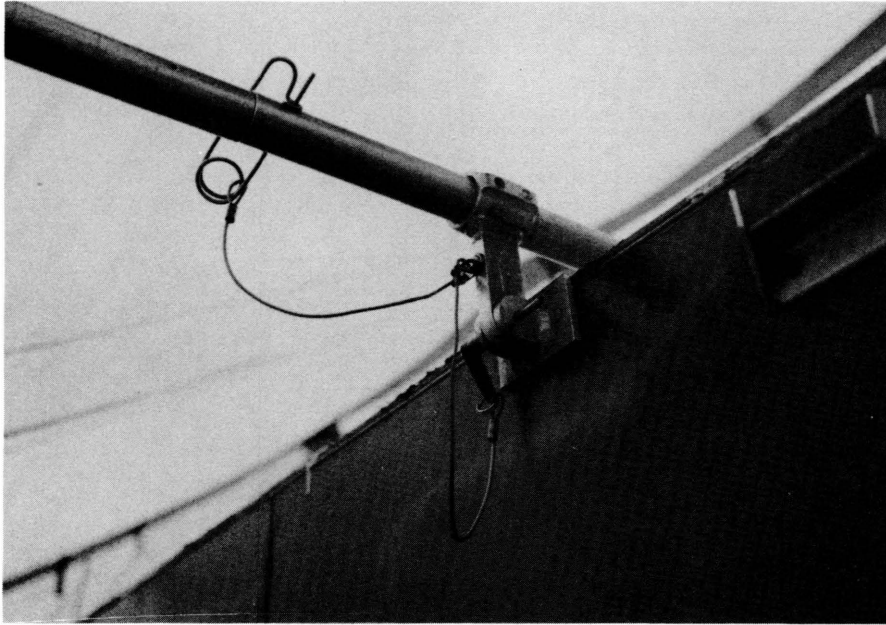


Figure 3.5.13. Red and black horizontal struts join to make one piece and are pinned to the wall.

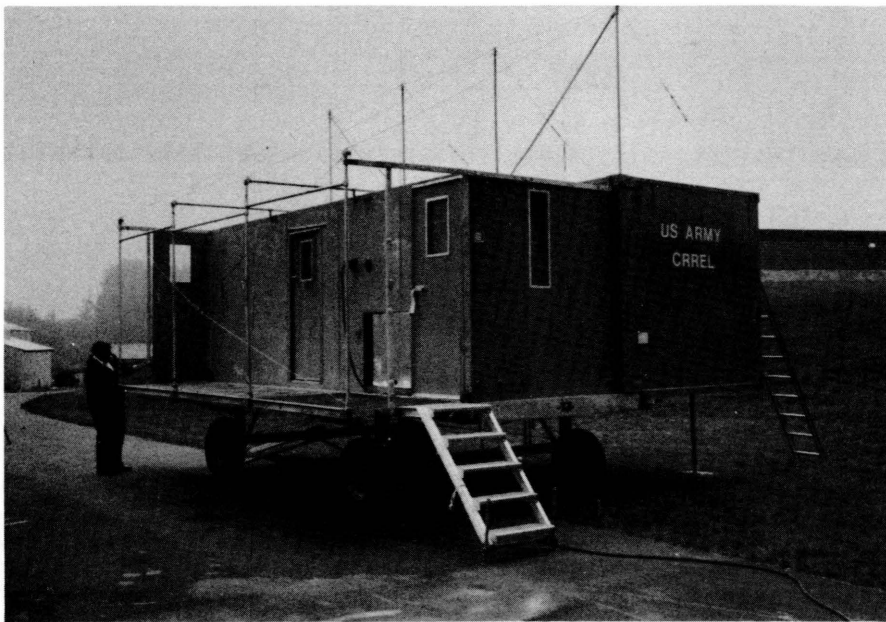


Figure 3.5.14. The completed structure of cables, poles and doors.

### 3.5.1.6 Erecting the Cable System

At this point, the uprights should be secured along the porch (station 1), and along the roof joint (station #3). The cable should be attached along the far edge of the roof (station #5).

Now take the sockets numbered "3" that are the intersection points of the cables and cap the #3 poles. Secure them in place.

Place the sockets numbered "1" on the remaining free ends of the cables over the upright poles on the porch. Secure them. Attach and tighten the two diagonal cables on the porch so the uprights are vertical.

Hang the porch doors on the aluminum angles attached to the wall. The captured bolts should be slid into the slots and tightened from the outside.

### 3.5.2. Erecting the Tent Fabric

A complete framework of poles and cables should now be ready to support the tent fabric (Fig. 3.5.14). Place the bag containing the fabric on the roof. Extract the tent. Look for the corners labeled green #5 and yellow #5. These are the starting points. The writing should be inside the tent.

There is a cable running through the hem of the tent. Attach the ends of the cable with S-hooks to the green and yellow attachment plates at station 5. The cable should tuck under the clips that run along the edge of the roof. Close the clamp on one end of the cable to lighten it. Now the tent is firmly attached along one edge and is heaped over the cables coming down from the ridge-line.

Next pull the tent up over the ridge, down the other slope of the cables, and over the tops of the poles on the porch so it drapes completely over the roof of the shelter and hangs down around all the unattached sides.

Attach the wire hem along both gable sides as before. From station #5 to #3 a clamp tightens the straight run. From station #2 to #1 the cable runs around a peg at the top of the door jamb on the tent strut. It then descends vertically to where it attaches under the porch to another draw clamp attached to a piece of aluminum angle shown in Figure 3.5.15.

A nylon cord laces the long side of the porch to the hooks under the porch, drawing it tight and tying the ends off. Tie off the triangular tab on the tent panel adjacent to the door under the porch.

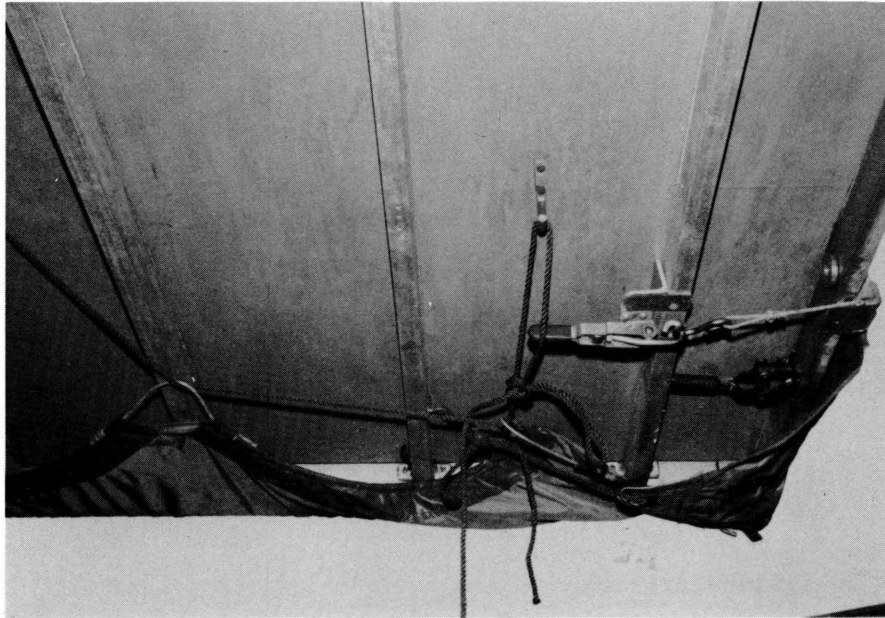


Figure 3.5.15. The edge of the tent is laced to the underside of the porch. A clamp mounted on a detachable fitting tightens the hem cable running down the door jamb.

The leather wear patches should correspond with the corners of the frame. In order to stretch the fabric into place one person can push outward on the patch while another pulls in the desired direction. Sometimes a firm blow with the fist helps. If the material is tight, tie it off and wait for dew or frost to stretch the material so it draws into place. Figure 3.5.16 shows how the tent should look.

### 3.6. UNPACKING THE CONTENTS

When the mobility gear, the deployment beams and the tent have been unpacked and installed, a few items remain to be installed. Place the microwave oven on the kitchen counter adjacent to the sink. Clamp the portable toilet to its base in the closet behind the front door. Set up the card tables in the deployable room, one adjacent to the opening from the kitchen as a dining table. The chairs belong around the tables. Set up the day-beds along the end walls in the deployable room. Insert the "Luxo" lamps in the wall brackets. Store the shower in a suitcase anywhere out of the way. Distribute the mattresses on the four bunks.

### 3.7 STRIKING THE SHELTER

Striking the shelter is the reverse of expanding it. First, drain any tanks holding water to prevent freezing according to the check list



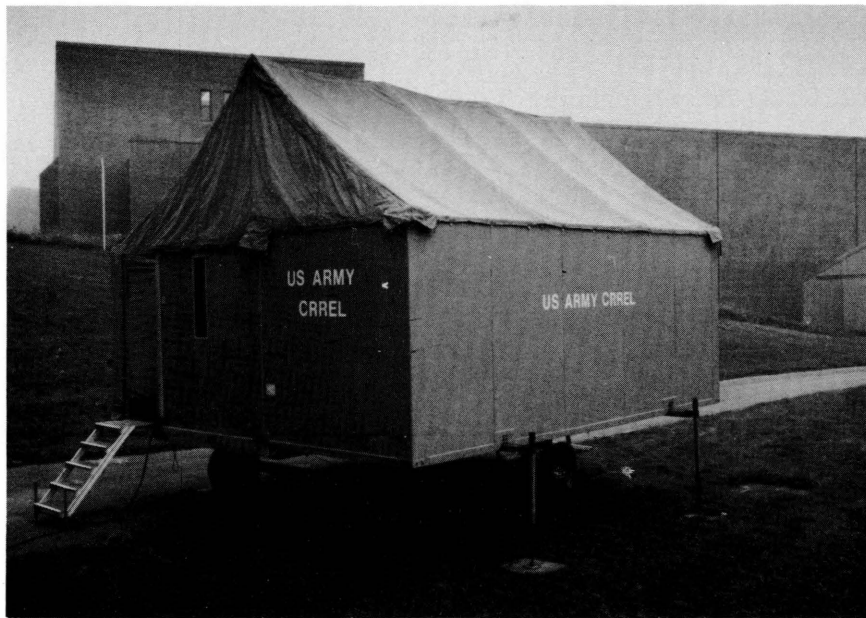


Figure 3.5.16. Fully erected tent should look like this.



in Appendix XI. Then follow the check list for packing the furniture and equipment in Appendix XIII. Next, follow the check lists for striking the tent (in Appendix VI) and stowing it (in Appendix XIII). Then follow the check lists for striking the hardwall portion (in Appendix IV) and stowing it (Appendix XIII). If the shelter is to be shipped as an ISO container, follow the description in section 2.3.6.2 and stow the legs as described under Mobility Equipment in Appendix XIII. Figures 3.7.1 through 3.7.12 demonstrate correct packing procedure.

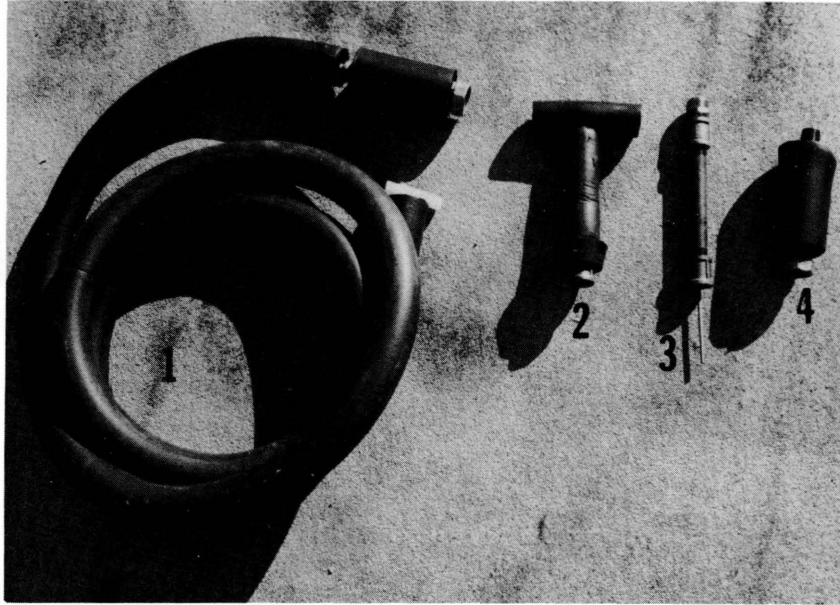


Figure 3.7.1 Stow water hook-ups in water compartment.

1. Wastewater hose
2. Snow melter plug
3. Snow melter drain extension
4. System drain extension

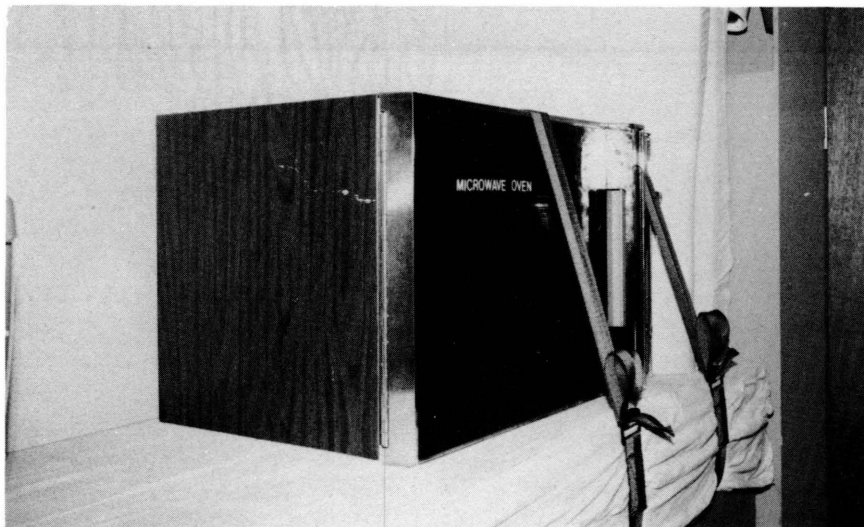


Figure 3.7.2 Arrange two mattresses forward of and two under the microwave oven on upper left bunk.

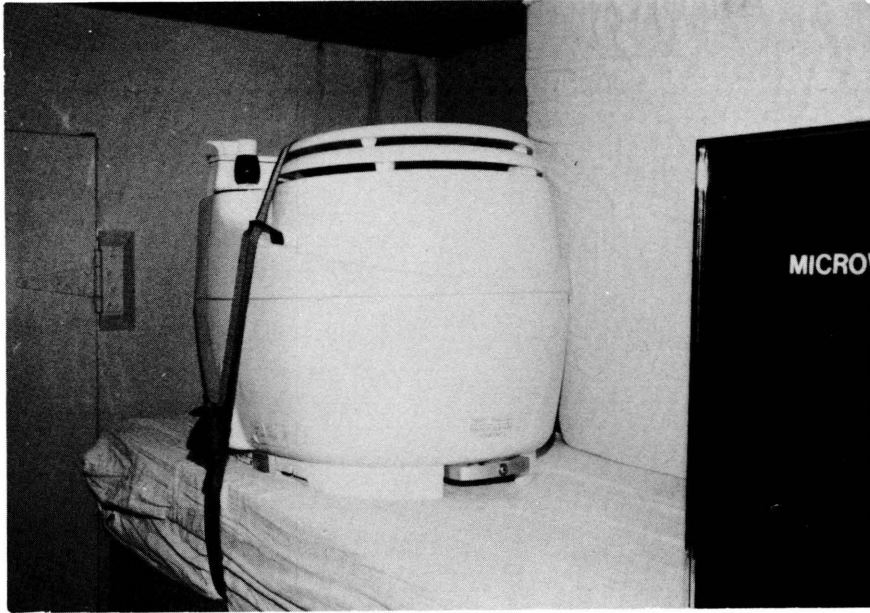


Figure 3.7.3. Strap down the toilet on the upper left bunk.

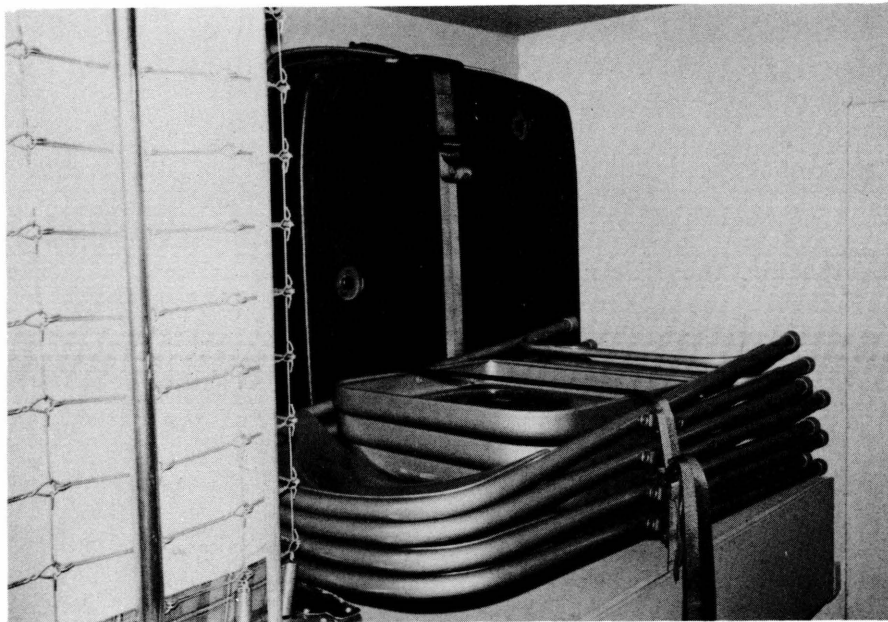


Figure 3.7.4. Strap day cots, portable shower and chairs to the upper right bunk.

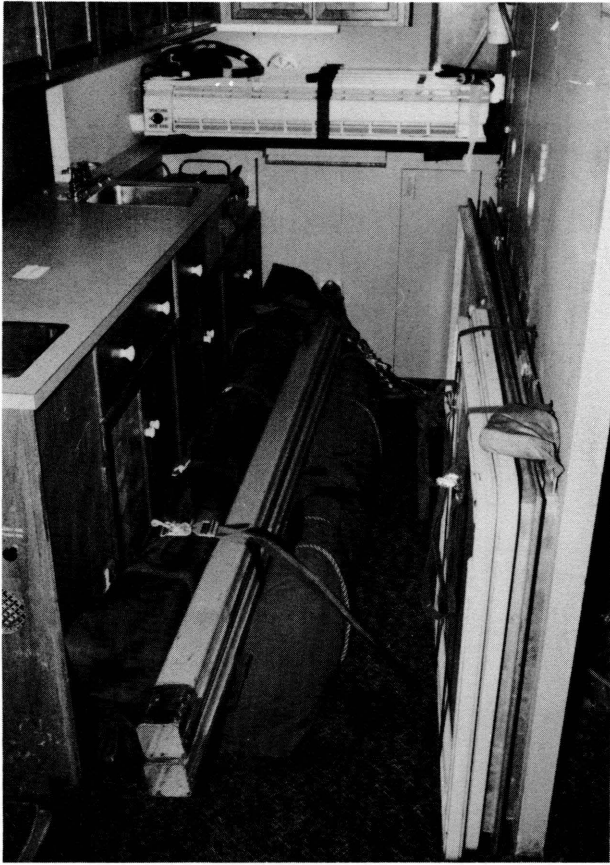
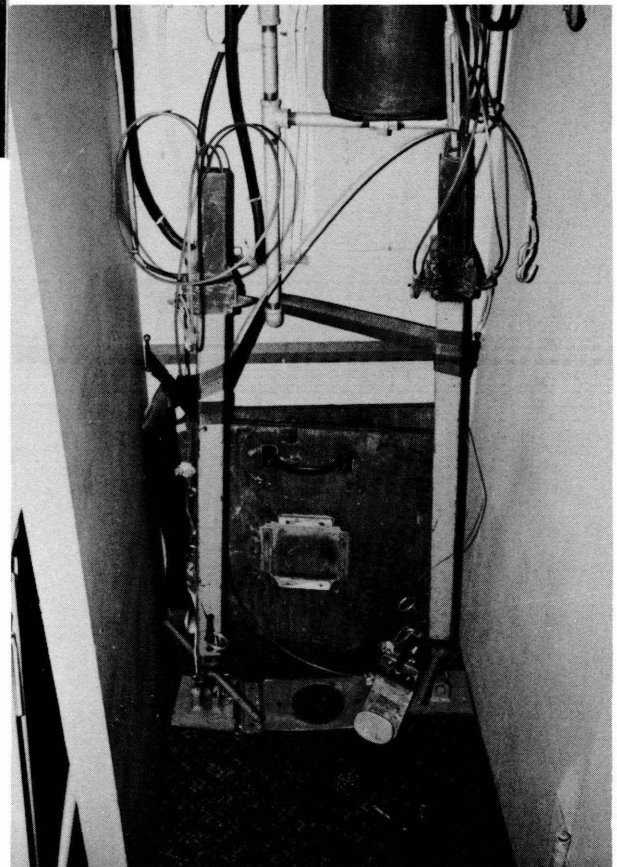


Figure 3.7.5. Card tables, tentage fabric and struts, porch doors, and **expansion** beams. Foam pads the ends of the beams against the freezer compartment.

Figure 3.7.6. Expansion beam jacks and pads are stowed in the toilet compartment.



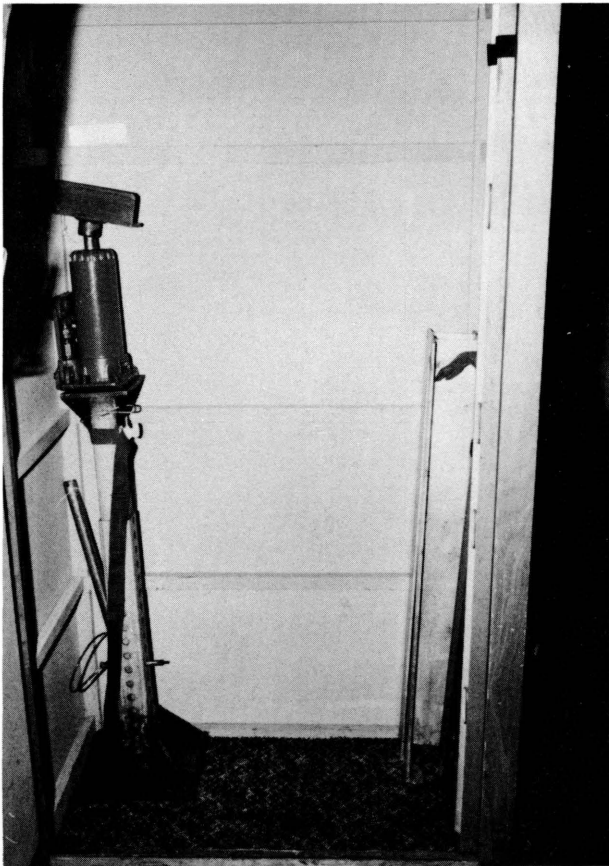


Figure 3.7.7. Utility jack, level, wrecking bar, and engine ways are stowed just inside front door.



Figure 3.7.8. Skis are strapped onto lower left bunk.



Figure 3.7.9. Wheels are strapped to the lower right bunk.



Figure 3.7.10. Cross members and steering assembly padded on the end with foam stowed between the tent and the porch doors.





Figure 3.7.11. Main jacks are strapped into the toilet compartment.

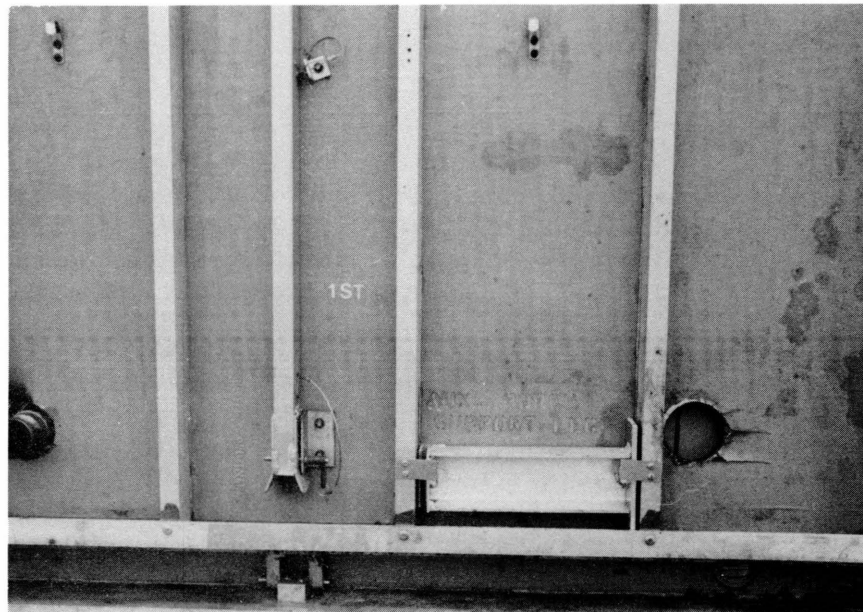


Figure 3.7.12. Auxiliary porch support legs should be taped into their brackets.

## SECTION 4: OPERATION OF UTILITY SYSTEMS

### 4.1 THE UTILITY SYSTEMS

The utilities include electrical, heating, and water systems. The electrical system includes two distribution networks, 125 V a.c. and 12 V d.c. The 125-V system is powered by an 8-kW gasoline-powered alternator. The 12-V system runs on storage batteries which are recharged by the 125-V system. The shelter can accept 125-V a.c. power from external sources.

The prime heating system uses waste heat from the gasoline engine, distributing it through the shelter via a forced hot air system. A gasoline-powered auxiliary heater runs when the shelter's main systems are shut down.

The water system starts with a holding tank that doubles as a snow melt container. Water is transferred to a gravity tank that provides the pressure head for the system. A wastewater tank is emptied only when full to avoid freezing problems in the discharge tube.

The shelter also contains safety systems for fire and carbon monoxide, equipment for storage and preparation of food, furniture, and provisions for personal hygiene.

### 4.2 THE ELECTRICAL SYSTEM

#### 4.2.1. Description of the Electrical System

Primary electrical power comes from one of two sources, the on-board gasoline-powered alternator or an outside hook-up to line power. A switch on the electrical distribution panel determines which alternative is active or, in its neutral position, disengages all power.

The alternator (Figure 1.2.4, item 1) is an 8-kW Generac unit powered by a 1000-cm<sup>3</sup> industrial grade four cylinder Opel gasoline engine. The alternator supplies 33.3 A at 240-V a.c. or 66.6 A at 120-V a.c. single phase power. It supplies a maximum of 30 A at 12 V d.c. for self-tapering battery charging from the main rotor. The engine supplies a maximum of 15.6 HP at 1800 RPM. The alternator should run during times of substantial activity in the shelter, such as during the morning and evening meals and during activities preparing for or winding up a day's activities in the field. When the activity level is low, such as at night or while the inhabitants are in the field, the alternator should be shut down to conserve fuel.



When the alternator is not in use, a back-up 12-V d.c. power system is available. An auxiliary heater uses this system to pump and ignite fuel. The 12-V lights in every room draw on this system. The power source is two storage batteries rated at 96 A-h which are recharged by a battery charger that runs off the 120-V a.c. system when it is in operation.

IMPORTANT: Check battery acid levels and the security of hydrogen vent caps before using 120-A a.c. power.

On-board and line 120-V a.c. systems share the electrical distribution panel. The line entrance consists of a 240-V a.c., 30-A male plug which mates to a heavy extension cord. If only 120 V a.c. is available, an adapter taps power through two of the three available legs in the 240-V a.c. plug to provide power to the most important circuits in the shelter. Ground-fault interrupters ground the electrical outlets to safeguard personnel from electric shock.

#### 4.2.2. 120-V a.c. Systems

##### 4.2.2.1. On-Board Power

To obtain on-board power, start the alternator with the switch on the utility wall facing the kitchen counter (Fig. 4.2.1, item 1). Follow the check list in Appendix XII. Depress the switch to the start position until the engine fires up. Depress the switch to the off position to kill the engine. A voltmeter should register in the green range mounted near the switch (Fig. 4.2.1, item 2).

For cold starts it may be necessary to open the engine port and reactivate the choke after the engine starts. A start button is located on the engine itself. The choke should be on a rich setting for easier cold starts. This will cause noisy operation until the engine warms up.

To improve cold starting from extreme cold soak conditions, use the auxiliary heater to preheat the engine. A flexible hose attached to the heater can direct the warm air from the heater into the engine compartment. This procedure is especially recommended to keep the engine warm while it is off.

CRREL Internal Report 615 contains operational specifications and maintenance data for the alternator.

##### 4.2.2.2. Outside Line Hook-up

When an outside source of power is available, the external hook-up to the shelter can be used. The hook-up is a waterproof socket adjacent to the main door (Fig. 4.2.2). The four-prong extension cord fits a 240-V a.c. 30-A outlet. An adapter uses two of these legs to plug the most

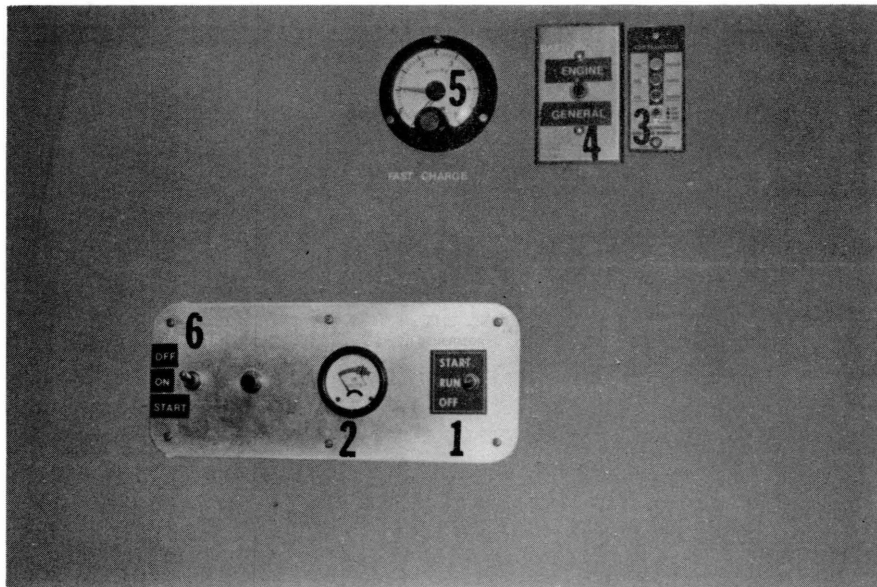


Figure 4.2.1. The remote control panel:

1. Alternator remote start
2. Voltmeter
3. Battery charge level monitor
4. Engine battery/general 12-V system monitor switch
5. Timer for battery fast charge
6. Auxiliary heater remote start

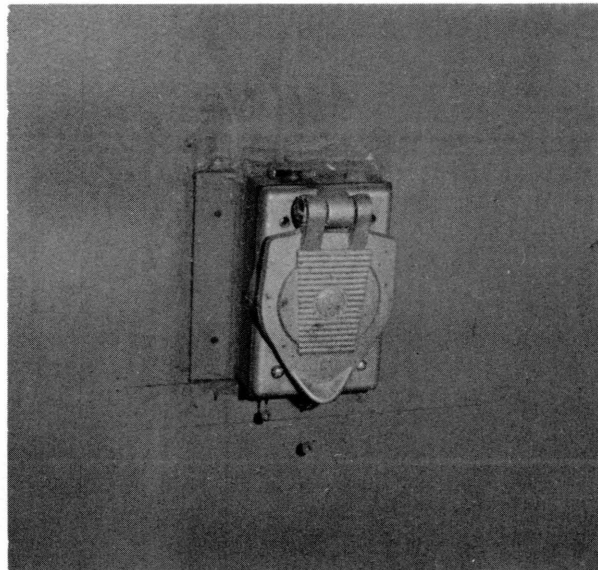


Figure 4.2.2. Exterior power inlet.

important circuits into a 120-V a.c. 30-A outlet. Another adapter permits plugging into an ungrounded 240-V a.c. 20-A outlet.

#### 4.2.3. 12-V d.c. System

##### 4.2.3.1. Charge Monitoring

Since 12-V d.c. operation relies on batteries as the source of power, it is important to know the batteries' condition. A small panel (Fig. 4.2.1, item 3) with three lights in a column mounted near the engine start switch on remote control panel monitors battery charge level.

The lights indicate the condition of the general 12-V d.c. system only when the adjacent switch is pressed (Fig. 4.2.1, item 4). When the switch is not pressed, the lights indicate the level of the engine start battery while the engine fuel pump is working but the engine is not cranking. It is normal for the indicator to read low during actual cranking. When the switch is pressed, the lights indicate the level of the main 12-V batteries if the system is draining 12 V d.c. and the batteries are not charging. A test switch mounted on the panel tests the bulbs and buzzer and turns the panel off if desired.

##### 4.2.3.2. Recharging

The 12-V storage batteries are trickle charged as long as 120-V a.c. current is available. A timer provides a higher rate of charge (Fig. 4.2.1, item 5). The timer should not be set for a period longer than one hour.

To start the higher rate of charging, press the red button. Running the timer for longer than an hour may evaporate the battery electrolyte or overheat the battery plates.

#### 4.3. THE HEATING SYSTEM

##### 4.3.1. Description of the Heating System

The shelter has two sources of space heating. Waste heat from the alternator (Fig. 1.2.4, item 1) is the main source. This system works like an automobile heater. A thermostat diverts hot engine coolant from the radiator to a fan-coil unit (Fig. 1.2.4, item 6), composed of a heater core and a fan. The fan blows a mixture of fresh and inside return air through the heater core and then forces it through the shelter. This heat source operates only when the alternator is running.

When the engine is not running, a gasoline-powered auxiliary heater (Fig. 1.2.4, item 2) is available. It is above the engine compartment and requires 12-V d.c. power for pumping and igniting fuel.

#### 4.3.2. Primary Heating

To obtain heat from the engine, place the valve handle (Fig. 4.3.1, item 1) located near the floor at the end of the kitchen cabinet in the horizontal position. Flip the nearby switch (Fig. 4.3.1, item 2) to circulate air through the heater coil and distribute it through the shelter. A thermostat on the wall above controls the fan when the switch is in the lower "on" position. A knob (Fig. 4.3.1, item 3) on the other side of the same panel controls fresh air entering the shelter via the heater. Pull the knob to cut off fresh air.



Figure 4.3.1. The primary heat exchanger:

1. Coolant circulation valve
2. Blower switch
3. Fresh air intake control.

#### 4.3.3. Auxiliary Heating

To start the auxiliary heater, press the spring-loaded start switch until the heater has warmed up enough to sustain itself. The switch is on the remote start panel (Figure 4.2.1, Item 6). A click indicates that self-sustained operation is possible.

When directing the air from the heater into the engine compartment, open both port holes so that air, after heating the engine, will heat the shelter as well.

After the heater has been turned off the fan may cycle on and off a number of times during the cooling-off period. Check for water in the carburator if the heater stops accidentally.

#### 4.4 THE WATER SYSTEM

##### 4.4.1 Description of the Water System

The water system has four main functions: 1) to collect water from nearby sources, either as snow or free-running water, 2) to store hot and cold water, 3) to distribute water for drinking, washing or recharging the chemical toilet, 4) to dispose water after use.

First place the water in the snowmelt/hold tank (Fig. 1.2.4, item 7). If the water is frozen, direct engine waste heat into the snowmelt tank with the diverter valve under the hot water tank (Figure 4.4.1, Item 5).

The snowmelt tank can hold 75 gal. of water below the opening. It can hold a maximum of about 15 ft<sup>3</sup> of snow, which might provide a minimum of 55 gal. of water. This could last a party of four from one to four days, depending on how well they conserve.

Where water is available unfrozen, pipe it directly into the snowmelt/holding tank. When necessary, treat the water with chlorine in this tank.

Transfer the water out of the snowmelt/holding into the gravity tank (Fig. 1.2.4, item 8) before it freezes. The gravity tank has a capacity of 58 gal. and feeds directly into the 12-gal. water heater (Fig. 1.2.4, item 9).

The water heater has both an engine coolant heat exchanger and an electrical resistance coil. The gravity tank is shallow and mounted near the roof of the shelter in the utility compartment to provide an adequate head for the system.

**There are three normal outlets for the water:** two sinks in the kitchen counter and a filtered tap mounted on the utility wall by the kitchen window for drinking water.

Wastewater accumulates in a holding tank (Fig. 1.2.4, item 10). The holding tank is full when water rises in the drains. Pushing the handle under the kitchen sink allows the water to siphon outdoors in one

continuous discharge, avoiding the possibility of freezing caused by repeated slow draining.

#### 4.4.2. Maintaining a Water Supply

Prepare the water system according to the check list in Appendix VIII. First, install the snow melter drain plug in the center snow melter hole and the wastewater hose in the far right hole (see Fig. 3.7.1, Items 1 and 2).

##### 4.4.2.1. Melting Snow

Collect snow or ice from a nearby unpolluted source, bring it up the steps to the landing adjacent to the snowmelter access door and dump it into the snowmelter. Close the door when the compartment is filled with snow.

Follow the check list in Appendix IX. Heat from the bottom of the snowmelt container and a hot water spray from the shower head melt the snow.

First, the engine must be warm to provide hot coolant for the heat exchanger in the compartment. Next, wet the bottom of the snowmelt tank with water from the gravity tank by opening the valve shown in Figure 4.4.1. Close the valve and turn the diverter valve labeled in Figure 4.4.2 to the shower position (left).



Figure 4.4.1. The demand side of the water compartment.

1. Cold water demand.
2. Hot water demand.  
Both have drains to snow melt tank.
3. Allow water to flow through valve before turning on heater.
4. Heater element switch.
5. Snow melt (left)/water heater (right) diverter valve.



Follow the checklist in Appendix IX. Heat from the bottom of the snowmelt container and a hot water spray from the shower head melt the snow.

First the engine must be warm to provide hot coolant for the heat exchanger in the compartment. Next, wet the bottom of the snowmelt tank with water from the gravity tank by opening the valve shown in Figure 4.4.1. Close the valve and turn the diverter valve labeled in Figure 4.4.2 to the shower position.

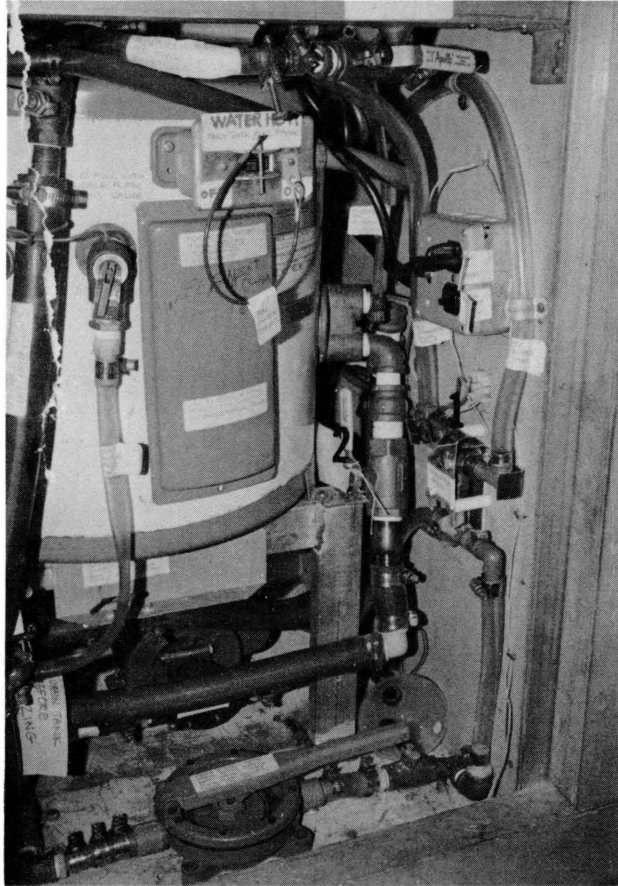


Figure 4.4.2. The input side of the water compartment.

1. Diverter handle to right for filling demand tank. to left operates shower.
2. Handle parallel to hose for engine coolant heating of hot water.

Prime the system, if necessary, with the hand pump. Turn on the circulating pump with the switch mounted just inside the left-hand utility compartment access door. Allow the pump to run until the water level stops rising in the gauge mounted next to the refrigerator compartment. This indicates that the snow-melting process is complete. The next step is to charge the gravity tank as described in section 4.4.2.3.

#### 4.2.2.2. Taking on Water

If water can be obtained in a liquid state, pump it directly into the snowmelt/hold tank. When temperatures are below freezing, leave



the supply line empty of water between fillings of the snowmelt/holding tank. Take care that water in that tank does not freeze. Use the snowmelt heat exchanger before shutting the engine down to heat the water in the snowmelt tank before a cold night.

#### 4.2.2.3. Charging the Gravity Tank

To transfer water from the snowmelt/holding tank into the gravity tank at the top of the utility compartment, follow the checklist in Appendix X. Make sure the diverter valve is in the correct position (right, Fig. 4.4.2).

Now turn on the electric pump and allow it to run until its sound changes, a sign that it has run dry in the snowmelt/holding tank. After 6 or 7 min. check if the pump is overflowing the gravity tank and allowing water to run through the standpipe in the gravity tank back down into the snowmelt/holding tank. If so, shut the pump down.

When the occupants have used enough water, pump the remaining amount from the snowmelt/holding tank into the gravity tank.

An auxiliary hand pump is mounted in parallel to the primary electric pump in case of pump failure and for priming. To use it, position the valve handles at either end parallel to the pump handle. The handle draws on the upstroke and expels on the downstroke.

#### 4.2.2.4. Charging the Water Heater

Fill the water heater completely before turning the heating element on. Open the safety valve until water flows steadily. Turn on the switch mounted at the top of the tank (Figure 4.4.1, Item 4) for electric water heating. To use the tank's heat exchanger, turn the valve handle shown in Figure 4.4.2 (Item 2) parallel to the pipe and turn the diverter valve under the heater (Figure 4.4.1, Item 5) to the right.

### 4.4.3 Using Water

#### 4.4.3.1 Drinking Water

Drinking water is obtained from the spigot mounted on the utility compartment wall adjacent to the kitchen window. This water passes through a charcoal filter housed in a cartridge mounted on the wall.

Treat all water obtained in remote locations according to accepted procedures. Mixing chlorine in the snowmelt/holding tank is one method. The charcoal filter will help remove unpleasant tastes and odors from any such treatment.

Water will not flow readily through the filter until it has been loosened to the point of leaking and then retightened.

#### 4.4.3.2 Wash Water

Starting flow through the spigots in the sinks may require opening the valves at the bottom of the freezer (Figure 4.4.3).



Figure 4.4.3. Water system drain valves. (Other drain valves are in the water compartment and adjacent to the wastewater holding tank.)

Properly treated water is safe for washing dishes, etc. Draw such water from the hot or cold taps mounted on either kitchen sink.

#### 4.4.4 Wastewater

##### 4.4.4.1 Normal Operation

All water from the kitchen sink collects in a holding tank beneath the right-hand sink. Make sure the valve handle at the base of the tank is upright. When the tank fills, it backs up into the sink. Depress the lever below the sink for about 10 seconds to start the water siphoning out of the tank. The siphoning stops automatically when the tank is empty. The water flows from the tank to an outside connection near the deployment joint. Dispose of the "grey" wastewater from this point as local regulations require.

#### 4.4.4.2 Draining the Water System

Drain the entire water system if the building might freeze. Follow the checklist in Appendix XI. The system can drain through three outlets: the center external fitting on the snowmelt/holding tank, the system drain second from right, or the wastewater holding tank drain.

Place the valve handle at the base of the wastewater holding tank in the horizontal position to bypass the siphon. Open all the spigots into the sinks. Open the drains from the gravity tank and water heater to channel the water into the snowmelt/holding tank. Open all three valves at the base of the freezer (see Fig. 4.4.3).

Drain the snowmelt tank directly using the pipe with the protruding rod. Remember to loosen the cover on the electric pump.

### 4.5 SAFETY SYSTEMS

#### 4.5.1 Description of Safety Systems

Fire is the greatest enemy to building occupants in the cold regions. Therefore the shelter has an automatic fire extinguishing system and hand-held extinguishers. There is also a fire-smoke detector and alarm. The presence of a gasoline engine on board makes carbon monoxide (CO) poisoning a hazard. A CO detector and alarm minimize this danger.

#### 4.5.2. Fire Extinguishers

Fire in the engine or heater compartments activates the automatic fire extinguisher automatically. A handle adjacent to the main door in the WC activates it manually.

A loud bell rings when the system is activated and runs until the CO<sub>2</sub> extinguishing medium is exhausted. The sensing system is powered by 24-V batteries located behind the large 12-V batteries.

Portable fire extinguishers should be used for fires located elsewhere. Fires on the alcohol stove should be extinguished with water.

#### 4.5.3. Carbon Monoxide Detection

The carbon monoxide monitor is located in the WC adjacent to the main entry door. It can be turned off with a switch on the 12-V d.c. panel. When the unit is connected for the first time after shut-down it sometimes gives a false alarm. Set the knob to "purge" for an hour after the red light goes out and return to "alarm." Its operation is described in CRREL Internal Report 615.

#### 4.5.4. Smoke Detection

The smoke detector is located on the ceiling in the WC. It is battery operated and should be tested periodically by depressing the test button. Its operation is described in CRREL Internal Report 615.

### 4.6 EQUIPMENT

#### 4.6.1 Kitchen Accessories

The kitchen equipment includes a microwave oven and an alcohol stove. The microwave oven cooks using high-powered radio waves that excite the water molecules in the food, thereby warming it. Because the heating takes place uniformly throughout the food, a meal cooks much more quickly than it would normally. Read the manual thoroughly before attempting to cook anything.

#### 4.6.2. Toilet

The toilet is a recirculating chemical toilet. Instructions for its use are in Internal Report 615 and on the unit under the cover. The chemical mixes with water; therefore it must be protected from freezing. Renew the chemical medium after about four or five days of use.

Empty the contents of the toilet into a suitable receptacle. In most remote locations the waste should be stored and returned to civilization for proper disposal.

The contents of the toilet are emptied by pulling on the handle bar at the base of the unit. This handle should never be pulled unintentionally. Toilet operation is described in Internal Report 615.

#### 4.6.3. Portable Shower

A portable shower unit plugs into the 12-V d.c. receptacle above the entry to the deployable room. It packs in a black 62 cm (30 in.) square suitcase.

The shower uses 5 gal. of hot water in the base and circulates this water through the shower head and back into the base for re-use. To take a shower, rinse, then turn off the shower, soap up, and then rinse off the soap.

#### 4.6.4. Furniture

The shelter furnishings consist of two card tables, two day beds, and three Luxo swing-arm lamps. Four bunks in the bunkroom double as storage for personal belongings and spare equipment.

Position the card tables and day beds as shown in Figure 4.6.1. Insert the Luxo lamps in the sockets provided about 4 ft up from the work/living room. The bunks can be rearranged within the bunkroom by stacking them on one another or tilting them 90°.

Do not obstruct the air vent at the far end of the bunk room. One bunk is constructed with an opening at its foot to allow for warm air to enter the bunk room.

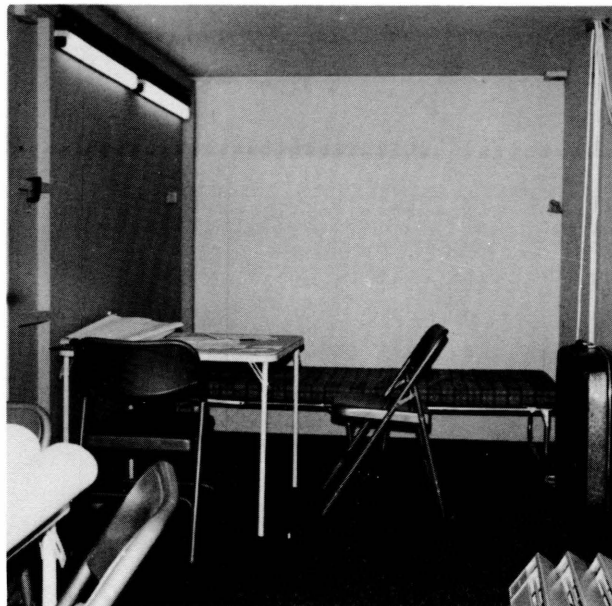
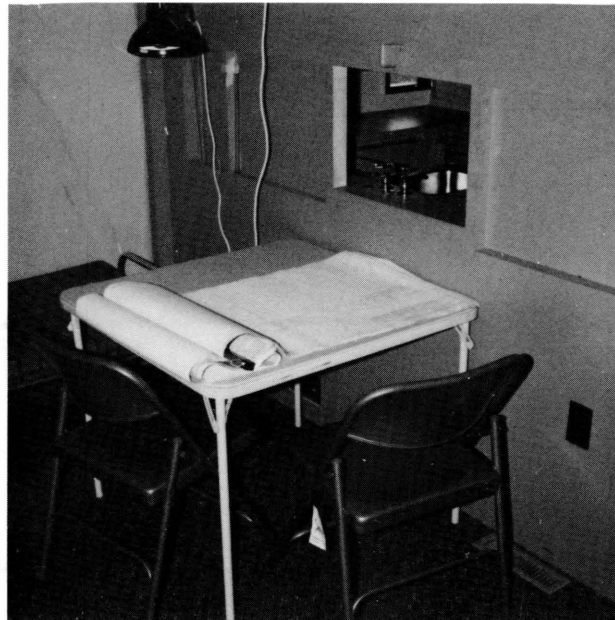


Figure 4.6.1. A suggested layout of the furniture in the deployable room. Figure 1.2.4 shows the overall suggested plan.

Appendix I

Check List for Loading the Shelter

x = mandatory    o = optional    - = does not apply

<u>Equipment Required</u>	<u>Truck</u>	<u>C-130</u>
1. 1/2-in. drive crank (speeder) handles (1 for every 2 people)	x	x
2. 1/2-in. drive ratchet handles (1 for every 2 people)	x	x
3. 3/4-in. sockets for (1) and (2)	x	x
4. "come-along" hand winches - 2 needed	x	o
5. portable aircraft winch	-	o
6. 8-ft pipe - 4 needed	x	x
7. Snubbing line	o	o
8. Ramp support pedestal	-	x

<u>Loading Steps</u>	<u>Truck</u>	<u>C-130</u>
1. Emplace ramp support pedestal.	-	x
2. Align shelter and <u>disconnect steering rods.</u>	x	x
3. Jack shelter above bed height.	x	x
4. Overlap shelter and bed.	x	x
5. Place pipe roller at front of shelter.	x	-
6. Lower shelter end onto bed.	x	x
7. Remove first set of legs.	x	x
8. Jack shelter bottom flat with cargo bed.	x	x
9. Roll center of shelter well past end of bed.	x	x
10. Add pipe rollers at both ends of overlap.	x	-
11. Roll shelter to next strut line.	x	x
12. Retract legs.	x	x
13. Remove legs.	x	x
14. Roll shelter on bed.	x	x
15. Stow underpinnings.	x	x
16. Stow tools and bolt.	x	x

Note: Further details for self-loading are found in section 2.3.2.2 for trucks and 2.3.3.2 for the C-130.



APPENDIX II

Check List for Unloading the Shelter

x = mandatory    o = optional    - = does not apply

<u>Equipment Required</u>	<u>Truck</u>	<u>C-130</u>
1. 1/2-in. drive crank (speeder) handles (1 for every 2 people)	x	x
2. 1/2-in. drive ratchet handles (1 for every 2 people)	x	x
3. 3/4-in. sockets for (1) and (2)	x	x
4. "Come-along" hand winches - 2 needed	x	o
5. Portable aircraft winch	-	o
6. Snatch block	-	o
7. 8-ft pipe - 4 needed	x	-
8. Snubbing line	x	x
9. Ramp support pedestal	-	x
<u>Unloading Step</u>	<u>Truck</u>	<u>C-130</u>
1. Emplace ramp support pedestal.	-	x
2. Unpack underpinnings.	x	x
3. Emplace snubbing line.	x	x
4. Emplace snatch block.	-	o
5. Emplace come-alongs/winch.	x	-
6. Roll shelter past strut location.	x	x
7. Install legs and struts (see check list).	x	x
8. Tighten cross cables.	x	x
9. Extend legs until shelter bears on ground.	x	x
10. Roll shelter off past first set of legs.	x	x
11. Install legs and struts (see check list).	x	x
12. Tighten cross cables.	x	x
13. Extend legs until shelter bears on ground.	x	x
14. Lower shelter when clear of bed and connect steering.	x	x

Note: Further details for self-unloading are found in Section 2.3.2.3 for trucks and 2.3.3.3 for the C-130.

### Appendix III

#### Check List for Expanding Hard Wall Shelter

Note: The shelter legs are assumed to be installed.

<u>Step</u>	<u>Reference</u>
1. Locate shelter on site	3.3.1
2. Release porch support brace retaining pins (2 each).	3.4.1.
3. Release porch slide latches (2 each).	3.4.1
4. Deploy porch (at least two people).	3.4.1
5. Unpack stairway.	
6. Attach stairway.	
7. Unpack skis (for use as footing pads).	
8. Install skis.	
9. Detach steering rods and level shelter.	3.3.3
10. Unpack deployment beams, jacks and footing pads.	
11. Install deployment beams, jacks and footing pads.	3.4.2.1
12. Level deployment beams with the deployment jacks.	3.4.2.1
13. Attach cables to corner fittings and tighten.	3.4.2.2
14. Unbolt deployable section.	3.4.2.2
15. Expand shelter (use two people only).	3.4.2.2
16. Secure deployable section with pins.	3.4.2.2
17. Lower deployable floor.	3.4.2.3
18. Detach floor hoist from floor.	3.4.2.3

Note: Further details for deploying the hard wall portion of the shelter are found in sections 3.3 and 3.4 of O&M Manual.

## Appendix IV

### Check List for Striking Hard Wall Shelter

#### Procedure Step

1. Level shelter.
2. Attach floor hoist to floor.
3. Raise and latch deployable floor.
4. Unpin deployable section.
5. Close deployable section (use two people only).
6. Bolt deployable section at each column base (2 bolts each)\*.
7. Remove deployment beams and jacks.
8. Retract screws and struts on deployment jacks to their minimum extension.
9. Stow deployment beams and jacks.
10. Remove and stow skis (if travel is to be on wheels).
11. Remove and stow stairway.
12. Retract main jack legs to minimum extension.
13. Connect steering rods.
14. Stow tools.
15. Stow porch and porch support braces.

\*It may be necessary to employ a cable hand winch to pull the column onto its base.

## Appendix V

### Check List for Erecting the Tent

<u>Procedural Step</u>	<u>Reference</u>
1. Unpack tent framework and cables.	
2. Place attachment fittings at color- and number-coded locations.	3.5.1.3
3. Install attachment fittings.	3.5.1.4
4. Lay out tent poles at color- and number-coded locations.	3.5.1.3
5. Install vertical tent poles.	3.5.1.5
6. Install door jamb, horizontal struts, and horizontal poles on porch.	3.5.1.5
7. Lay out tent cable.	3.5.1.3
8. Attach tent cable to ridge poles.	3.5.1.6
9. Attach gable cables to eave lines at stations 1 and 2.	
10. Unpack tent on roof of shelter.	3.5.2
11. Attach tent to eave line, station 5.	
12. Raise tent over ridge line and past porch eave line.	
13. Attach tent gables to shelter and strut along green and yellow sections.	
14. Attach tent to door jamb and latch under porch.	
15. Lace bottom of tent's porch wall to underside of porch.	
16. Unpack and install porch doors.	

Note: Further details on erecting the tent are found in section 3.5.

## APPENDIX VI

### Check List for Striking the Tent

#### Procedural Step

1. Remove and pack porch doors.
2. Unlace bottom of tent's porch wall from underside of porch.
3. Unhook tent from along door jamb and gable ends.
4. Lift tent over the ridge line and place between cables.
5. Unhook tent from deployable eave line.
6. Stow tent.
7. Coil and bind gable cables.
8. Remove and stow ridge cable.
9. Remove and stow long and short struts and poles in separate cases.
10. Remove and stow attachment fittings.

## APPENDIX VII

### Check List for Installation of Legs

#### Procedural Step

1. Match each leg in pair with color-coded location.
2. Place leg in upright position.
3. Crank leg until its extension allows holes to match.
4. Install at least one bolt on leg loosely.
5. Align holes of diagonal strut.
6. Install at least one bolt in strut loosely.
7. Install remaining bolts with light pressure.
8. Adjust legs to hang from building.
9. Place the cross-beam in the pockets.
10. Install the crossing cables.
11. Extend jacks until building bears firmly.
12. Tighten crossing cables.
13. Tighten all bolts firmly.
14. Raise building clear of its resting place.

Note: Further details for installation of legs are found in Section 2.2.2.2.



## APPENDIX VIII

### Check List for Water System Preparation

#### Step

1. Install snow melt tank drain plug "T handle" (middle hole under snowmelt tank).
2. Install wastewater drain pipe (far right hole).
3. Install wastewater drain insulated tube so that it has no dips to trap water that could freeze.
4. Close drains at base of freezer compartment.
5. Proceed with snow melter check list or fill snow melt tank with water.

## APPENDIX IX

### Check List for Snow Melter

#### Procedural Step

##### Start-up:

1. Fill compartment with loose snow and ice.
2. Turn the diverter valve under water heater full left.
3. Run engine.
4. Monitor water level of compartment in sight tube.
5. When water appears, follow Routine steps 2 through 7.

##### Routine:

1. Drain water from water heater until visible in sight tube.
2. Fill compartment with snow and ice.
3. Run engine with coolant diverter full left.
4. Turn off valve above water heater.
5. Divert pump water circuit to snow melt shower.
6. Run pump until snow is melted.
7. Follow steps 8 through 14 in Holding Tank Check List.

Note: Further details on use of the snow melter are found in section 4.4.2.1.

## APPENDIX X

### Check List for Holding Tank

#### Step

1. Close hose restricter at bottom of water heater.
2. Close valves on holding tank and water heater drains.
3. Tighten cover on water pump.
4. Tighten water filter on drinking water tap.
5. Open valves on both ends of hand pump.
6. Prime lines with hand pump.
7. Close valves in (5).
8. Direct diverter valve to right to fill holding tank.
9. Open valve above water heater.
10. Run electric pump.
11. Monitor pump inlet for water flow (sound usually changes with low water).
12. Monitor hose in (9) for holding tank overflow.
13. Turn off pump within 30 seconds of running dry.

Note: For further details see section 4.2.2.3.

## APPENDIX XI

### Check List for Drain Water System

#### Procedural Step

1. Remove snow melt drain plug and install drain extensions (Figure 3.7.1, Items 3 and 4) in center snowmelter hole and second hole from right.
2. Open all valves\* and faucets in water system.
3. Open hose restricter on bottom of water heater.
4. When faucets no longer run, empty trap on drinking water filter.
5. Loosen cover plate on electric water pump.
6. Store four drain fittings in water compartment:
  - a. Snow melter drain plug
  - b. Snow melter drain extension
  - c. Water system drain extension
  - d. Wastewater drain hose

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\*Wastewater holding tank drain  
Cold water drain to snow melter  
Hot water drain to snow melter  
Three valves at foot of freezer compartment

Note: For additional information see section 4.4.4.2.

## APPENDIX XII

### Check List for Alternator

#### Step

##### Start:

1. Switch electrical source on power distribution panel to "steet power."
2. Switch Electrical Systems Monitor to "test," then "on."
3. Divert coolant valve under water heater to full right.
4. Check battery acid levels and security of hydrogen vent caps.
5. Start engine.
6. For cold starts open port and deactivate choke.
7. Switch electrical source to "generator power."
8. Open exterior side doors on engine compartment.

##### Stop:

1. Close exterior side doors.
2. Kill engine after two minutes.

Note: For additional information see section 4.2.2.1

APPENDIX XIII  
Check List for Packing

<u>Step</u>	<u>Reference</u>	<u>Figure</u>
Furniture and Equipment:		
1. Stow all supplies and equipment not belonging to the shelter in cupboards and bunks.		
2. Stow lamps on bunks.		
3. Transfer all mattresses to upper left bunk: two horizontal and two against side and front walls.		
4. Strap down microwave oven inside against forward left corner of upper left bunk with glass tray and cookbook secured.	3.7.2	
5. Strap down toilet at aft end of upper left bunk.	3.7.3	
6. Strap day cots, portable shower, and chairs to upper right bunk.	3.7.4	
7. Strap card tables to wall beneath remote engine and heater controls.	3.7.5	
Tent:		
1. Place tent bag along left cabinets on floor in kitchen.	3.7.5	
2. Place two bags of poles on top of tent next to cabinets.	3.7.5	
3. Place three fittings bags among strapped items on upper bunks.		
4. Strap porch doors over card tables.		
Deployment Equipment:		
1. Strap beams over tent next to poles: Take a wrap around the beams before tightening. Pad the forward ends with foam.	3.7.5	
2. Strap deployment jacks to inside of toilet compartment	3.7.6	
3. Strap jack and level inside right closet.	3.7.7	
4. Check for all tools and sockets to be on rack.		
Mobility Equipment:		
1. Strap skis to left bunk.	3.7.8	
2. Strap wheels to right bunk.	3.7.9	
3. Strap cross members and towing tongue assembly to floor between tent and doors. Use foam to pad forward ends.	3.7.10	
4. Strap main jack legs into toilet compartment.	3.7.11	
Miscellaneous:		
1. Lock front door.		
2. Tape auxilliary porch support legs to their brackets.	3.7.12	