

Alternative uses for locally-available building materials

THE DEVELOPMENT OF ALTERNATIVE USES FOR LOCALLY-AVAILABLE
BUILDING MATERIALS, PARTICULARLY BINDING AGENTS, IN
ORDER TO DECREASE THE BUILDING COST, AND INCREASE THE
QUALITY OF CONSTRUCTION IN SELF-BUILT HOUSING

By

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ABSTRACT

To provide homes for everyone despite explosive population growth, the development and maximum use of locally-available building materials must be considered. For most populations, particularly in developing countries, the simplifying of building techniques and encouragement of self-built housing are important tools in improving housing conditions.

This study is concerned to determine new uses for sulphur, a widely available material, in the field of housing. The techniques suggested are simple and could be successfully employed in self-built housing.

Two sanitary units were built with simplified plumbing and assembly. These units require a minimum of space and reduce the erection costs. Reduction in water and power consumption are also achieved.

A self-built house with a pre-cut timber system suitable for self-help is studied with respect to the costs of the principle phases of construction. The problem of contingency housing is also sketched out.

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PREFACE

This work forms part of research done in Minimum Cost Housing Studies at McGill University, financed by a grant from the Federal Governments' Central Mortgage and Housing Corporation.

The problems I have chosen to investigate are presented in two parts. Part one is the results of experiments which deal with the use of sulphur in building construction; in the form of sulphur-concrete; as a binding agent; and for increasing the quality of construction in self-built housing. Part two is the sanitary aspects which is a significant factor in increasing the building cost. A timber system is also presented with a view of self-built housing using locally-available building materials. At the end of part two I made a study of contingency housing and the immediate needs of shelter for people affected by disasters.

I wish to acknowledge the assistance I received from the Brace Research Institute of McGill University; Crane Canada Ltd.; the Department of Civil Engineering of Sir George Williams University; the Departments of Electrical, Civil and Metallurgical Engineering of McGill University; and above all, the School of Architecture workshop.

My thanks to Gundars Kajaks and Salama Saad of McGill, and Mamadou Lamine Bob of the University of Montreal, who assisted in the experiments and preparing the forms.

I am finally indebted to my colleague, Witold Rybczynski of Minimum Cost Housing Studies, for much helpful aid during the experimental work and for his assistance in preparing this study.

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INTRODUCTION

The great driving force behind housing conditions today is the population explosion. It took 200,000 years for man to reach his first thousand million, but only 100 years to reach his second. We now have well over three thousand million people, the doubling time seems to be about 35 years, in which case the world population will be between six and seven thousand million by the year 2000, eighty to ninety percent in the developing countries.

Urban populations are multiplying at faster rates; in the year 1800 the world had fifty cities of over a hundred thousand people; today there are nine hundred. To ensure reasonable housing for everyone in the year 2000, it will be necessary to build 1000 million dwellings in the present century, (UN estimate).

Demand and shortages of water grow together, supply conditions are grossly unsatisfactory in most countries. Supply and wise use of water are required at all levels.

The necessity to make economically available dwellings for all the population requires the reduction of building cost. Considerable attention should be given to the development and productivity of the entire complex of building materials production and of the construction industry.

Housing is obviously influenced by the building materials which are readily available in the region, and which thus limit the number of alternative forms of construction. This limitation does not mean that good housing cannot be achieved, the challenge is certainly great but it is a rewarding one.

Many materials which are inexpensive and available in many countries such as sulphur and lead can reduce the building cost by their use as building materials. Research needs to be undertaken to apply such materials in building construction and particularly for self-built housing. Improvement of the already existing locally available building materials like stone, timber, earth, reeds, thatch and bamboo in self-built housing should be the primary aim of the technological development.

Mechanization of house building should be considered to produce more and better homes at lower cost. To make the construction operation independent of weather conditions by assembling complete structures in a shop is one of the basic considerations for the use of prefabrication.

Periodic and seasonal unemployment in construction is more common than in other industries. Prefabrication helps in the solution of this problem.

In countries where serious shortage of capital goes hand in hand with a surplus of labour, efforts in the form of self-help housing are of great importance for improving housing conditions.

The building materials industry should keep the cost as low as possible and provide building components that require a minimum of assembly and employing self-built methods. Simplifying of sanitation and building components has a great effect on housing improvement.

The development and simple use of locally available materials can be also employed in disaster areas where immediate needs of shelter are required. Self-help housing is an important factor for the rehabilitation of those destroyed areas.



At present, of approximately 90 developing countries, 52 have a per capita annual income of less than \$100, 23 between \$100 and \$200, and 16 between \$200 and \$300. Given these low per capita incomes in developing countries, a supply of housing services at a reasonable cost is a factor of great social importance.



A potent method for mobilizing new resources which are not normally available for other types of investment are self-help and mutual aid. They are particularly applicable in rural areas where a tradition exists for self-built housing from local materials, or among persons in urban areas who are recent immigrants from rural areas.

Research needs to be undertaken to reduce the disadvantages of such traditional materials as earth, thatch, reeds, bamboo and stone as they are available and known building materials for the majority of self-builders. Any techniques developed should be always considered from the point of view of using local materials and technology to improve what already exists.

PART I

SULPHUR

1. What is the Problem? The deterioration of housing conditions in different parts of the world requires development of low cost building techniques using inexpensive equipment, unskilled labour and a maximum use of locally produced building materials. Inexpensive binding agents that can be used in assembling bricks, blocks, stones and other small size building components require development. Self-built housing using indigenous materials requires different techniques and approaches.

We should also consider the water shortage problem and its effect on building construction. It requires 800 gallons of non-saline water to produce one ton of cement. It would be advantageous to have building concretes available that use no water.

2. Proposal We propose to use sulphur as a building material in the form of sulphur concrete, as a binding agent, and as a reinforcing impregnant for porous materials. Sulphur exists in many parts of the world (see map) and particularly in volcanic regions. In the last few years, in response to the dangers of sulphur dioxide pollution from gasoline engines, a new source of sulphur is the oil refinery, where sulphur is extracted from the oil.

The availability, indeed over-abundance, of sulphur at this time, its low cost, the relatively simple techniques that can be used to employ it as a building material, and also the fact that it is locally available in many developing countries make it a particularly attractive material for minimum cost housing.

3. Advantages and Disadvantages There are many advantages to using sulphur as a building material. Small investment is required for machinery and tools. It is widely available and inexpensive (1971 price in Alberta \$7 per ton). It has good water impermeability. It adheres strongly to a wide range of materials. It has no taste, no smell, no action on the skin, it is a poor conductor of heat and electricity and it is insoluble in water. When sulphur is mixed with fibres it becomes an excellent binding material. Sulphur cures in a matter of minutes. Sulphur has a high resistance to salt and acid solutions. As an impregnant it improves the quality and strength of porous materials such as concrete, wood, fibreboard, asbestos and paper. By mixing sulphur with sand and aggregate, one can have a fast-setting high-strength concrete. Sulphur can be indefinitely stored, and also re-used. Casting forms can be used many times.

Sulphur also has some disadvantages. It has a relatively higher pouring cost and more equipment for melting and casting is needed. It requires fast pouring because the temperature in the mixer is difficult to control. After setting, some voids appear, due to contraction. This problem can be overcome by adding asphalt or sugar to the molten sulphur (U.S. Bureau of Mines). Sulphur is also susceptible to bacterial oxidation in soil.

One of the disadvantages that previously eliminated sulphur from being used as a building material was its flammability. In fact in the past sulphur was used as fuel. Today a number of different and cheap additives have been developed (Southwest Research Institute, San Antonio, Texas) to be used in concentrations of 3% - 6%. The advantages are that within minutes of casting, depending on the thickness of the sulphur, the mold can be removed, and also as soon as the sulphur is cool, it is completely cured (concrete takes seven to twenty-eight days to cure).

4. Future Recommendations Priority should be given to developing better and larger scale melting and mixing equipment. Research should be carried out in using sulphur in low cost housing. Techniques have to be developed with respect to placing the sulphur in molds. With the aid of spray equipment modified sulphur formulations should be investigated as waterproof coatings for adobe, earth and clay roofs and walls. A pilot project in the form of a small house should be built using sulphur concrete in order to compare cost and quality of construction.

PROPERTIES OF SULPHUR

Sulphur is a non-metallic chemical element that was discovered in prehistoric times. It was first classified as an element by Lavoisier in 1777.

One cubic foot of sulphur weighs 129 pounds (2 tons/cubic metre), its melting point is between 240°F and 246°F (114°C - 119°C), and the boiling point is at 832°F (444.6°C). Sulphur ignites at 475°F (245°C).

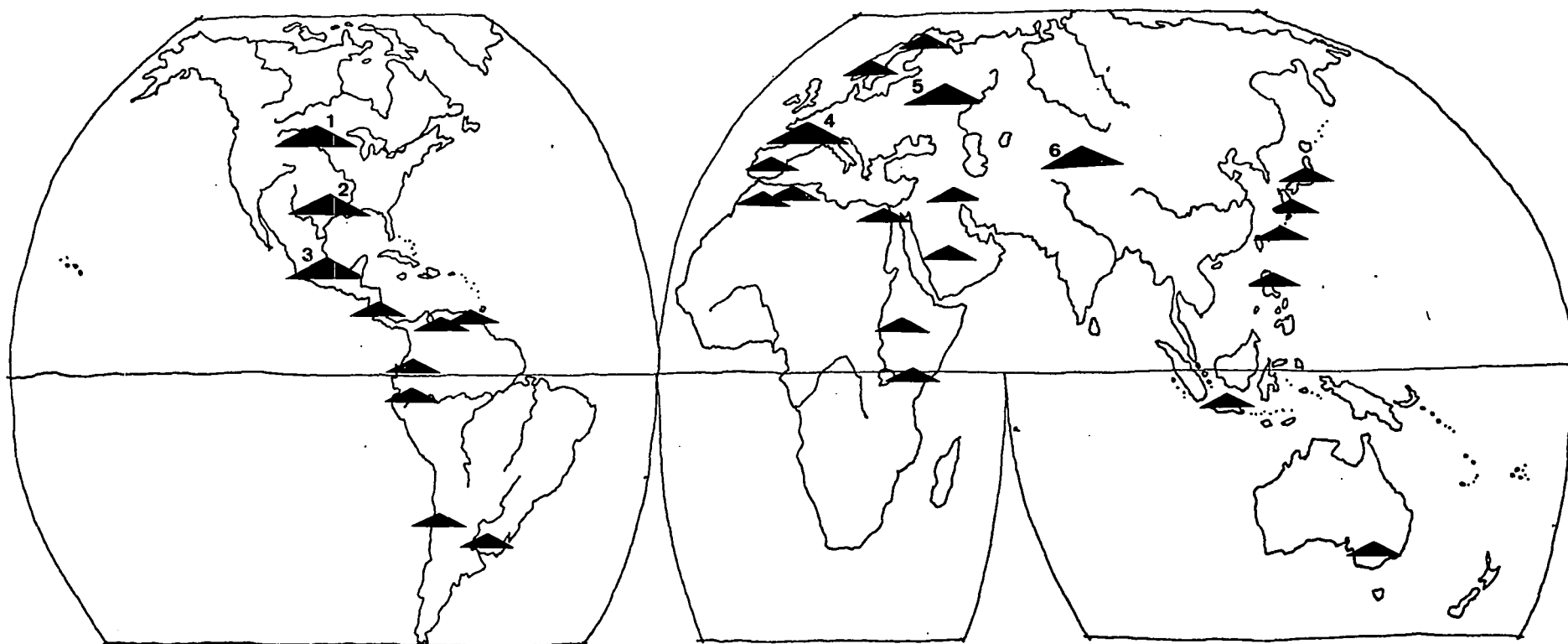
The uses of sulphur are many and varied. Roughly half of all sulphur produced is used as agricultural fertilizer. It has been proposed that sulphur be used in the construction of sewers and drains, as sulphur is resistant to acids and corrosive liquids. The Department of Chemistry and Chemical Engineering of the Southwest Research Institute, San Antonio, Texas found that it is possible to obtain a compressive strength of 2700 psi (189 kg/cm^2) using 16% by weight sulphur and high strength aggregates, and 1730 psi (121 kg/cm^2) compressive strength by cutting back the sulphur content to 11%. For use in housing we need only 1500-2500 psi ($105\text{-}175\text{ kg/cm}^2$).

The tensile strength of sulphur concrete depends on the grading and type of aggregate, and the amount of sulphur in the mixture. The highest strength is obtained by mixing 40% sulphur with 60% sand (by weight). Increasing the sulphur content will weaken the strength. It is possible to increase the tensile strength by more than 65% to 670 psi (47 kg/cm^2) by adding 5% carbon black to a mixture of 70% and 25% sand. (1)

The use of plasticizers will overcome many of the objectionable characteristics of sulphur. Dr. B.R. Currell of the Department of Chemistry of the North London Polytechnic in his report of August 1971 demonstrates methods of plasticizing sulphur in order to turn it into a flexible material (5). Such a material, using unsaturated hydrocarbons as plasticizers, could have application as a roofing membrane. Colouring of sulphur is possible by adding minerals or organic substances or other materials (2).

The work illustrated here deals with the use of sulphur as a building material for the construction of minimum cost housing. This was initiated because of the favourable characteristics such as waterproofing, fast curing, strength and availability as well as high quality surface characteristics.

Experiments were carried on to determine new uses and applications for this material in the field of housing. The basic properties and strengths are already well documented, and continued investigation should result in practical low cost construction techniques, and better evaluation of the performance of this material in the field under various conditions.



MAP SHOWING WORLD SOURCES OF ELEMENTAL SULPHUR NOW BEING MINED

▲ SULPHUR PRODUCER ▲ MAJOR PRODUCER
 Canada, USA, Mexico, France, Poland, USSR

World Production of Sulphur in 1970 (millions of tons)

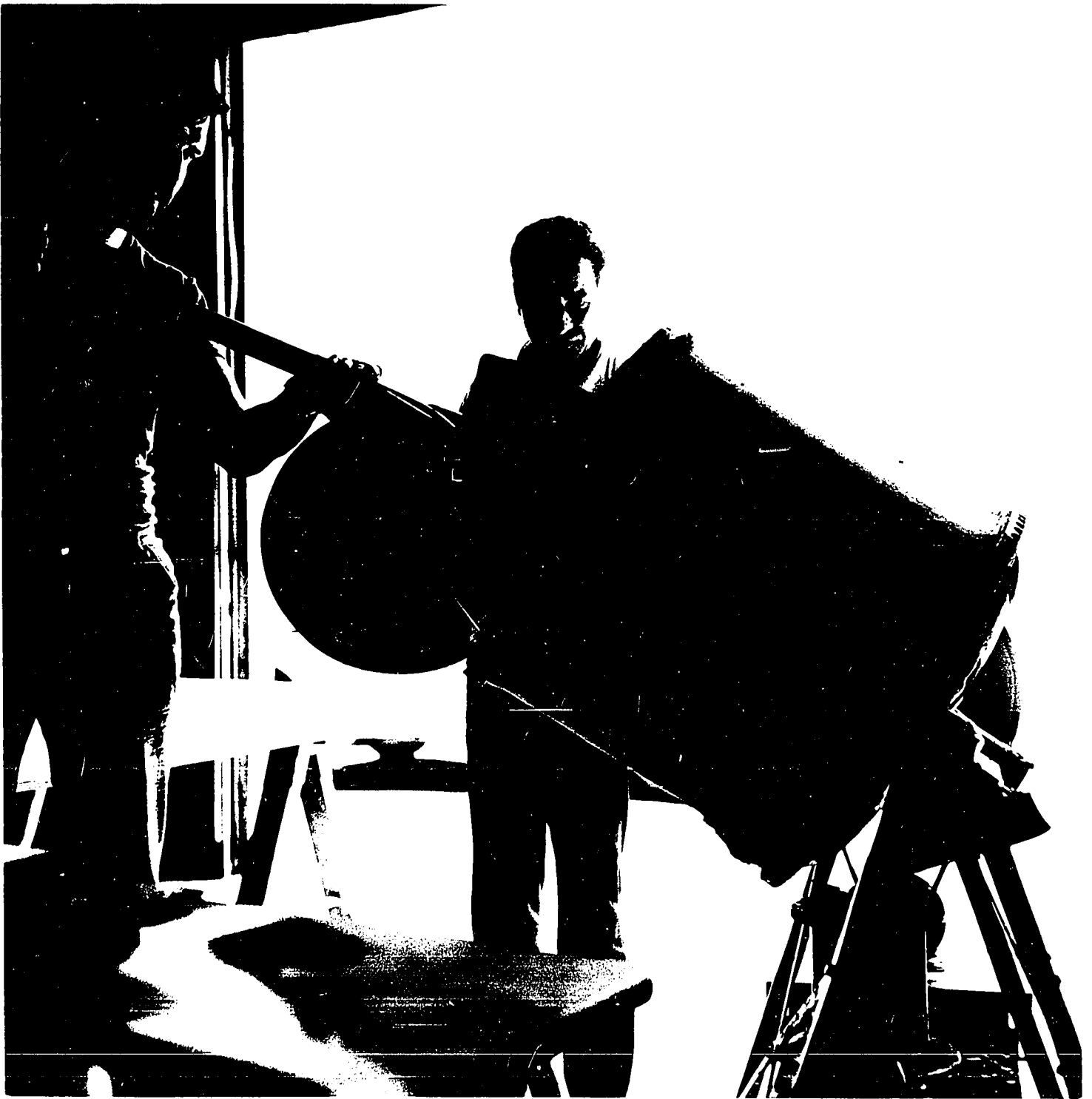
	World Total	W.Europe	E.Europe	North America	Asia	Other Countries
Sulphur(all-forms)	41.5	8.0	11.2	15.2	3.5	3.6
Elemental sulphur	22.5	2.2	4.9	12.8	0.8	1.8

Source:
 The British Sulphur Corp.Ltd.



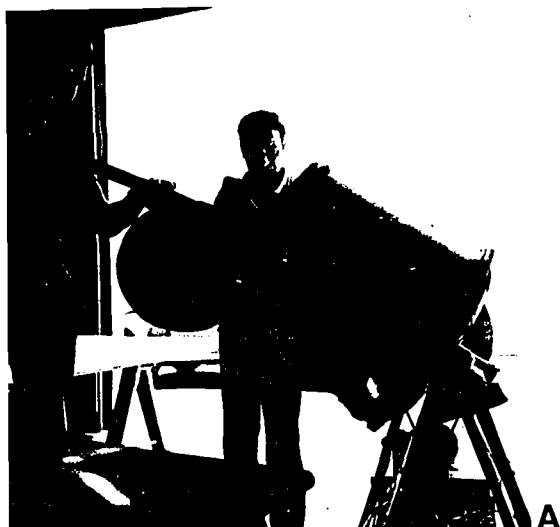
EQUIPMENT

The above photo shows the three cubic feet capacity, electrically powered concrete mixer used to mix the sulphur, sand and aggregate. The mixer was insulated with fibreglass wrapped in asbestos mat. The mouth was closed with a wooden lid to conserve heat. The mixer barrel and its contents were heated by one burner head placed below the cast-iron base of the mixing barrel. Butane gas was the fuel used. Since the walls of the mixer are of sheet metal it is only the base that conserves heat, and it was for this reason that the heat source was placed below the base.



EQUIPMENT

The above photo shows the three cubic feet capacity, electrically powered concrete mixer used to mix the sulphur, sand and aggregate. The mixer was insulated with fibreglass wrapped in asbestos mat. The mouth was closed with a wooden lid to conserve heat. The mixer barrel and its contents were heated by a burner placed below the cast-iron base of the mixer barrel. No gas was used for fuel. Since the walls of the mixer are of cast iron, it is only the base that conserves heat and it was found that the heat was lost from the base of the mixer.

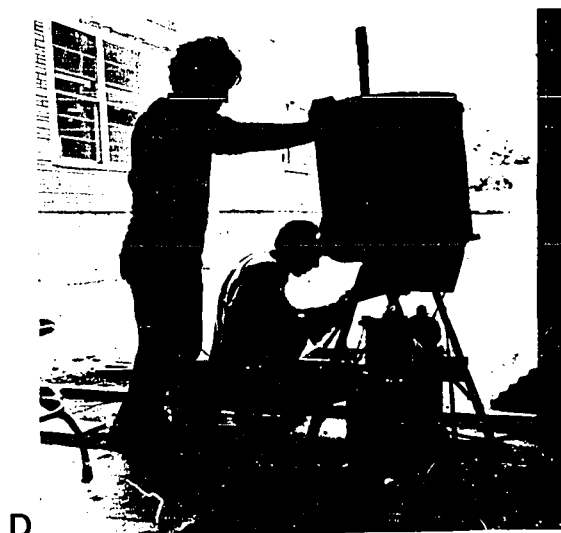
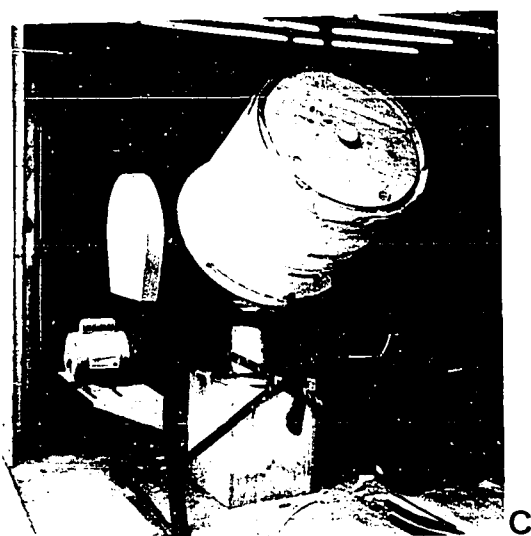


HEATING

The sand was first heated in the mixer to a temperature between 270°F and 300°F (140°C - 150°C), this temperature range is above the melting point of sulphur and below the point where liquid sulphur becomes viscous. This technique was decided upon because when sand and sulphur were mixed simultaneously lumps of sand and partially melted sulphur made it difficult to work with the mixture, and total melting of the sulphur never took place as it was insulated by the sand.

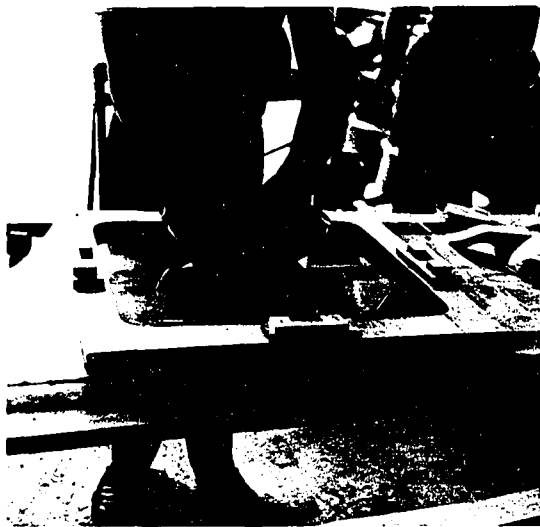
Photo A. Pre-heating sand in the mixer. It took 30-45 minutes to heat the iron base and bring the temperature of the sand to the proper level. However once the thermal inertia of the mixer is overcome, successive mixes took only 10-15 minutes. Once the sand was heated the sulphur was placed in the mixer. Photo B.

Photo C. If used continuously for an extended period of time the heat would melt the grease in the moving parts of the mixer. It was found better to use low heat for longer periods of heating. Photo D.



CASTING A SULPHUR CONCRETE BASIN

An inexpensive sulphur wash-basin was to fit over a standard PVC tank. A wooden frame of 4Mx5M (16"x20") was made with a thickness of $\frac{1}{2}$ " (13mm). Shallow metal cooking pans were used as molds. A 4" (10cm) diameter hole was made in the top of one pan and aligning blocks attached on four sides. The mold for the flat top was in two parts. The metal exterior mold was varnished to allow it to break away. The inner mold was left in the form, the lining of the washbasin being thus formed.



1



2



4



3

Photos 1 & 2 Placing the wooden frame on a sheet of glass to give smooth finish to the top of the basin. The inner mold is held in place with masking tape.

Photos 3 & 4 Pouring the molten sulphur/sand mixture into the mold, using a plastic beaker. The $\frac{1}{2}$ " slab is poured first, and one minute later the top mold is aligned in place.

Photo 5 Pouring is continued through the 4" diameter hole, to form the concave basin.



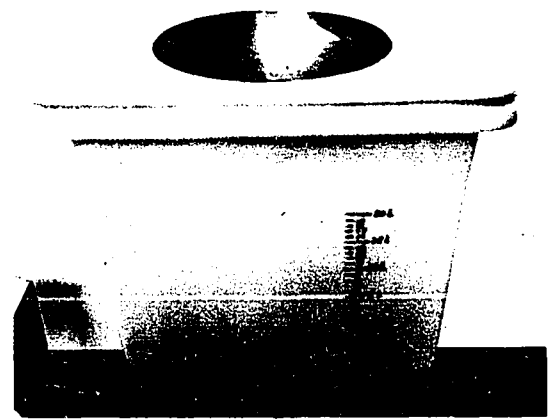
Photo 6 It was necessary to place weight on the topmost mold to keep it from being pushed up by the pressure of the sulphur.

Photos 7 & 8 The finished basin in place on top of the PVC water tank. The basin weighs 20 pounds. The mixture used was 50% sand and 50% sulphur.

5



6



7



8

Cost of the Basin

1 metal pan	\$1.20	
Sulphur/sand	0.15	
	<u>\$1.35</u>	Material Cost

Total time spent in casting 0.25 man-hours.



CASTING

In addition to the mixer a one gallon electric melting pot was used to melt smaller quantities of sulphur. The advantage of this pot is that with a rheostat the temperature can be exactly set and controlled. The pot is useful for mixing pure sulphur with asbestos fibre, saw-dust and fibreglass. The pot was also used for impregnation of porous materials.

Photo 1 Casting from the pot directly to produce a thin-wall bowl. The mix is asbestos fibre and sulphur. A hole has been drilled in the top mold and a plastic funnel taped to the mold.

Photo 2 A larger funnel was found to let out the accumulated air bubbles inside the mold.

Photo 3 Similar casting except that the mold is wooden. Here a cast-iron ladle is used to pour the mix. If the spoon is pre-heated the sulphur will not cool during the pouring process. However direct casting from the pot showed better results.

Phot 4 Casting a sulphur facing on a concrete slab using a piece of glass as formwork. This gave an extremely polished water impermeable surface to the concrete.



Photo 5 A profiled post cast in sulphur concrete. On the left the mix was made in the pot and the sand and sulphur have separated. On the right the sulphur has been mixed in the mixer, and a homogeneous mix results.

Photo 6 Casting a scaled down model of a wall, using an aluminum mold.

SULPHUR COATING IN HOUSING CONSTRUCTION

For the last 12 years the Southwest Research Institute has been experimenting with the use of sulphur/fibre composites as binding agents in masonry wall construction. The application method requires a minimum of equipment. Several tests of the strength of sulphur coated joints have been done. Tensile strength, shear strength, bond, creep, temperature effects, waterproofing and fireproofing have been tested. The results favour the use of sulphur as a building material, particularly where self-help and low cost are important factors.

The sulphur/fibre composites contain fibres that should be less than $\frac{1}{2}$ " (13 mm) in length; longer fibres give uneven mixtures. To improve the impact resistance of the joint any conventional sulphur plasticizers can be used, an aryl polysulphide or an aliphatic polysulphide is preferred however (6). Dicyclopentadiene not only improves the impact resistance, but also acts as a fire retarder (8).

To apply the coating to a surface any convenient method, such as brushing or spraying, can be used. The hardening time of the coating is 30 seconds to 5 minutes, depending on the plasticizer content, which can vary from 2% to 10% by weight. If the coated object is to be moved it is preferable to allow the composition to set for a longer time, 10 to 15 minutes (6).

According to Mr. John Dale of Southwest Research, concrete blocks weighing 36 pounds each were stacked dry to form a wall 8' high and 10' long, with a window in the centre. The sulphur/glass fibre composite was then painted over the joints. The entire process took 30 minutes. Tests showed the coating to be stronger than conventional mortar. The mix used was 3 parts chopped stranded glass fibres, 90 parts sulphur, 0.5 parts colourizer, and 6.5 parts poly-sulphide plasticizer (by weight). (6)



1



2

Photos of past experiments done with Sulphur/Fibre Coatings

Photo 1 Applying sulphur coating to wooden blocks. An ordinary paintbrush is used. Immediately after application the wood can be turned over and the joint painted on the other side.(8)

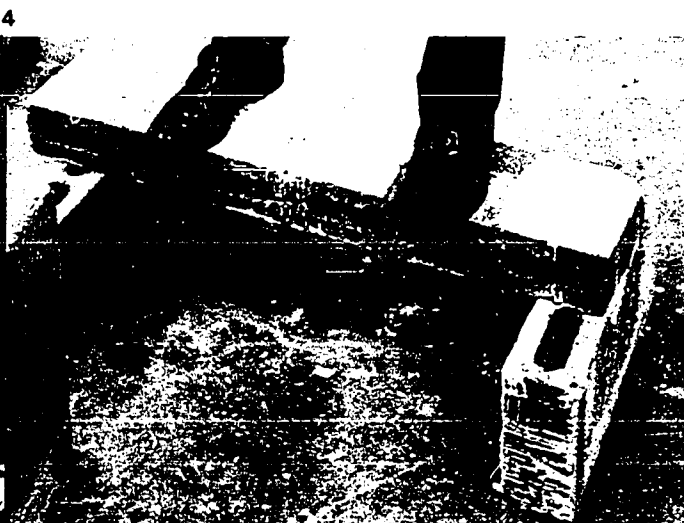
Photo 2 Applying sulphur/fibres to concrete blocks stacked dry.(8)

Photo 3 The finished wall after painting the joints with sulphur/fibre composite (3).

Photo 4 Two 16" long blocks joined to form a beam by painting the joint with sulphur/fibre composite. It was subjected to the load of one man 10 minutes after the joint was painted. There was no failure.



3



4

COST COMPARISON OF 100 SQUARE FEET WALL OF CONCRETE BLOCK (6)

Conventional Construction

Concrete blocks \$ 29.90
Mortar, mastic 13.97
Labour 87.15

TOTAL \$131.02

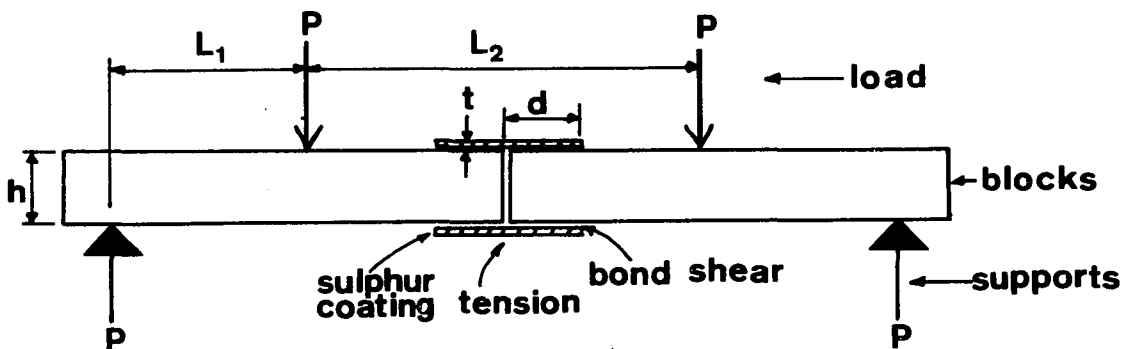
Sulphur-fibre coated

Concrete blocks \$ 29.90
Sulphur/fibre mix 19.50
Labour 18.60

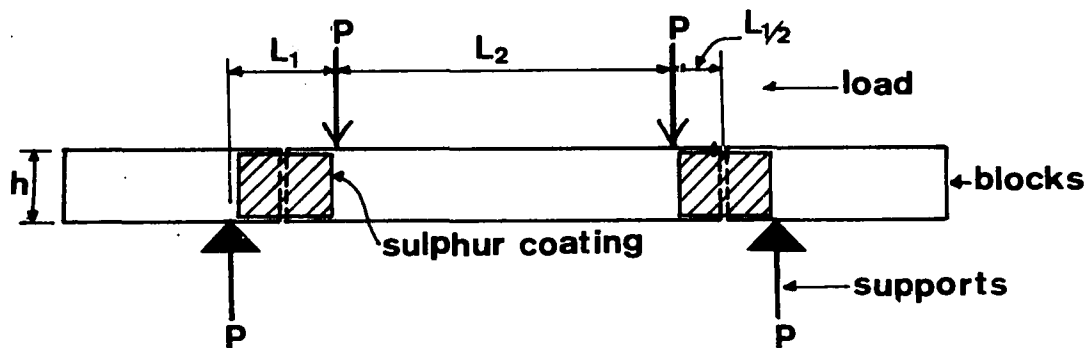
\$ 68.00

From the above comparison it is evident that watertight construction with concrete blocks costs half as much using the sulphur/fibre coating, as conventional mortar jointing.

For tests of tension, shear and bond of such construction see (8).



1) Tension and bond strength



2) Shear strength

Above is a diagram of testing apparatus used by Anderson and Testa at Columbia (8), in order to determine the strengths of coated joints. No bond failure occurred even when "d" was reduced to $\frac{1}{2}$ ". No clear shear failures occurred. Instead all specimens apparently failed by tension in the coating. All shear strengths exceeded 570 psi. None of the tests gave a tensile strength for pure sulphur of less than 160 psi, and many were higher. The strongest bonds were developed with rough surfaces.



A

B

MOLDS

Most of the molds shown on these pages are made for use in the kitchen and are available in most hardware stores.

Photos A A mold made from two wood bowls. The bowls were placed upside down on a sheet of glass and the sulphur poured through a hole in the top. It is necessary to coat wood molds with varnish or lime to prevent adhesion.

Photo B On the left, a cheap paperboard bowl that was coated with sulphur. On the right a cooking pan that was used to make the molds for a washbasin, shown in Photos D (see also page 18).

Photo C A mold made with a wood frame a lead sheet. The lead does not stick to the sulphur, but a chemical reaction does take place between the lead and the sulphur.

Photos E A mold made from two plastic bowls. The plastic partially melted during cooling and the sulphur adhered to the mold.

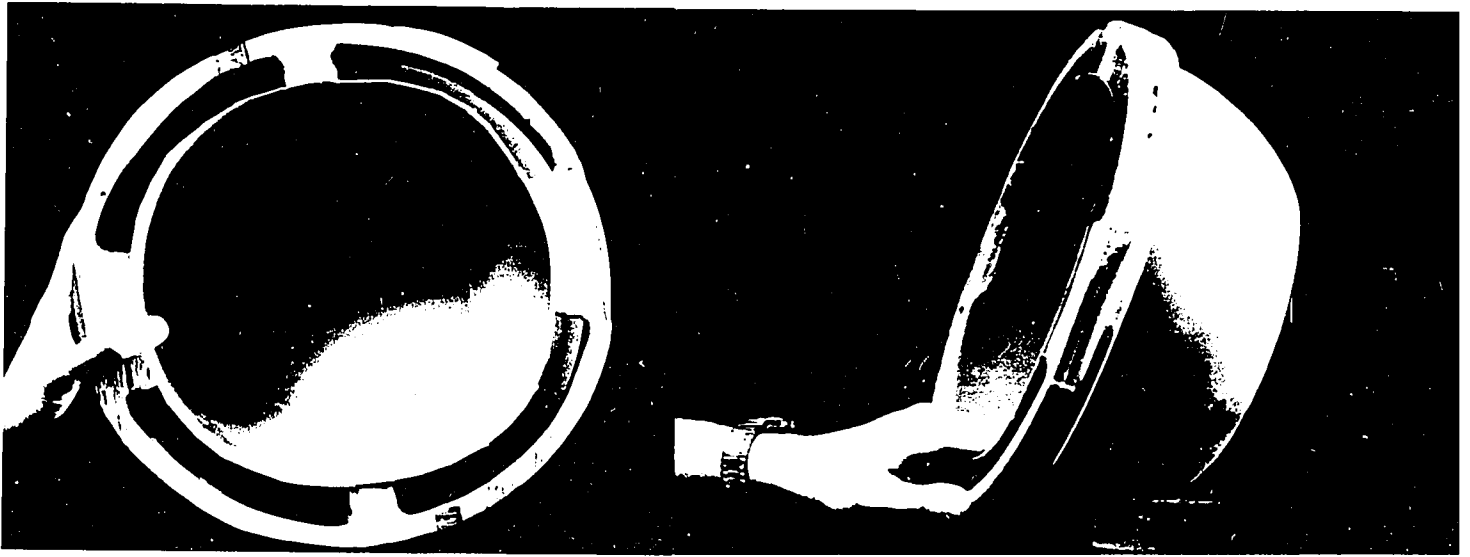
Photos F An aluminum mold that could be used many times and does not require any coating. It gives a glossy smooth surface.

Photos G A heat resistant Pyrex mold gives the best results. It does not crack as would glass and gives a smooth glossy finish.

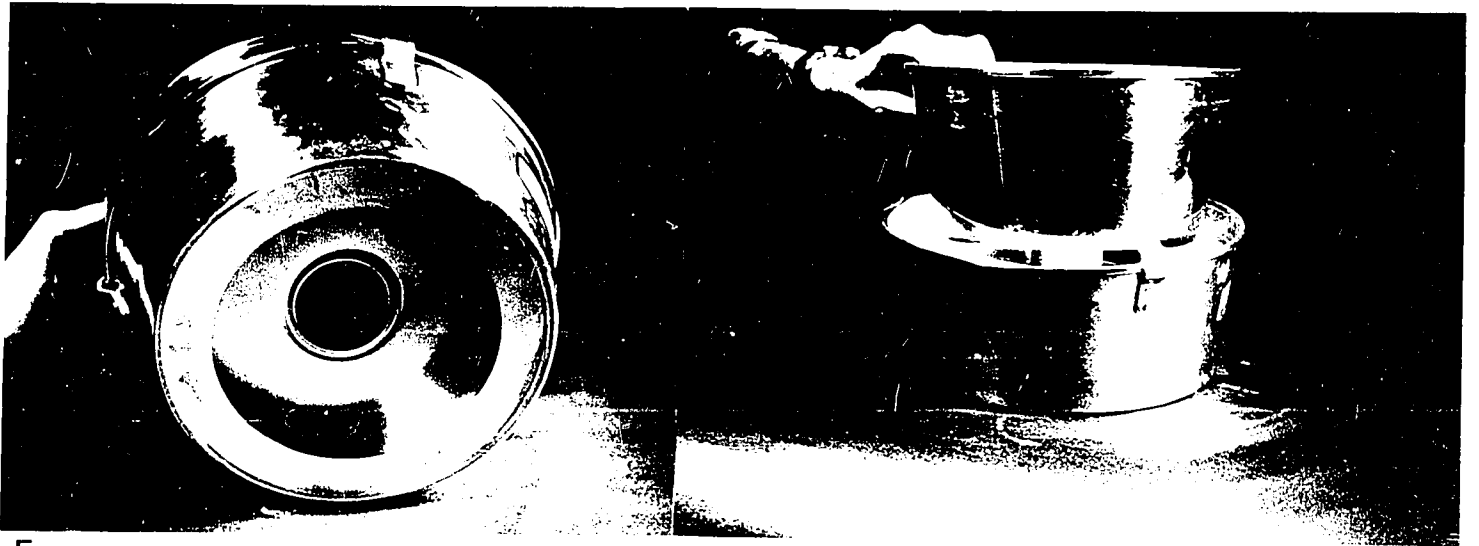
C

D

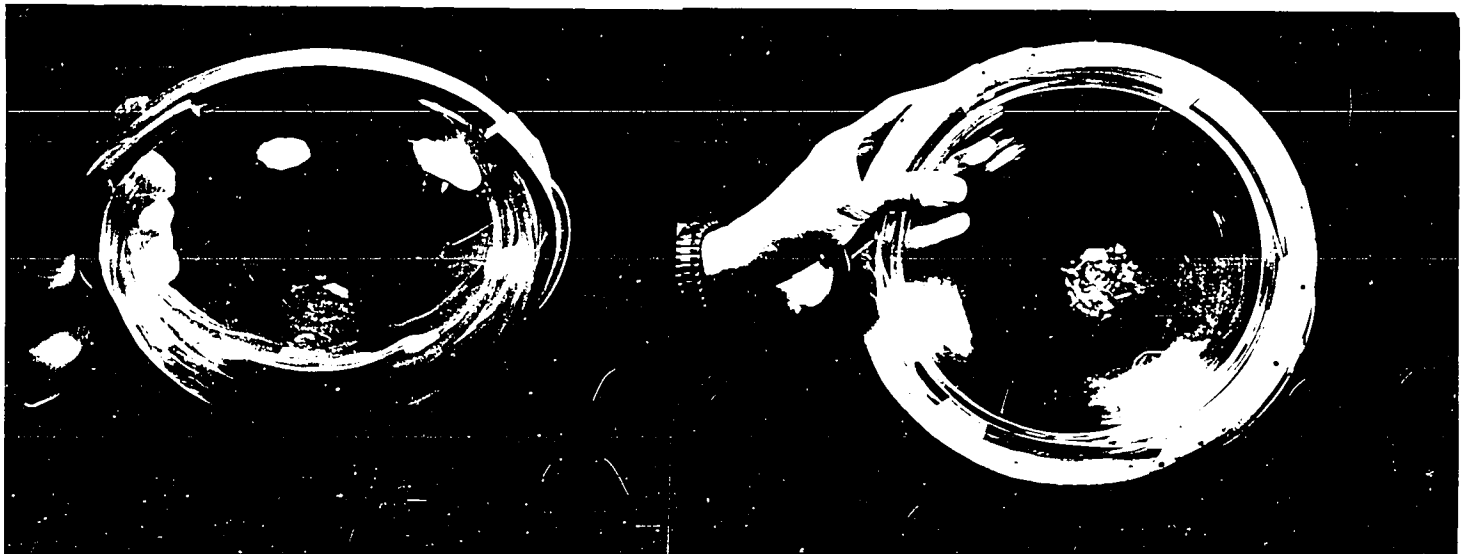




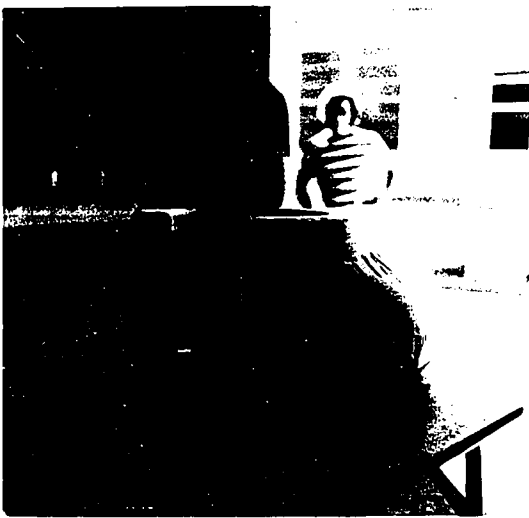
E



F



G



1



2



3

CASTING WITH A GYPSUM MOLD

With the cooperation of Crane Canada Ltd. it was attempted to cast a basin using a gypsum mold that is normally used for casting ceramic basins. This type of mold has never to our knowledge been used with sulphur. Photo 1 shows the assembled three-piece mold. Photo 2 shows a preliminary try with a small piece of the mold. As this proved successful we decided to proceed with the full mold. During the casting a number of cracks appeared in the gypsum though no leaks developed. However, as Photo 3 shows it was impossible to remove the mold. Photo 4 shows the mold being broken. As Photo 5 shows there was 100% adhesion between the sulphur and the gypsum. It was quite impossible to separate any of the casting from the mold.

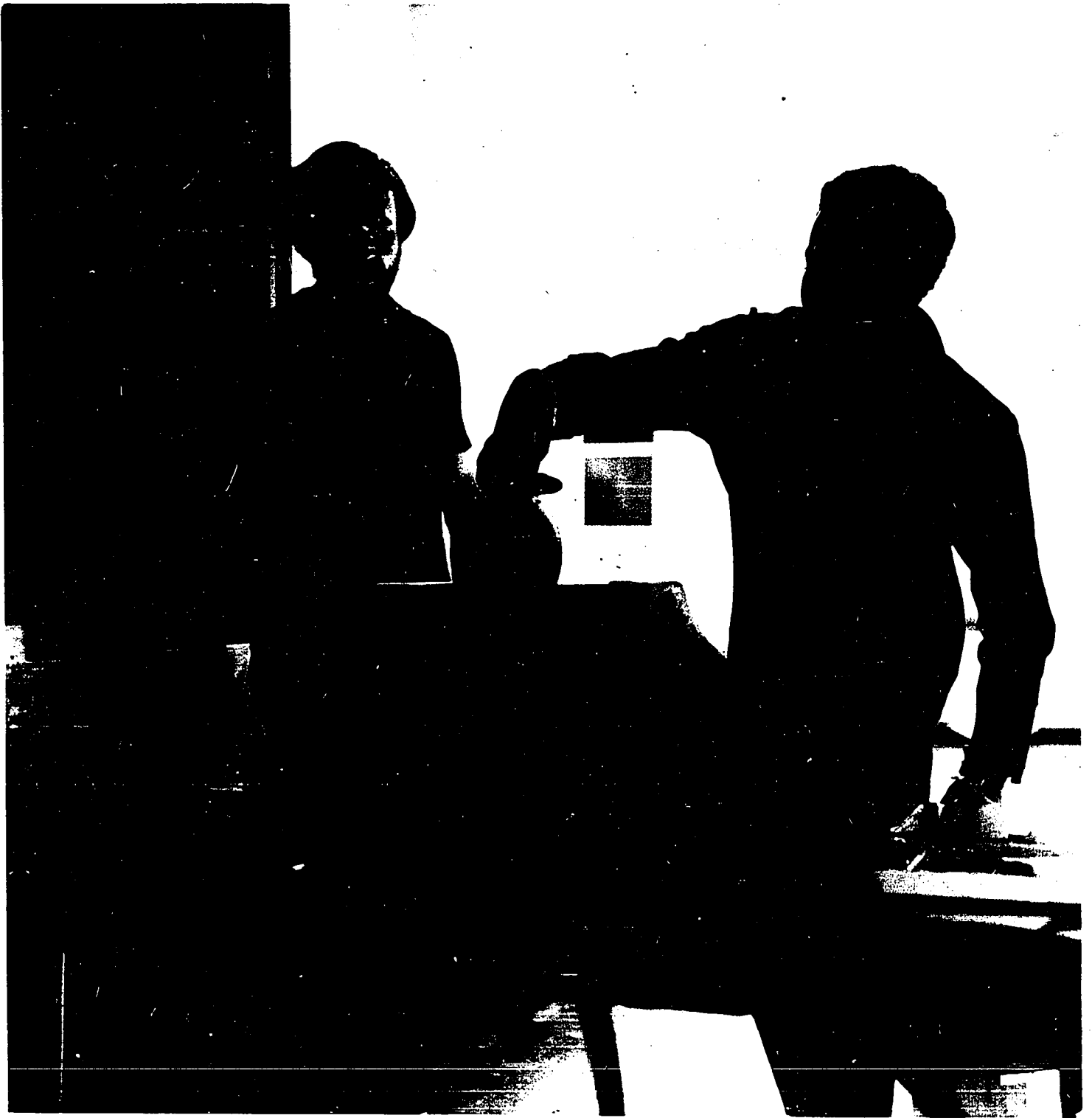


4

The results of this experiment point out that existing gypsum molds could not be used with sulphur. Even if a suitable releasing coat could be found there is still the problem of the initial heat-cracking of the gypsum, which means that the mold can only be used one time. It is possible that this could be overcome by using thinner walls in the mold. The thick walls are required in the ceramics industry to draw out the moisture from the clay.



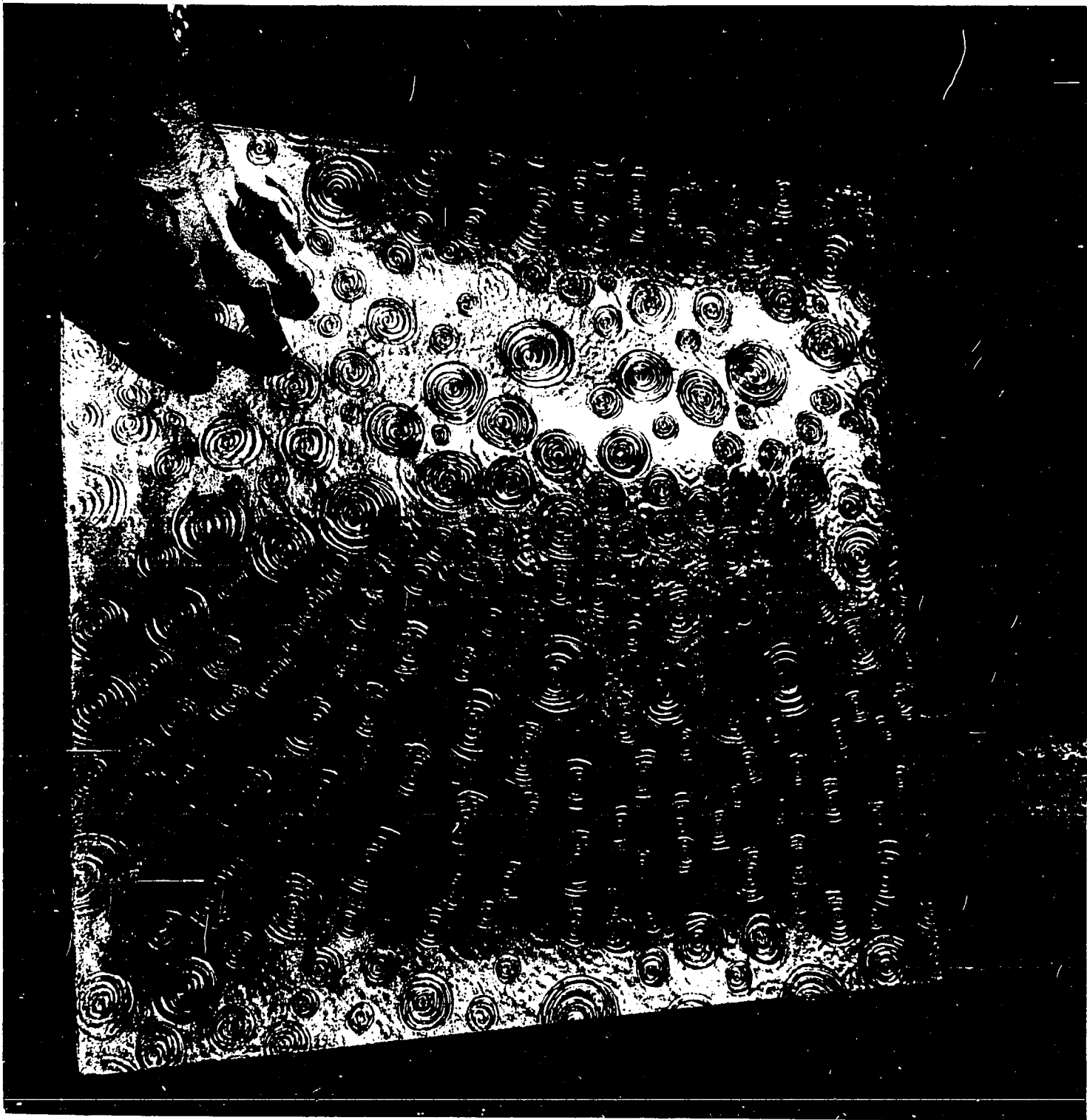
5



Above, casting with sulphur concrete and the gypsum mold.

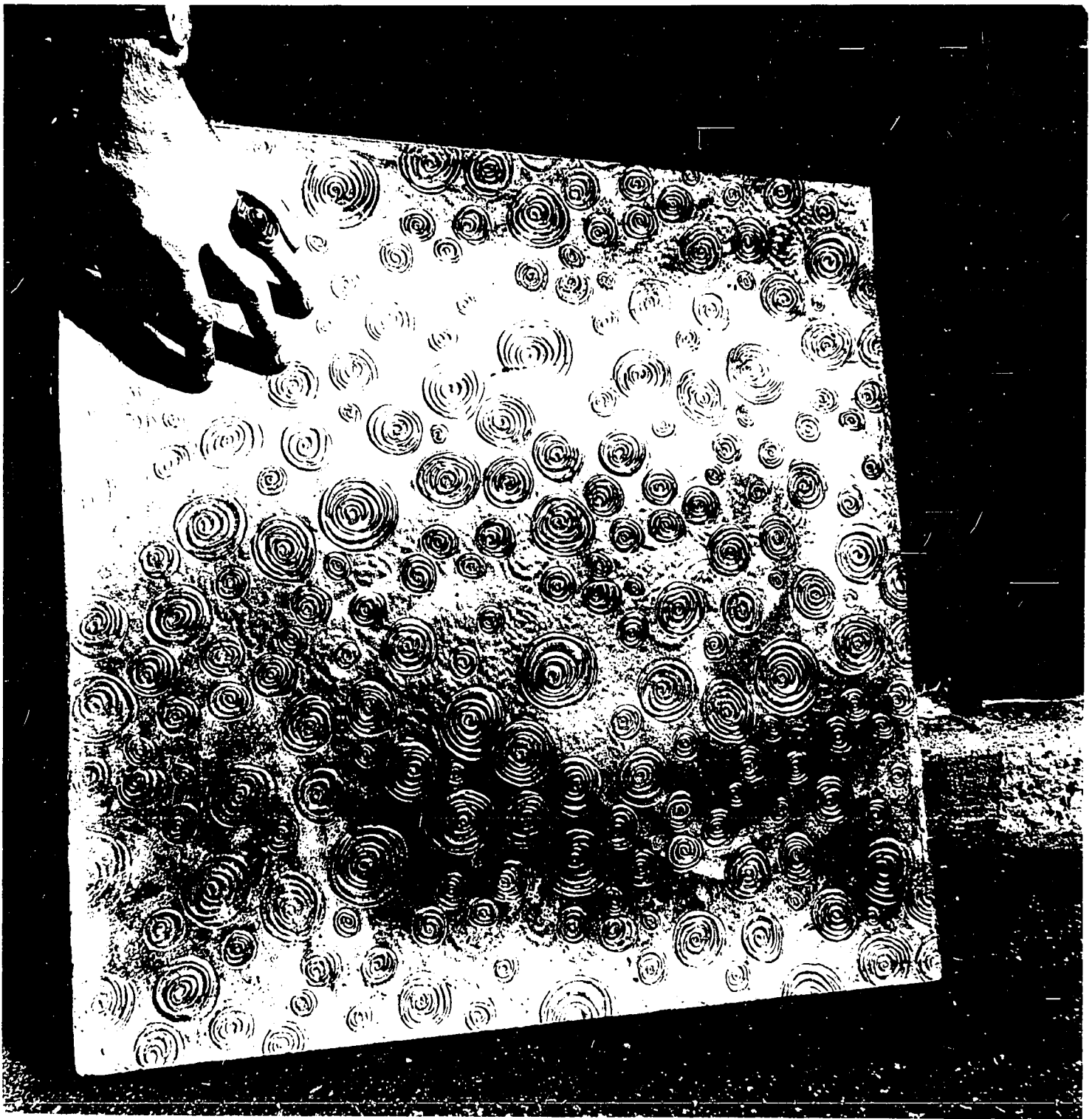


Base, finished with sulphur concrete, and the original mold.



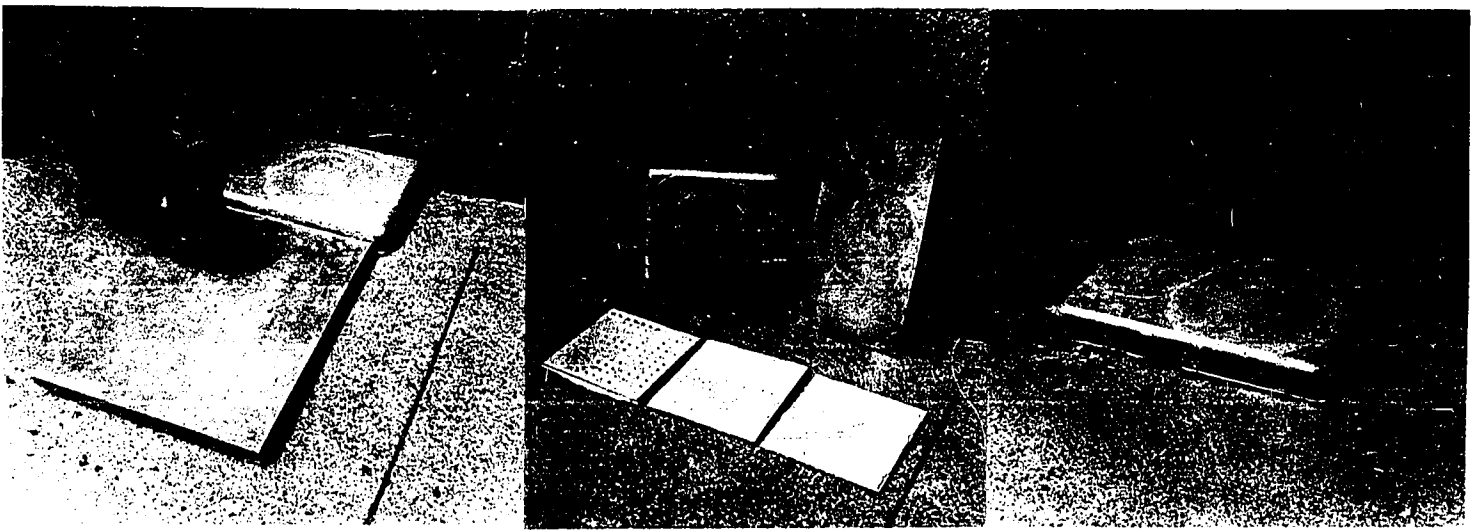
SLABS AND TILES

The 6M x 6M (24" x 24") slab shown above is one of a series of experimental slabs that were cast using a sulphur concrete mix. The form is made with wooden edges and masonite bottom, to produce a slab three quarters of an inch (20 mm) thick. The casting procedure was similar to that described previously, using the concrete mixer. Small size basalt aggregate was added to the sulphur/sand mix. The decorative finish of the above slab was achieved by placing a sheet of plastic in the mold.



SLABS AND TILES

The 6M x 6M (24" x 24") slab shown above is one of a series of experimental slabs that were cast using a sulphur concrete mix. The form is made with wooden edges and masonite bottom, to produce a slab three quarters of an inch (20 mm) thick. The casting procedure was similar to that described previously, using the concrete mixer. Small size basalt aggregate was added to the sulphur/sand mix. The decorative finish of the above slab was achieved by placing a sheet of plastic in the mold.



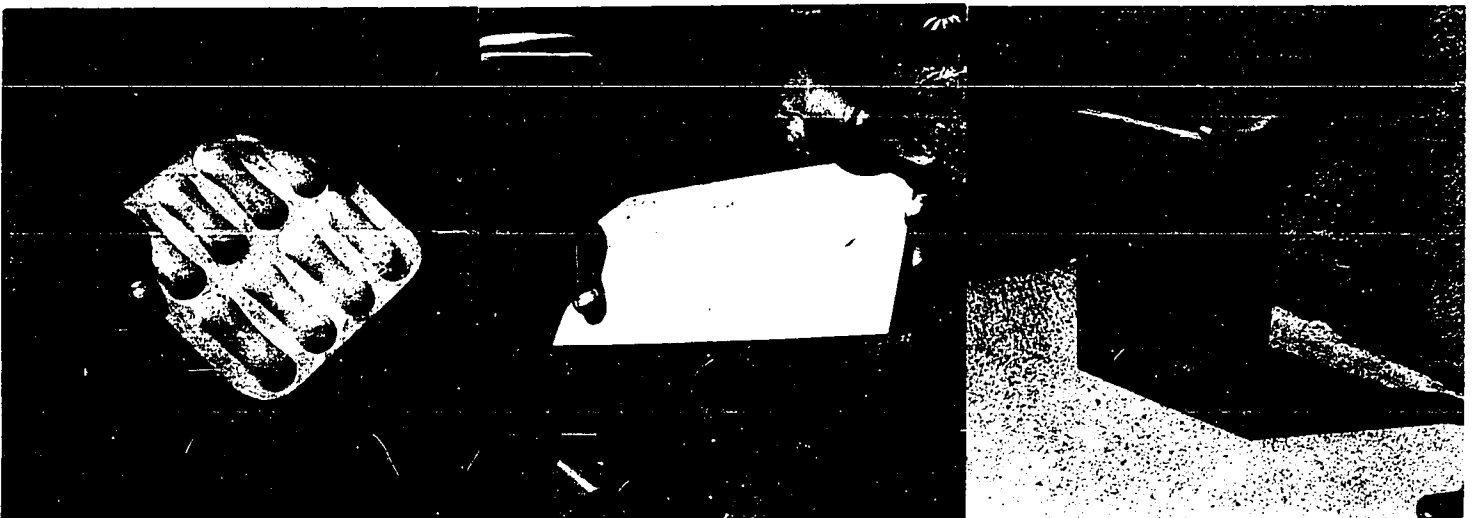
The three quarter inch thick sulphur-concrete slab was strong enough to walk on. Waterproofing and strength of sulphur-concrete permit it to be used for housing in general and particularly for bathrooms and kitchens, as well as for exterior use. Samples were subjected to atmospheric conditions during the summer, and further tests will be carried on during the coming winter, to determine any possible deterioration during freezing and thawing cycles.

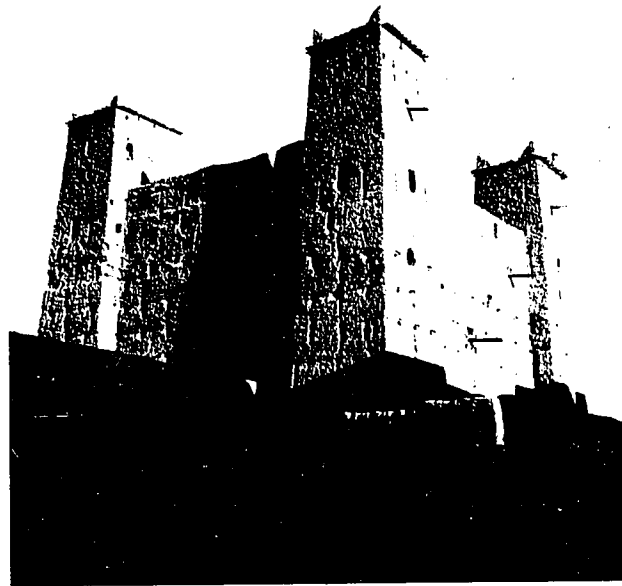
The photos above show different sizes and thicknesses of floor slabs and tiles

Below left, a tile with decorative finish. Experiments have also been carried out to give no-slip finishes to floor tiles.

Below centre, a very thin tile, $\frac{1}{4}$ " (6 mm) thick of relatively large size, 6" x 12" (15 cm x 30 cm). This type of tile is light, strong and waterproof and could be used in kitchens and bathrooms. As it was cast on glass it has a smooth and shiny marble-like surface.

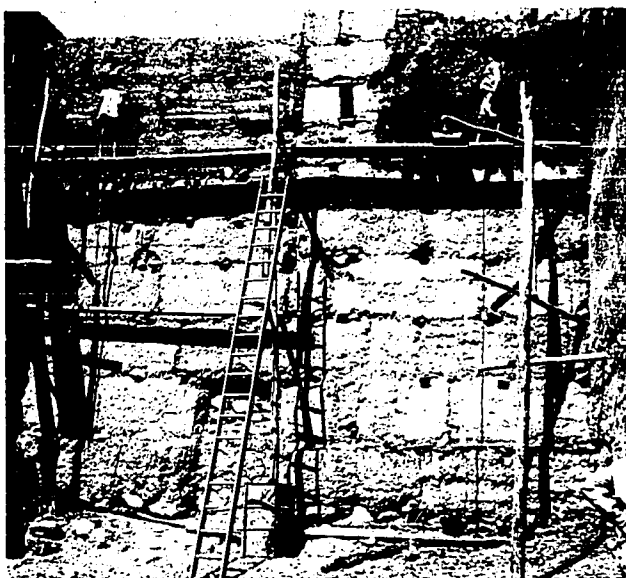
Below, right, a modular slab 3M x 4M, $\frac{3}{4}$ " thick (20 mm). It was cast on an aluminum form which gives a less shiny finish than a glass form, thus the tile is more suitable for flooring.



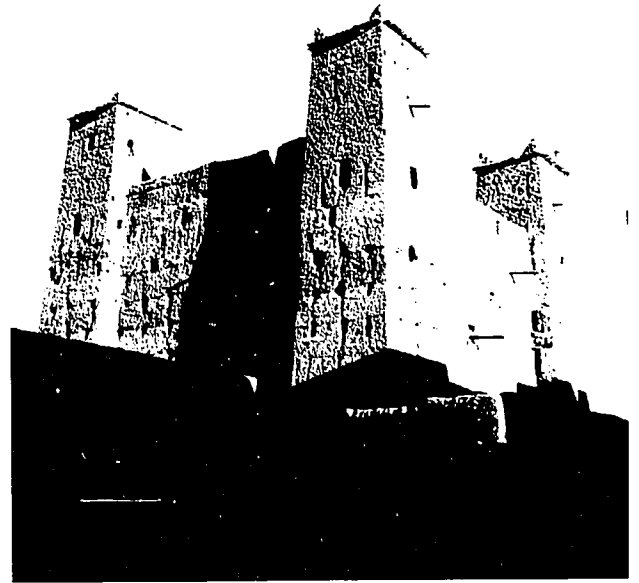


PROTECTIVE COATINGS

The durability of locally available materials such as adobe, clay or thatch is often short due to rain and wind. These materials have the advantages of availability, high thermal inertia and suitability to local conditions. A waterproof coating would extend the life and quality of such construction. The investigation of sulphur spraying equipment should have high priority in order to improve housing conditions.

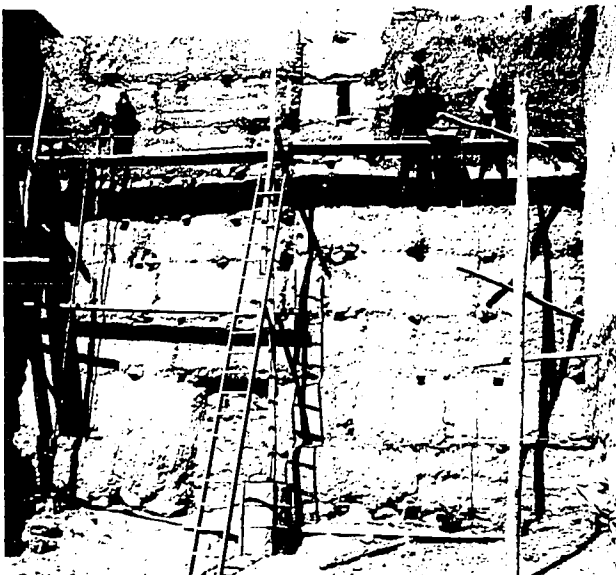


Experiments have already been carried on for some years in the use of sulphur as a coating for baskets in order to produce cheap basins and other types of waterproof containers. The coating can be applied by spraying, painting or impregnating with sulphur. It would be possible this way to make a kind of home-made tile using wicker, to provide a cheap material for roofing where clay is not available.

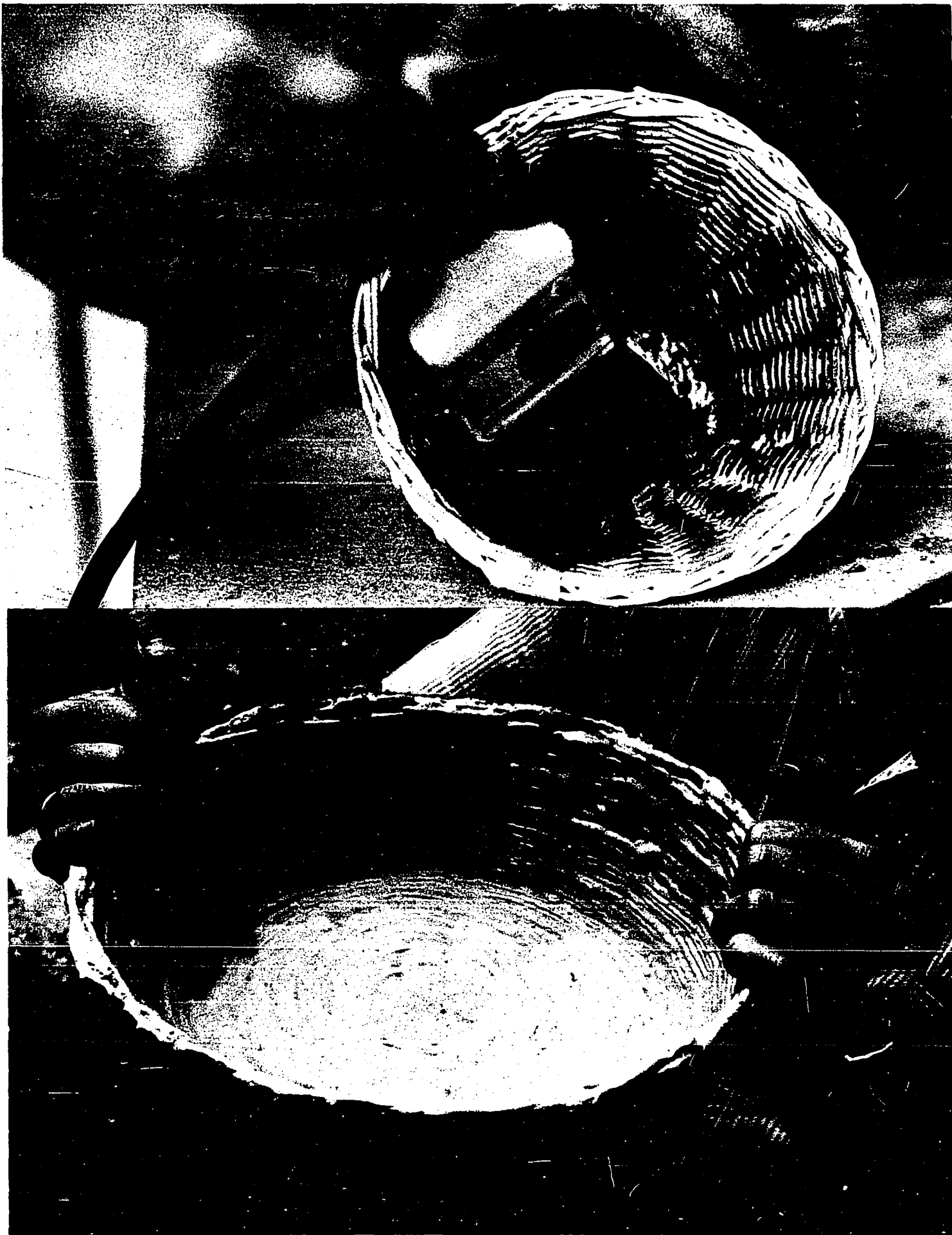


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WALLS

The main objective in casting-in-place the entire wall using sulphur concrete is to eliminate joints and so to reduce the cost and time of assembly. In the photos above can be seen small scale examples of walls cast with aluminum molds and mesh reinforcing. Techniques must be developed before this kind of large size casting can be attempted. In such casting, as forms can be removed 10-30 minutes after casting, the number of forms can be lessened.

Below left, A modular sulphur storage box unit.

Below centre, a sandwich of styrofoam and sulphur concrete. As the hot mix melts the styrofoam the bond is very strong.

Below right, a conventional brick with an impermeable sulphur coating.



WATER ABSORPTION

The worst enemy of building materials is moisture penetration.

Water should not be allowed to remain at the wall surface. Sulphur-sand and sulphur-concrete walls are relatively impervious to water and weather changes.

The table below shows the results of water absorption tests carried out on sulphur-sand samples and other building materials

MATERIAL	Weight (lbs.)	Weight after 1 hr. (lbs.)	Weight after 24 hrs. (lbs.)	%water absrp. after 1 hr.	%Water absrp. after 24 hrs.
Sulphur-sand block	3.00	3.00	3.00	-	-
Sulphur-concrete block	5.65	5.65	5.65	-	-
Sulphur-sand tile	0.55	0.55	0.55	-	-
Sulphur-sand tile (1)	2.75	3.00	3.00	9.10	9.10
Sulphur-sand basin (1)	21.00	21.50	21.50	2.38	2.38
Asbestos-cement sheet	1.37	1.50	1.75	9.50	27.80
Asbestos Mat	0.50	1.50	1.50	200	200
Clay Brick	4.50	5.00	5.40	4.18	20.00
Soil-cement block 1(2)	14.15	16.21	16.36	14.60	15.60
Soil-cement block 2 (2)	14.98	17.00	17.07	13.50	14.00

(1) These samples had some holes due to incomplete mixing.

(2) Data from "Some Aspects of Low-Cost Housing", see (14).

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PART 2

A. SANITARY UNITS

1. What is the Problem? One of the most important factors to consider when trying to improve living conditions is the provision of basic hygienic sanitation. Many diseases and epidemics are caused by sub-standard, or complete lack of sanitation.

A relatively high proportion of the cost of a house is in the pipes and fittings needed for water and sewage. This becomes particularly true when the structure is of locally available materials and costs very little. One solution to this problem has already been described in the section on sulphur, and that is to develop techniques whereby sanitary equipment can be self-built using locally available materials, such as sulphur concrete.

It is necessary to simplify the methods and techniques for satisfying the basic requirements of personal hygiene, in order to bring the cost as low as possible. On the other hand it is also necessary to consider ways of reducing the amount of water necessary to flush toilets. In North America the annual water consumption for a household is 88,000 gallons (396 cubic metres), 40% of this water is used for flushing. It would also be advantageous to find more efficient methods of heating water to be used for washing. At present most methods over-heat and store water in large quantities, not only is this a waste of energy, not to mention space, but the resulting water is usually hot enough to scald the user, who must mix it with cold water again.

2. Proposal At Pennsylvania State University experiments have shown that the pumping cost for collecting laundry and bath-water and recycling it for toilet use is one-eighth the cost of fresh water. It is felt that yearly savings will offset the cost of the system in a number of years. More importantly there is a 25-40% reduction in water consumption. (1)

In the United Kingdom, Ideal Standard Limited is marketing a dual-flush toilet cistern. The flushing handle has two positions and can release either one or two gallons according to requirements.

The Wallace-Murray Corporation of Pittsburgh, Pennsylvania has developed a bathroom where all fittings are pre-installed.

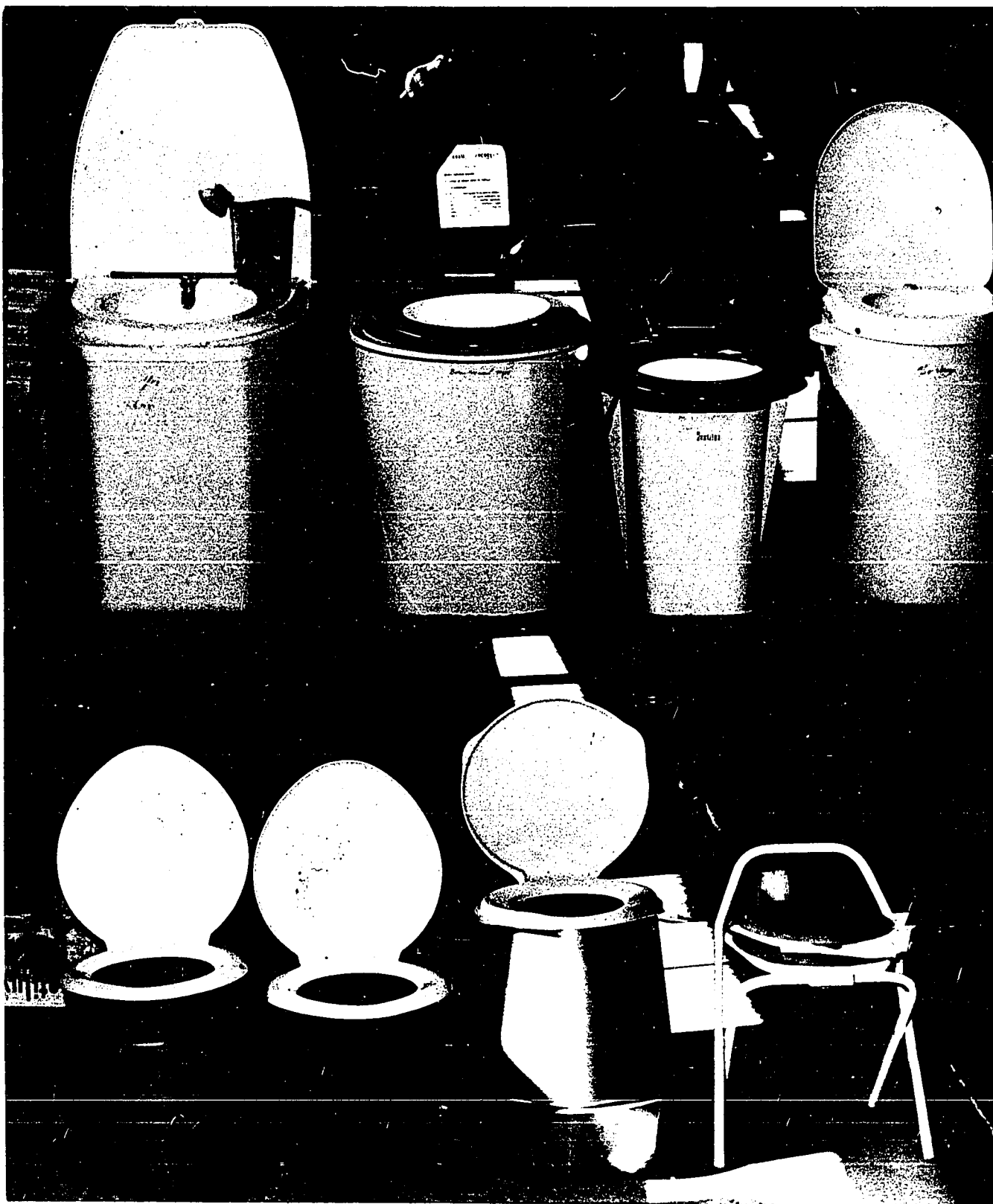
In Europe, Latin America, Asia and Australia, small electric water-heaters are in use that heat water continuously as the flow is turned on, rather than storing hot water.

Our study was made to develop a simple sanitary unit that would reduce the cost of plumbing and installation, and that could be connected to supply lines and drains in an uncomplicated way. We were also concerned with trying to reduce the amount of water and energy used. The use of such a unit was seen in rehabilitation of urban houses, in adding new sanitation to rural houses, and as bathrooms in vacation homes.

3. Advantages and Disadvantages The unit is designed to be used not only in new constructions, but in existant houses. There is no need for cavity walls, or for breaking and patching walls in order to install the unit. The unit occupies less space than the conventional bathroom. By eliminating a trap, and simplifying the fixtures, costs are reduced.

The proposal is only for places with piped water and electricity. The flushing of the tank is not conventional, since it receives water from the sink.

4. Future Recommendations Production of prototype models should be undertaken to determine from practical experience and day-to-day use problems. These prototype units should be installed in new and renovated dwellings. The production of small electric heaters should be encouraged in Canada, and gas heaters should be investigated for those areas without electricity.



These photos indicate different kinds of toilets which are being commercially produced in Europe and in the Americas, and which are not connected to a central system. These toilets were used in a demonstration project organized by the United Nations in Peru, for use in areas where there are not water supply and sewage available. These toilets are electrical, chemical and re-cycling.



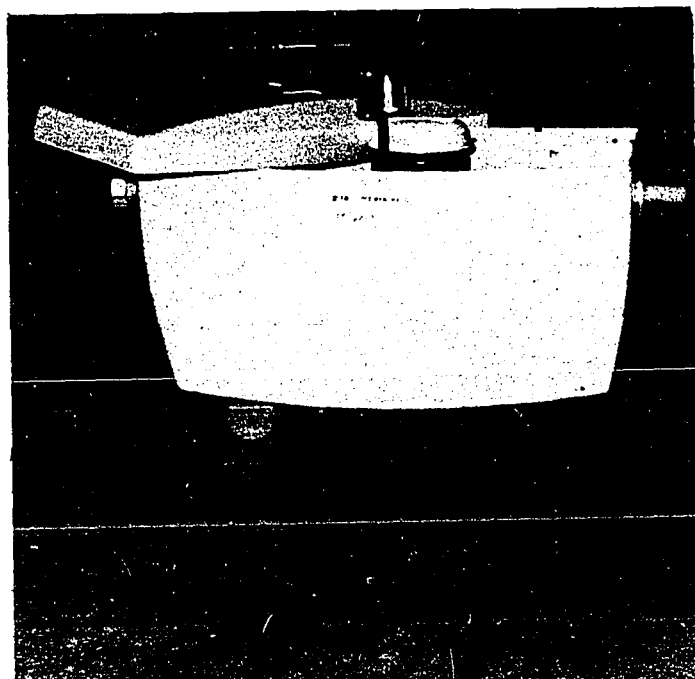
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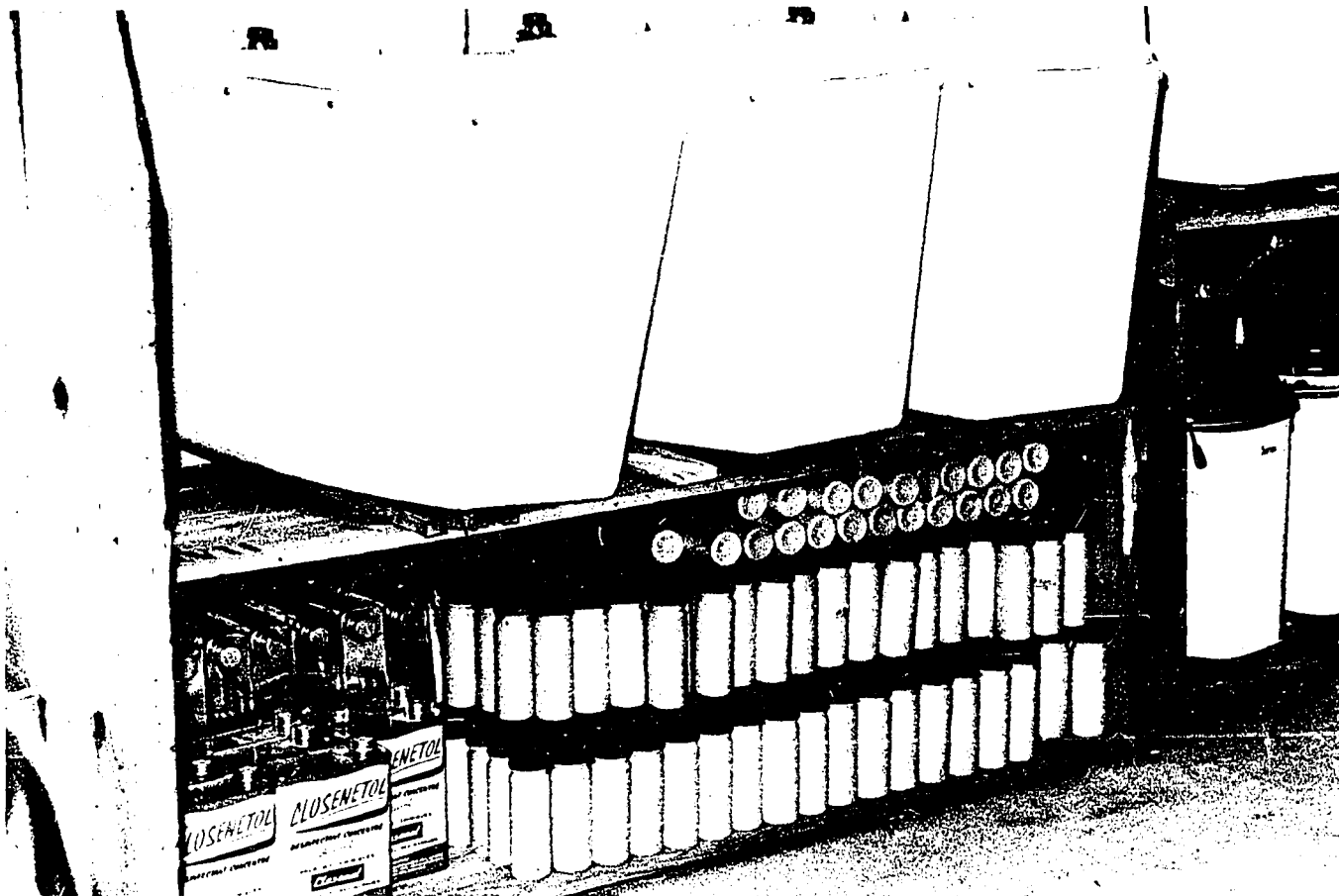


Above, a type of chemical toilet produced in France, for use in rural areas. It provides an acceptable alternative to conventional water-flushing sanitation.

Right, a water tank which can flush 4 litres of water, or eight litres in the case of solid waste.

The upper photo on the facing page shows the pre-assembly of water distribution pipes for a self-help project. The lower photo shows the types of sanitation equipment being produced in Formosa.

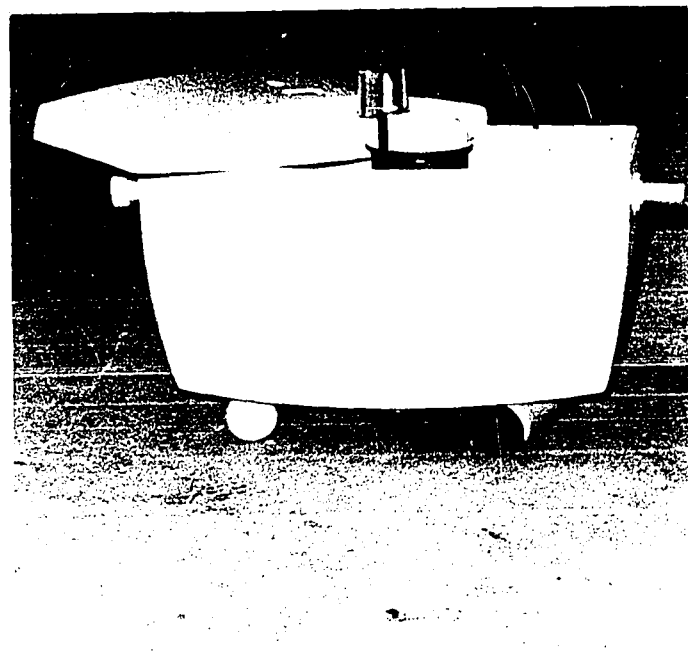


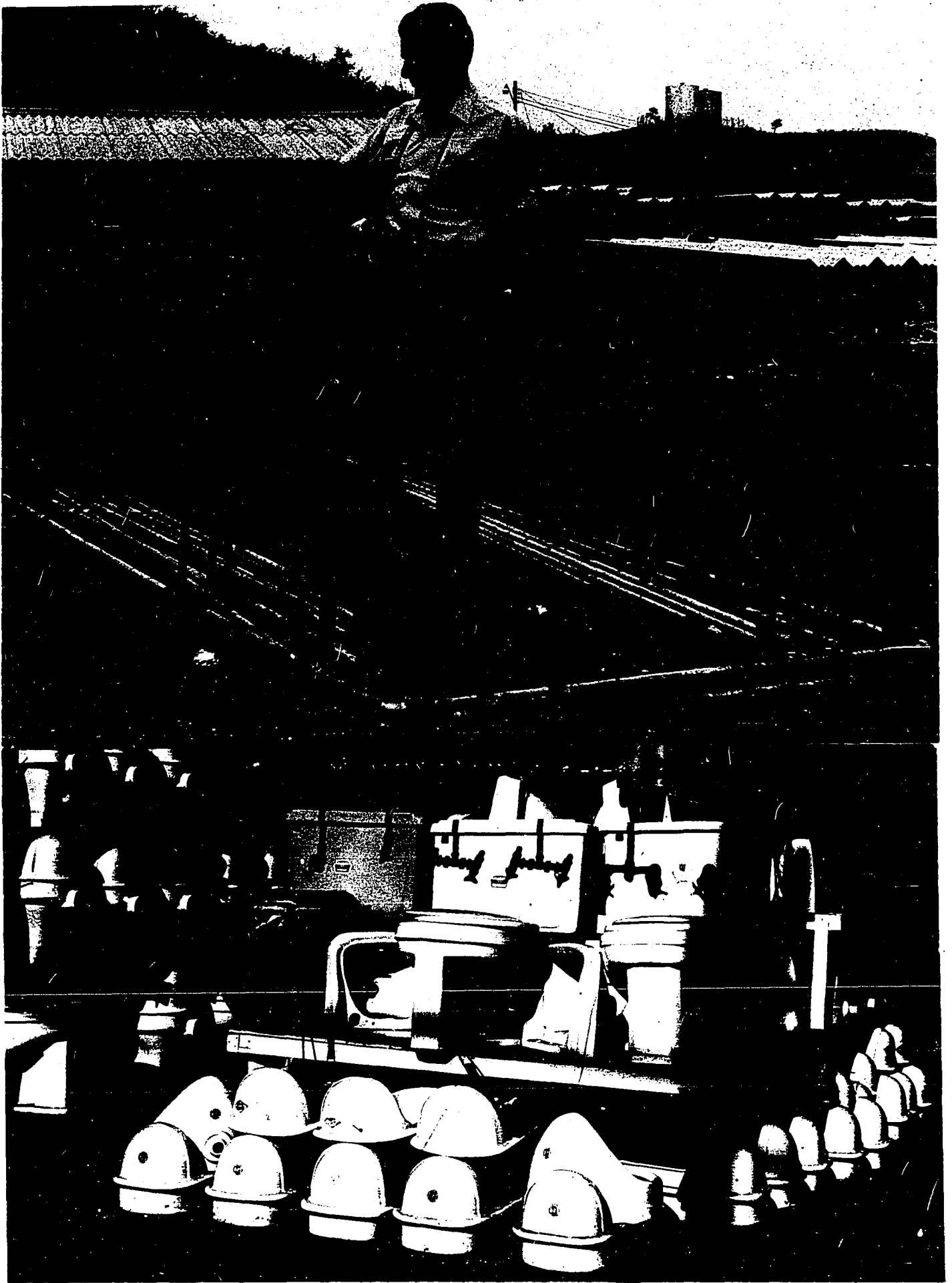


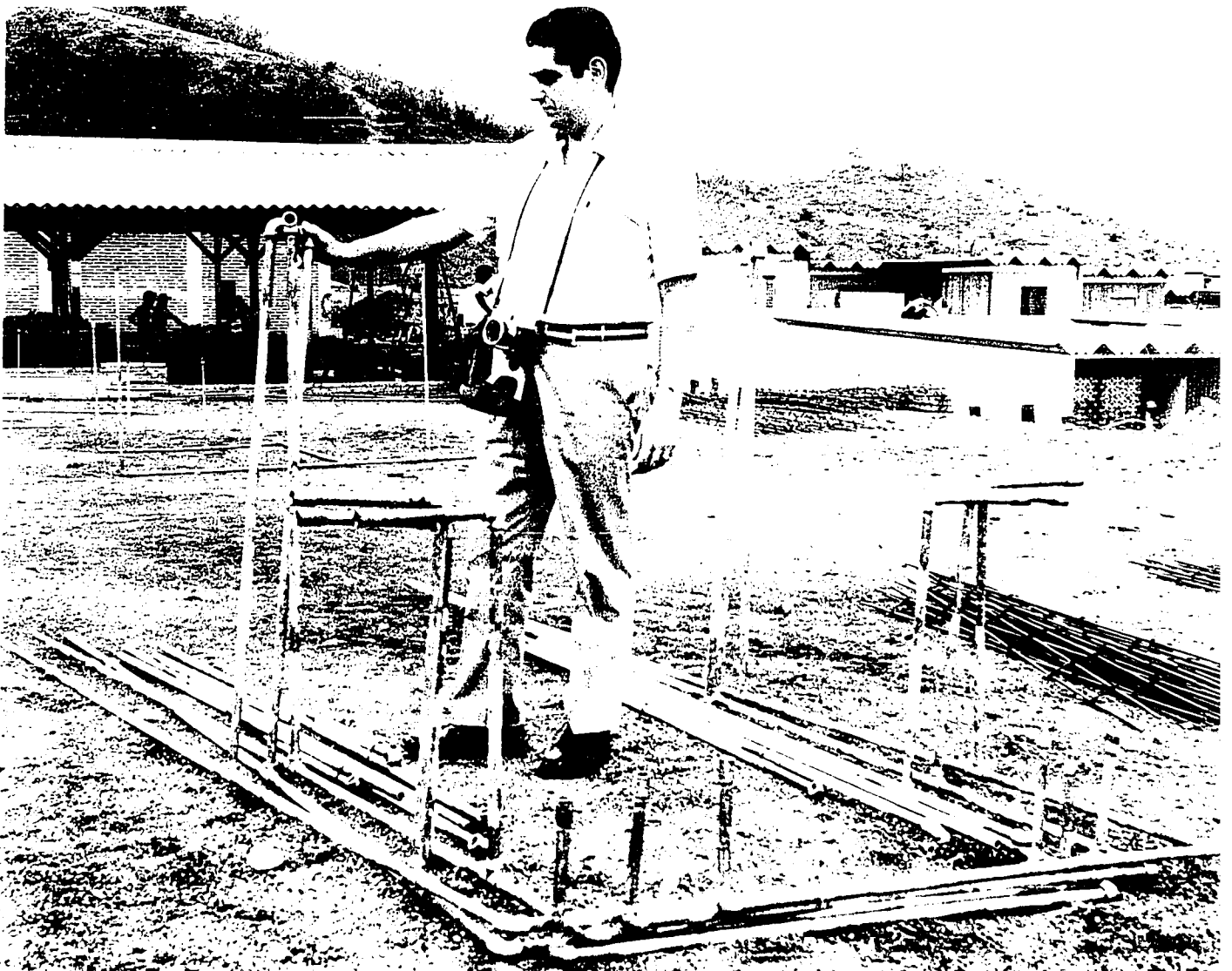
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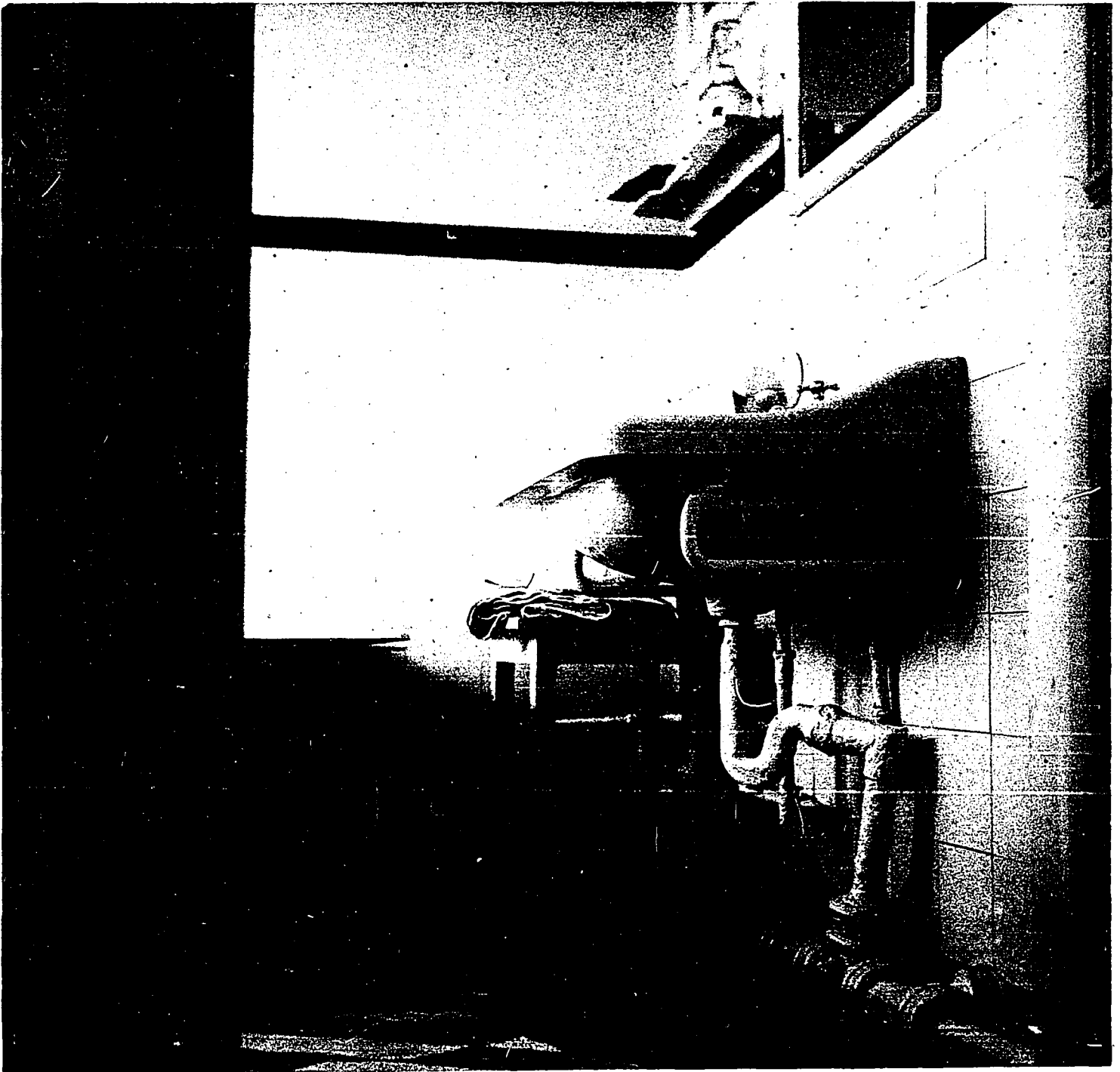
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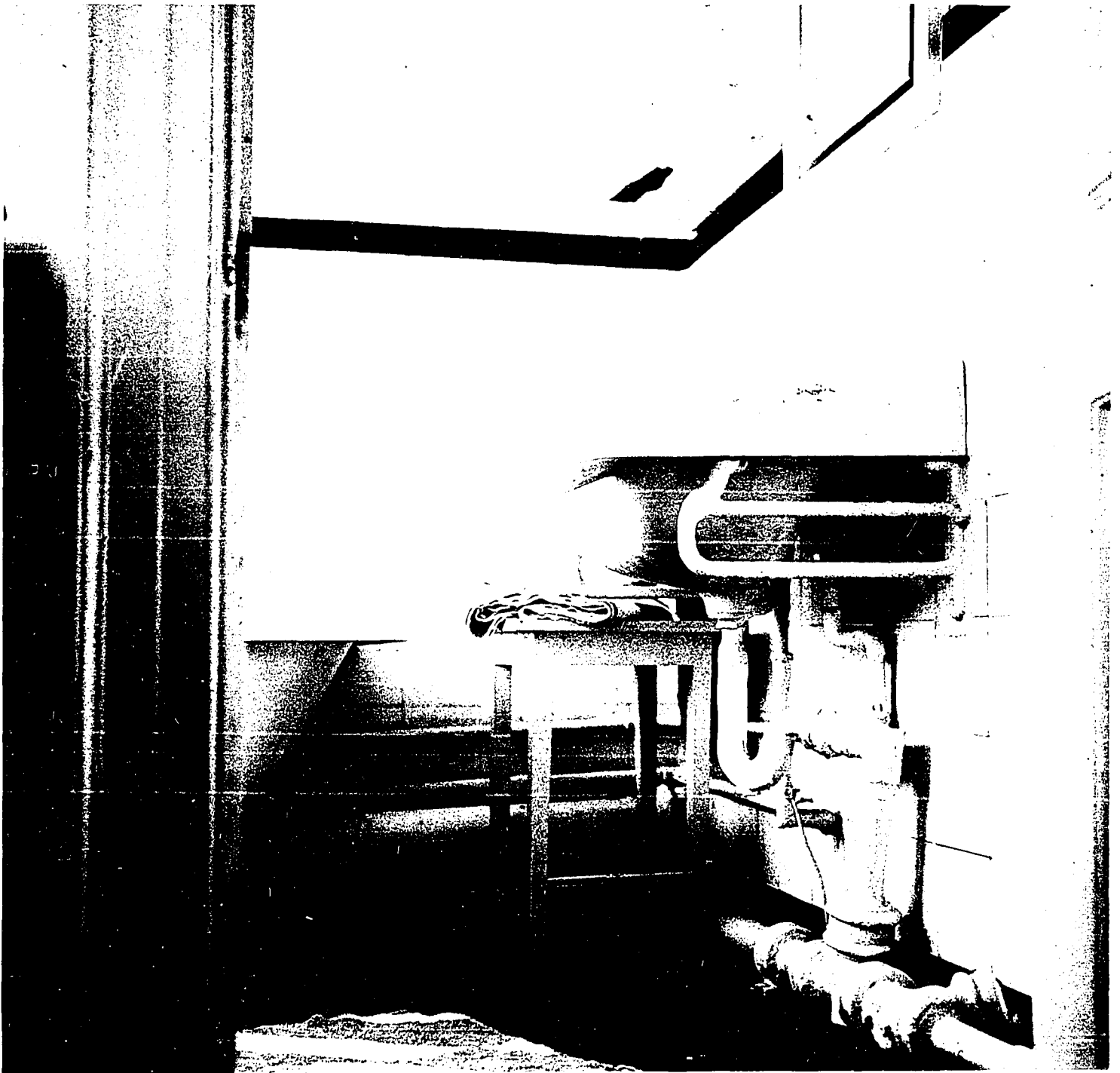




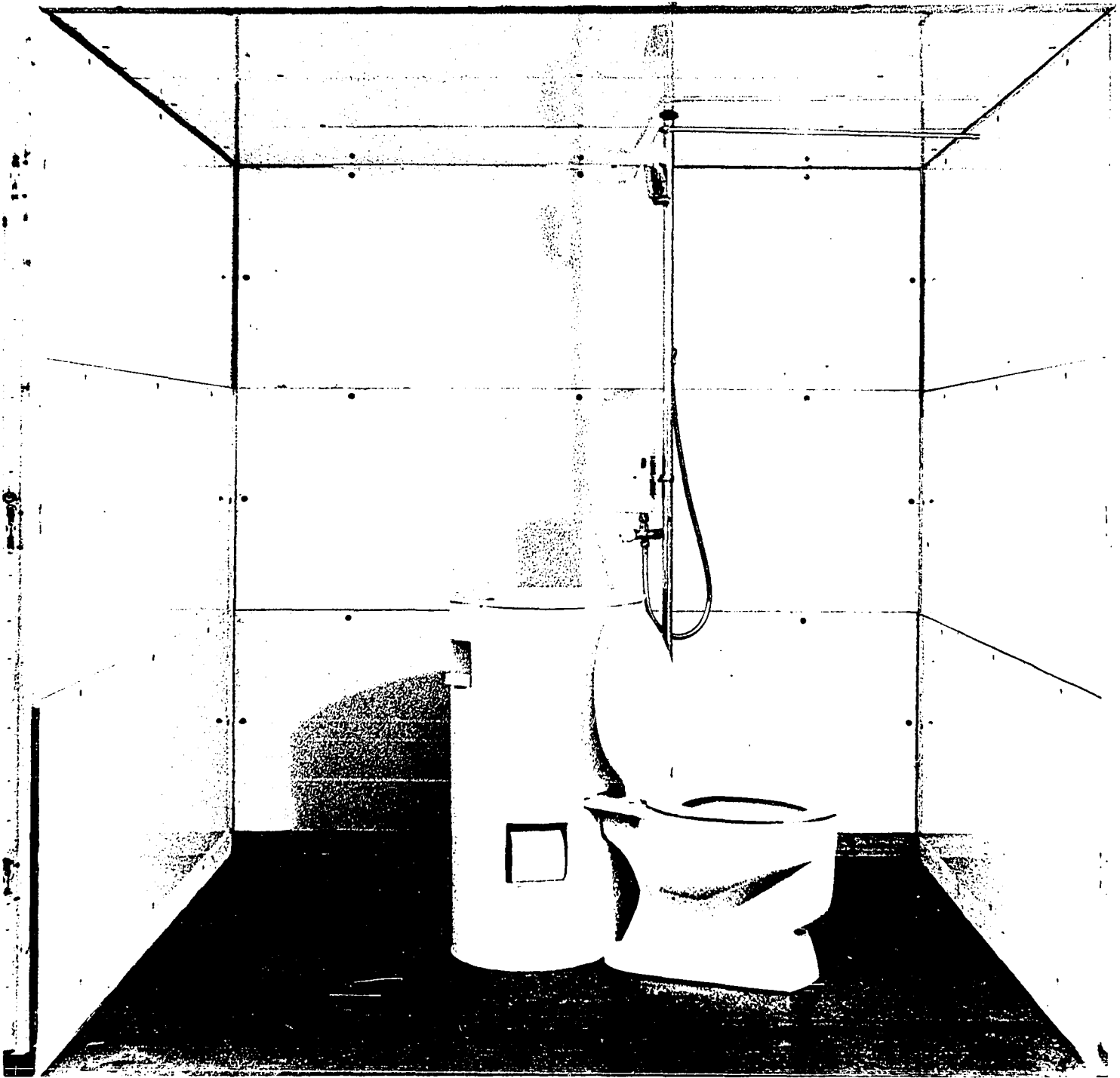




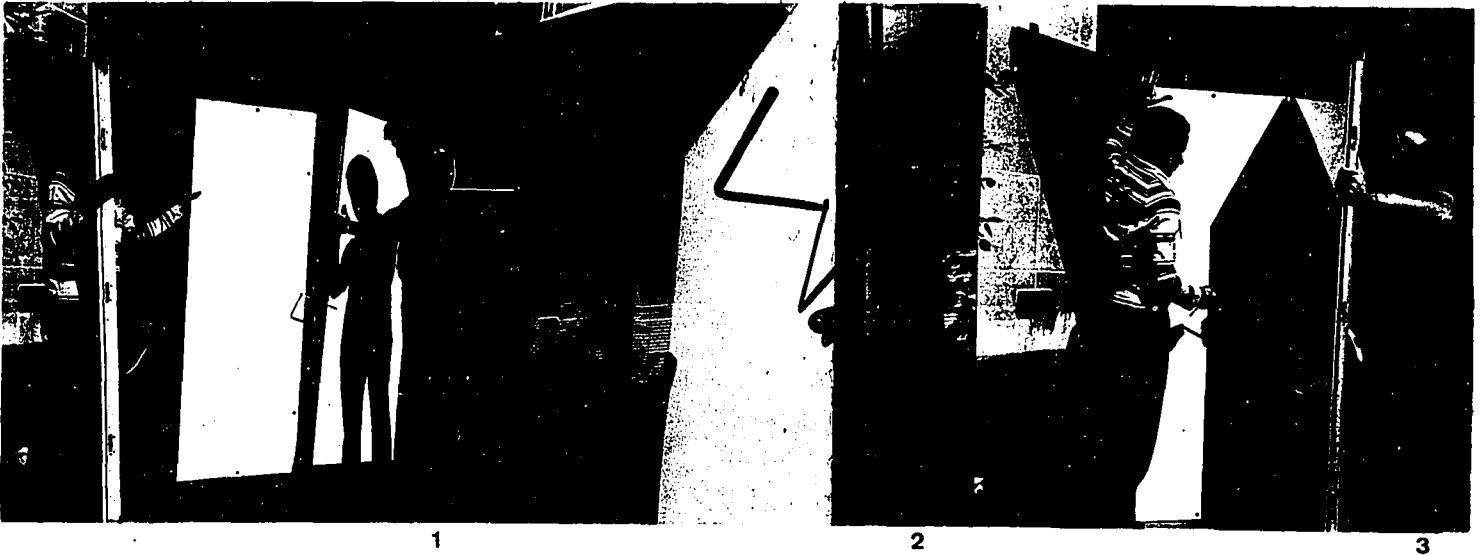
Above, a clear indication of the amount of piping necessary for hot and cold water supply and drains. In today's housing it costs a great deal of money to hide this piping in cavity walls and floors. This also complicates scheduling of construction and duration of work. In addition, all this camouflage is done by skilled and highly paid workmen.



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This proposed Sanitary Unit simplifies the piping installation by avoiding the necessity of breaking any walls. There are no pipes to hide. The unit could be easily installed in a short period of time by unskilled labour. It has all the required functions as well as hot water, and is furthermore, inexpensive.



THE SHELL OF THE SANITARY UNIT

The proposal is for two separate elements, the Sanitary Unit, and the Shell.

The wall panels which constitute the shell were developed by the Department of Civil Engineering of Sir George Williams University for the purpose of testing and analyzing panelized building systems.

The panel is 6' x 2' (1.8m.x6.0m.), and is a sandwich of aluminum facings 0.25" (6.4 mm.) thick cemented to a 2" (5 cm.) styrofoam core. The edges are wood. Each panel has eight aluminum connectors, five male and three female.

Fifteen panels are used to build the 18M x 18M shell, including the roof. Eight wood members 6' (1.8 m.) long are required to join two panels at right angles. These members are 2" x 2" (5 cm x5 cm) and each have twelve female connectors. One man-hour is required for erection.

Photo 1 The assembly of two panels in-line. Panels are aligned by the tongue and grooves.

Photo 2 The only tool required for erection is this L-shaped wrench which is used to turn the male connector and fix the panels together, much like locking a door.

Photo 3 To connect two panels at 90° it is necessary to use an additional member.

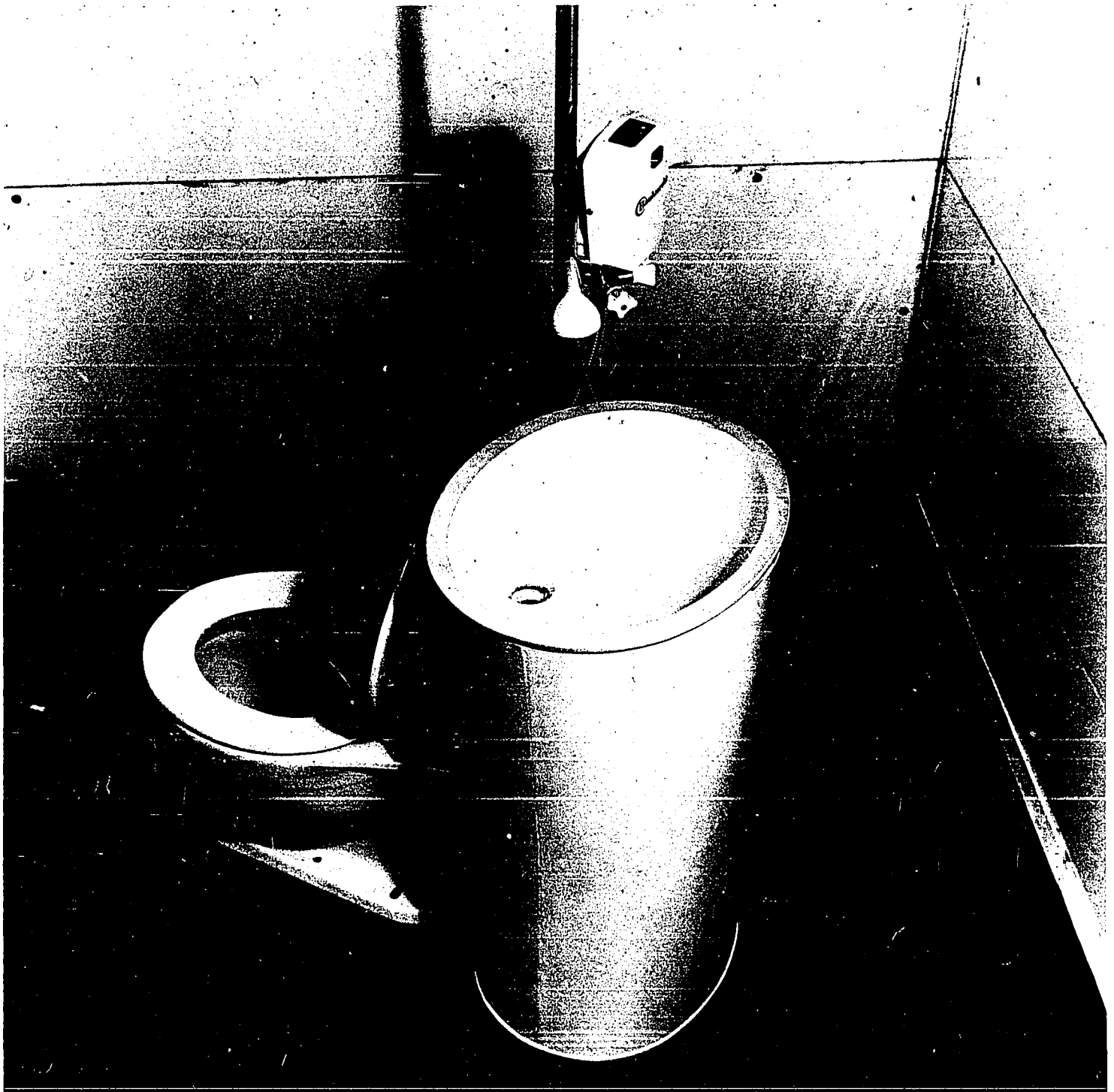
We feel that this system has possibilities for self-built housing due to the simplicity in erection. The cost is relatively low, \$ 1.70/ft.² (\$ 17.90/m.²).



Above, the assembly of two panels to form a meeting of ninety degrees.

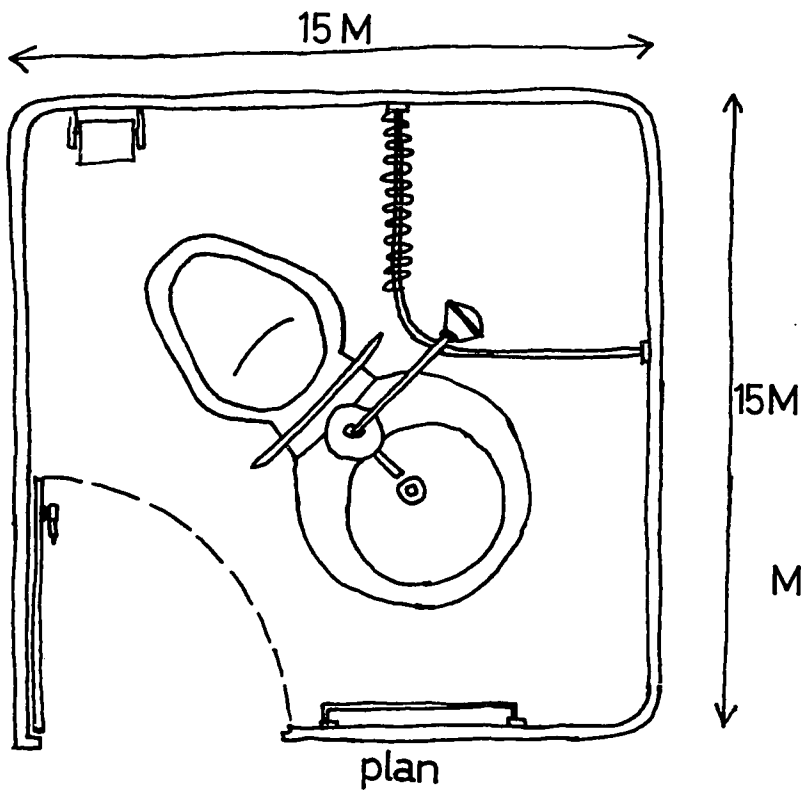
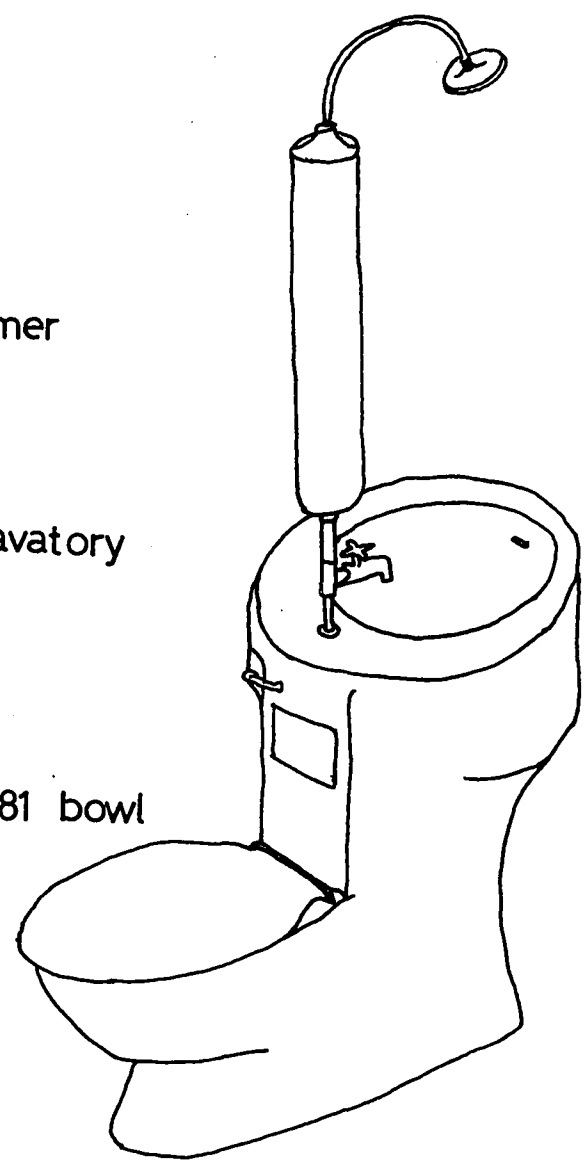
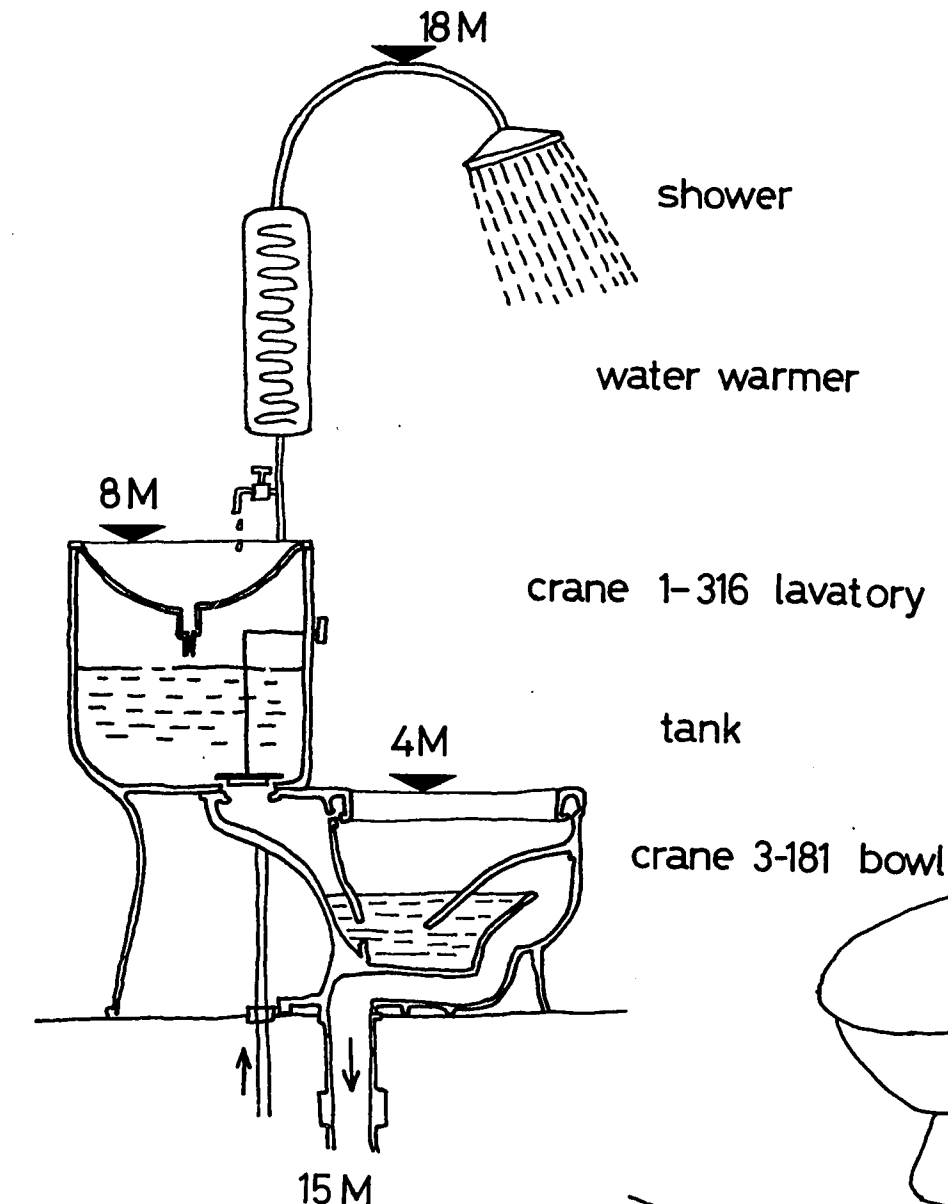


Above, the assembly of two panels to form a meeting of ninety degrees.



Minimum Sanitary Unit 1 consists mainly of standard fixtures manufactured by Crane Canada Ltd. The water tank is made to receive the lavatory. Thus the dirty water is stored and used to flush the toilet. The tank is of wood, asbestos or fibreglass.

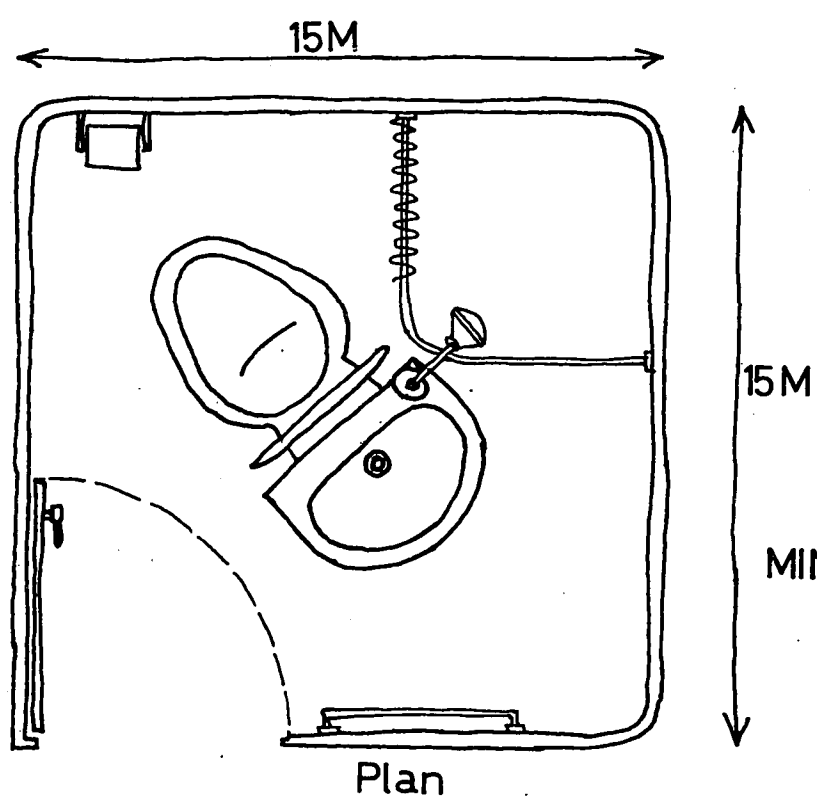
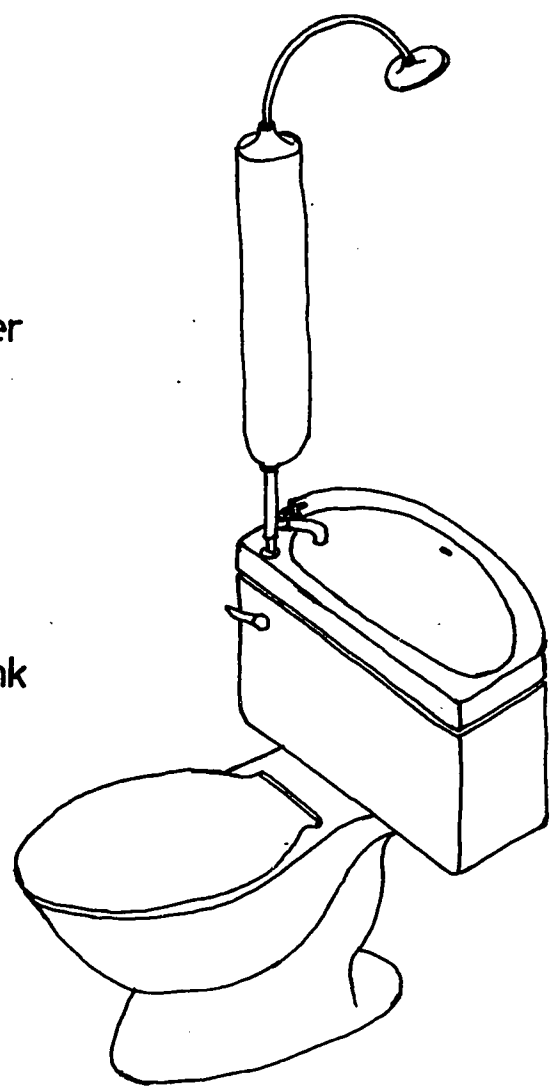
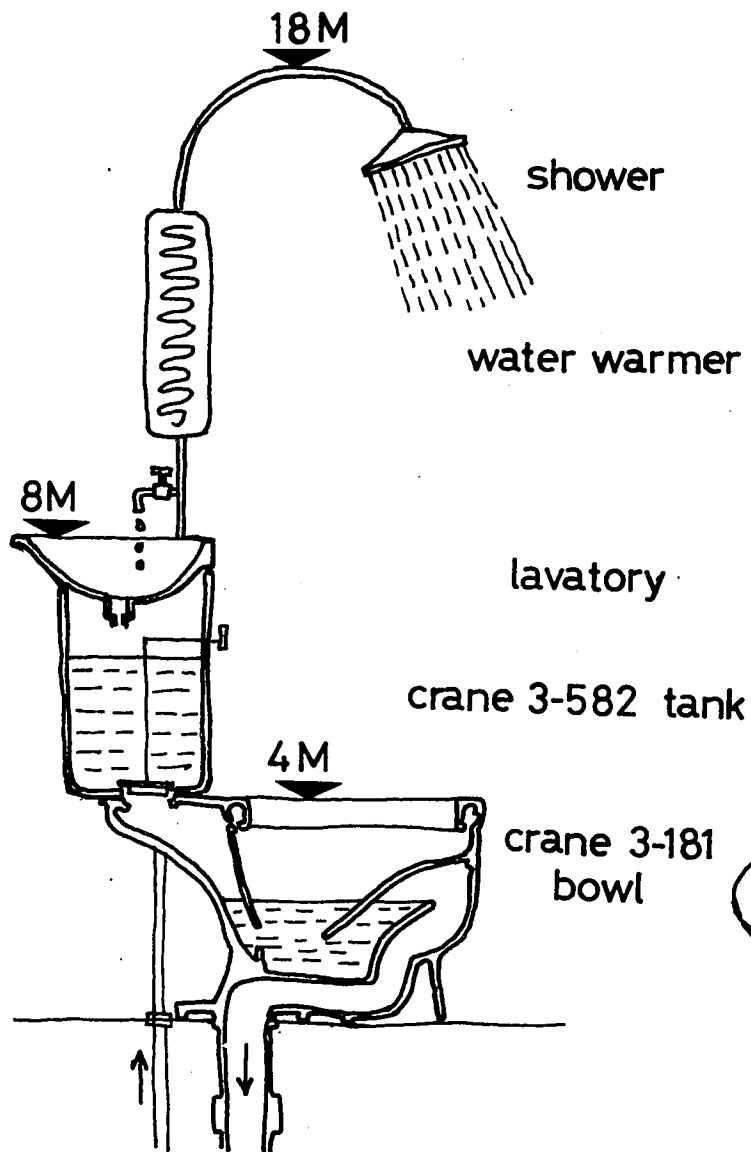
A column adjoining the unit contains all electrical work as well as water supply, and is considered as suitable for total prefabrication. The water heater is fixed to the column, and feeds the telephone shower, which becomes a lavatory tap when fixed in the lower position. There is also an intermediate showering position for children.



MINIMUM SANITARY UNIT 1



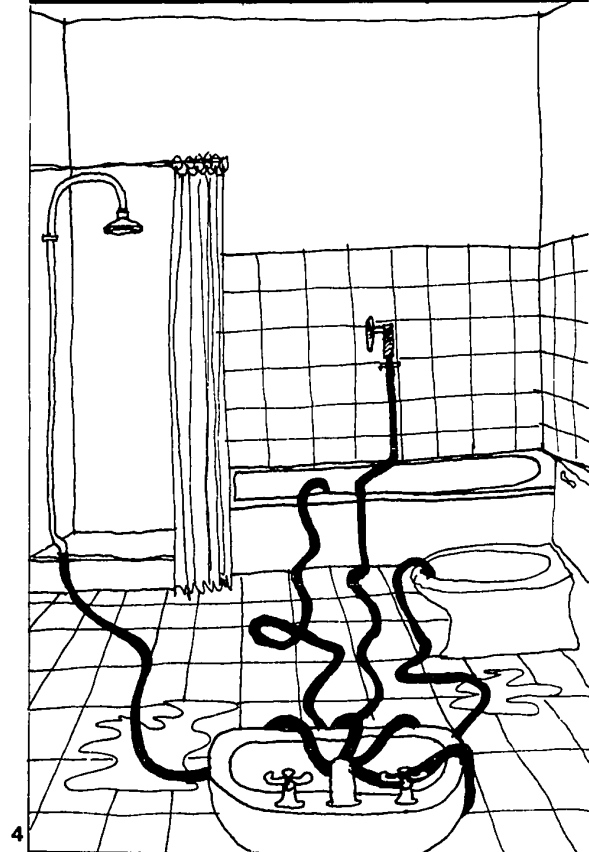
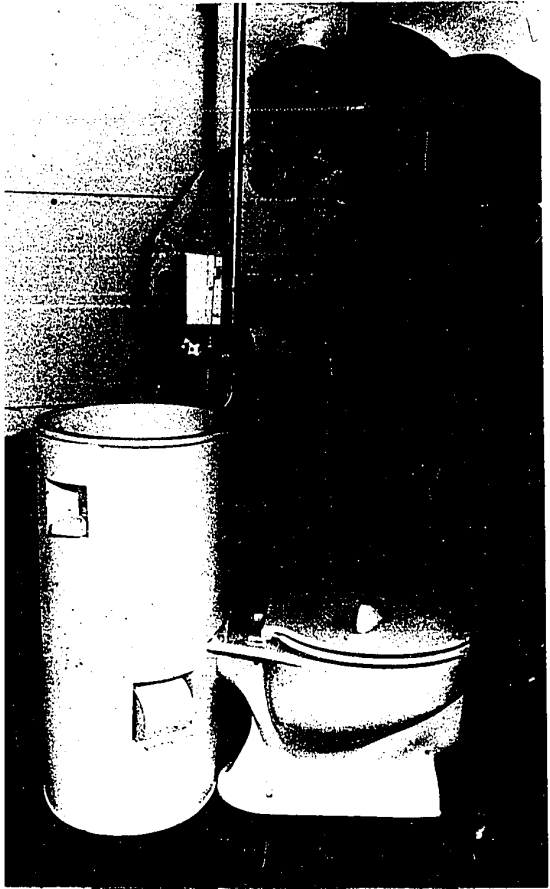
Minimum Sanitary Unit 2 is a cheaper version of the first unit, and simply replaces the standard water tank cover with a lavatory made to fit over the tank. This lavatory is of porcelain, and cantilevers over one side to form a larger basin. This type of sanitary unit is more basic than the previous one and requires less area. The plumbing and electrical "tree" is identical.



isometric

15M

MINIMUM SANITARY UNIT 2



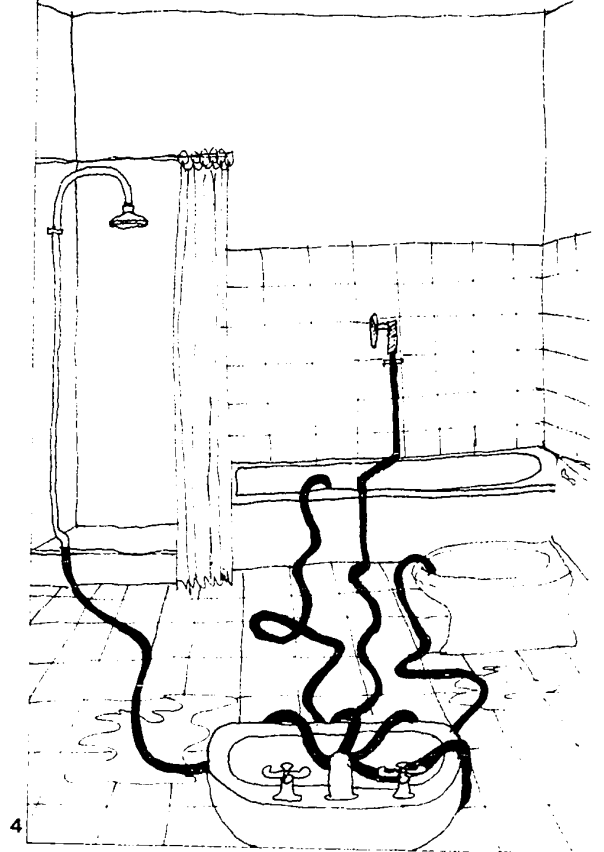
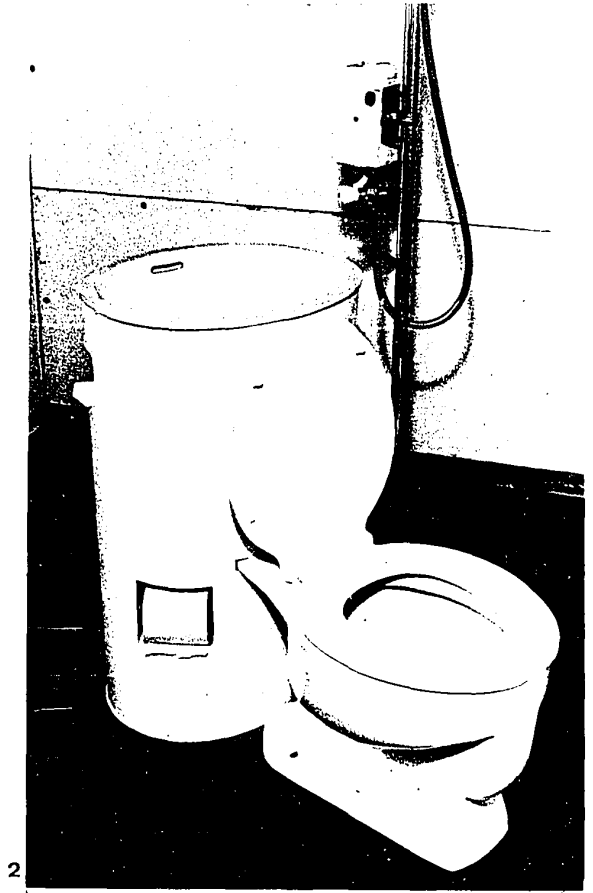


Photo 1 Installing the water heater, which takes only a few minutes. The water pipe inside the column supports the heater.

Photo 2 The completed unit, with the telephone shower in position for showering. The hot and cold controls are on the heater itself, which is located to be used for hand-washing and showering.

Photo 3 At the top of the column can be seen the shower curtain rods as well as the lighting fixture.

Diagram 4 The water connections for a three fixture bathroom are shown here as if they were left in the room, rather than being hidden in the walls. In fact if one were to show hot and cold as well as drains a maze of pipes would result.

Photo 5 Using the telephone shower to wash one's hair.

Photo 6 Using the telephone shower for hand-washing, in the lower position. The circular shape of the basin allows it to be used from different sides. In this photograph the unit is oriented in a different way within the shell.

Photo 7 Minimum Sanitary Unit 2 in position in the shell. As can be seen, this unit requires less space, though the pipe emerges in the same place. The rectangular shape of the lavatory reduces its flexibility in positioning as it can be approached from one side only.



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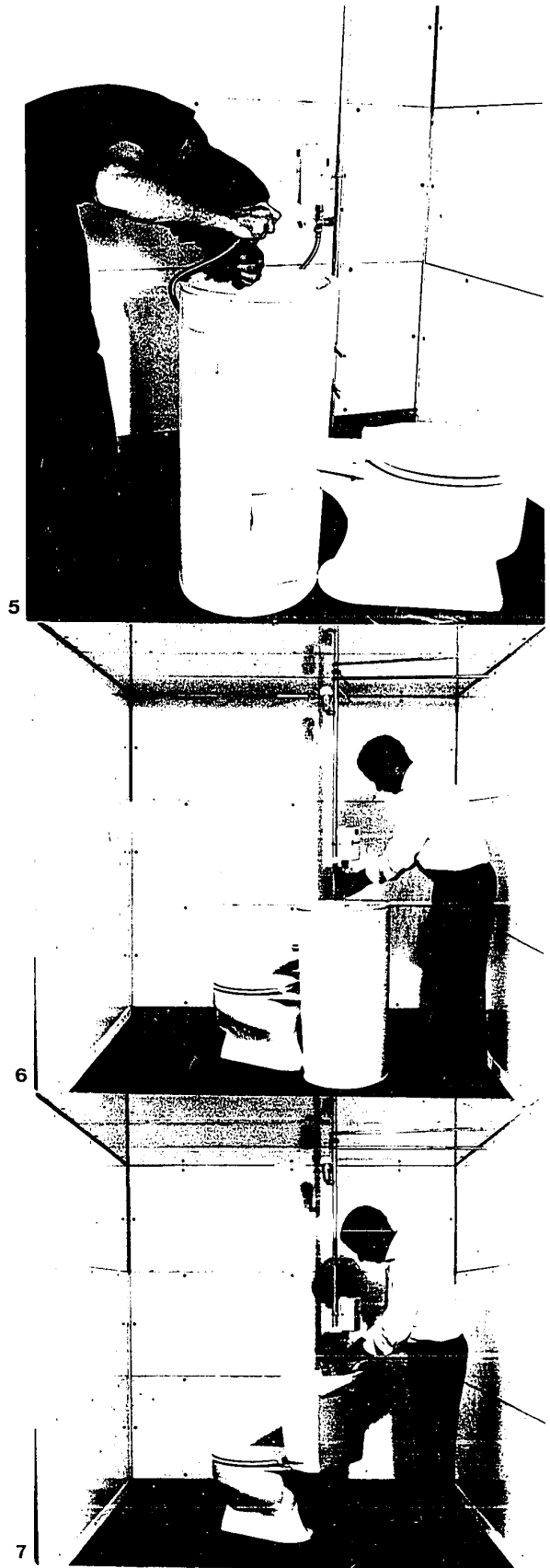
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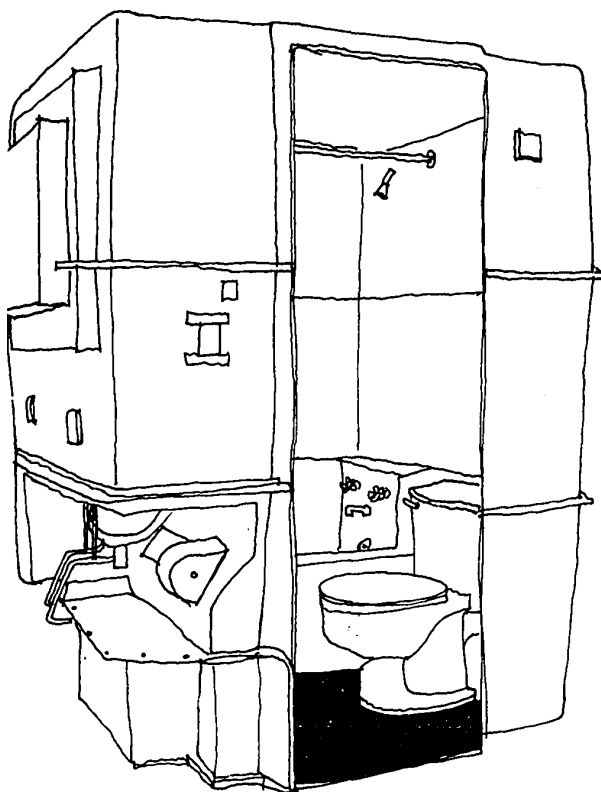
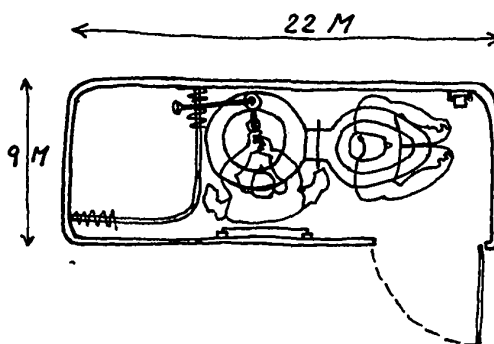
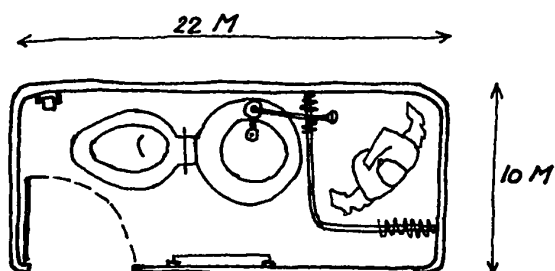
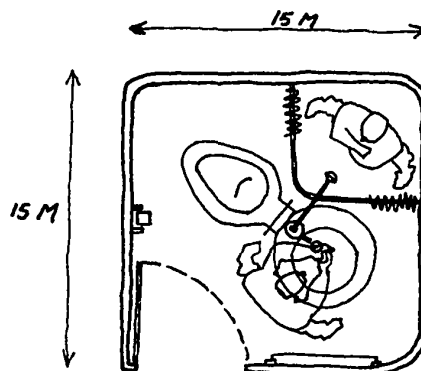
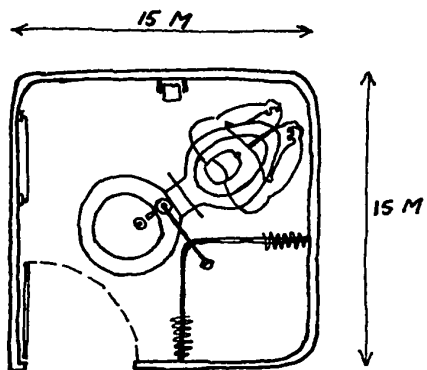
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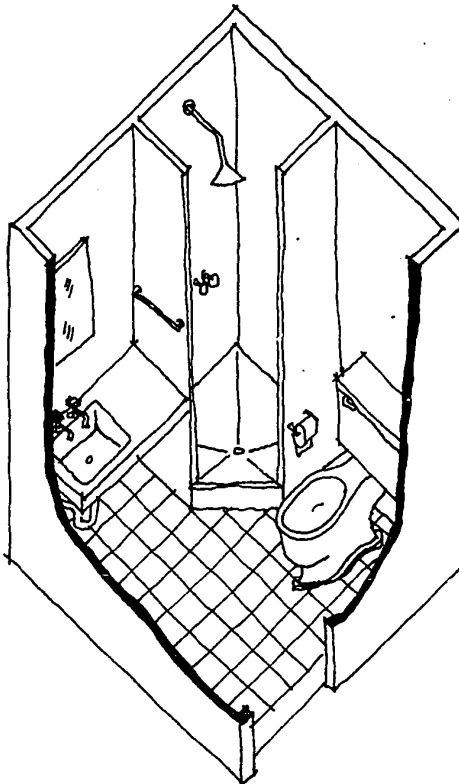


Above, alternative locations of the unit in different sized shells.

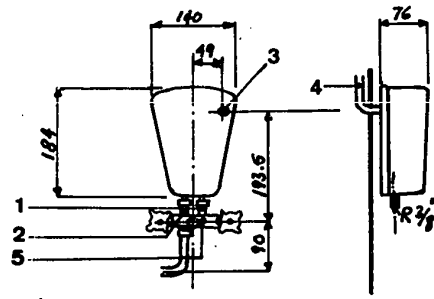
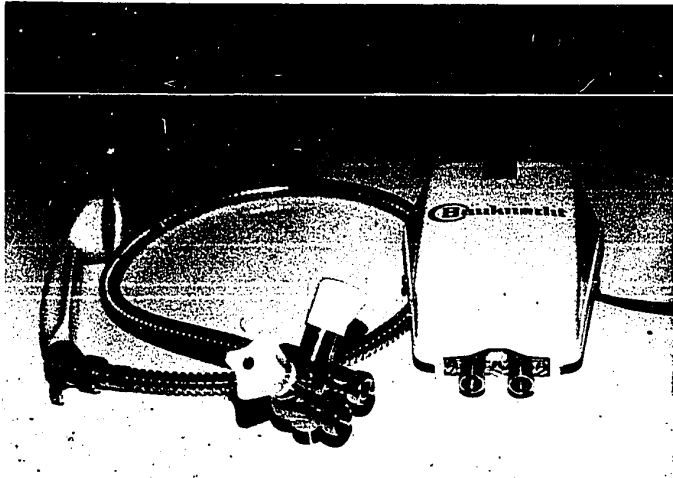
Left, a four piece modular bathroom unit of 650 pounds (295 kg.) shipping weight. Each section can be installed by two men without cutting or fitting, and takes a matter of hours. The walls, tub and lavatory are of reinforced plastic. Supply pipes and fittings come in integral assemblies, so the only work done on-site is roughing-in and electrical work.

The unit is manufactured by Crane Co., New York City, and costs US \$ 1,719, including ventilator and ventilator/heater. This cost is too high for the majority of people. Transportation costs from the factory in Alliance, Ohio must also be considered.

Item	Material	Installation	Total
1. Walls	50	145	193
2. Ceramic Tile	150	190	340
3. Door	33	15	48
4. Shower	195	150	345
5. Lavatory	155	90	245
6. Water Closet	230	135	365
7. Soil Pipe	65	15	80
8. Water Heater	190	75	265
Total	\$ <u>1368</u>	\$ <u>928</u>	\$ <u>2296</u> ◊



COST ANALYSIS OF CONVENTIONAL 3-FIXTURE BATHROOM



1. Cold water inlet with valve.
2. Warm water outlet.
3. Electrical power inlet.
4. Electrical inlet, side view.
5. Cold water supply.

ELECTRIC WATER HEATER

The water is heated immediately by two variable heat-resistor which are located in the water flow, hence maximum use is made of heat energy available.

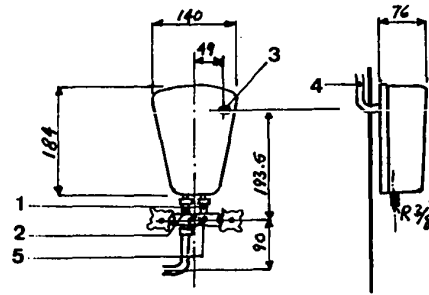
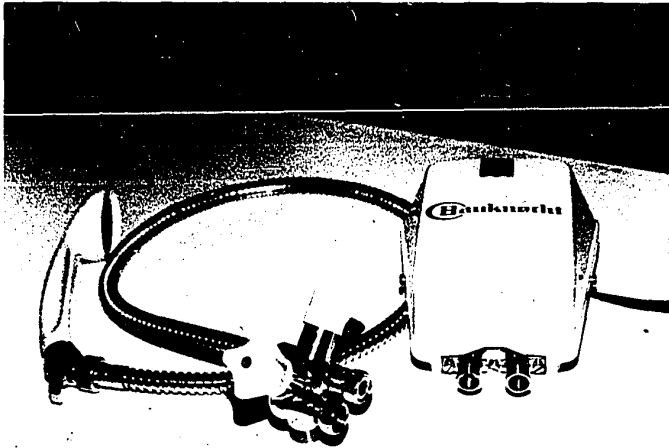
Heating starts automatically by water pressure within the heater. Water enters the the heater when the hot tap is turned on. The heater requires a water pressure of 17 to 220 psi (1.2 to 15.4 kg/cm²). It is possible to produce heaters that will operate with lower pressures. A pressure valve allows using the heater at pressures over 220 psi.

The heater can be connected directly to the water pipe and does not require fixing to the wall. Cold water at a temperature of 60° Fahrenheit (15°C) flowing at 0.06 cu.ft./min (1.7 l./min) will be heated to over 105°F (40°C). Because the water flow is uninterrupted there is no pressure within the heater.

The water heater weighs 2 pounds (0.9 kg.), costs about \$55.00 and is produced by G.Bauknecht GmbH, in Stuttgart, West Germany.

Selected Reading

1. Research in the College of Engineering, Pennsylvania State University June 1968 pp.33
2. Urban Water Supply Conditions and Needs in 75 Developing Countries, Dietrich & Henderson Public Health Paper 23 WHO
3. Inexpensive Sanitary Installations for less Industrialized Countries, Norges Byggeforsknings Institutt St.3418 E5201 1964 Norway
4. Man's Perpetual Quest for Water, Unesco Courier June 1970



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2. Urban Water Supply Conditions and Needs in 75 Developing Countries, Dietrich & Henderson Public Health Paper 23 WHO
3. Inexpensive Sanitary Installations for less Industrialized Countries, Norges Byggforskning's Institutt St.3418 E5201 1964 Norway
4. Man's Perpetual Quest for Water, Unesco Courier June 1970

PART 2

B. TIMBER SYSTEM

1. What is the Problem? Timber is the commonly available building material in Canada and other northern countries. Likewise many countries in the humid tropical belt still have large forest areas where wood is plentiful. Timber properly seasoned and preserved can be a durable material.

A potent method for mobilizing new resources which are not normally available for other types of investment are self-help and mutual-aid. They are particularly applicable in rural areas where a tradition exists for self-building in locally available materials.

To take maximum advantage of the financial resources available for solving the housing problem, it is necessary to reduce costs without harming the quality of construction. To do this it is necessary first of all to have a knowledge of the actual cost of the construction, and hence what changes will give an appreciable increase in productivity.

This information will be helpful in determining the degree of convenience in employing self-help; in delivering partially built houses; in the total or partial prefabrication of elements; and in the problem of transport and its costs.

2. Proposal This is an investigation of a particular Canadian construction system through a cost analysis of materials and labour by the principle phases of construction. This study follows the uniform methodology of studying construction costs proposed in the United Nations Report, TAO/LAT/53,E/CN.12/CCE/SC4/26 (1966).

The Pan-Abode system can be defined primarily in terms of the wall construction. The walls are 3" or 4" thick, tongue and groove cedar logs, notched at the corners to overlap. All notching and openings are pre-cut in the factory. The coded walls are assembled by laying up and impacting the logs. Floors and roof are conventionally built. This case study deals with a house built by one colleague in 1969.

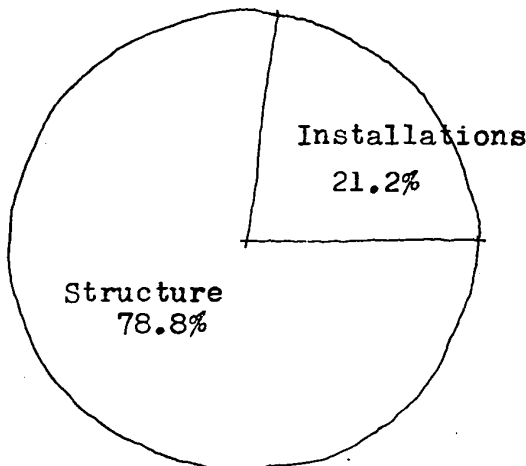
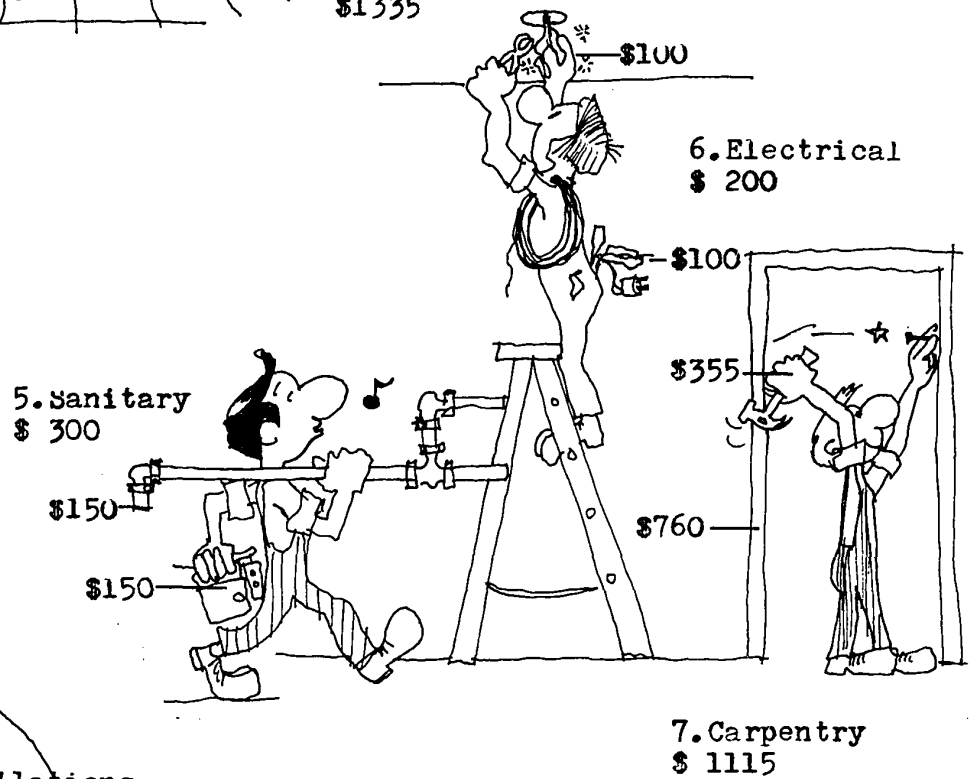
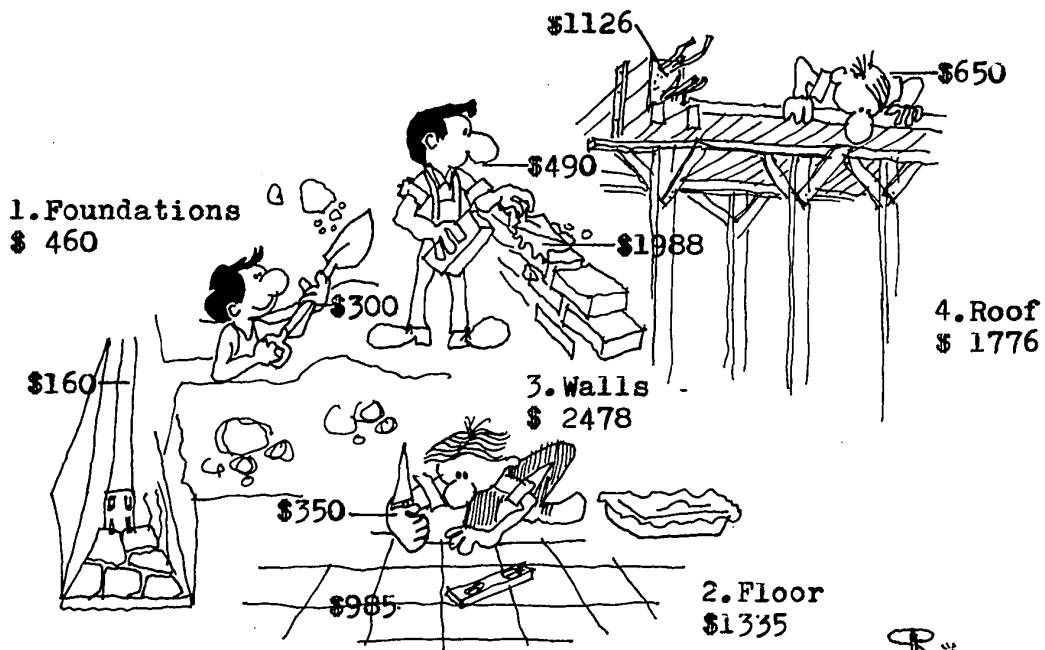
3. Advantages and Disadvantages The main advantage of this system is the extremely simple method of assembly of the walls. The fact that all pieces are pre-cut in the factory and that there is no cutting and fitting on the site, not only reduces waste but allows unskilled labour to erect the building. It is evident that the system uses a great deal of wood due to the solid wall construction, this disadvantage may however be offset by the mass-production and standardization capabilities of the system. The solid wood wall, having good insulation characteristics and durable surface finish is able to combine exterior finish, structure, insulation and interior finish functions in one. It should be mentioned that this system makes use exclusively of cedar, and is not necessarily feasible with all kinds of timber. Since cedar is a relatively soft wood, there is a large expansion due to temperature change, and the resultant vertical movement precludes construction over one floor high.

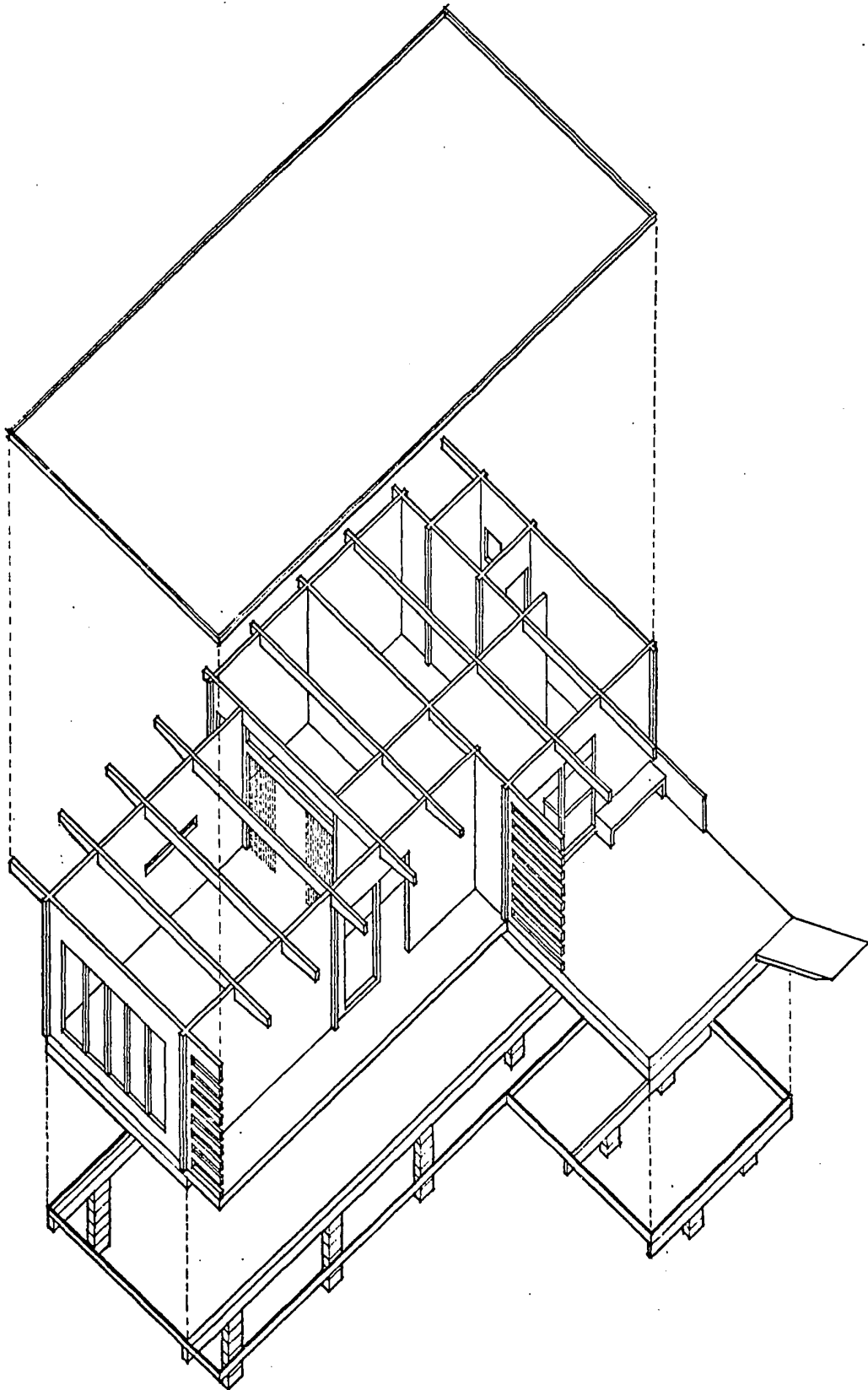
4. Future Recommendations Research should be carried on to determine a limited number of modularly dimensioned log lengths, which could be pre-cut and used to build different basic homes. Such a basic house could grow as the family's means increase. Methods of adding to or extending the system should be investigated.

Although the solid wall system is valuable for exterior walls it is not ideal for interior partitions and alternate types of partition walls should be examined. These should be looked at with self-building in mind.

The adaptability of the system to different kinds of roof construction and floors should be looked into.

A prototype house should be built out of standardized log lengths in order to illustrate various possibilities and develop future alternatives.







ISOMETRIC OF HOUSE BUILT USING THE PAN-ABODE SYSTEM, SHOWING PRINCIPAL COMPONENTS (FOUNDATIONS,FLOOR,WALLS,ROOF) AS IN THE COST ANALYSIS.

CANADA
 Covered Area : 800 ft.²
 Cost per ft.² : \$9.50
 Habitable area : 610 ft.²
 Cost per ft.² : \$12.50

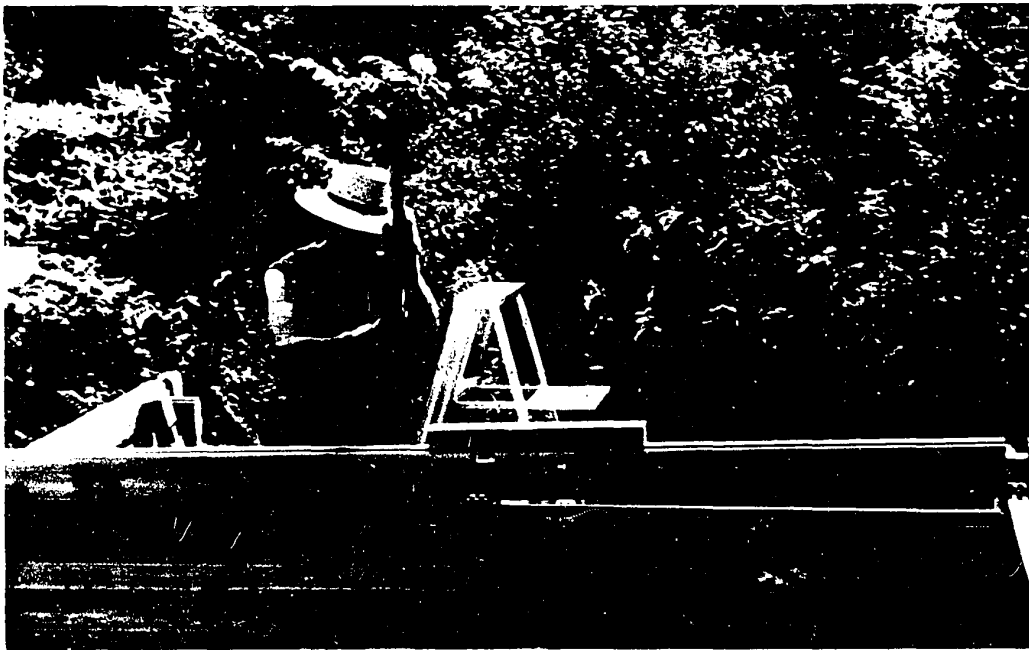
Cost analysis of materials and labour by
 the principle phases of construction
 (in US dollars)

Phase of Construction	Cost	% Total Cost	Qty.	Unit Cost	Cost per ft. ² of habitable area
Structure					
1. Foundations	460.00	5.9			0.80
2. Floors	1335.00	17.7	610 ft. ²	2.20	2.20
3. Walls	2478.00	32.2	1200	2.06	4.08
4. Roof	1776.00	23.0	800	2.22	2.92
Total	<u>6049.00</u>	<u>78.8</u>			<u>10.00</u>
Installations					
5. Sanitary	300.00	3.9			0.55
6. Electrical	200.00	2.6			0.83
7. Carpentry	1115.00	14.7			1.12
Total	<u>1615.00</u>	<u>21.2</u>			<u>2.50</u>
Total Cost of the House	 <u>7664.00</u>	<u>100.00</u>			<u>12.50</u>

Phase of Construction	Materials	Labour	Total Cost
Structure			
1. Foundations	160	300	460
2. Floor	985	350	1335
3. Walls	1988	490	2478
4. Roof a) Structure	682	250	932
b) Membrane	444	400	844
Installations			
5. Sanitary	150	150	300
6. Electrical	100	100	200
7. Carpentry	760	355	1115
Total	<u>\$5269</u>	<u>\$2395</u>	<u>\$7664</u> 

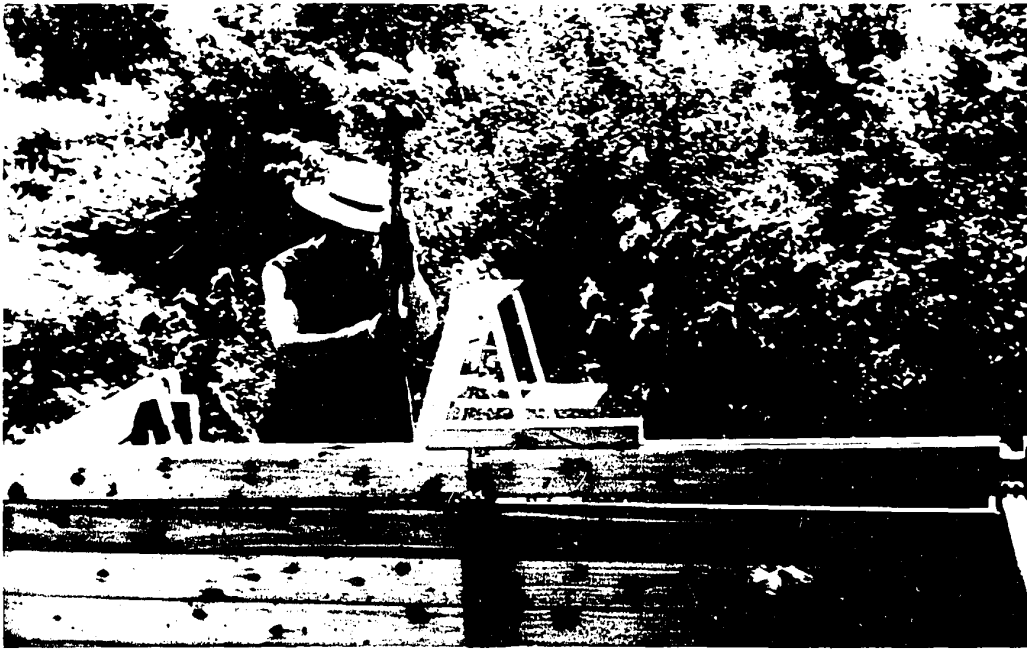
<u>Total Cost</u>	\$ 7664	100 %
Materials	5269	67.5
Labour	2395	32.5
<u>Structure</u>	6049	78.8
Materials	4259	54.3
Labour	1790	24.5
<u>Installations</u>	1615	21.2
Materials	1010	13.2
Labour	605	8.0

LABOUR & MATERIALS

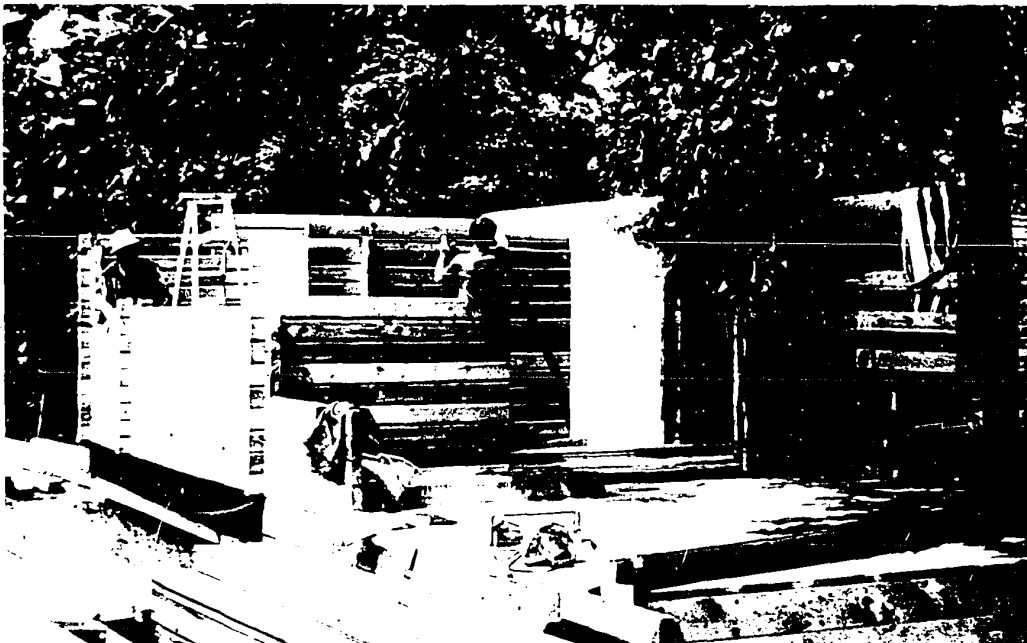


Photos taken during construction showing the assembly of pre-cut components with minimum of tools. The small-size of the components permits easy handling, and since they are self-aligning one man working alone can construct the house. Logs must be hammered together to create tight weather-proof joints. It is possible to take apart the construction and re-erect in another location, as no nails are used.





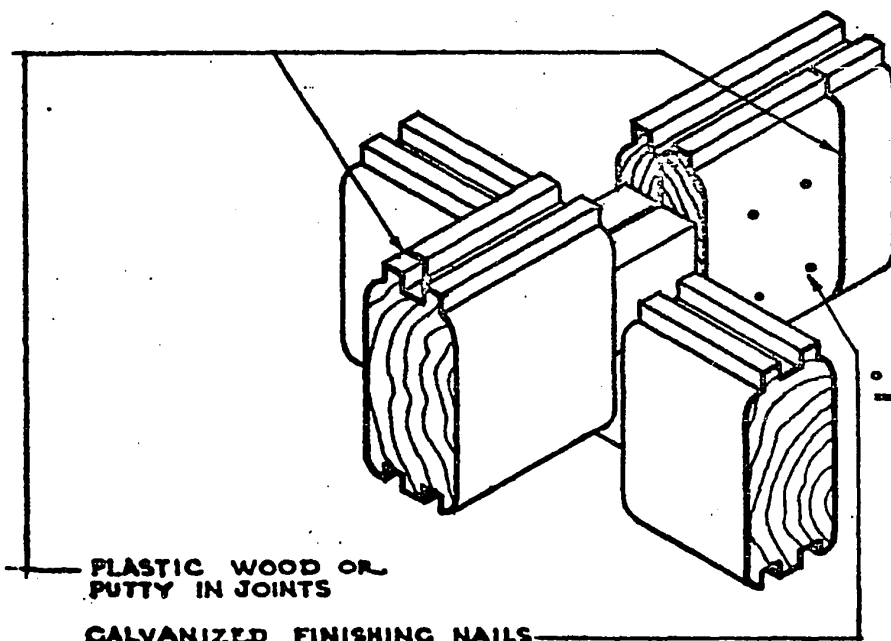
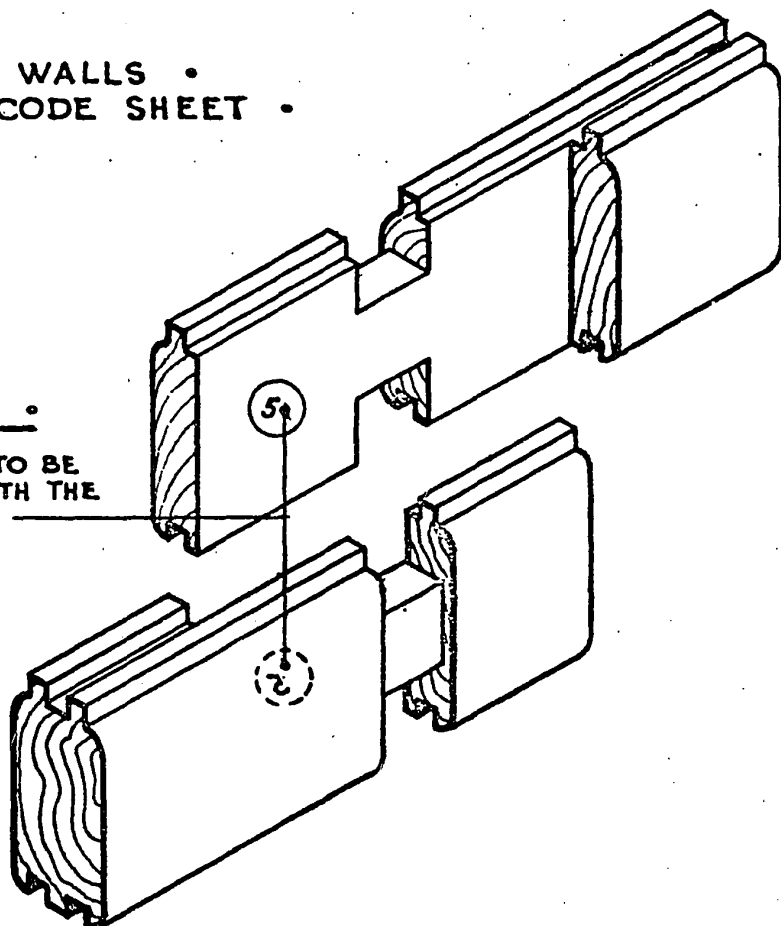
Photos taken during construction showing the assembly of pre-cut components with minimum of tools. The small-size of the components permits easy handling, and since they are self-aligning one man working alone can construct the house. Logs must be hammered together to create tight weather-proof joints. It is possible to take apart the construction and re-erect in another location, as no nails are used.



- LOG SPLICE IN LONG WALLS •
- MARKED 'S' ON LOG CODE SHEET •

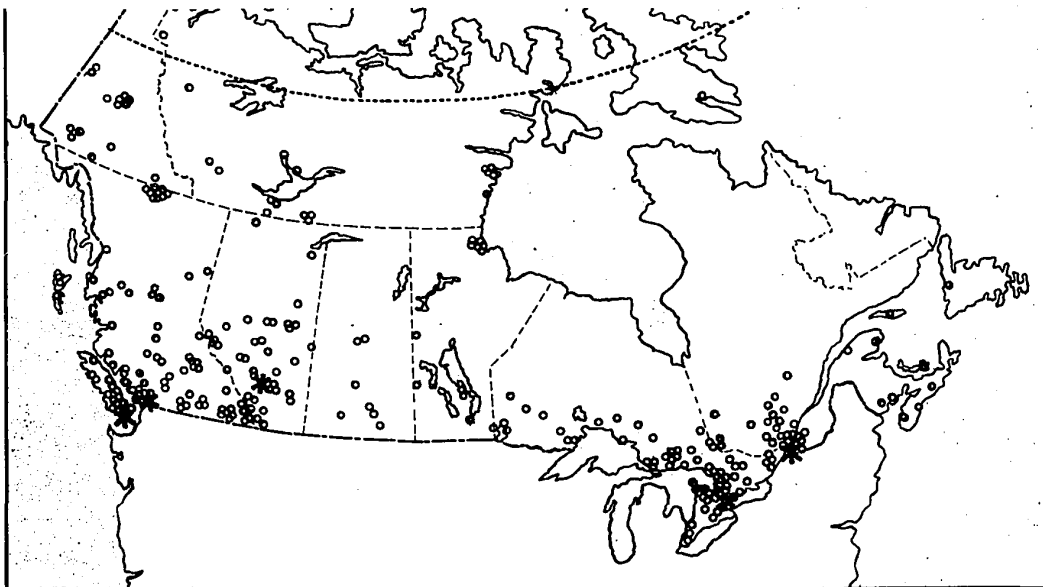
• BEFORE ASSEMBLING •

NOTE :- THE TWO SPLICES TO BE MATCHED, ARE MARKED WITH THE SAME NUMBER IN CIRCLE.



• ASSEMBLED •

- LOG SPLICES •



- SOME OF THE AREAS IN WHICH PAN-ABODE BUILDINGS ARE LOCATED.
 * OFFICES ACROSS CANADA.

SPECIFICATIONS covering the materials supplied in the STANDARD PAN-ABODE PACKAGE

FOUNDATION BEAMS*

2" x 8" for laminated 6" x 8" beam, as required. (Necessary quantity for construction on concrete perimeter wall.)**

FLOOR JOISTS*

2" x 6", 2" x 8", 2" x 10" to National Building Code Requirements.

FLOOR*

2" x 6" tongue and groove No. 3 common Western Red Cedar sub-floor supplied in random lengths.

WALLS AND PARTITIONS

Supplied in Select Western Red Cedar 3" x 6" double tongue and groove Pan-Abode logs, pre-dipped in water repellent preservative, machined tongue and groove, notched to form a "lock-joint" at all intersecting points. All logs stamped with their appropriate wall code letters.

PURLINS

4" x 6" — 4" x 14" as required.

ROOF BOARDS

2" x 6" tongue and groove dry Western Red Cedar roof boards.

ROOFING*

For 4/12 rise gable roof, asphalt shingles; for flat pitch and shed roof, mineralized surface rolled roofing (Cedar shingles or shakes obtainable for 4/12 rise gable roofs at extra cost.)

DOORS

Fitted in frames, complete with hardware.

Single Entrance Doors—

2" cedar slab door, with lock set and ornamental straps.

Double Entrance Doors—

French Doors, 4 lite, horizontal wood bars.

Back Doors—

No. 510 glass top Mahogany Flush Panel door.

Interior Doors—

Mahogany Flush Panel doors supplied for every room.

WINDOWS

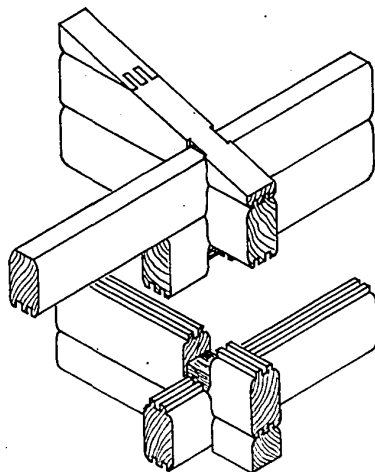
Casement type, opening out, glazed sash. Fitted in frames, complete with friction hinges and fasteners. One priming coat.

INTERIOR AND EXTERIOR TRIM

1" x 4" Clear Western Red Cedar casing for all window and door frames; 1" quarter round to finish all joints. Cedar bevel siding base trim to cover joists only, 1 1/4" x 10" Barge Boards and Fascia Boards.

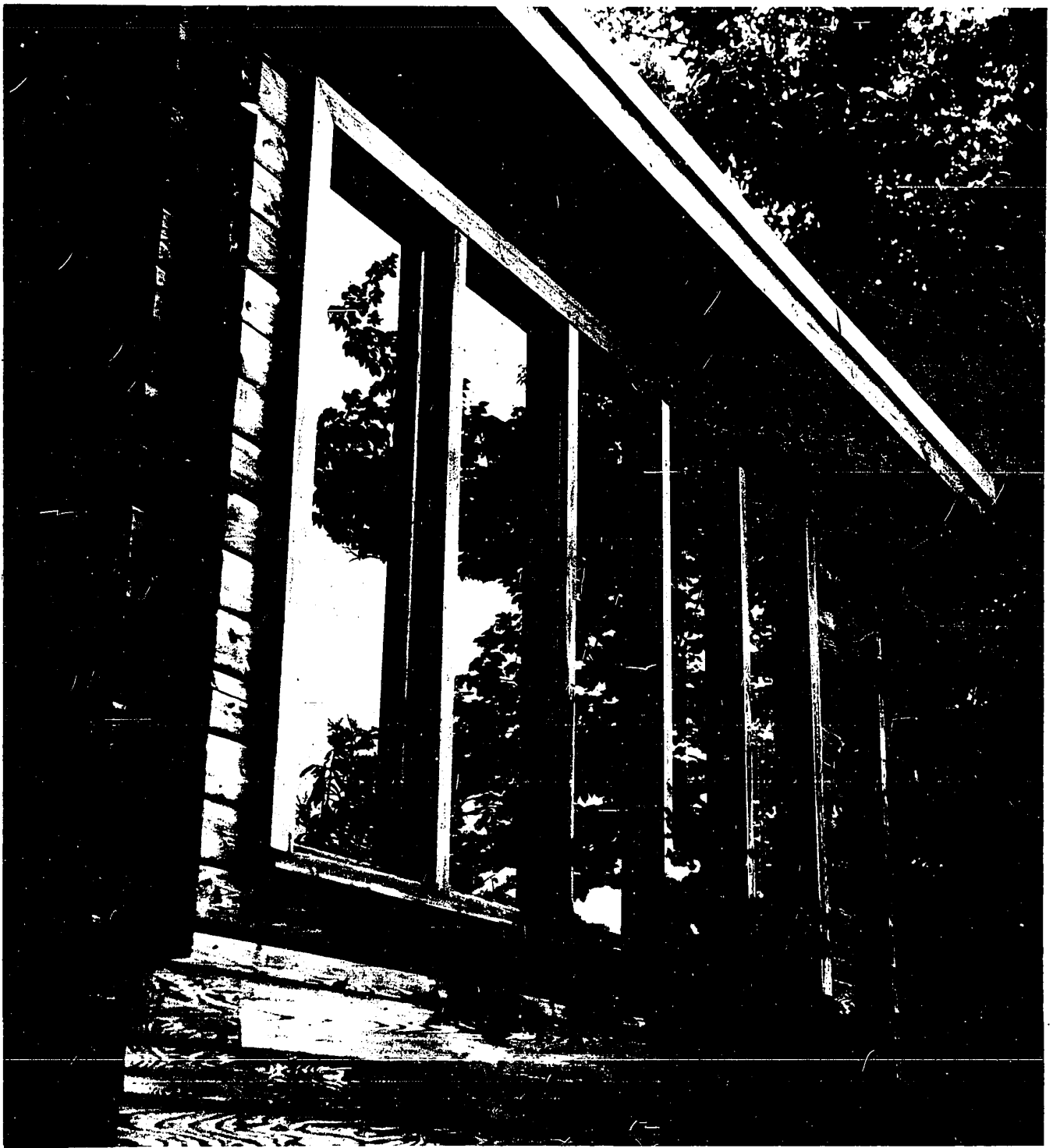
MISCELLANEOUS

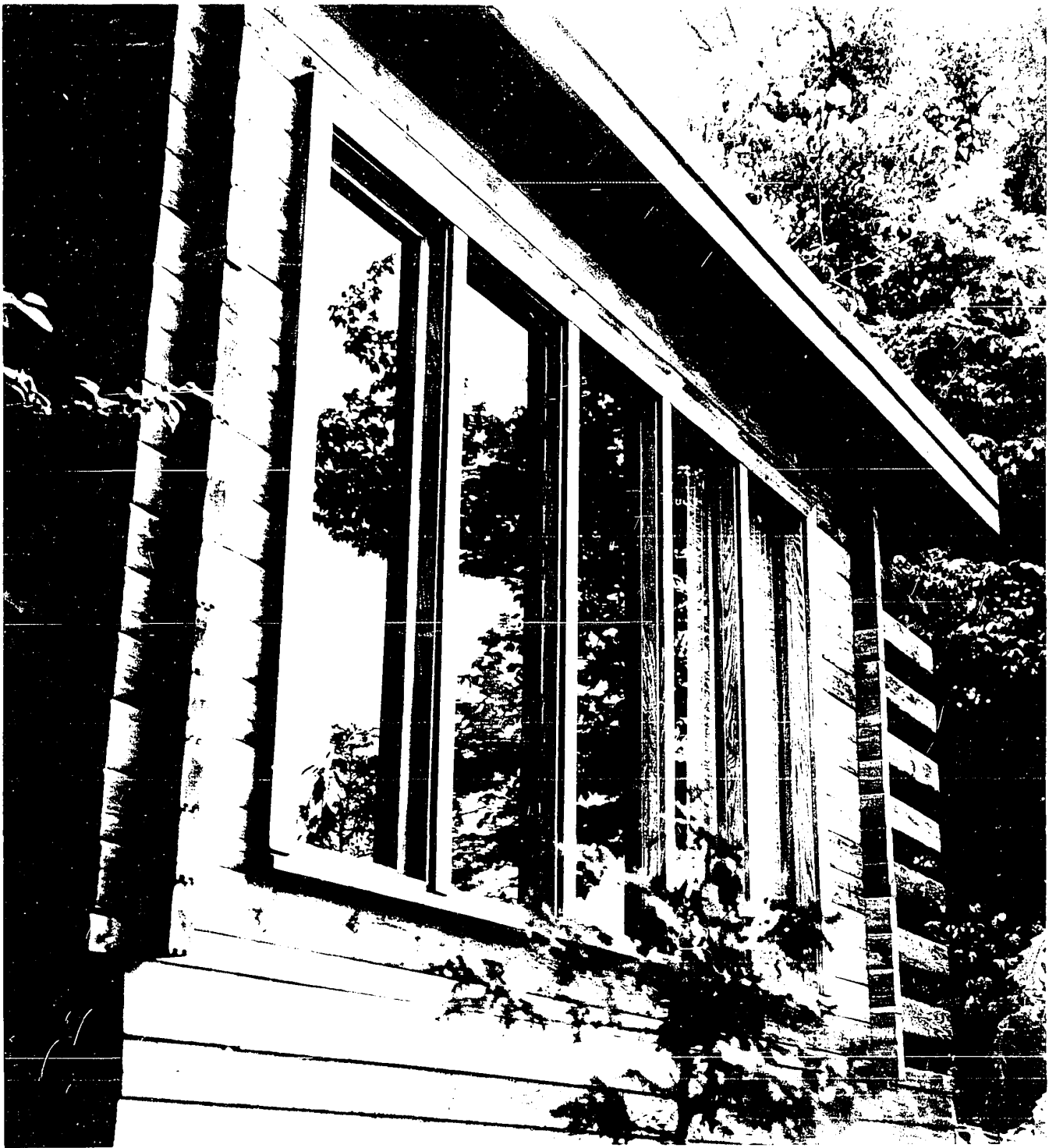
Packing for use around windows and exterior doors, galvanized flashing and copper weather stripping. All required common, finishing and roofing nails.*



Can. Patent 738652
 U.S. Patent 3257762 and others

PAN-ABODE BUILDINGS LTD.
 8585 Fraser Street, Vancouver 15, B.C.
 Telephone (Area Code 604) 321-9128





PART 2

C. CONTINGENCY HOUSING

1. What is the Problem? Several times each year, in different though often predictable parts of the world, thousands of people at a time are deprived of shelter and basic services as a result of natural and man-made disasters. Hurricanes and earthquakes are a part of everyday life in certain areas. Wars and political upheavals, though less predictable, are no less common.

The immediate needs of the people affected by such disasters are medical aid, water and food, and clothing. Also some form of shelter and basic services are required in the interim period before destroyed settlements are rebuilt.

Many different types of contingency housing are needed, depending on resources available locally, accessibility of the disaster area, climate, and available aid.

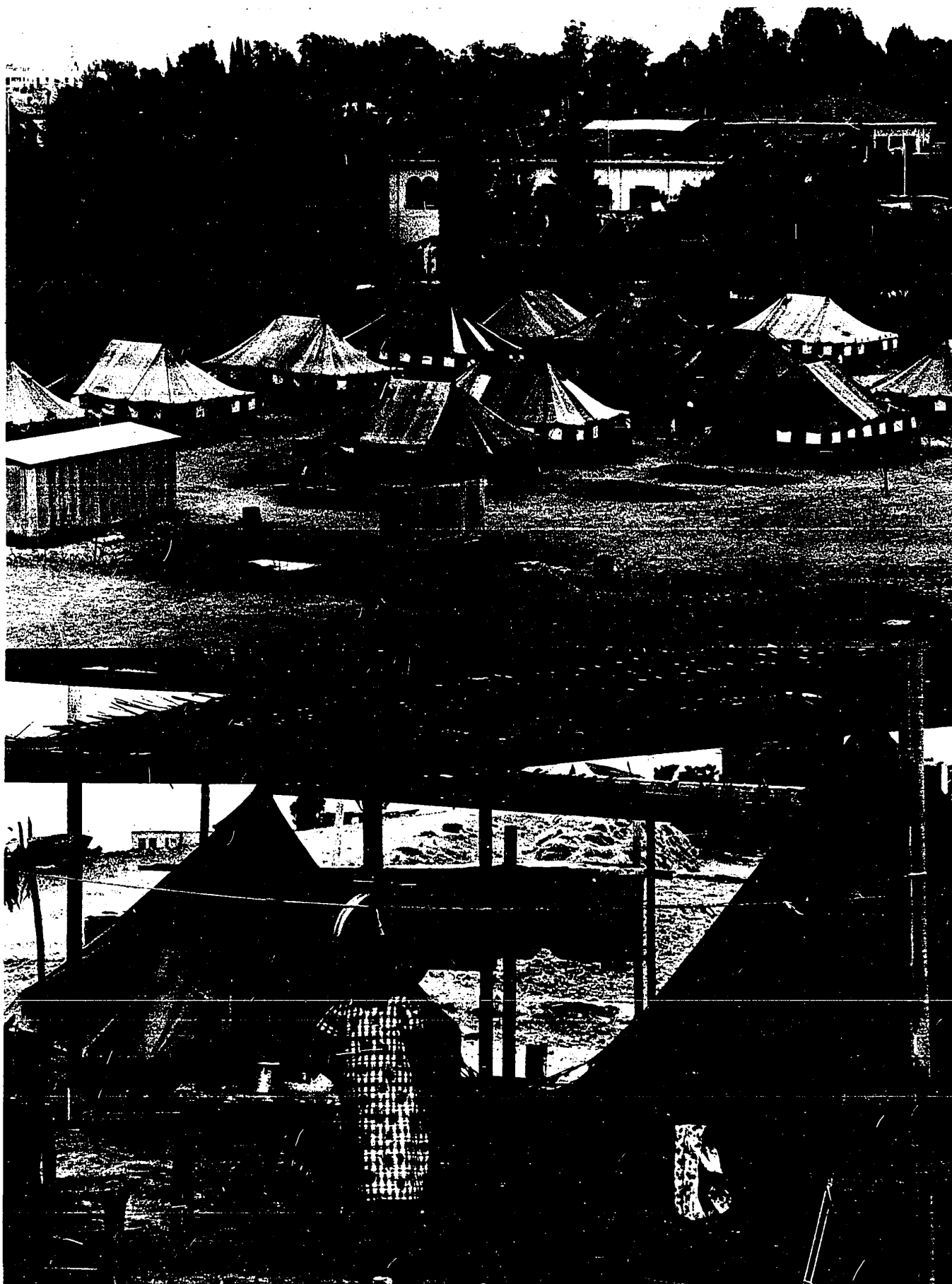
2. Proposal There are two types of distinct need in a disaster area with respect to housing, one is short-range immediate relief, and the second is long-range rehabilitation.

The short-range immediate relief can be in the form of bilateral assistance from outside to satisfy the basic housing requirements of protection from heat, rain or cold, as well as the provision of basic sanitation, and water supply. Materials and technology pools ought to be set up in different regions to enable this aid to be given in the shortest possible period of time.

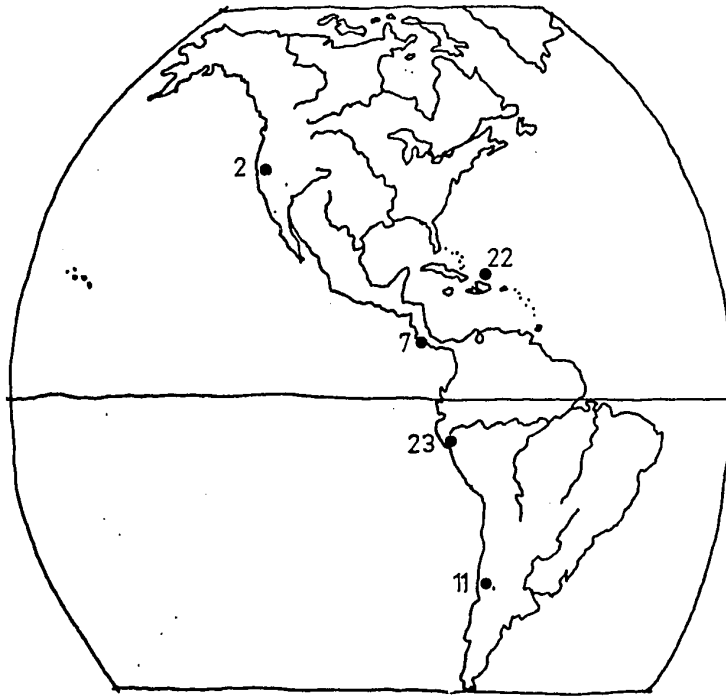
Long-range rehabilitation should be considered with the development and use of local resources in mind. Any assistance should be in the form of pilot plants and demonstration projects on the better use of locally available materials such as timber, stone or bamboo.

Presently most immediate aid has been more or less makeshift or improvised, and unfortunately of too short duration. There is a need for evaluation of past experiences with disasters in order to better assess the priorities, as well as more complete documentation of future disasters with respect to immediate needs, efficacy of aid, and problems encountered. There is a lack of documentation on, for instance, the long-term effects of immediate relief housing on permanent settlements.

The formation of an international agency responsible for disaster relief would be a desirable thing. Industrialized countries such as Canada should offer assistance in the form of bilateral aid, and through such agencies as C.I.D.A. should investigate disasters more fully, not only after they occur, but in order to offer more useful aid when they do.



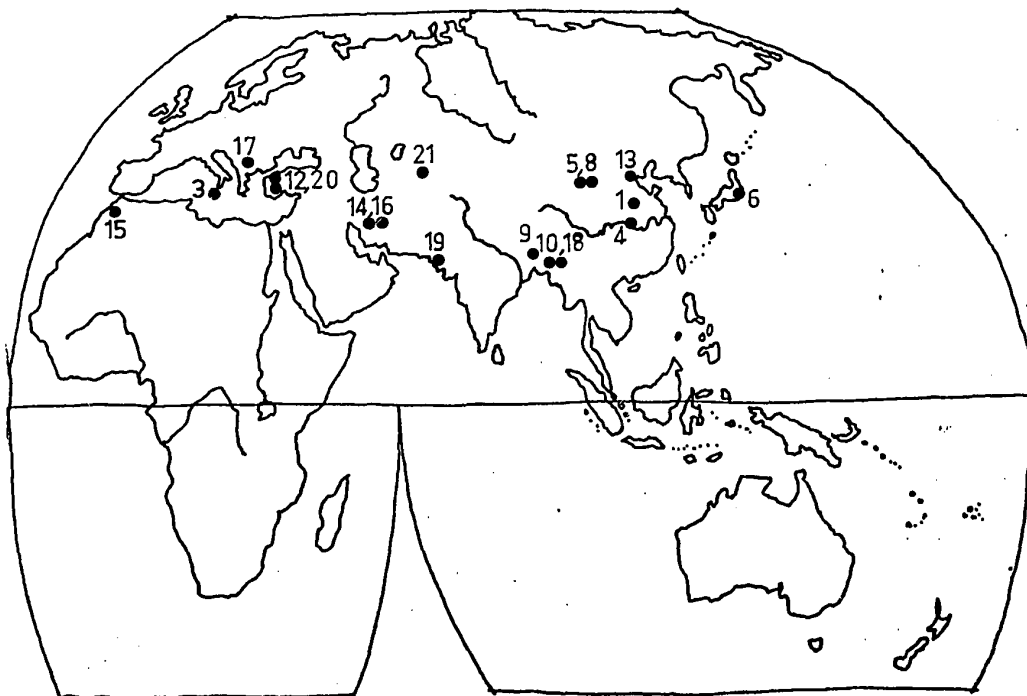




MAJOR DISASTERS OF THE TWENTIETH CENTURY

see world map

1. Flooding of Yellow River in China
900,000 dead (1887)
2. San Francisco earthquake and fire
250,000 homeless (1906)
3. Messina earthquake
50% mortality (1908)
4. Flooding of Yangtze River
100,000 dead (1911)
5. Earthquake Kansu Province, China
180,000 dead (1920)
6. Tokyo and Yokohama earthquakes
200,000 dead, cities destroyed (1923)
7. Mangua, capital of Niceragua destroyed
by earthquake (1931)
8. Earthquake, Kansu Province
70,000 dead (1932)
9. Earthquakes in India and Pakistan
50,000 dead (1935)
10. Cyclone in East Pakistan
22,000 dead (1936)
11. Chile Earthquake
40,000 dead (1939)



12. Anatolian earthquake, Turkey
30,000 dead (1939)
13. Floods in Tientsin, China
200,000 dead (1939)
14. Earthquake in North Iran (1957)
15. Agadir, Morocco destroyed by earthquake
20,000 dead (1960)
16. Iran earthquake
10,000 dead (1962)
17. Skopje, Yugoslavia destroyed by earthquake
(1963)
18. Cyclone in East Pakistan
Six million homeless (1965)
19. Karachi cyclone, West Pakistan
10,000 dead (1965)
20. Earthquake in Turkey
100,000 homeless (1966)
21. Earthquake in Tashkent, USSR
250,000 homeless (1966)
22. Hurricane Inez in Caribbean
100,000 homes destroyed
23. Earthquake in Peru
30,000 dead (1970)

NATURAL DISASTERS

FIRE

EARTHQUAKES

HURRICANES

FLOODS

EPIDEMICS

DROUGHT

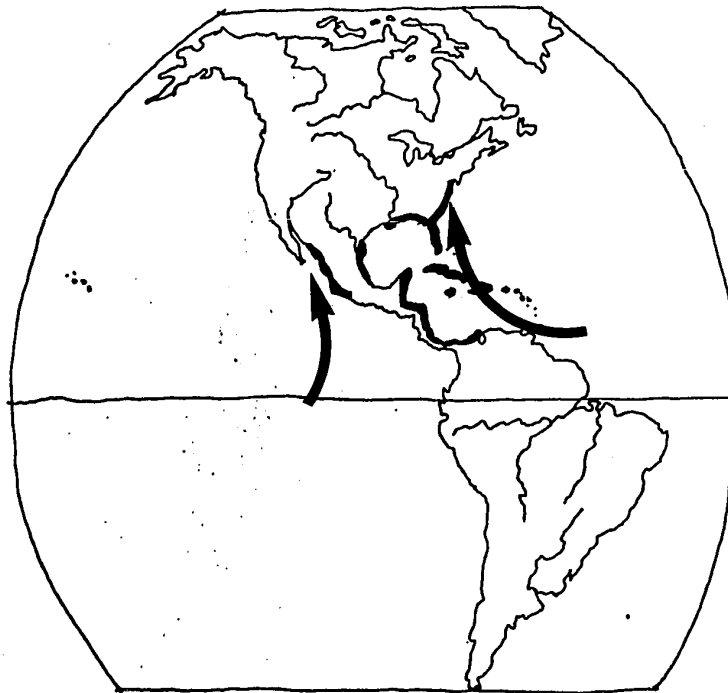
LANDSLIDES

MAN-MADE DISASTERS

WARS

MIGRATIONS

REFUGEES

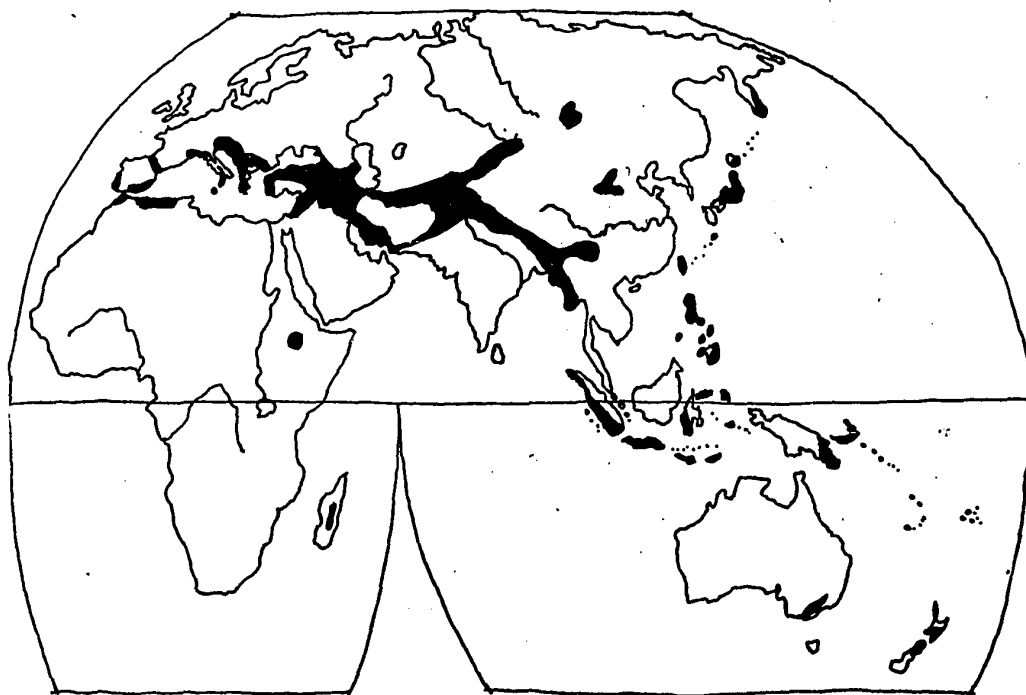
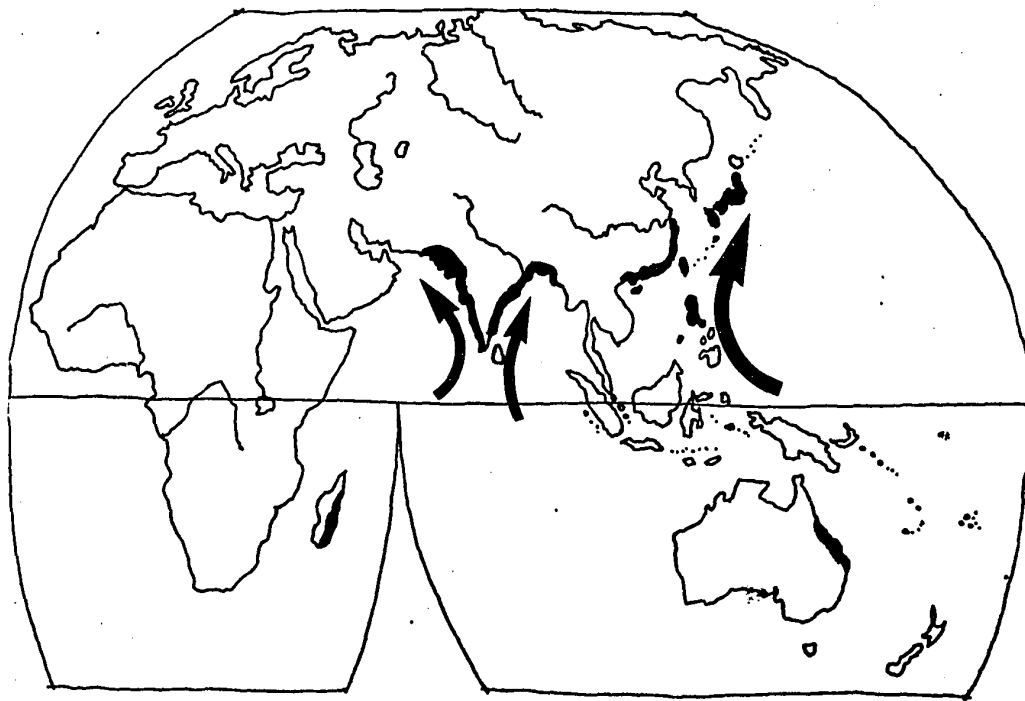


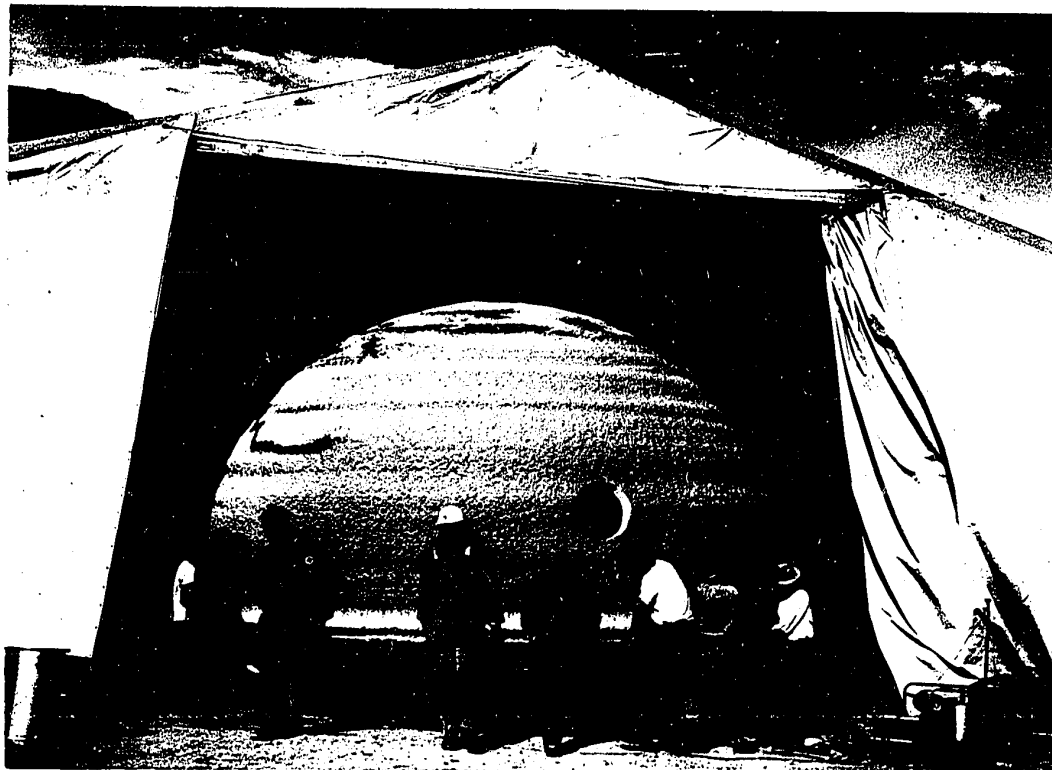
HURRICANE AREAS OF THE WORLD



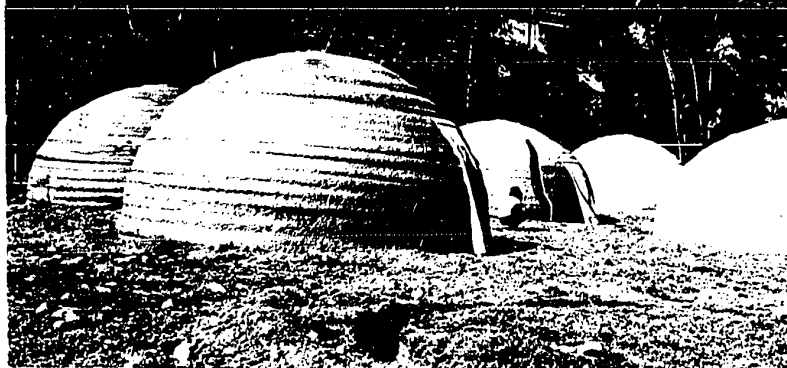
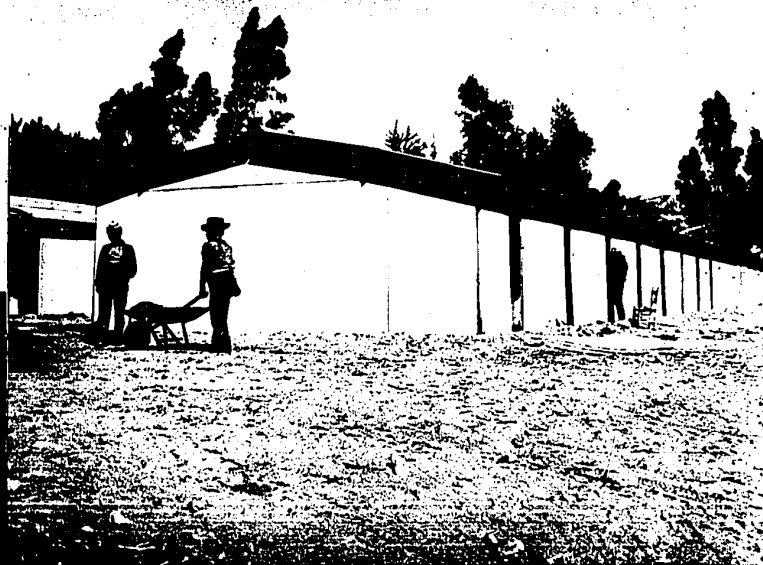
SEISMIC REGIONS OF THE WORLD

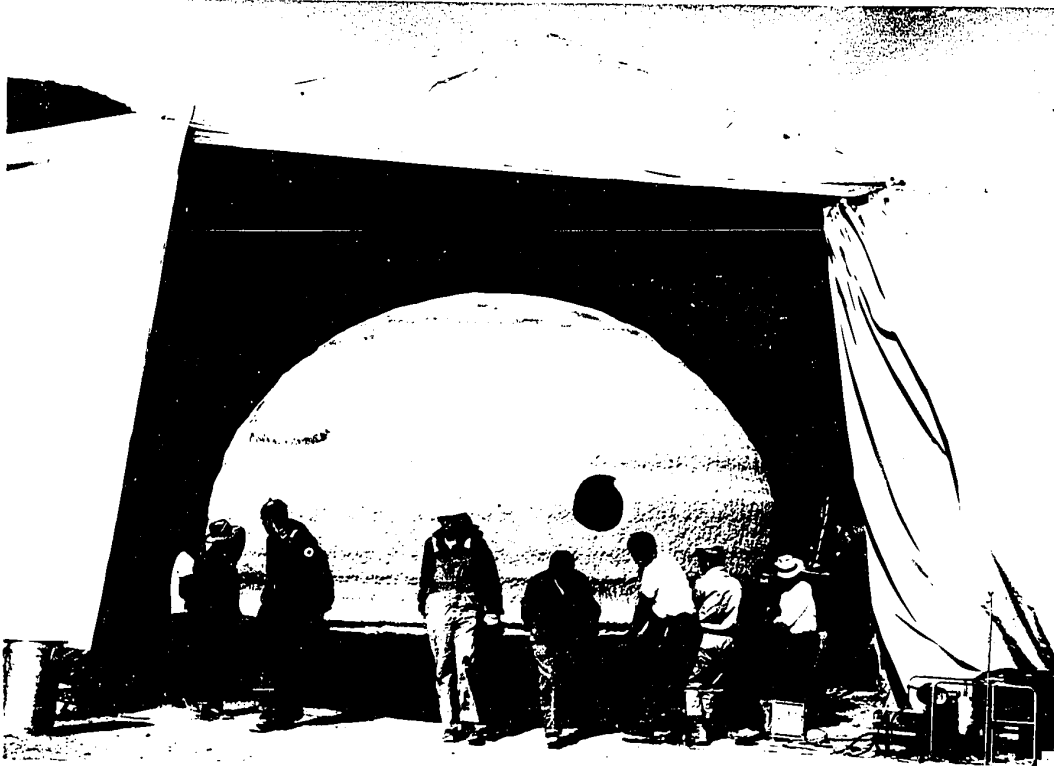
AFTER DE BALLORE



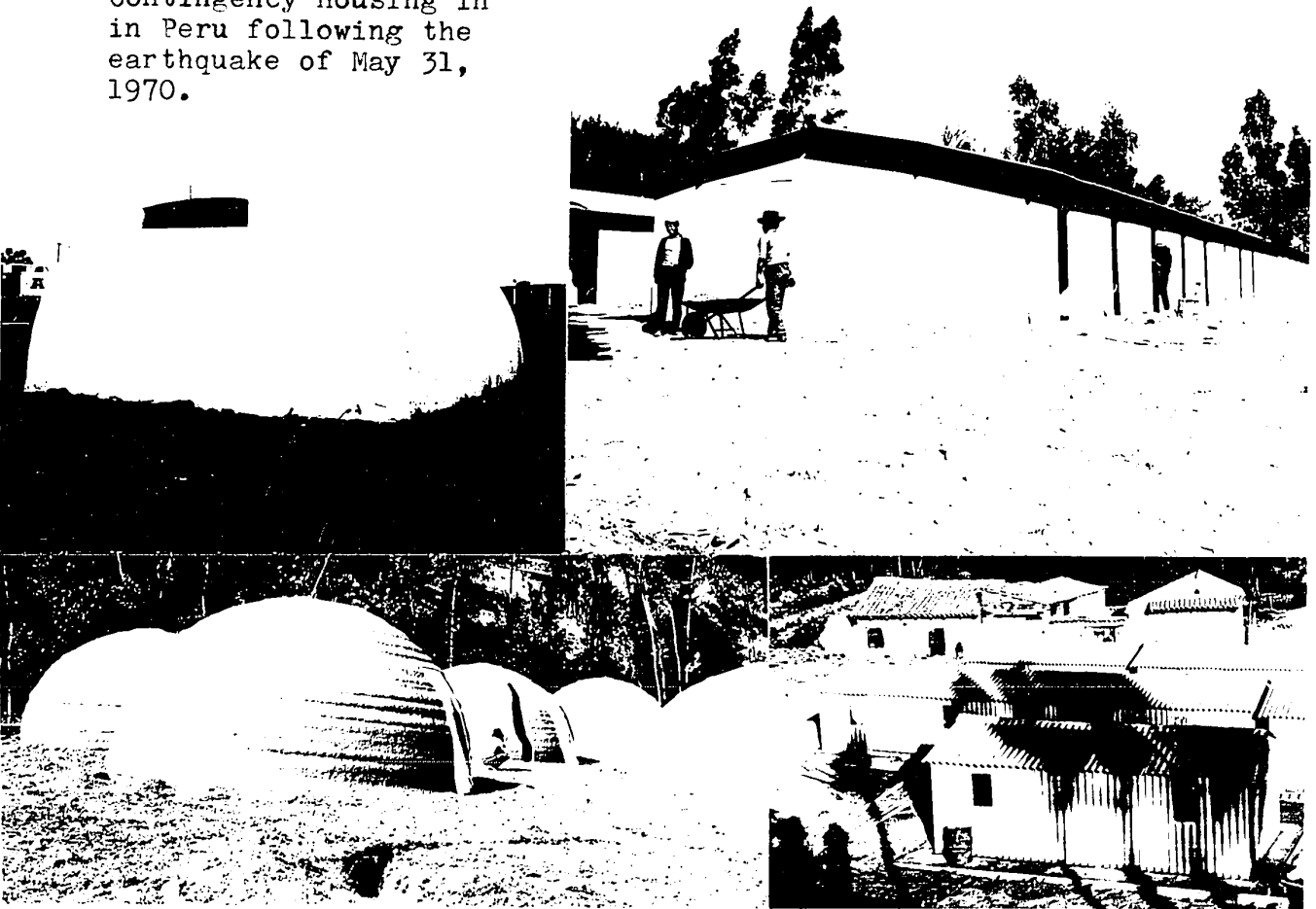


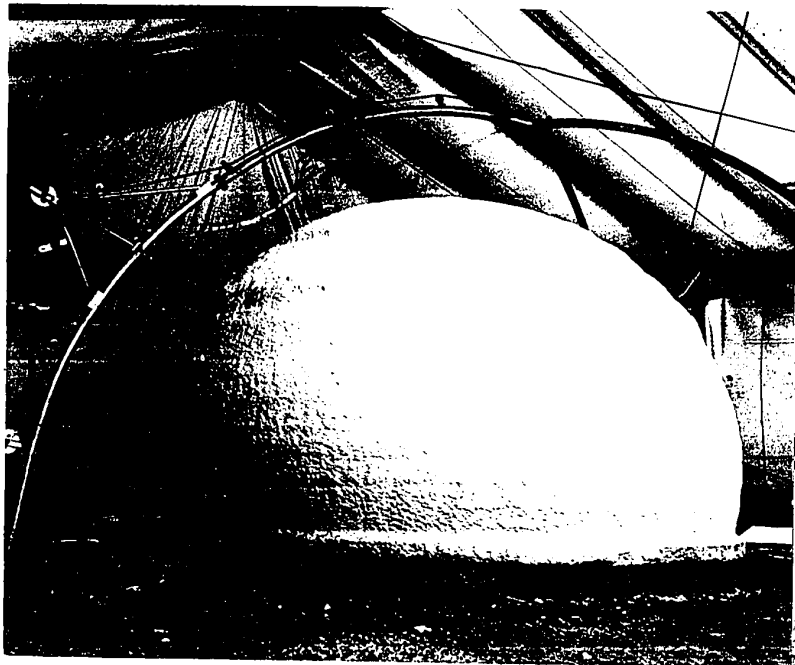
Contingency housing in
in Peru following the
earthquake of May 31,
1970.



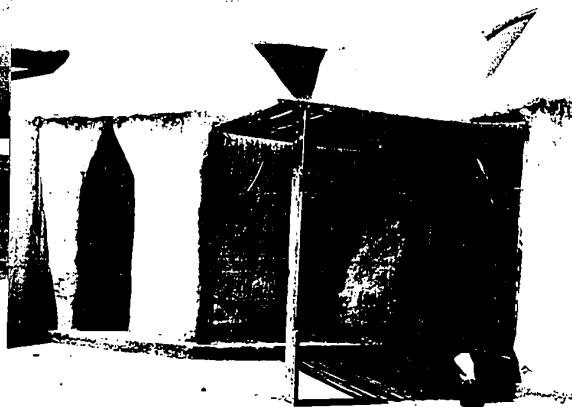


Contingency housing in
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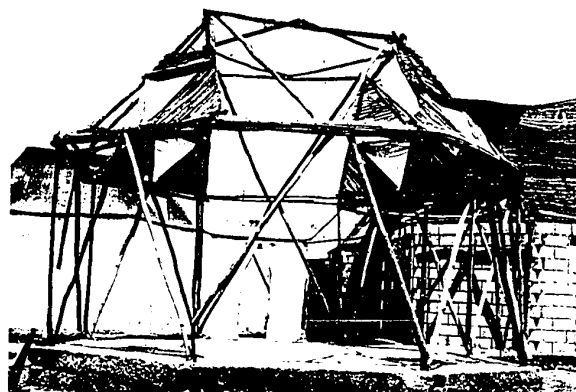




Below, experimental work in Rabat, Morocco by CERF using locally available timber, rattan and gypsum.



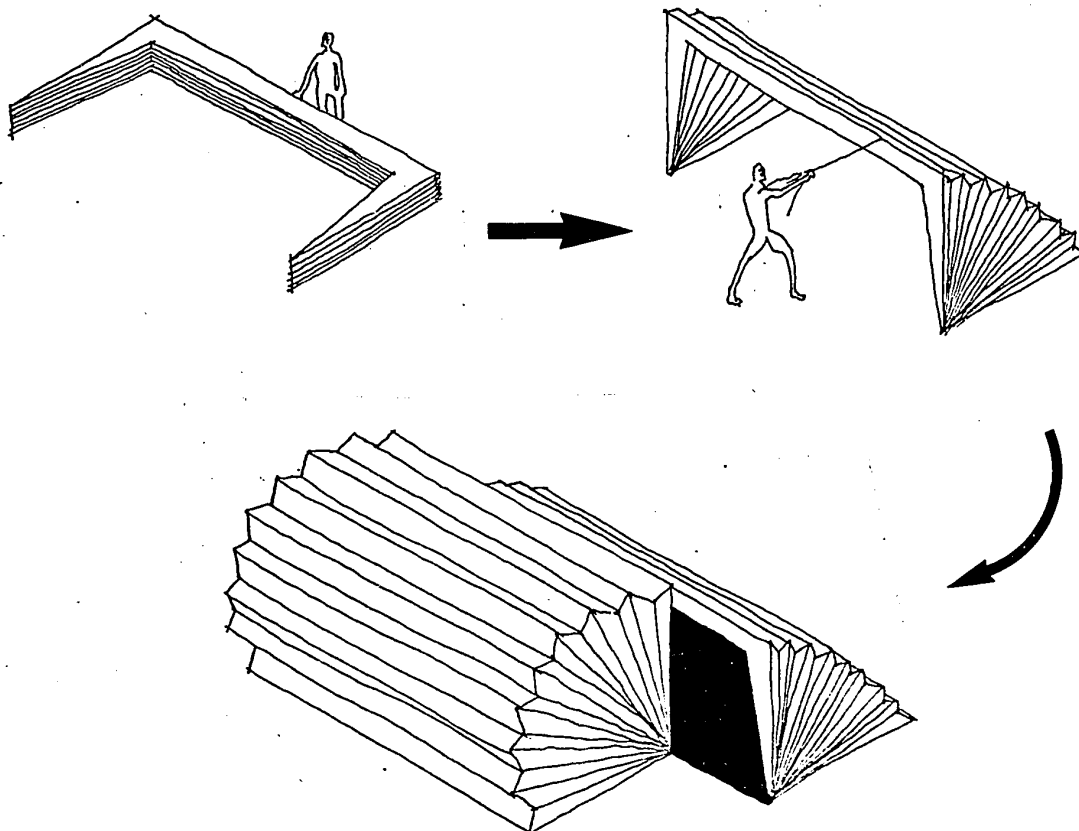
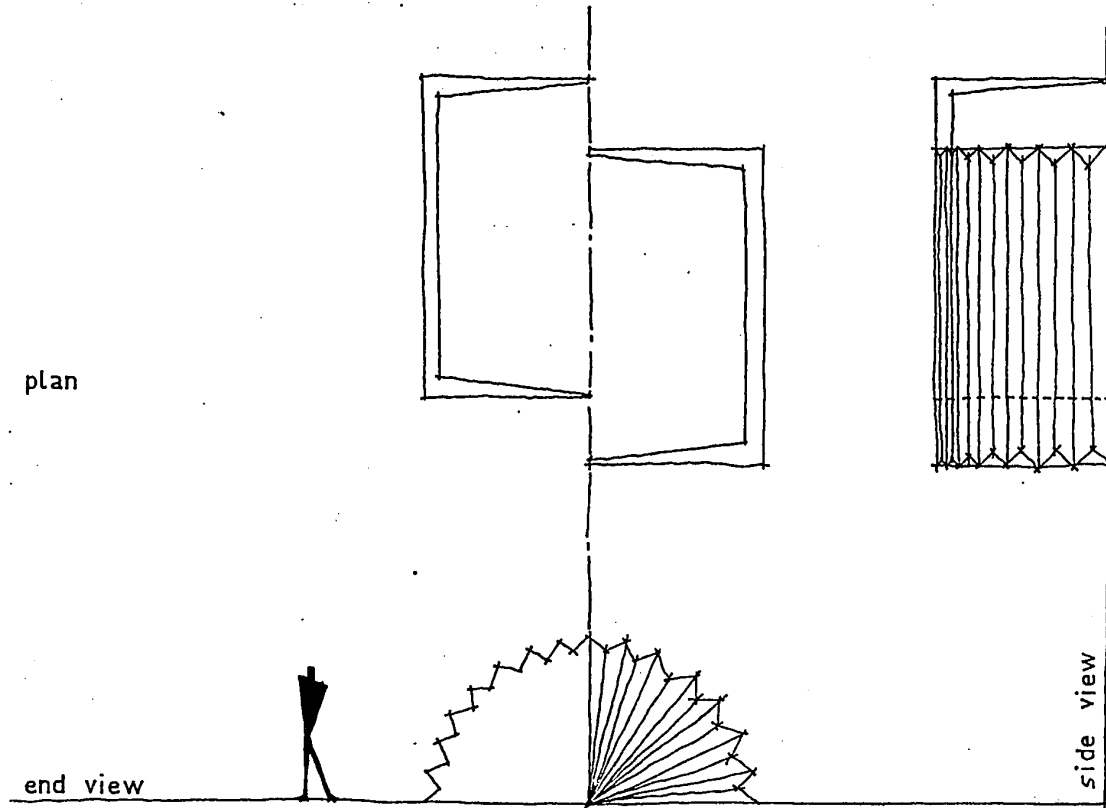
Above, polyurethane domes by the Bayer company. Weight 270-350 kg. Diameter 5m. Construction time 1½ hours. Cost US\$ 100. The plastic is sprayed onto an inflated mold and painted with fire-retardant paint.

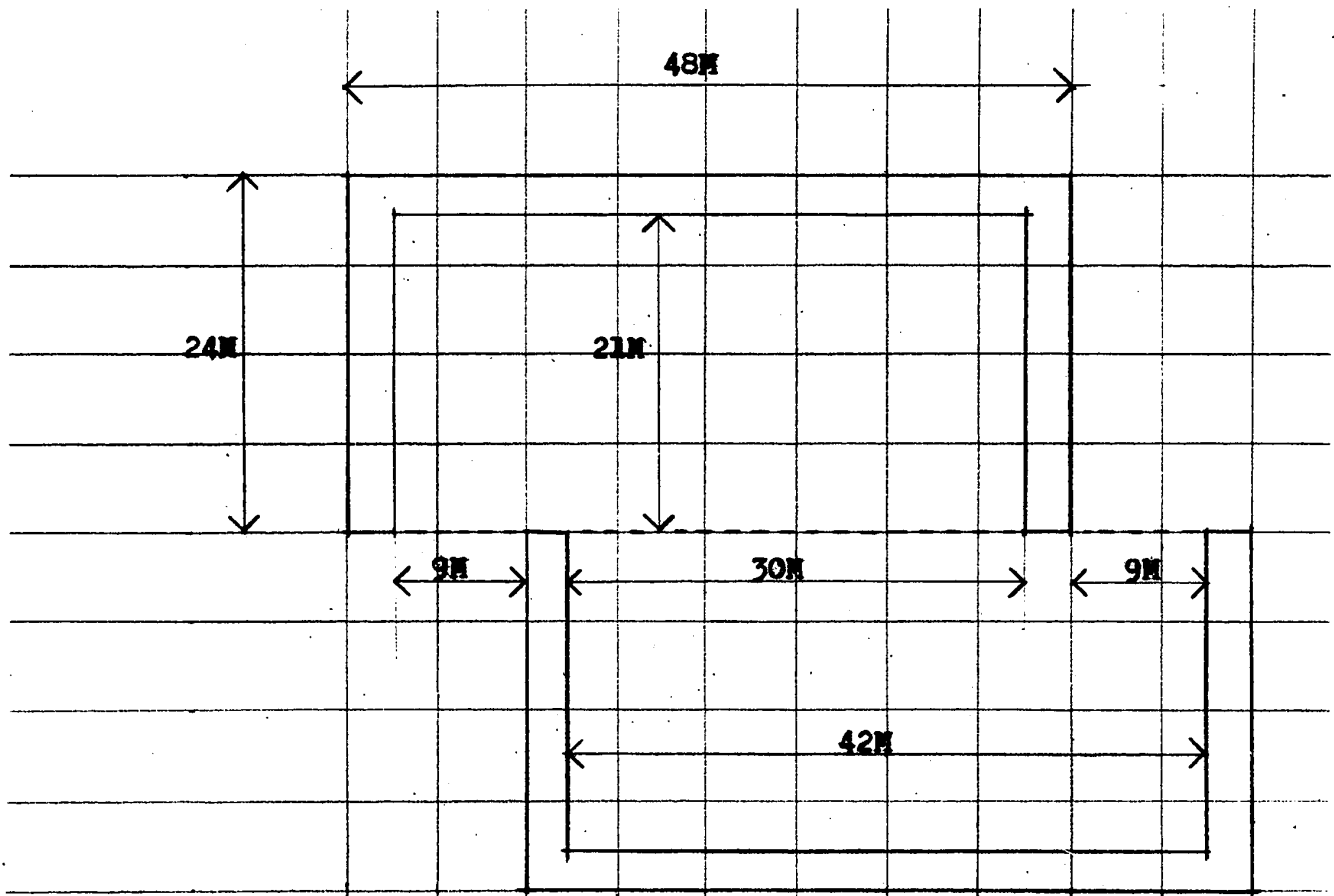


Below, refugee encampment in Cyprus.



PROPOSAL FOR CONTINGENCY HOUSING THAT IS PREFABRICATED AND
TRANSPORTED TO THE SITE. SHELL MATERIAL IS VINYL ON WIRE FRAME

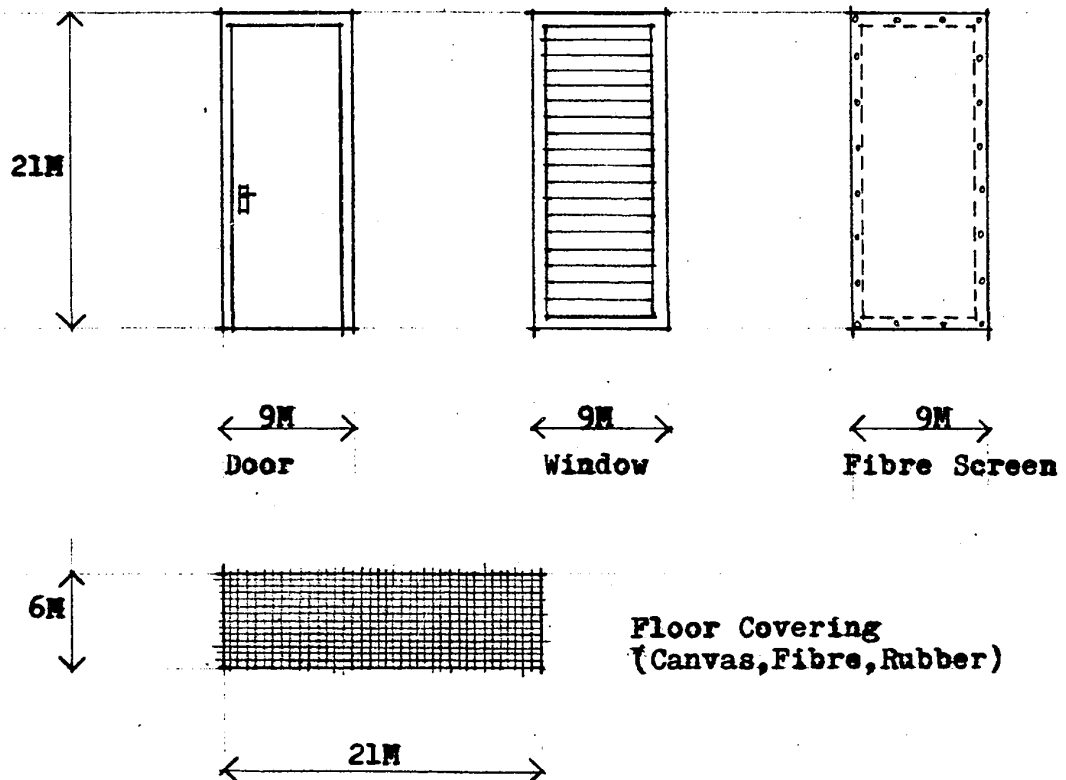


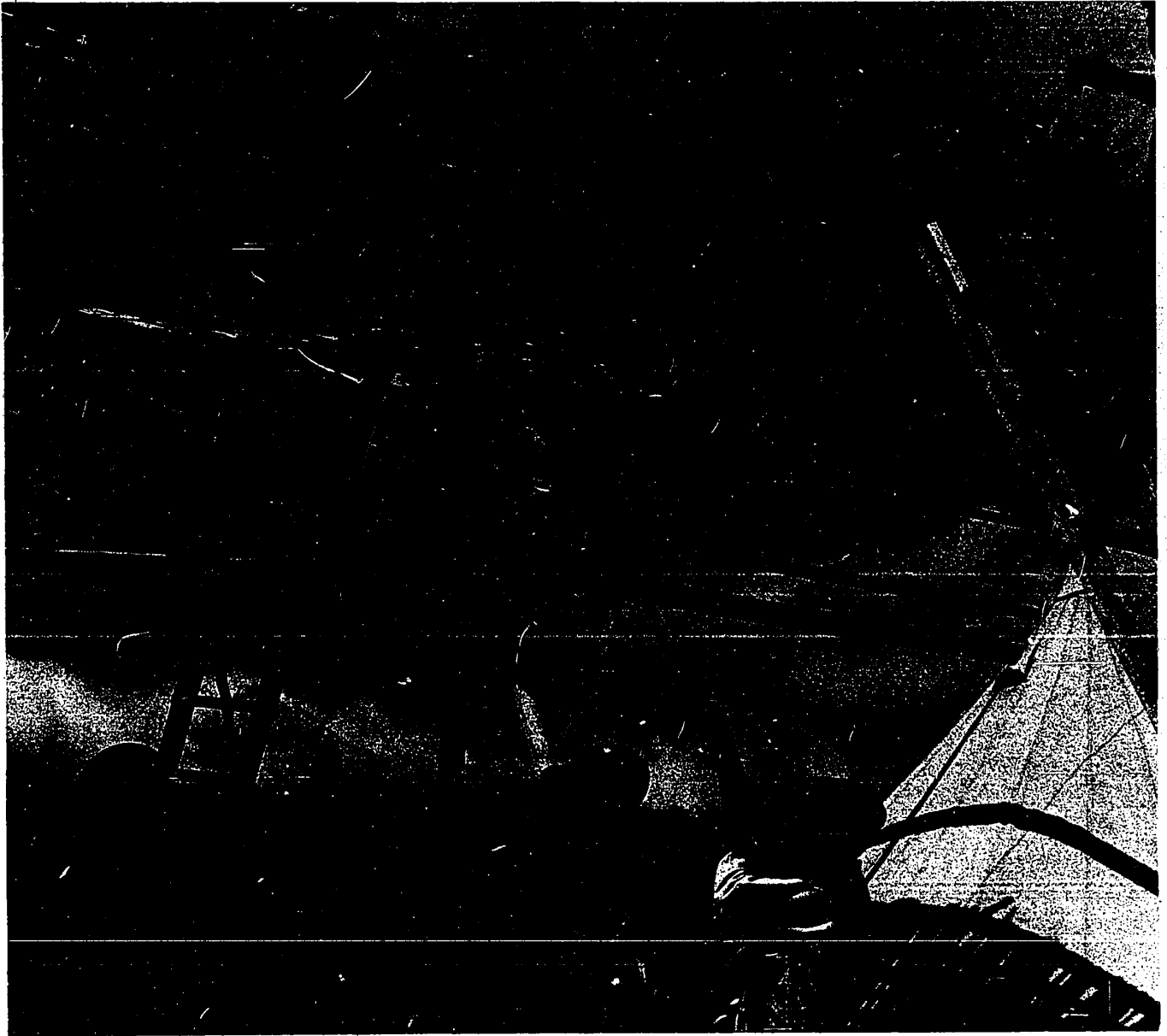


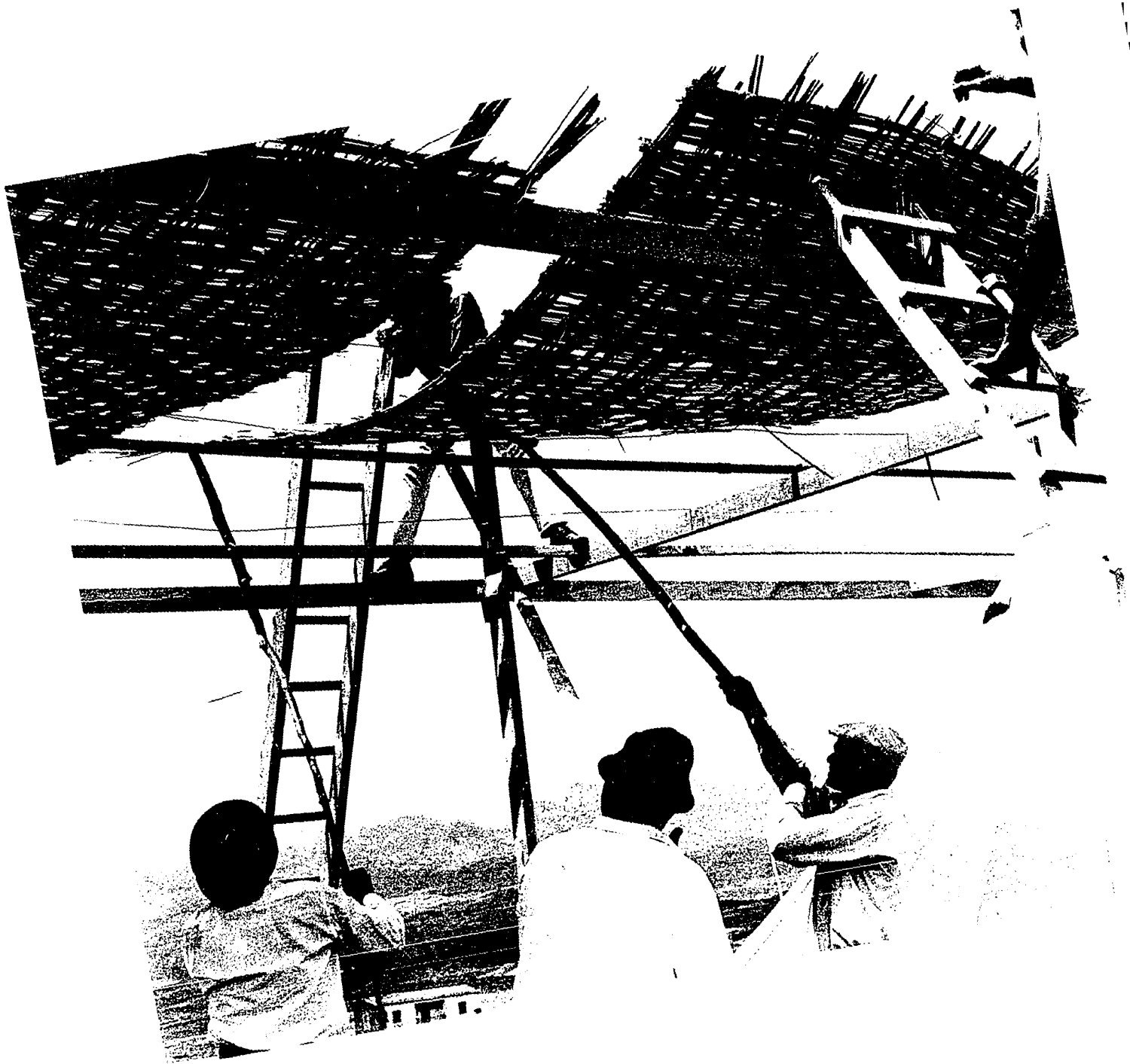
PLAN

Measurements in basic modules
Planning module = 6M x 6M

1M = 4" = 10 cm.







Suggested reading

The Alaska Earthquake AIA Journal V.42 Dec. 1964 pp.35-42

Preliminary Report on the Geologic Events Associated with the May 31, 1970 Peru Earthquake Ericksen and others, Geological Survey Circular No. 639 Washington 1970

Emergency Aid Edward D. Mills Arch. Review V. 141 June 1967 pp.409-412

New York Times Articles on Peru Earthquake beginning on June 1, 1970 continuing daily until June 8.

Rebuilt Agadir Arch. Review V. 113 Oct. 1967

Rehabilitation and Reconstruction following Natural Disasters U.N. Economic and Social Council Reports E/C.6/52 Add. 6 & Add. 7 (Parts 1&2)

Emergency Housing Peru AD. V. 141 May 1971 pp.264-5

Résumé annuel d'information sur les catastrophes naturelles 1969
Unesco Paris 1971