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LOW-COST SLEEPING FACILITY

Final Report

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NATICK, MASS.

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CLOTHING & ORGANIC MATERIALS DIVISION

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SUMMARY

During this study two prototype bunking facilities were developed which incorporate low cost and maximum space utilization. Both units utilize a metal framework with a plywood sleeping surface and are capable of being tiered 3, 4 and 5 high for high density sleeping. The units are also capable of being assembled and disassembled with a minimum of effort and time and can be converted to sitting and messing facilities. The recommended bunk size is 75 inches long by 24 inches wide with 20 inches vertical spacing. The cost estimate per person in quantity purchases is estimated at $3.00 or less.

Any further investigations in this area should include more extensive studies on the sleeping surface material, development work on the refinement of the prototypes, development of a color coding system to facilitate ease of assembly, a detailed instruction booklet for assembling the units and a specification for purchase.

LOW-COST SLEEPING FACILITY

1. Introduction

The study and development of low-cost sleeping facilities for fall-out shelters was initiated by the U.S. Army Quartermaster Research & Engineering Command under Work Order No. OCD-OS-62-46 to the Department of Defense, Office of Civil Defense.

A program is currently being conducted by the Office of Civil Defense which will identify approximately fifty million shelter spaces in existing buildings and other structures. Structures that provide an adequate protection factor will be identified, marked and stocked with essential food, water, sanitation equipment, medical equipment and radiation monitoring equipment. At this time, no provisions have been made for sleeping facilities in these potential fall-out shelters. This project was initiated to develop an extremely low-cost sleeping design which can be used in conjunction with these potential fall-out shelters.

The general objectives are shown in the work order from Office of Civil Defense (Appendix A) and the specific objectives of the contract are:

To explore the characteristics of sleeping facilities suited for fall-out shelters.

To determine or consider the feasibility of utilizing various combinations of tiered facilities including demounting and storage capabilities.

To determine the adaptability of sleeping facilities in regard to different shelter configurations, variations of ceiling heights and area restrictions, obstructions or interference and to study the feasibility of converting the sleeping facilities into sitting facilities.

To develop a sleeping facility consistent with the maximum space utilization in shelters at an extremely low cost.

a. Shelter Design

The basic design criteria for shelters are outlined in several publications, but for the purpose of this study, space is of prime importance rather than protection factor, ventilation requirements, or other factors. To be considered for a fall-out shelter, an existing structure should be able to accommodate a minimum of 50 persons, allocating 10 sq. ft. per person. The structure should also have a minimum of 6 1/2 feet head room for at least 50% of the occupants and 4 ft. for the remainder.

Since the sleeping units would have to be incorporated into an existing structure, the configuration of the shelters would be one of the major factors governing the design of the sleeping facilities.

Most of the shelter areas are expected to occur in unfinished basement areas and will be rectangular in shape, varying from a square area to a long narrow corridor, which may be L, U, E, or H shaped, but basically rectangular.(1)

Several existing buildings which had been evaluated as having a protection factor of 100 or greater were visited in the Worcester, Mass., area for the purpose of viewing first hand actual structures that could be converted to fall-out shelters.*

As a result of visiting potential shelter spaces, it was obvious that a great variety of configurations will be encountered during the survey phase of the shelter program. In addition to the numerous configurations encountered, it became apparent that a great variety of interior restrictions and limitations would also be encountered. Restrictions such as pipes, ducts, lighting fixtures, false ceilings and walls, temporary partitions, storage cabinets, and permanently installed equipment would have to be considered if sleeping facilities were to be installed.

The design of a standardized sleeping unit for all the different configurations and restrictions encountered becomes a very complex problem as compared to installing sleeping units into a standardized fall-out shelter.

b. Low-Cost Requirements

Another of the controlling factors in the design of a sleeping unit is the cost per sleeping surface. Since the National Shelter Survey Program is considering approximately 50 million shelter spaces(2) it is mandatory that the cost per space be kept extremely low or the total cost of equipping a shelter would become impractical.

From the cost aspect then, it follows that the designs of the sleeping units must be held to a minimum or be completely standardized to one or two units. A cost of two dollars per shelter space has been estimated(4) and this is the figure that was used as a goal for the units in considering designs for the sleeping facilities.

c. Human Factor Considerations

Human factors recommendations are made for consideration in design of the interior of community fall-out shelters.

*Worcester, Mass., had been chosen as one of the pilot cities in the United States for the National Shelter Survey Program.

It is necessary to assume that the population of a community fall-out shelter will probably be a group composed of the most difficult and unlikely combination of individuals, including babies, children and teen-agers, aged and infirm, sick and injured, and admixtures of social and cultural strata comprising racial and minority groups, all compressed together in an overcrowded space. In the presence of such stress-producing factors, the small physical details of a survival shelter are apt to become very important to the individual occupants, especially during prolonged, enforced habitation. Thus it should be remembered that what appears trivial at present may become very important in the actual situation.

Equipment inside shelters should be simple and operable by a novice or an incapacitated or aged person. This is a practical as well as economical point of view. Also, it should not take great strength or combined group action to accomplish essentials, because survival should not depend upon the composition of shelter groups. If there are no able-bodied men in a group, this group would still have a chance to maintain itself.

Directions for operation of equipment should be short and clear, couched in terms that are familiar to the poorest reader who is able to use the language. There is no point in providing information which, although it can be read, cannot be understood.

The use of modular construction inside shelters will permit re-use and recombination of the components daily into other facilities. Manufacture of the shelter components in a variety of colors might help to reduce the monotony which will be encountered. Also, different colors could serve as coding such as color contrasting bed platforms to indicate sick persons.

The use of modular construction would also serve to create work and, therefore, activity. The units could be broken down daily to provide either floor space or other required facilities, and reassembled as needed. Such work may be artificial, but would give people something to do. The need for activity produced by enforced idleness may turn out to be one of the worst problems contributing toward people's tendencies to leave the shelter before the outside radiation level has dropped to a safe value.

2. Initial Design Concepts

The initial design concepts basically fell into either one of the following two categories: fixed supported units or free standing units.

a. Fixed Supported Units

The fixed supported units were further divided into the following sub-divisions:

Wall-Supported Units

This type unit has definite advantages in that it can be supported readily by relatively inexpensive wall supports and can be folded against the wall for storage when not in use. However, there are several disadvantages inherent in a wall-supported unit in the type of structure which will be utilized for shelters. Since the buildings likely to be utilized for fall-out shelters would vary considerably in size and shape each potential shelter would require an engineering lay-out to determine the positioning of wall brackets to support the bunks. After the initial location of bracket positions they would then have to be installed. Due to the variation in structures several types of wall brackets would have to be utilized which would result in a variety of items being utilized both between shelters and within shelters. In some shelter areas sections of the walls would be nonavailable due to impediments such as pipes, vent ducts, wiring and false walls. In large shelters wall spaces alone would not be sufficient to accommodate all occupants for sleeping purposes. This would result in the wall-supported type unit in addition to some other type (ceiling suspended or free-standing) to accommodate the remainder of the occupants. This again would result in a variety of fixtures and bunking units within each shelter and excessive expense.

Ceiling Suspended Units

Ceiling suspended units have advantages in that inexpensive brackets could be used for suspending a bunk unit and the units could be hoisted to the ceiling during non-sleeping hours. However, most of the same disadvantages that applied to the wall-supported units also apply here. Each shelter area would have to be pre-engineered to locate suspending brackets. Although inexpensive brackets might be available they would have to be installed in each shelter which would be extremely expensive. Due to the variation in ceilings several types of brackets would have to be utilized. In addition, ceiling space in some areas would not be able to be utilized due to impediments and false ceilings.

Stanchion Supported Units

Stanchion-supported units were another alternative investigated. This type of unit was utilized in the U.S. Navy Radiological Defense Laboratory shelters(5)(6)(7) and in the U.S. Navy, Bureau of Yards & Docks test at Bethesda, Maryland. This type of unit utilized stanchion supports from floor to ceiling between which bunks can be suspended. This configuration has the definite advantage of being able to provide a high degree of rigidity in the sleeping units. In the shelters referenced above, this type of installation was the logical approach, since the uprights or stanchions could be incorporated into the original design of the shelter or, at least, the attaching studs for holding stanchions could be installed

during the building of the shelter. In the case of existing buildings, the installation of stanchions or stanchion mounts becomes a costly project because each shelter requires individual surveying, engineering and modification before the stanchions or mounts can be installed.

The use of fixed stanchions would therefore result in many designs of items being required within, as well as between. Each shelter would present an ordering and stocking problem of parts required for the units.

b. Free Standing Units

From the view of standardization and simplicity the only feasible approach was to design a free standing unit that could be utilized in any shelter regardless of size or configuration. Due to the height requirements of the shelters(1), one standard unit would not suffice since tiering of units is desired at three to five high; so the alternative was to design a standard 3, 4, and 5 tier unit.

c. Prototype Dimensions and Spacing Requirements

A study was conducted to determine the optimum length and width of a sleeping surface for use in a fall-out shelter.

The dimensions were based on anthropometric data from a military population. Although this data does not represent a civilian population it is the best detailed data available and is considered feasible for determining the dimensions of the bunk. The optimum bunk dimensions were established as 75 inches long, 24 inches wide, with a spacing of 20 inches between tiers. Since such a short period was available for prototype development, these recommended dimensions were not reflected in the units developed, but can easily be accomplished as a refinement.

The length of the bunk was set at 75 inches. This dimension exceeds the 99th percentile of stature of the military population and therefore should include the majority of the civilian population.

The bunk width was set at 24 inches. This dimension was based on the shoulder breadth measurements of the military population and will also exceed the 99th percentile.

The spacing between tiers was set at 20 inches. This dimension was a compromise between the ease of entrance into the tiers and the maximum that could be allowed to maintain the stability and compactness of the overall framework when tiered five high. Spacing of less than 20 inches between bunk units resulted in difficult entry into the unit for large people. The lower tier was started at 6 inches above the floor.

A comparison of dimensions between several types of sleeping units is shown below:

Dimensions (in)	Recommended QMR&E Unit	Military Litter	Stirope's Stretcher Bunk	Troop Ship Bunk	Folding Cot	Single Bed
Length	75	72	76	76	77 1/2	78
Width	24	22	24	26 1/4	27	36

3. Approaches to a Tiered Unit

There are many existing designs available utilizing tiered units in both military and commercial applications and there are many available structures which can be adapted for sleeping surfaces such as storage racks or scaffolding units.

A logical starting point was sleeping arrangements designed for the U.S. Navy for high density troop transport during World War II. Blueprints were obtained from the Design Section of U.S. Naval Shipyards in Boston, Massachusetts, and Norfolk, Virginia, which depicted the types of sleeping accommodations utilized during World War II. These prints were screened for applicability to this project. In the majority of cases the Navy bunks were either wall-supported or hung from overhead; some free standing units were utilized but these were welded to the steel decks to improve rigidity. The shipboard problem, although similar in some respects to the shelter problem, was dissimilar in that the units would be used for a longer period of time than is anticipated for shelter bunks, and they had to be designed to withstand the forces of rolling and pitching of the ship. Because of these two reasons, the units were designed and fabricated from heavier and costlier structural material than is required in this application.

a. Commercially Available Bunks

U. S. Army tiered bunk facilities were investigated but were found to be too expensively designed and were only capable of being tiered two high which would not be adequate for this study.

Commercially available sleeping units were also investigated, but tiering capabilities were not available to the degree required and commercial units were too expensive to be considered at all. A typical commercial unit is the one being utilized by the Massachusetts Civil Defense Headquarters. These units are two wide and two high for sleeping four people. They are mounted on rollers and are capable of being folded

compactly when not in use. This unit sells for approximately $160.00 or $40.00 per person. This price does not include the cost of the mattresses which are required.

After reviewing the available sleeping facilities both military and commercial, it was decided that a completely new unit would have to be designed and developed to keep within the price requirements involved in this project.

4. Material Investigations

The material investigation was sub-divided into structural materials that would be utilized for the basic rigid framework and the surface material that would be used for the sleeping surface.

A survey of existing materials was conducted in each of these areas to ascertain the best material at a minimum cost which could be utilized for the sleeping units.

a. Surface Materials

The choice of a sleeping surface material was a difficult problem because of the wide variety of materials that are available.

Since so many materials were available, a criteria was set up to limit the selection of materials that would be tested on prototype test racks.

The original thinking on the surface material problem presupposed that the final item would be a flexible textile or plastic material that would conform to the body. In the final analysis, this original assumption proved to be faulty.

Criteria for Selection

The criteria for selection of a material was set up as follows:

Low-cost - In view of the low cost requirement of the overall unit it was mandatory that cost of the material utilized as the sleeping surface be kept to a minimum.

High-strength - Sufficient strength was required to allow people to sleep on the material and to withstand high stresses in the event of concentrated loads over small areas of the material as in the case of a person standing on the surface or several people sitting on the surface.

Low elongation - A material of low elongation was required to prevent undue sag during sleeping which would lead to discomfort. Excessive sagging would also necessitate an increase in the spacing requirements between tiered units.

Mildew resistance - This requirement is necessary due to the anticipated long storage requirements.

Permeability - A permeable sleeping surface would be more desirable than an impermeable surface because of the comfort factor. An impermeable surface would induce excessive perspiration and discomfort to the sleeper and would also increase the humidity of the shelter proper.

Fire resistance - Since fire inside the shelter would be hazardous, the material should preferably be fire-resistant or have a low degree of inflammability. Materials that could easily be made fire-retardant were considered.

Ease of cleaning - In view of the end use of the item, a material that could be easily cleaned preferably by wiping would be advantageous. The sleeping material would be subject to spillage of liquids and to soiling.

These were the criteria that the optimum surface material would possess and they were used as an aid in selecting or eliminating materials for final evaluations by cursory examinations. Some materials that were deficient in some of the requirements were still considered for final selection.

Materials

The materials to be considered were divided into the following general categories: Textiles; Plastics; Paper-Based; and Rigid Materials.

Textile Materials

Based on the above criteria, the Textile Engineering Branch chose the following 4 textile materials by cursory examination.

Cloth, Nylon, Rip Stop Spinnaker, Water Repellent.

Cloth, Nylon Plain Weave, Water Repellent.

Cloth, Filament, Nylon Duck, Plain-Weave, Water Repellent.

Cloth, Cotton Duck, No. 8 Hard Texture Duck, Mildew Resistant, Water Repellent.

These 4 samples were subjected to laboratory analysis. As a result of laboratory testing Cloth, Nylon Rip Stop Spinnaker was eliminated from further testing due to its low ultimate strength. The other three textile materials were selected for further testing on prototypes.

Plastic Materials

Plastic film and sheeting materials were considered for use but most of them were rejected immediately due to their high degree of impermeability, high elongation and low ultimate strength.

The only plastic material that appeared to fulfill most of the criteria required for selection was an experimental spunbonded polyethylene material being manufactured experimentally by E. I. duPont deNemours Company. The major drawback to this material was its high degree of impermeability; however, because of its extremely low cost, it was still considered as a possibility.

Plastic coated fabrics were eliminated because of their high cost.

Paper-Based Materials

Paper-based materials were considered for use mainly due to the low cost of some of the high-strength reinforced papers. Samples of wire reinforced, sisal reinforced and asphalt barrier materials were selected as possibilities and tested on prototypes.

Rigid Materials

Rigid materials have been used for sleeping surfaces in other studies(8) and two were considered as possibilities.

These materials would be required to have the properties outlined in the basic criteria for selection with the exception of the permeability factor. Since a rigid material would not conform to body contours permeability is not necessary because air spaces would be available around the body for cooling and reduction of perspiration.

Plywood and hardboard were both considered as possible candidates for sleeping surfaces and were tested on prototypes.

Several prototype sleeping designs were under investigation while the surface material investigation was in process. The selected surface materials were tested on these prototypes for final evaluation.

Testing

Testing of the surface materials was accomplished by attaching the material to the basic framework and loading each surface with 200 pounds of bagged sand (Figure 1).

Since several prototype frameworks were used for testing the methods of attachment to the framework varied. In some cases, the materials were attached to metal pipes by sewing loops into the edges and inserting the pipes into the framework "stretcher" fashion (Figure 2). In other cases, the materials were secured to angle iron side rails by the use of hairpin clips which were designed specifically for this purpose (Figure 3). The rigid materials were tested by supporting them between an angle framework (Figure 4).

Test Results

The surface materials were rated either satisfactory or unsatisfactory. Materials were rated unsatisfactory if obvious failures appeared such as inability to hold the weight due to insufficient ultimate strength, or if the material sagged excessively during loading.

The results of the initial tests are shown in Table I.

The materials that failed this initial loading test were eliminated from further consideration.

The remaining materials were tested with a static load of 400 pounds. Additional tests were run on the plywood to ascertain the minimum thickness that would suffice. It was found that 1/4-inch plywood with the grain running the width of the piece would adequately support a 400-pound load.

Cost Analysis

A cost analysis of the four materials was obtained and is shown in Table II. This cost breakdown is a material cost only and does not include any fabrication costs or those of attaching devices that may be necessary. The cost is based on a recommended bunk size of 6 feet 3 inches in length and 24 inches in width.

TABLE I

RATING OF VARIOUS SURFACE MATERIALS
FOR EXPERIMENTAL SLEEPING FACILITIES

	Nomenclature	Results of 200-Pound Load
1.	Cloth, Nylon, Water-Repellent, 4.3 oz/yd^2	Unsatisfactory - Excessive Sag
2.	Cloth, Filament Nylon Duck Water-Repellent, 12.8 oz/yd^2	Satisfactory
3.	Cloth, Cotton Duck No. 8 Hard Texture Duck, Mildew-Resistant, Water-Repellent 18.1 oz/yd^2	Satisfactory
4.	Spun Bonded Polyethylene 2.7 oz/yd^2	Satisfactory
5.	Sisal Reinforced Kraft Paper	Unsatisfactory - Ripped
6.	Asphalt Barrier Paper	Unsatisfactory - Ripped
7.	Wire-Reinforced Kraft Paper	Unsatisfactory - Ripped
8.	Plywood, 3/8" Thick	Satisfactory
9.	Plywood, 1/2" Thick	Satisfactory
10.	Plywood, 1/4" Thick	Satisfactory
11.	Hardboard, 1/4" Thick	Satisfactory

TABLE II

COST BREAKDOWN OF SURFACING MATERIALS

FLEXIBLE MATERIALS:

	Nomenclature	Weight	Manufacturer	Cost (Yd^2)	Cost/Bunk
1.	Cloth, Filament Nylon Duck Water-Repellent	12.8 oz/yd^2	Wellington-Sears Company	$1.75	$2.43
2.	Cloth, Cotton Duck, No. 8 Mildew-Resistant, Water Repellent	18.1 oz/yd^2	Government Stock	0.67* 0.80**	0.93 1.11
3.	Spun-Bonded Polyethylene	2.7 oz/yd^2	E.I. duPont deNemcurs Co.	0.20 - 0.25	0.28 - 0.34

RIGID MATERIALS:

	Nomenclature	Manufacturer	Cost (Ft^2)	Cost/Bunk
1.	Plywood (5/16") (Repaired) Int. (fortified glue)	Weyerhaeuser	$0.071***	$0.89
2.	Plywood (1/4") AD Interior	Weyerhaeuser	0.069***	0.86
3.	Hardboard (1/4") Tempered (Domestic)	Weyerhaeuser	1.28***	1.62
4.	Hardboard (1/4") Tempered (Imported)	Weyerhaeuser	.074	0.925

* Government stock price catalog (1 May 1962)

** Probable Replacement cost

*** Plywood prices based on delivery to East Coast; deduct approximately 1-1/4¢/ft^2 for f.o.b. West Coast.

If material costs were the only consideration, the polyethylene spun-bonded material would have been the logical choice for a surfacing material; however, the polyethylene material has two major disadvantages: it has a high degree of impermeability and it is not being produced commercially at the present time and future production schedules are not definite. For these two reasons, this material was eliminated from further consideration.

The 12.8 nylon filament duck was eliminated because of its high cost.

The domestic hardboard was eliminated from further consideration because of its relatively high cost and the imported hardboard, although competitive in price, was eliminated due to possible procurement problems.

The cotton duck cloth and the plywood were considered satisfactory for the final prototype design.

Selection of the Surface Materials

The plywood was selected for both prototype sleeping surfaces for the following reasons:

Cost- The plywood was less expensive than the cotton duck.

Attachment- The attachment of the surface material to the prototype framework was eliminated by use of plywood. With the use of a fabric cover, however, it was necessary to incorporate channels into the fabric to accommodate the side bunk rails or to devise some type of clip to hold the fabric in place.

Versatility- The plywood surface proved to be very versatile as opposed to a fabric surface. The plywood is capable of converting the sleeping facility into a sitting facility with or without backrests, a table and bench arrangement at mealtime, and storage racks when not being used for either sleeping or sitting purposes. A plywood bunk would also accommodate two or more sleeping children at the same time. With a fabric bunk, the results would be less satisfactory, since all occupants would tend to roll to the low-line of sag.

Safety- Plywood has the merit of safety in its favor. Its rigid surface will support hot drinks which would minimize any scalding accidents from hot liquids spilled from above. Smoking in bed would also be less of a hazard than with fabric bunks. Falls and similar accidents due to fabric failure through tearing and parting would be ruled out.

Orthopedic Consideration- Many people are unable to sleep in hammocks or fabric bunk-type facilities due to skeletal or muscular back injuries. Such people are faced with the floor as an alternative; a dangerous condition for themselves and other people who may be wandering around during the night.

Cleanliness- The plywood would probably be much cleaner during the occupancy period. Even though the surface becomes dirty, it can be cleaned by wiping or by abrasion. Fabric would probably become impregnated with dirt and present a serious cleaning problem under the circumstances of shelter living. A few of the usual accidents with children would render the orthodox fabric unpleasant to use.

Levels of Austerity- It must be kept in mind that the shelter occupancy would be during a period when survival is the prime consideration and the requirements for comfort will be minimal. However, under some circumstances, more than the minimal standards may be required. A plywood base has the advantage of being very adaptable for providing different levels of austerity for the sleeping surfaces. For the majority of instances, when only the most austere requirements are present, plywood provides an adequate sleeping surface. If less austere conditions are warranted, the plywood surface can easily be upgraded by the addition of various padding materials. Blankets, coats or other loose textile items would be the simplest padding to be added. Other alternatives would be disposable paper sleeping bags, plastic covered pads similar to play-pen pads or slabs of plastic foam. Perhaps the highest degree of comfort would be provided by polyurethane foam mattresses for sick, aged or other special cases. A list of padding materials with their estimated prices are outlined in Table III.

b. Structural Materials

Materials

As discussed earlier, the feasibility of using a supported structure was ruled out; therefore, a free standing unit would be necessary to accomplish the aims of this study. Any structural materials that were to be used in the fabrication of this item would be required to have sufficient structural stability to stand freely without any outside supports, such as wall brackets, ceiling brackets, tie braces or other anchors of similar nature. Among the materials that were considered for the structural components of the bunk units were wood, pipe, angle iron, and slotted angles. The members which were utilized were all commercially available shapes and sizes so that items could be made in as short a time as possible. In the early stages, no consideration was given to specially fabricated shapes or configurations, since these would have taken longer to fabricate and deliver than time would permit. It was considered that optimum progress could be

TABLE III

PADDING MATERIALS FOR EXPERIMENTAL SLEEPING FACILITIES

Padding Materials	Estimate Cost of Loose Padding
1/2" Polyurethane	$ .70
1" Polyurethane	1.25
1-1/2" Polyurethane	1.85
Cellulose wadding paper covered, 1" thick	.35
Paper sleeping bag	1.30

obtained by developing an overall configuration of the bunking units and then at a later date, as time was available, to refine the components to the most economical combination of sectional shapes and materials. The consideration of all of the structural materials was guided by factors such as low cost, ease of assembly, ease of disassembly, low storage requirements, durability in storage, commercial availability and ease of fabrication. Wherever possible, basic components requiring a very minimum of fabrication were used. Simple, durable fasteners were also used whenever possible, not only to minimize cost, but also to insure ease of erection and disassembly by whatever personnel would be available for this purpose. In designing the prototypes every attempt was made to cut down on the structural components, such as cross bars, excess uprights or stretchers, to reduce the amount of the material contained in the items. With the low cost per sleeping surface which was being aimed at, the principle cost in any of these units was to be the material; therefore, the less material which was used, the lower the cost of the unit.

Multiple sleeping facilities basically consist of a group of sleeping surfaces and some means of supporting them. The principle problem then is to get the minimum combination of sleeping surface material and supporting structure to give the rigidity, stability and durability which was required. The investigation covered not only the standard methods of high density sleeping, but also other commercial means of supporting horizontal surfaces in multiple tiers. Included in this were scaffolding, book shelves, storage racks, kitchen shelving and even some types of playground equipment. Most units investigated were either too light in construction for the requirements which were presented with this project, or too sturdy in construction. An example of the former would be bookshelves and of the latter, scaffolding. Because of the requirement that the bunks be capable of being tiered five high, and in consideration of the minimum size of the bunks, particularly regarding width, it was determined that the only means of obtaining sufficient stability in a high unit would be to make it two bunks wide. This would also result in cost reduction, since some of the structural members could be common to the two units, thus spreading the overall cost over a greater number of sleeping surfaces. The basic unit designed was one which was two surfaces wide and five surfaces high, with a capacity for 10 people. These designs also considered the possibility that when sufficient height was not available the uprights in these bunks could be reduced to four high or three high units by reducing the length of the upright. This design also permitted access to the sleeping surface from the conventional long side.

Structures

Wood

The first prototype was made of wooden 2 x 4's, 2 x 6's, and 3/4-inch plywood (Figure 4). It consisted of two end frames. Each end frame

had one piece of 2 by 6 five feet long, three pieces of 2 by 4 six feet long with short pieces of 2 by 6 fastened at the bottom to provide a bracing for the 2 by 4 uprights. The 2 by 4 uprights in addition were bolted to the 2 by 6 at right angles with two 5/16-inch stove bolts. This unit was designed to hold six bunks. The bunk surfaces were formed by the 3/8-inch plywood. This plywood was attached to the uprights by small 8-inch plate brackets which were screwed to the 2 by 4 uprights. The brackets consisted of a flat plate with four holes and two right angle pieces of 1/8-inch steel welded back-to-back so there was 3/8-inch plus 1/16-inch clearance between the flanges. This provided a slot for the plywood to slip through. Rigidity between the two end sections was obtained only through the holding power of the plywood in these U-shaped brackets. Assembly of the item revealed several things:

Extra clearance in the brackets was definitely needed since any misalignment of the brackets or the uprights or any warpage in the plywood tended to create quite a bit of binding. However, larger clearances did reduce the rigidity somewhat.

Some type of tie between the end sections, other than the plywood, would be necessary since there was probably at least 4 inches of end-to-end sway in the initial structure. This was accomplished by one 2 by 4 attached between the center uprights with a 1 inch wide steel strap, "U" shaped which tied them together.

The brackets can be simplified considerably.

The 3/8-inch plywood did not provide sufficient rigidity in that it bent too much; therefore, 1/2-inch plywood, at least, will have to be used.

Pipe

A prototype was designed and constructed of 3/4 inch extra-heavy wall steel pipe and slip-type joint Speed Rail fittings* (Figure 2). This was made with six vertical columns 4 feet 6 inches long, four end spacers 4 feet 1-1/2 inches long, and four sidespacers 6 feet 6 inches long. (All of the pipe fittings were for 3/4-inch pipe). Two types of joint connectors were used; at the corners, side outlet elbows, and in the center for the center vertical column, T's. These Speed Rail fittings are not threaded and the iron pipe slips into the fittings and is held in place with Allen head set-screws. To fasten stretcher poles to these pipes, an initial type of hook was worked out. A flat piece of the .100 inch steel was bent in the form of a "U" so it would fit snugly around the pipe, with the side legs of the "U" being bent up to form hooks holding 3/4-inch pipe. The nooks were held

*See Appendix D

to the pipe by a long screw. A sliding type clamp, with eccentric locking action, was also designed to achieve infinite vertical adjustability of the bunks. This also permitted a dual level of adjacent bunk surfaces during the day for use as table and bench combinations.

Slotted Angle

A third type of bunking unit was designed from slotted angles such as made by Lyons or Dexion*. This material has advantages in ease of fabrication, versatility of design, and ready adaptability. Since some standard Navy bunk frames were available, the initial items were designed to hold these frames. The first unit was designed to hold six bunks, with the side stretchers only four feet long. This resulted in the bunk frames or stretchers extending beyond the supporting structure; however, it required the use of less material. The bunk frames were fastened to the upright by hooks bent from .100 inch steel which were bolted to the uprights. Spacing between the bunks was 21 inches, with the bottom bunk 6 inches from the floor. The slotted angles were 2-1/4-inch by 1-1/2-inch by 14-gauge. This resulted in a very rigid structure. Another structure of this nature was designed and constructed five units high by two units wide to accommodate 10 people. It was found that this structure was not quite as rigid and required repositioning of the side braces and end braces as well as the addition of 6 inch by 6 inch gusset plates. These modifications resulted in a very rigid structure.

In reducing the amount of material required, the bunk frames were eliminated and instead a stretcher-type construction was used, wherein only two side poles of 3/4-inch extra-heavy wall steel pipe were inserted into pockets on the side of the cloth bottom. To get proper support, the side rails of the bunking unit had to be extended to the full length of the frame to support the stretcher poles at the ends. This also resulted in a unit which could be added onto from the end rather than from the side, which would have been necessary in the previous construction. During the fabrication of these units, work was also done on improving the means of fastening or attaching the hooks to the uprights. It was believed very desirable to have a quicker method of attachment rather than the use of bolts, which was time-consuming. Upon introducing the stretcher type bunks into the prototypes, the bunk width was accordingly reduced from the Navy dimensions to that recommended by the Army study.

Considering the good rigidity which was obtained with this slotted angle, a lighter duty angle (1-1/2 inch by 1-1/2 inch by 14-gauge) was utilized in a unit. Construction of this unit and testing indicated that,

*See Appendix D

while there was sufficient structural strength to support the ten people at an average of 200 pounds each, the amount of sway and bending would make it psychologically unacceptable for the persons who were required to use the large unit. It was therefore determined that the equivalent of the 2-1/4 by 1-1/2 by 14-gauge angle would be necessary to provide an acceptable unit.

The design of the slotted angle bunking facility revealed that to obtain the required rigidity in the structure, several side rails were required. Since these rails ran in the same direction as the bunk poles which were supporting the sleeping surfaces, a more economical unit could be obtained by increasing the number of side rails and eliminating the bunk poles altogether (Figure 5). Several designs for attaching or fastening the bunk material to the rails were investigated. One method determined to be feasible was using a single layer of cloth cut to size, with no other fabrication and attaching this to the rails by an elongated hairpin clip (Figure 3).

The final alteration made in the slotted angle type construction was the result of the desire to have a unit which was flexible in operation and easy to assemble and disassemble. The ordinary means of fastening slotted angles together is with bolts and nuts. It was found that assembly, even by experienced personnel, took approximately 2 hours. This was not considered acceptable, particularly in consideration of a possible requirement for daily disassembly, and the desirability of having a flexible unit for both sitting and mealtime purposes. At that time, a hooking arrangement was developed which permits the side rails to hook into the upright at any level desired (Figure 6). Assembly and disassembly is very easy and the bunks may be moved up or down at will. This would also permit some latitude in the spacing between bunks, should some specific instances require it (Figures 7, 8, 9, 10, 11).

Fabricated Channel

Another unit development was the result of discussions with commercial manufacturers who produce large, heavy-duty storage racks for use in warehouses. The Storack Corporation*, which uses a keylock principle in their standard shelving, was interested in this project and developed a greatly modified version of their standard rack in a much lighter construction (Figures 12, 13, 14, 15, 16, 17). This unit is made of 17 gauge roll-formed steel and is different from the other prototypes in that the members, instead of being standard commercial components, were specifically designed for this application. It consists of uprights with

*See Appendix D

slots to attach the horizontal beams (Figure 16). Attachment is accomplished by a "T" lug, punched from the beam, which slides into a "T" slot in the upright. In addition, a safety lock punched from the beam snaps into place when the rail is attached, preventing accidental disengagement of the rail. There are end braces which tie the unit together. Initial assembly of the unit revealed some side sway, so 4 sway braces of 1/4-inch rod were fabricated to diagonally connect through construction holes in the end braces.

The basic unit provides sleeping facilities for 10 persons. Extra notches are included in the uprights so that the unit can be extended by sharing three uprights and only adding 20 horizontal beams, 3 uprights and 4 end braces. The expanded unit would hold 20 people.

5. Prototypes Discussion

All of the units or prototypes developed contributed something in the overall development of the concept for the multi-tiered sleeping facilities. For example, the plywood used in the initial unit was selected as the sleeping surface in the final units; hooks developed for the initial slotted-frame unit for supporting the stretcher type bunks were incorporated in the final slotted-angle frame which did not incorporate stretchers; and the adjustable features which provided a bench and table from the same sleeping surfaces was originally conceived in the pipe frame prototype and was later incorporated into the other units. Therefore, the strengths and weaknesses of each unit were evaluated and provided a basis for progressing to the next step. The short time available required that several items be evaluated simultaneously; thus some units incorporated 2 or 3 concepts at the same time. Since the study of the dimensional requirements occurred simultaneously with the prototype development, it was not possible to incorporate the final dimensions in the actual prototypes.

Wood Frame

This unit, while it did not have the required stability and rigidity which was required, did indicate that a very low cost unit was available (approximately $2.00/person). This unit still could stand further investigation, since wood has the natural advantage of great strength to weight ratio; it is an extremely versatile material as far as fabrication and assembly goes; anyone can work with this material; and it is readily available in large quantities at low cost. It does, however, require more storage room than the slotted-angle or the fabricated channel units, since it does not nest as readily. It might also be more subject to pilferage.

Pipe Unit

The primary advantage of this unit was the easy assembly and disassembly. The Speed Rail fittings with Allen set screw anchors permitted

very rapid assembly of the pipes into a supporting frame. In addition, the use of sliding clamps on the upright permitted wide adjustability in the positioning of the bunk surfaces (Figure 2). This versatility led to the concept of using the bunk surfaces as benches and tables during the daytime. However, there were two major drawbacks to the use of this item. First, the corner clamps did not give sufficient rigidity to the frame. A redesign of the clamps would be necessary to get the required rigidity, but it is believed that they would be too costly considering the quantity required per bunk unit. Secondly, the use of pipe or tubing also makes this unit too expensive. It was recently learned that the Harvard Manufacturing Company* has produced a unit similar to this in the three high bunk. This unit has not been examined, but limited information available indicates that the construction is very similar, utilizing the same type of fastenings for the corners. Further investigation might prove interesting, although it is believed that expanding this into a five high unit would still lead to a unit which did not possess sufficient rigidity and would be too expensive.

Slotted Angle Unit

Of the constructions investigated, this was one of the two which shows the most promise for a free-standing, low-cost multiple-tiered sleeping facility. The material is versatile, readily available commercially, and in quantity procurement relatively low in cost. The unit began as a completely slotted angle frame; however, it evolved into a combination of slotted angle and specially fabricated side rails to get lower cost and more desirable assembly and disassembly features. As pointed out in the description of the unit, it was originally intended to support stretcher type bunks. This would have provided for very easy insertion of individual bunks by personnel using this unit. However, it did require that each bunk frame be assembled. In addition, when the units were designed to hold bunks tiered five high, it became necessary to provide several side rails to make the unit steady enough for public acceptability. When the parts of this structure were combined with the members used in the stretchers, the cost became excessive, running over $4.00 per person. The concept of combining frame members and bunk supports then became a logical solution to the economic problem. Since cloth type bunk materials were being considered at this time, the frame was designed to support these materials. Reasonably easy attachment and adjustability of the material was obtained with a hairpin type clip, which was designed for this purpose. However, it then became obvious that the plywood base material, which was used in other constructions, had many advantages and the structure was slightly altered to accommodate the plywood. Aside from the advantages of utilization which have already been cited, the

*See Appendix D

plywood also transfers the load of the person on the bunk more evenly to the bunk frame placing less strain on the frame. With other methods, there was considerable distortion of the side rails. The hooks which were pressed into the modified side rails enabled rapid assembly and disassembly of the side stretchers to the uprights (Figure 6). Anticipated cost for a 10-person unit is:

Steel framework	$30.76
10 plywood bunk surfaces	8.60
	$39.36 or $3.93 per person

It is considered that redesign of uprights and bunk rails can materially reduce the above cost.

Some further refinements are possible in this slotted angle construction such as:

Detailed analysis of the frame members for utilization of lighter gauge, higher strength steels providing more economy.

Possibility of designing special upright with only those holes which are required for the flexibility of arrangements in the bunking unit. This would allow a lower cost upright and in addition would remove the upright from the design of any particular manufacturer.

Modification of the hooking arrangement to allow easier assembly and more positive locking in position. This latter consideration is deemed essential.

Fabricated Channel

The other unit which showed promise as far as a multiple tiered bunking unit was concerned, was the unit manufactured by Storack Corporation. As stated earlier, this item is an adaptation of their standard heavy duty storage rack for warehouses. It was a major redesign, maintaining only the essential feature of a quick lock-in type rail which hooks into an upright member and locks in place. This unit's structural members were specifically designed for this purpose and therefore achieved a degree of refinement and economy not evidenced in the other units. The unit is easy to assemble, structurally rigid, versatile in arrangement, and low in cost.

Anticipated cost for a 10-person unit is:

Steel framework	$21.71
10 plywood bunk surfaces	8.60
	$30.31 or 3.03 per person

Anticipated cost for a 20-person unit is:

Steel framework-10 person	$21.71
Steel framework-10 additional	16.25
	$37.96
20 plywood bunk surfaces	17.20
	$55.16 or $2.76 per person

In construction, it is essentially the same as the unit described previously made from slotted angles. There are some refinements which are still possible with this unit such as:

Use of thinner gauge material of a higher strength steel.

Addition of more "T" holes in the upright to achieve greater variety of bunking arrangement and provide sitting and messing accommodations.

Slight improvement in the redesign of the hooking lugs to achieve greater strength and ease of manufacture.

Modification of "T" holes in uprights for easier assembly

Storack Corporation, in designing this unit, kept as a very important factor of design, the adaptability of the structure to mass production at low cost.

6. Recommended Bunk Units

This investigation had as its goal the design of one or more multi-tiered bunking units which could serve as sleeping facilities for fallout shelters. There were many requirements which were placed on these bunking units, such as ease of assembly, low cost, adaptability to any configuration of shelter which might be used, and adaptability in connection with any obstructions, either ceiling or floor which might be encountered. Other

factors included ready availability of materials for procurement, durability in storage, ease of assembly, ease of disassembly during the day, compactness in storage, adaptability for multi-purpose use, such as incorporating seating and table facilities in the unit and adaptability for several levels of austerity.

Consideration of all of these refinements led the investigation into many fields of materials and structures. The final phase of the investigation resolved itself into two units which have basically the same structural concept, but have some differences in design. These are the slotted angle bunk unit and the fabricated channel bunk unit. No tests have been conducted on either of these units as far as actual use by personnel is concerned; however, load tests during which 2000 pounds were placed on the unit (to simulate 10 persons at 200 pounds each) indicated there was sufficient structural stability and rigidity to serve the purpose for which they are intended. They incorporate all of the requirements stated and do so at a very minimum cost. While the anticipated cost of the fabricated channel unit is considerably lower than that of the slotted angle unit ($3.03 per person vs. $3.93 per person), it is believed that with further refinement, the slotted angle unit cost could be reduced to a comparable figure. Both of these units are adaptable to many different types of bunking surfaces; however, it is recommended that a 1/4-inch plywood sheet with the grain running perpendicular to the long axis of the bunk be utilized. Use of 1/4-inch tempered hardboard is also possible if a lower price can be obtained. The plywood incorporates many advantages which have been discussed previously. These include such factors as good orthopedic support, versatility as sleeping, eating and sitting surfaces, storage durability, low cost, ready commercial availability, ruggedness, good load distribution properties and possible utilization after evacuation of the shelter. The recommended size for each bunk is 24 inches wide by 75 inches long with 20 inches vertical spacing between bunks. The nature of the bunking units showing the greatest potential gave no natural storage area for personal effects; however, it is considered that an inexpensive accessory for the final bunk design could be developed to accomplish this purpose.

7. Litter Cots

Combination litter cots were investigated as a possible approach to the shelter sleeping problem and, although most commercially made items were priced too high to be considered as the primary sleeping unit, it is recommended that consideration be given to the inclusion of a small percentage of a combination litter-cot in each shelter.

These units would be particularly advantageous for use by incapacitated or injured personnel, who would require such units in the event of an attack. This type unit would also be available for use during any natural disaster such as hurricanes, tornadoes or floods in which Civil Defense personnel would play a prominent role.

An item such as this, which could handle the dual responsibilities mentioned, would be more economical than one which was stored for very long periods of time waiting for one catastrophe which may never occur.

Combination litter cots are available from commercial suppliers and one of those is shown in Figure 18. This unit is manufactured by Davis Aircraft Products Company* and was designed for use in standard military aircraft and vehicles. This particular unit is capable of being stacked to 4 high with excellent rigidity and could double as a sleeping unit in a fallout shelter or as a stretcher for carrying incapacitated personnel in the event of a nuclear bomb attack or a natural disaster. Since it is designed to be accommodated in military aircraft and vehicles, litter patients could be evacuated without any further modification to the unit. The cost of this type unit is presently about twenty dollars, but could probably be reduced several dollars by the elimination of some of its features which may be desirable for aircraft installation but which would not have any particular advantage for use in fallout shelters (e.g., its ability to withstand an 8 G load).

8. Recommendations for Further Investigation

During this study, two prototypes were developed for high density sleeping in fallout shelters. The items developed are strictly prototypes and are not refined to the degree where they could be manufactured on a production basis.

There are several factors which should be considered. These include:

Incorporation of prototypes into an actual shelter test to indicate any undesirable features.

Further investigation into the type of metal that should be used in its construction. (The prototypes are made from a mild steel and they probably would stand up longer in assembly and disassembly if they were produced from a harder, lighter gauge steel).

Refinement of bunking units through improvement of safety locks, hooking devices, greater flexibility of arrangement and improved rigidity and strength.

*See Appendix D

Investigation in more detail of cushioning materials and pads for providing various levels of austerity, with specific recommendations for 3 or 4 levels.

Further investigation should be undertaken on surface sleeping materials. Due to its extremely low cost, the spun-bonded polyethylene should be re-evaluated for use as a surface material when the disadvantages outlined in the report are eliminated.

Initiation of a color coding system to facilitate the ease of assembly and disassembly of the units.

Preparation of instruction manual to outline the method of assembly of the units.

Preparation of a specification to purchase the required number of units, as the final step in the program.

9. References

1. Preliminary Systems and Components Catalog, Fallout Shelter Program. Office of the Chief of Engineers, Department of the Army (PSCC Rev., 16 April 1962)

2. Specifications and Costs of a Standardized Series of Fallout Shelters, U.S. Navy Radiological Defense Laboratory Report TR-366, 6 October 1959

3. Fallout Protection, What to Know and Do about Nuclear Attack. Department of Defense, Office of Civil Defense, H - 6 December 1961

4. New Civil Defense Program. Ninth Report by the Committee on Government Operations

5. U.S. Navy Radiological Defense Laboratory - Preliminary Report on the Shelter Occupancy Test of 25-29 July 1960

6. Habitability Test of the NRDL 100-Man Shelter. American Institute for Research, February 1960

7. U.S. Navy Radiological Defense Laboratory - Preliminary Report on the Shelter Occupancy Test of 3-17 December 1959

8. Proceedings of the meeting on Environmental Engineering in Protective Shelters. National Academy of Sciences - National Research Council, 8, 9, 10 February 1960

9. Anthropometry of Army Men, by Dr. Russell Newman and Robert White; Environmental Protection Section Report No. 180, Research & Development Branch, Military Planning Division, Office of The Quartermaster General, September 1951

LIST OF FIGURES

Fig. 1 Slotted Angle Unit With Partial Sandbag Load For Test Showing Comparison of Deflection of Fabric and Plywood Under Load

Fig. 2 Pipe Frame Bunk Unit Showing Stretcher Attached by Hooks and Sliding Clamp

Fig. 3 Slotted Angle Unit Showing Bolted Construction and Hairpin Clip for Fabric

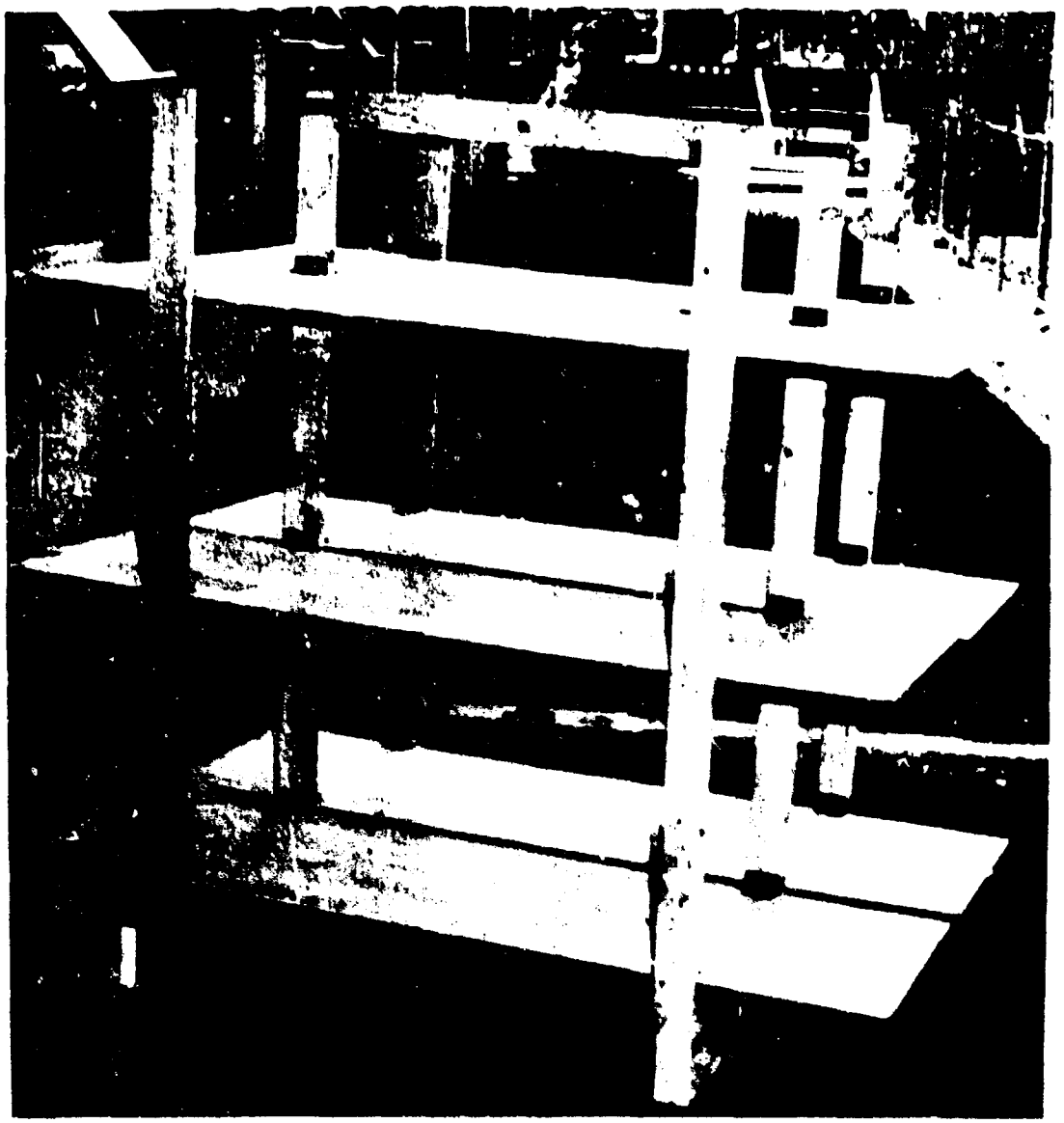


Fig. 4 Wood Bunk Unit

Fig. 5 Slotted Angle Unit Showing Bolted Construction and Plywood Surfaces

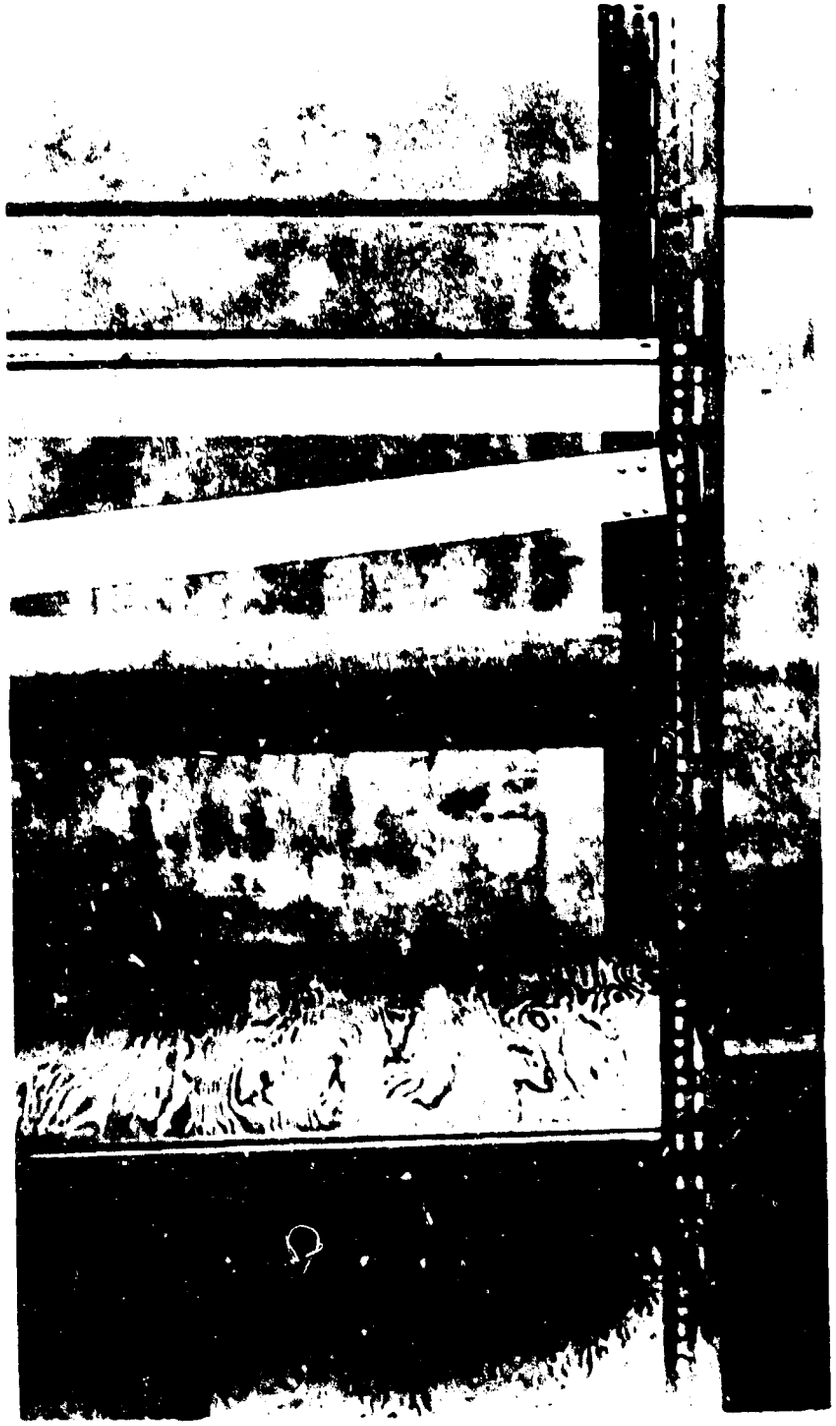


Fig. 6 Slotted Angle Unit Showing Attachment of Side Rails

Fig. 7 Slotted Angle Unit - Knocked Down

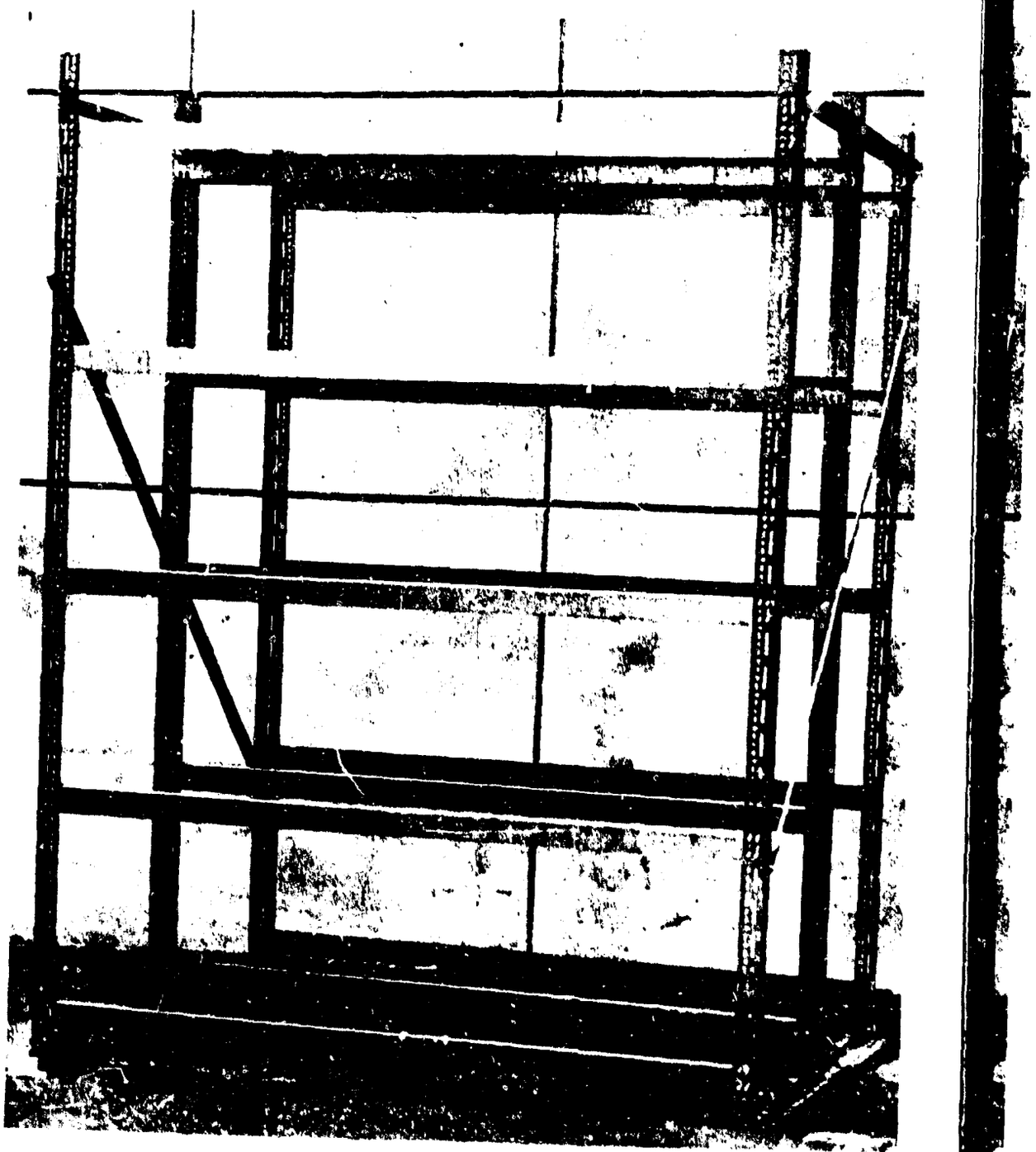


Fig. 8 Slotted Angle Unit - Assembled

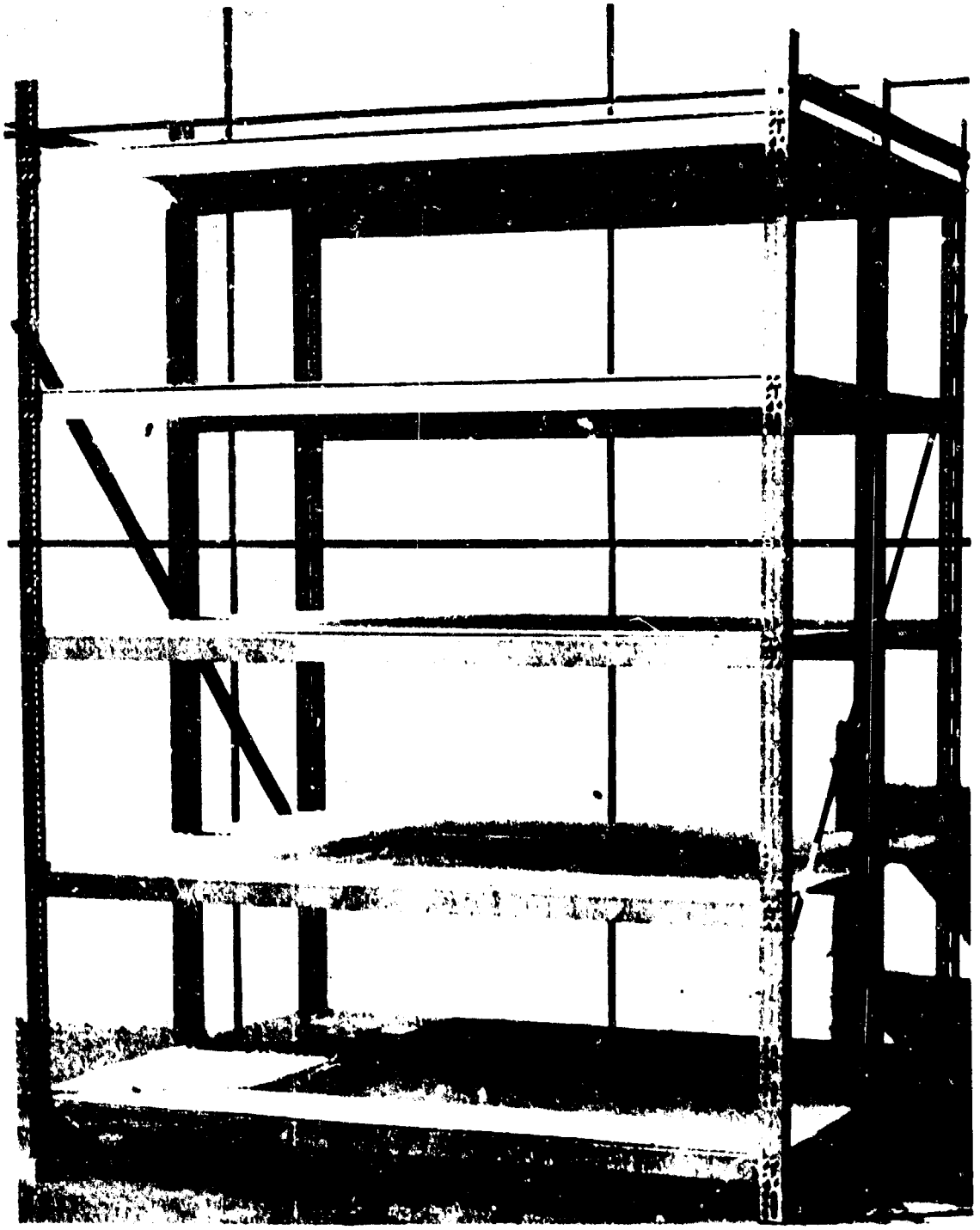


Fig. 9 Slotted Angle Unit Assembled with Plywood Sleeping Surfaces

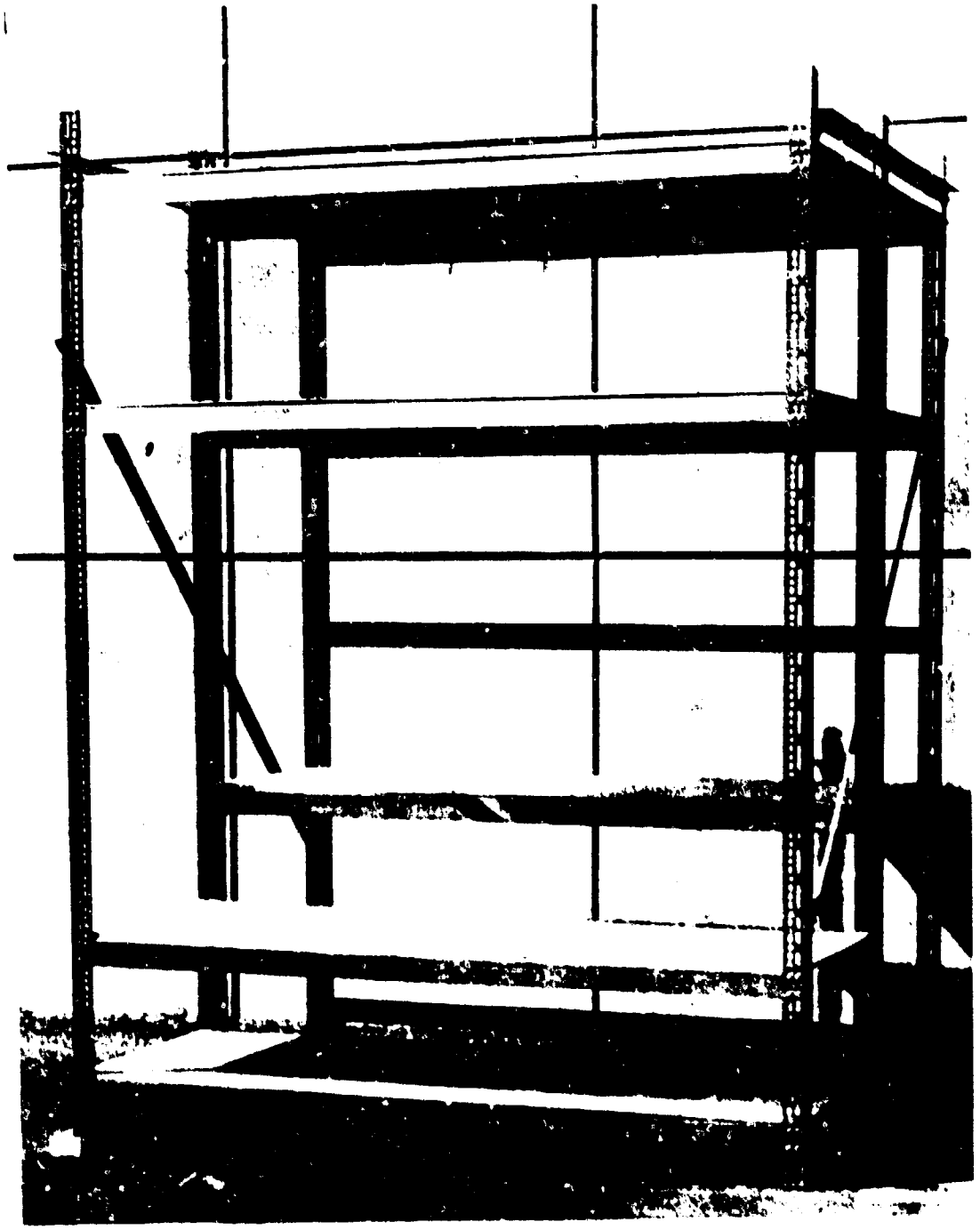


Fig. 10 Slotted Angle Unit Showing Two-Level Seating and Eating Arrangement

Fig. 11 Slotted Angle Unit Showing Bench With Backrest

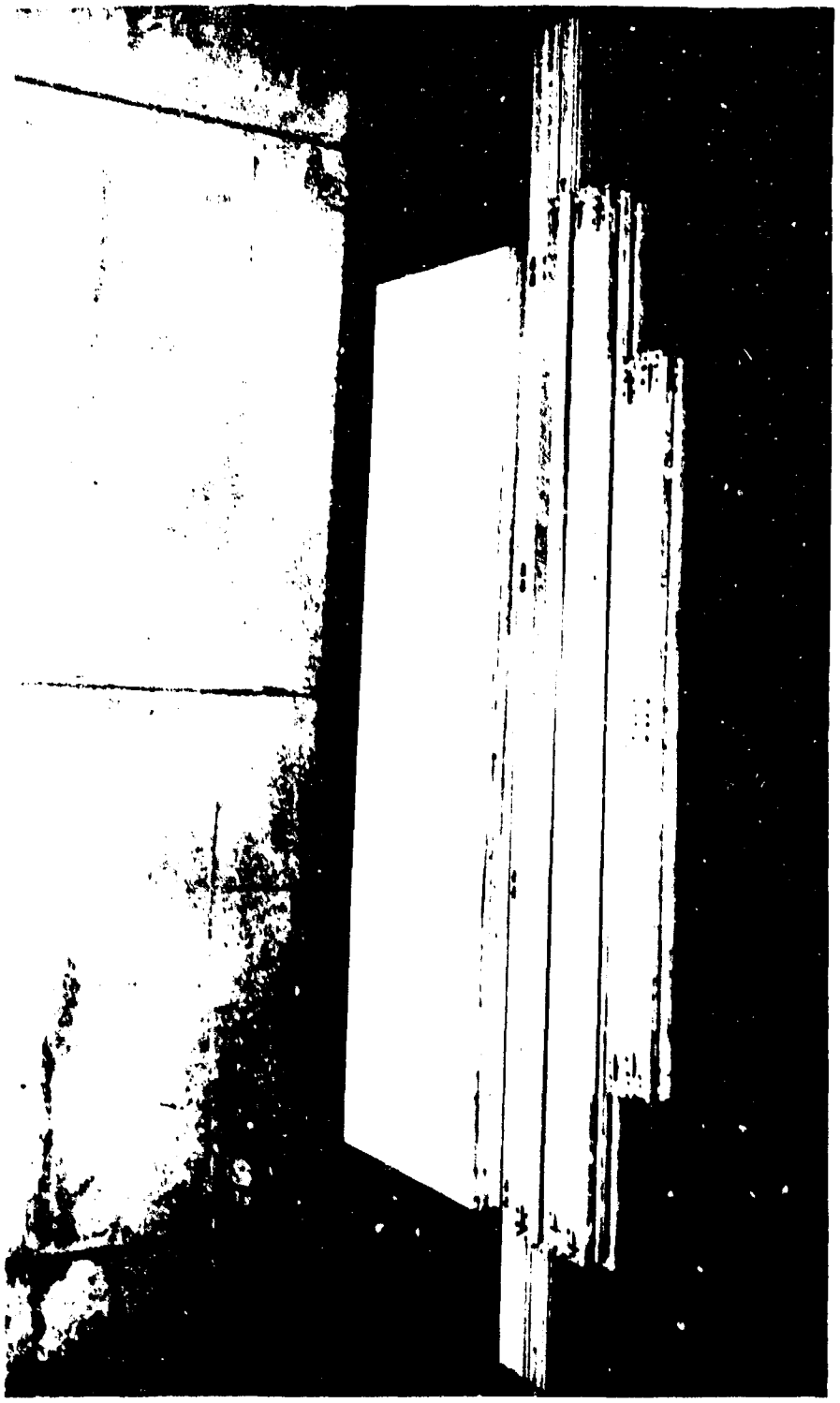


Fig. 12 Fabricated Channel Unit - Knocked Down

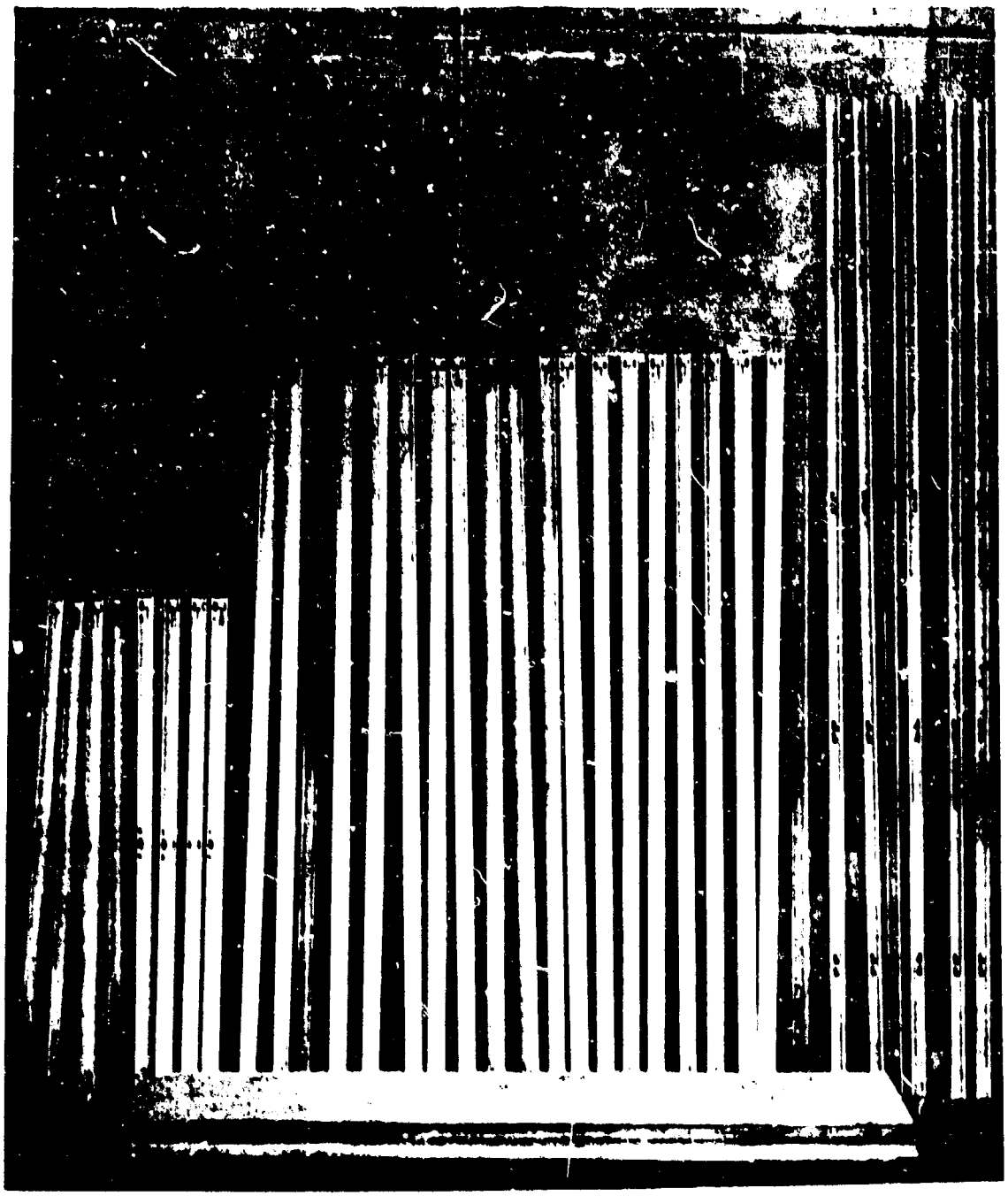


Fig. 13 Fabricated Channel Unit Knocked Down Showing Components

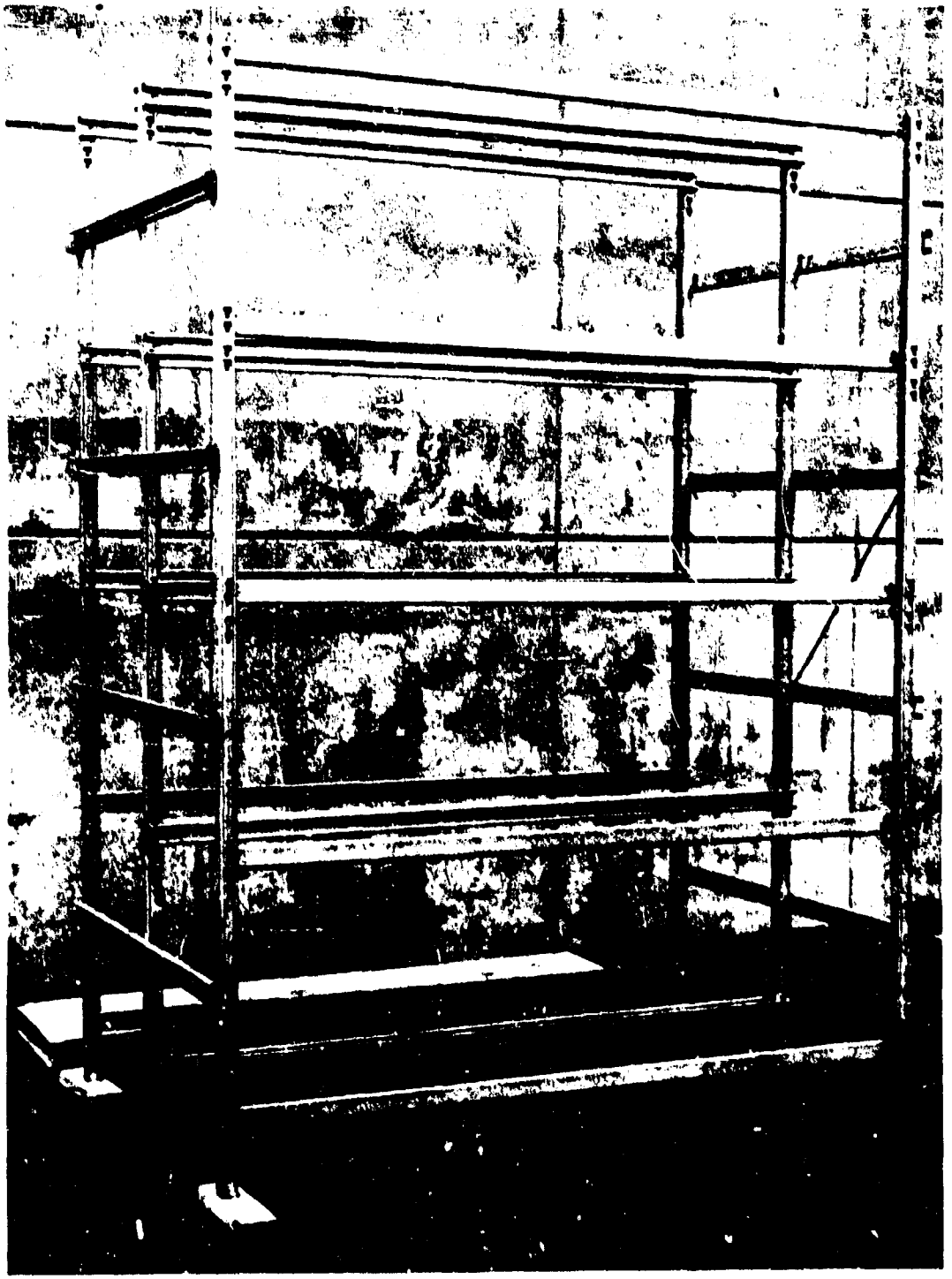


Fig. 14 Fabricated Channel Unit - Assembled

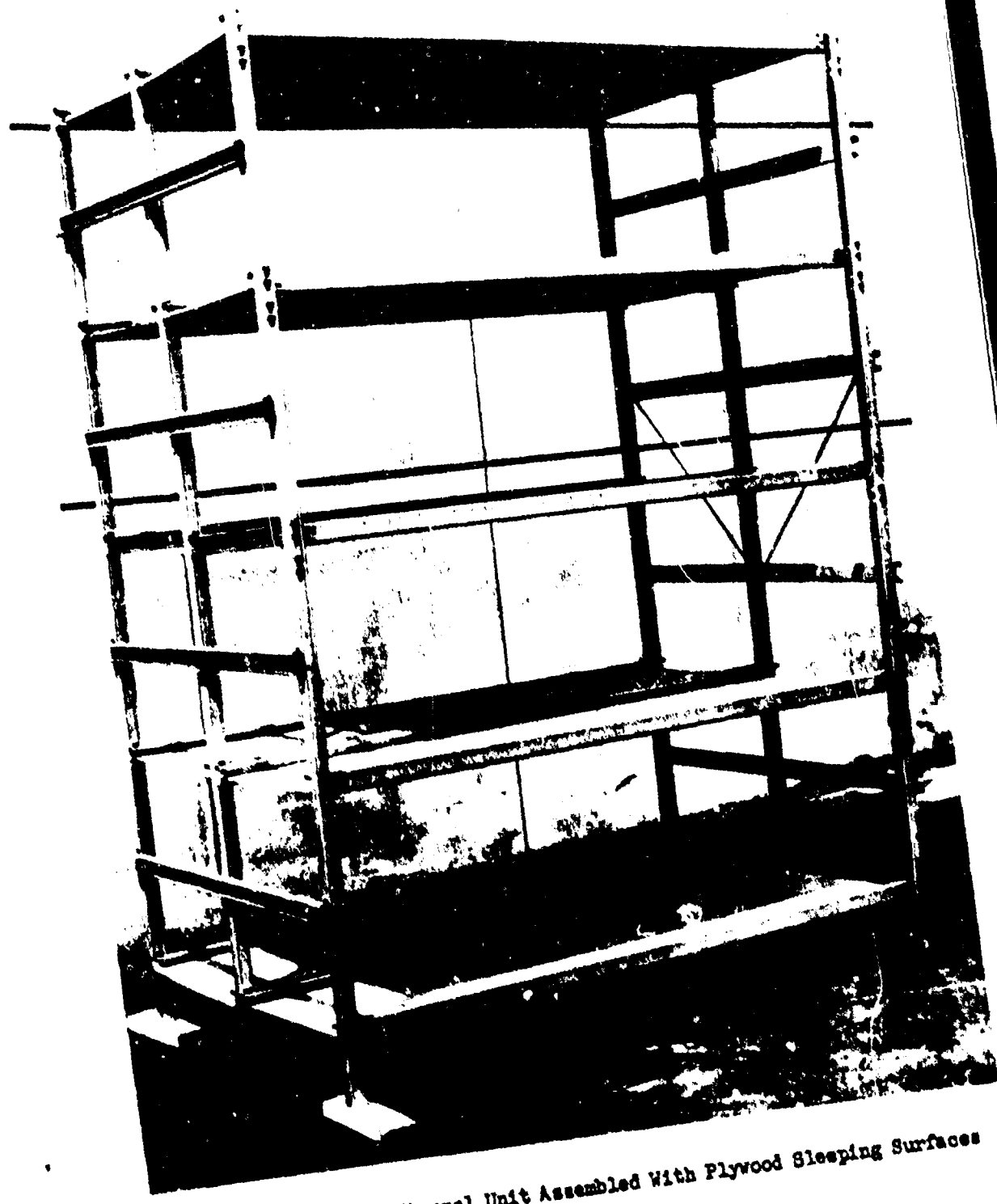


Fig. 15 Fabricated Channel Unit Assembled With Plywood Sleeping Surfaces

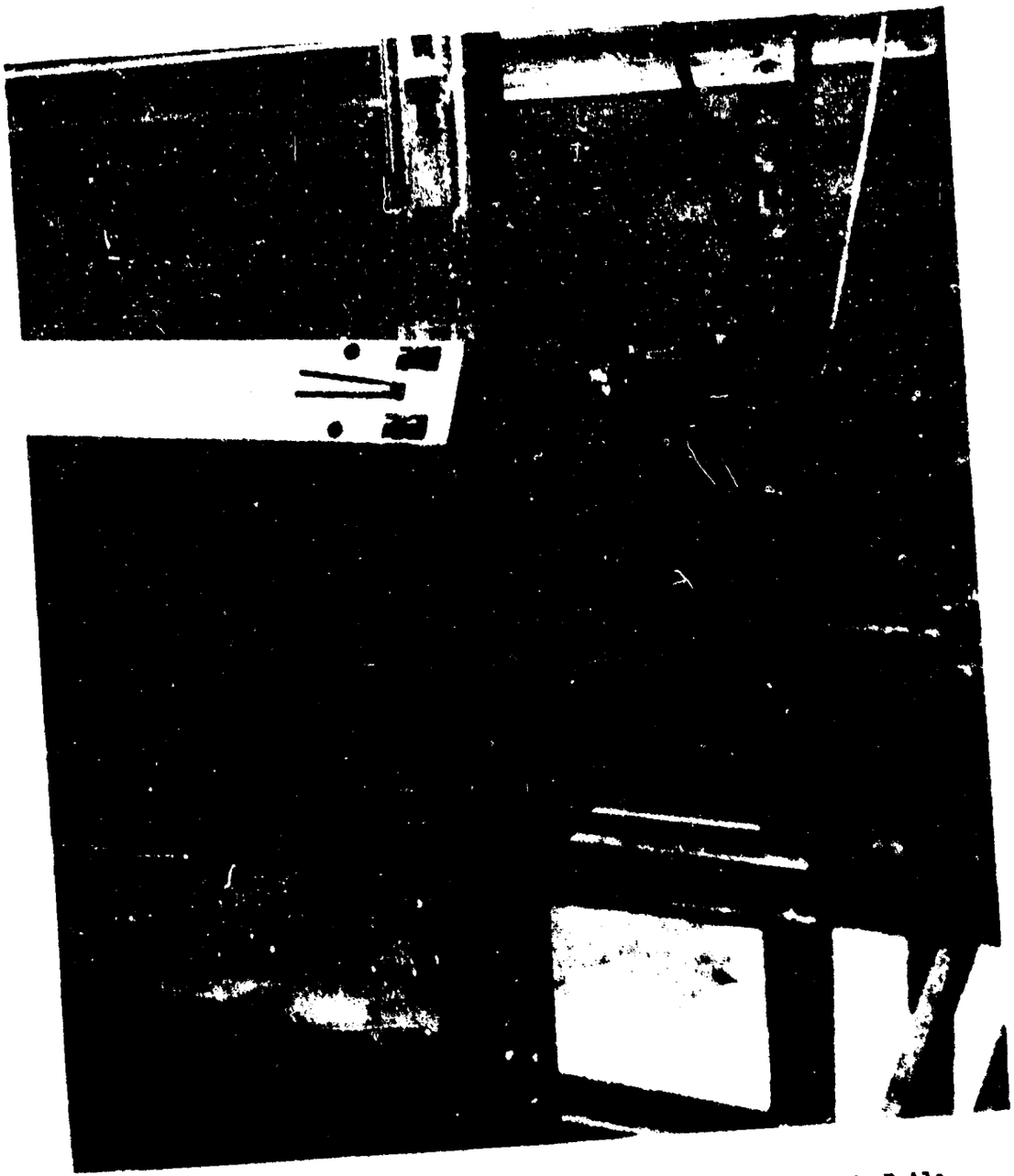


Fig. 16 Fabricated Channel Unit Showing Arrangement of Side Rails

Fig. 17 Fabricated Channel Unit Showing Bench With Backrest

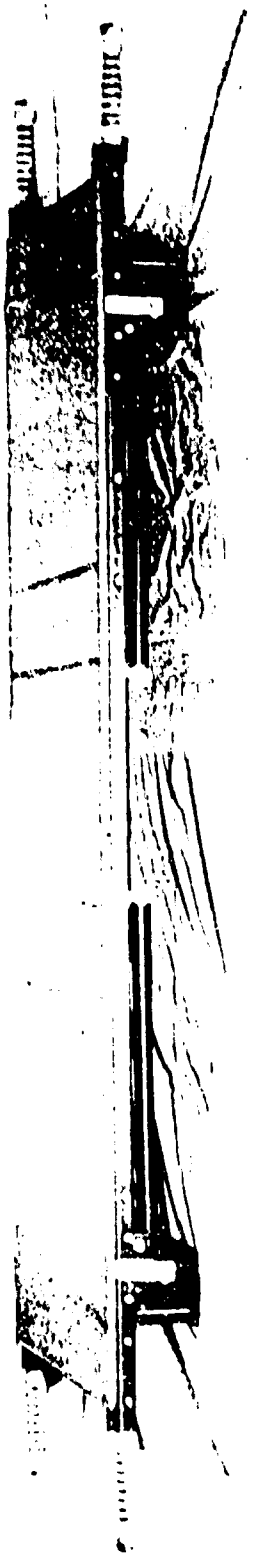


Fig. 18 Litter Cot with Legs Folded For Use as Litter

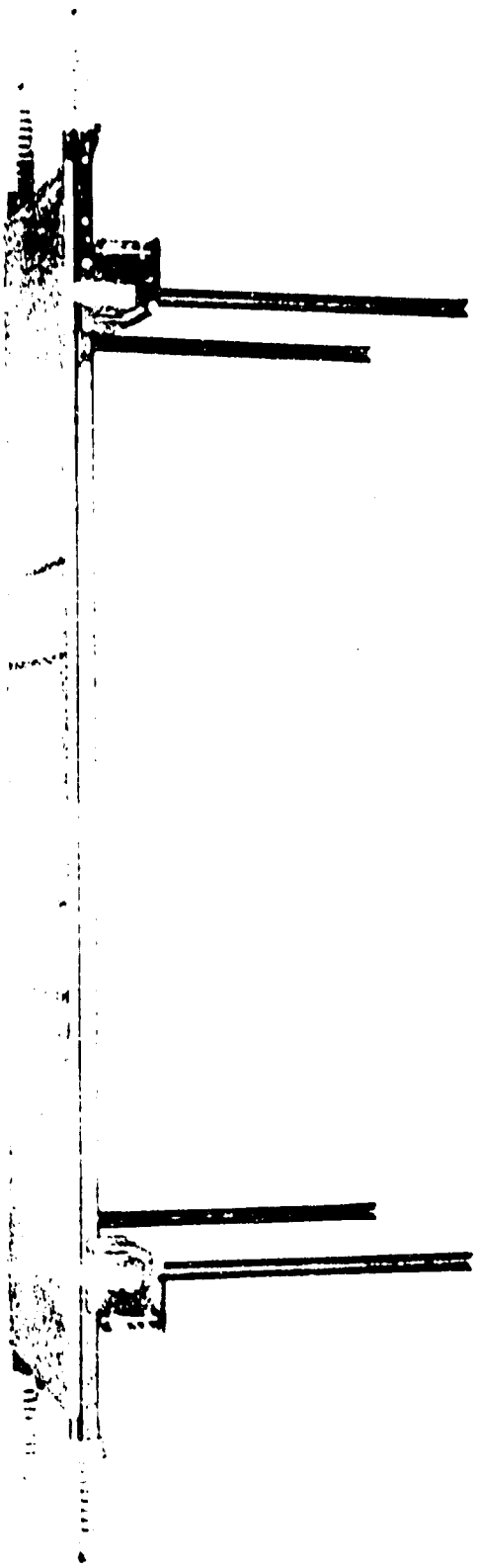


Fig. 18a Litter Cot with Legs Extended for Use as Cot

APPENDIX A

Work Order, Office of Civil Defense

Work Order No. OCD-08-62-46
Project No. 1310

WORK ORDER
Between
DEPARTMENT OF DEFENSE, OFFICE OF CIVIL DEFENSE
And
DEPARTMENT OF THE ARMY, QUARTERMASTER RESEARCH AND ENGINEERING COMMAND

Department of the Army
Headquarters
Quartermaster Research and Engineering Command
U. S. Army
Quartermaster Research and Engineering Center
Natick, Massachusetts

Attention: Philip J. Rork
Lt. Col., QMC

By virtue of Executive Order 10952 dated July 20, 1961, an order is hereby placed with your Command for furnishing the following services to the Office of Civil Defense.

In consultation and cooperation with the Office of Civil Defense, the Department of the Army, Quartermaster Research and Engineering Command, shall, in accordance with the Quartermaster Research and Engineering Command proposal letter of 11 December 1961, reference QMREC-R, (1) Develop and test one or more designs for low-cost sleeping facilities consistent with maximum space utilization in shelters; (2) Explore the characteristics of low-cost sleeping accommodations especially suited to shelters; (3) Examine the feasibility of attaining various combinations of the following features in tiered low-cost shelter sleeping facilities: Three-to-five tier capacity; demountability, complete and partial; storability (including consideration of minimal space requirements and maximum shelf life in relation to temperature and ventiliation conditions expected in shelters); floor, ceiling, and wall supports (flexible, hinged, other); minimal essential durability; minimal sizes; capability of adaptation to different kinds and configurations of shelter space, with typical variations in ceiling heights, room sizes, ceiling and floor impediments such as pipes, ducts, machinery, and equipment; adaptability to use for sitting or simultaneous use for sleeping and sitting, including the possibility of combining back rests; stability; comfort, adaptability to head-to-foot use (including information and evaluation of advantages or disadvantages in such use); simplicity of setting-up procedures, covering

skill, strength, and tools required; minimal height-above-floor and spacing-between-bunks requirements, correlated with ceiling-height requirements for different numbers of tiers, feasibility of tiering that starts at heights a number of feet from the floor, to allow for such impediments as permanently installed equipment or machinery, or automobiles in underground parking garages; feasibility of including small space or spaces for personal belongings. Designs shall combine different features. Relative costs, space requirements, and efficiency of facilities that combine sleeping and other functions, as compared with the cost and effectiveness of other facilities for sleeping and sitting, for example, shall be covered. Designs may range from those involving permanent prepositioning of sleeping equipment, to those requiring minimal permanent preparations or interference with normal uses, such as coverable sockets for stanchions. Consideration shall be given in some designs to the possibility that some shelters may be used as living quarters in a postattack period. Existing designs from a wide range of sources for possible adaptation and cost reduction shall be reviewed. For example, designs developed by military and commercial sources for troop transport and other purposes, and those contained in studies made for the Office of Civil and Defense Mobilization by the Naval Radiological Defense Laboratory, Dunlap and Associates, and American Institute for Research, shall be reviewed. The services shall be coordinated with the Department of Navy, Bureau of Ships, particularly with respect to any proposed sub-contract. Five copies of interim reports on significant findings, 5 copies of quarterly progress reports, and 200 copies of the final report shall be furnished to OCD. The services for which funds are made available under this Work Order shall be completed on or before 30 June 1962.

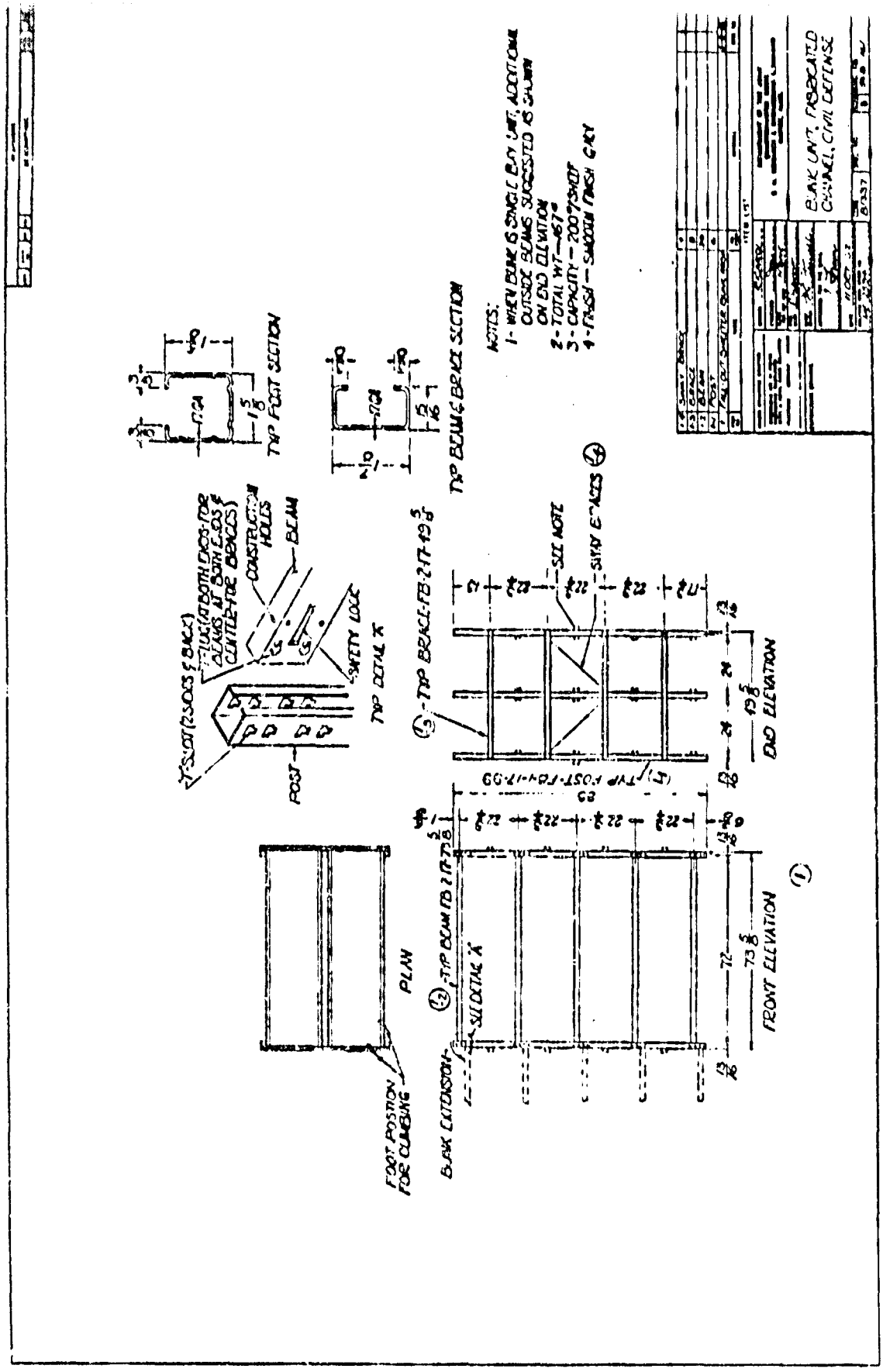
Funds in the Amount of $100,000 will be reserved on our records on a reimbursable basis to cover the cost of work performed. Reimbursable billings shall be forwarded to the Comptroller, DOD, OCD, Battle Creek, Michigan, citing Appropriation 4320100 and Accounting Classification 02/52/06000/9/72046.

If this order is acceptable, please sign and return three copies to the Contract Division, DOD, OCD, Battle Creek, Michigan. The original is for retention in your files.

DEPARTMENT OF DEFENSE OFFICE OF CIVIL DEFENSE	DEPARTMENT OF THE ARMY QUARTERMASTER RESEARCH AND ENGINEERING COMMAND
By_____ Charles T. Westcott	By_____
Title Contracting Officer	Title_____

APPENDIX B

Bunk Unit, Fabricated Channel



APPENDIX B- Bunk unit, Fabricated Channel, Civil Defense

APPENDIX C

Erection Instructions

ERECTION INSTRUCTIONS

Fabricated Channel Bunking Unit Manufactured by Storack Corporation
Evanston, Illinois

1. Components:

Basic unit for sleeping 10 persons consists of:

Posts	6
Beams	20
End Braces	8
Sway Braces	4
Bunk Bottom	10 (not furnished)

2. Assembly:

a. Lay 2 posts on floor, parallel, with "T" slots facing up and open part of post facing in.

b. Attach 3 beams between the posts by slipping the "T" lugs into the upper "T" slot of each pair of "T" slots, utilizing the lower 3 sets of slots. (Note: When slipping "T" lugs into "T" slots make sure that straight portion of safety lock is up. There is a slight taper in the lugs and slots and the components will not completely seat if not properly matched. Be sure that the safety lock snaps into place.)

c. Repeat (a) and (b) to have 3 sets of posts and beams.

d. Stand up 3 sets of posts and beams and hook in end braces.

e. Attach balance of beams, having one set of beams on each side of the center posts.

f. Attach sway braces on each end of unit by slipping into round construction holes between 2nd and 3rd end braces.

g. Slip pieces of plywood or hardboard into slots in beams.

APPENDIX D

Commercial Sources of Materials

COMMERCIAL SOURCES OF MATERIALS

Speed Rail - Hollaender Manufacturing Company, 3841 Spring Grove Avenue, Cincinnati 23, Ohio

Lyon Metal Products, Inc., Aurora, Illinois

Dexion, Inc., 39-25 62nd Street, Woodside 77, New York

Storwal Corporation, 2100 Greenwood Street, Evanston, Illinois

Davis Aircraft Products, Inc., 1191 Spofford Avenue, New York 59, N. Y.

Harvard Manufacturing Company, 7619 Grand Avenue, Cleveland 4, Ohio