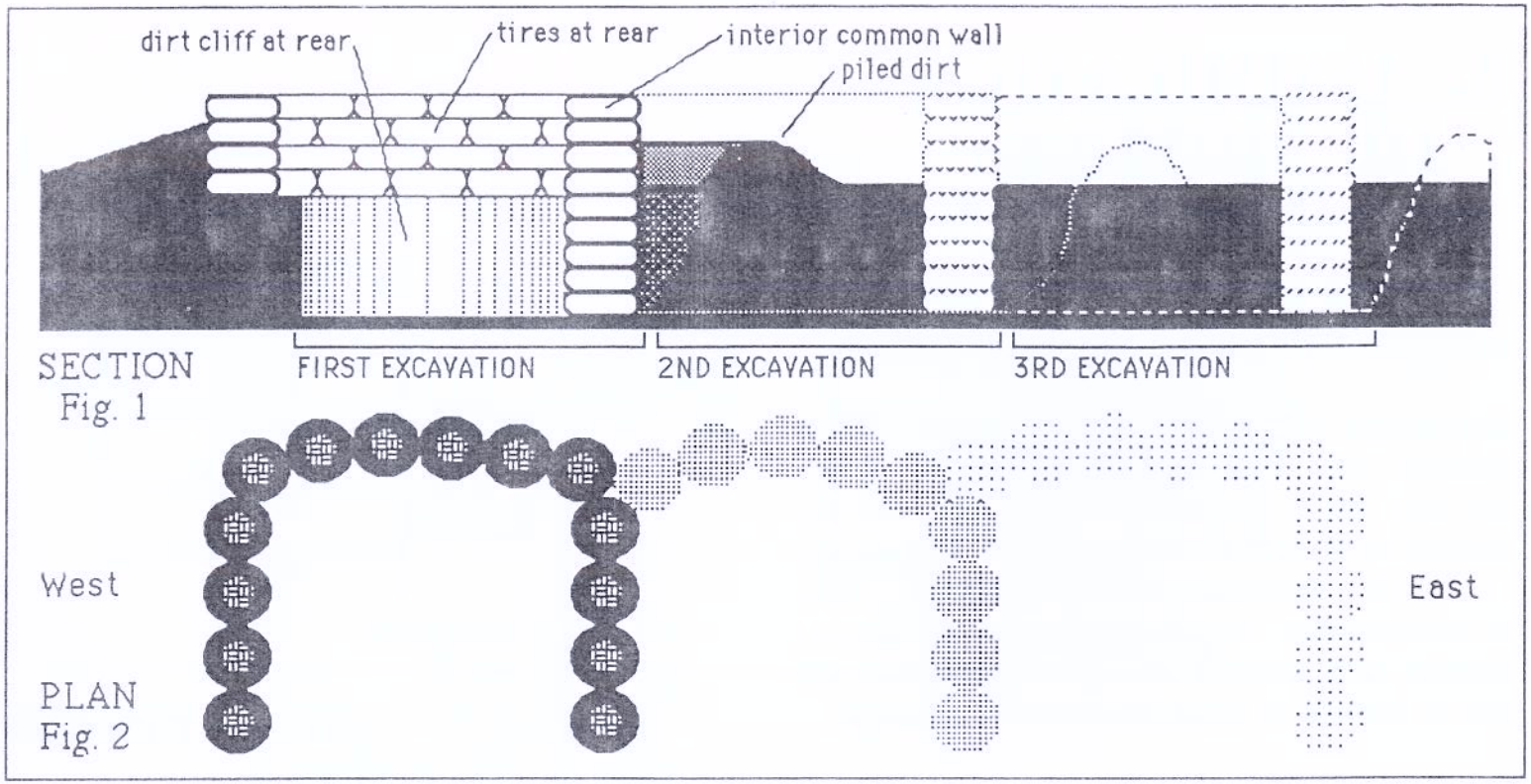
8. ASSIMILATION OF MODULES AND DETAILS

THE DETAILS INVOLVED IN ASSIMILATION OF "U" MODULES

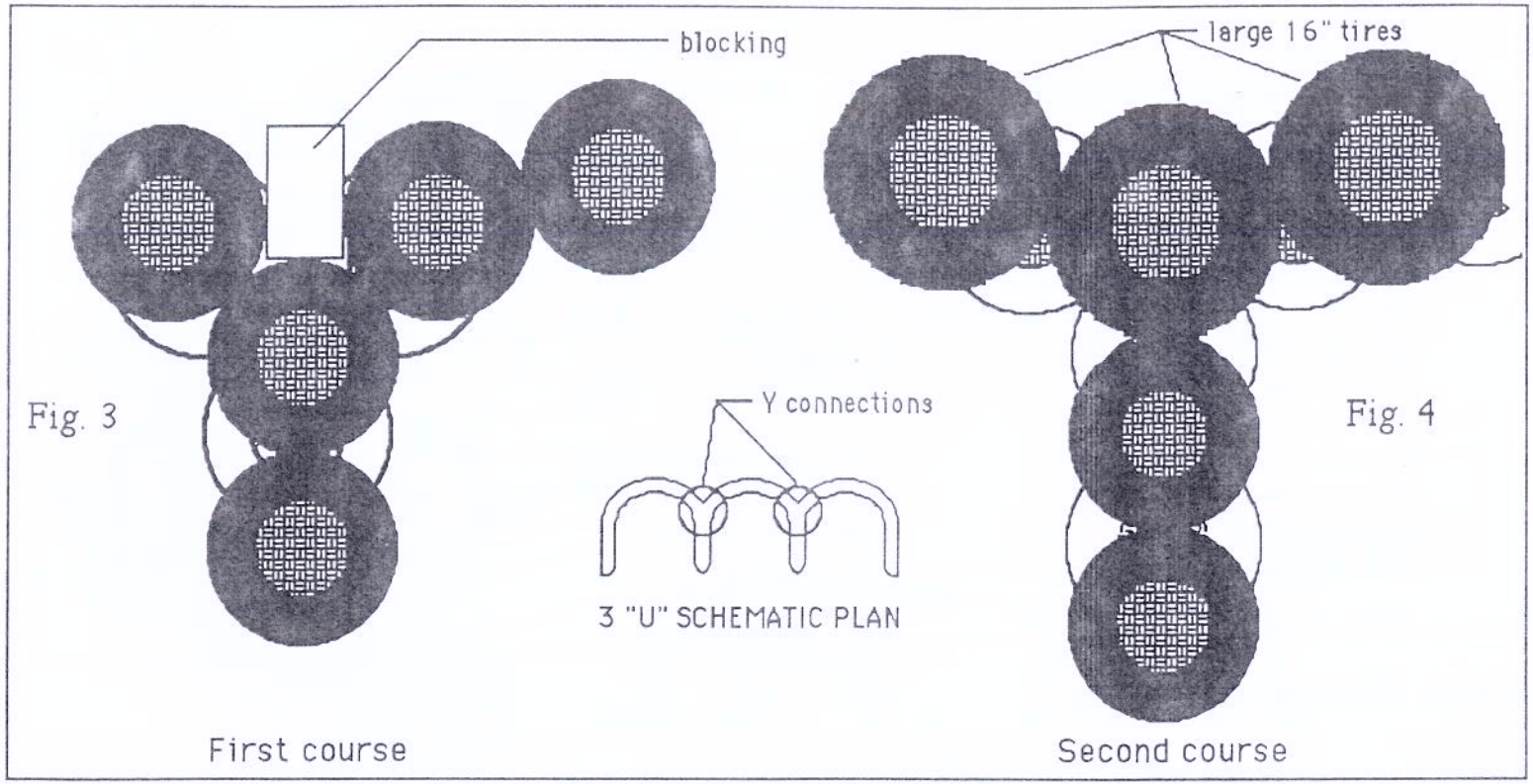
Now that you know how to build a "U" module and how to add the green house hallway on to it, you are ready to learn the details necessary to assemble more than one "U". This information, together with a few miscellaneous structural and mechanical details, will provide enough information for you to be able to build your own "Earthship".



JOINING "U's"

Building more than one "U" involves a different initial excavation than a single "U". The east/west structural section above (Fig. 1) illustrates that each excavation is taken far enough to fully accommodate the interior common wall. This is so that the common wall can go all the way down to floor level. This is necessary since it is excavated on both sides.

The second excavation would then accommodate the next "U" and the next common wall. It is advisable to excavate in steps (one "U" at a time) as shown (Fig. 2). This allows piled dirt to be accessible for tire pounding and also keeps the project in simple steps and operations that are easy for the novice builder to deal with.



Y-Connections

Building more than one "U" also involves a Y connection not encountered before. The diagrams above show the alternate coursing patterns necessary to accommodate this joint. Blocking (Fig. 3) is installed to allow alternate courses of tires to always overlap each other in staggered coursings. This staggered coursing provides the structural integrity of the wall. It is important never to have two tires directly on top of each other in these joints.

On the alternate course over the blocking (Fig. 4) a large #16 tire would be needed to provide the necessary overlaps. The important thing to remember in a "Y" joint is to create overlaps in alternate courses however you can – with larger tires, with blocking, etc. The purpose being to "knit" all three walls together.

Fig. 5

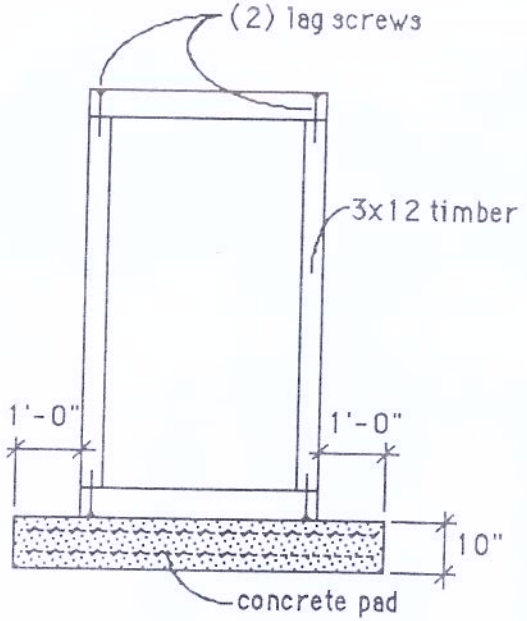
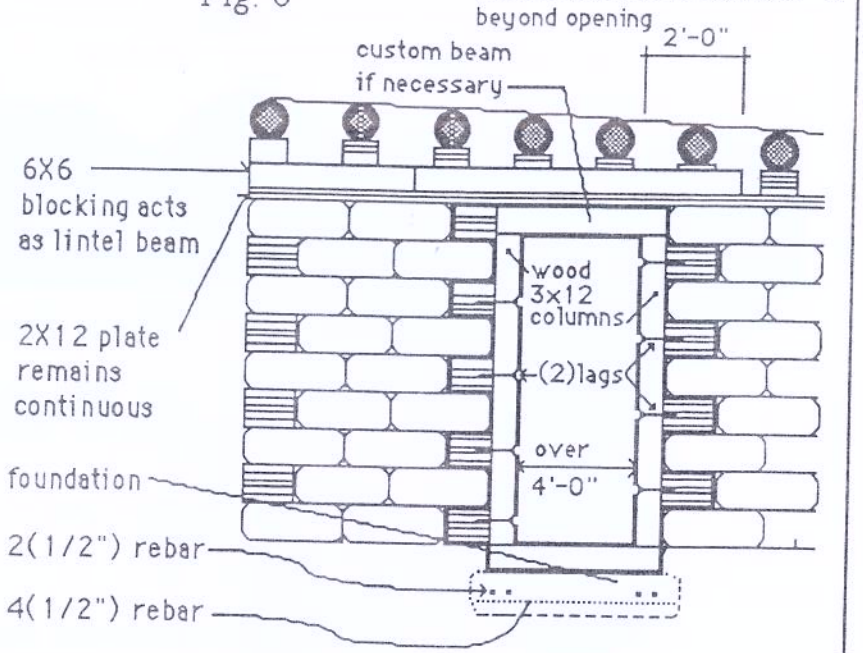


Fig. 6

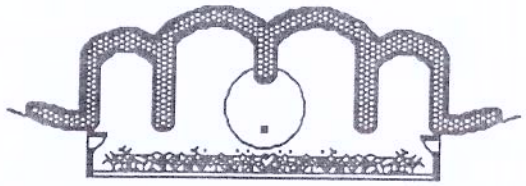


WALL BREAKTHROUGH

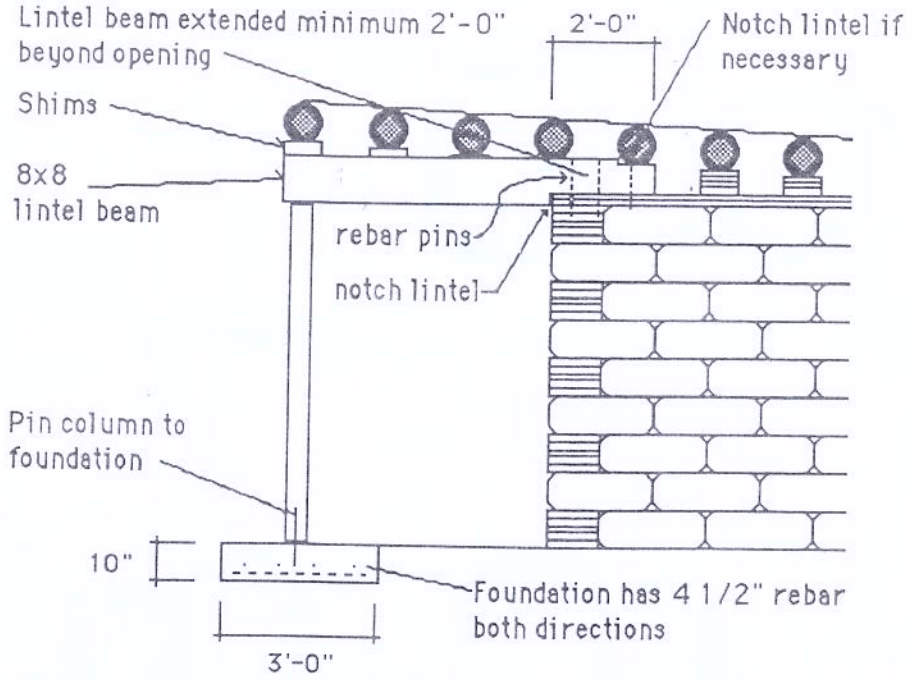
It is best not to break through a tire wall into another "U" for economical and thermal reasons. However when a breakthrough in a tire wall is necessary the main consideration is not to break the structural continuity of the wall. **The double 2x12 plate should never be interrupted.** The opening should be built out of rough sawn 3x12 timber or an equivalent thickness of laminated dimension lumber (Fig. 5). This opening box should then be placed in position on a 2'-0" concrete pad as shown.

This pad should have (4) 1/2" rebar for its full length. Tires and blocking are then laid to the box on either side. It is best to locate this box by laying out the ground course of tires so it will relate to actual tire coursing. The timber box should be lag screwed to the 1/2 blocks as the wall goes up. If possible, the 6x6 shim should be extended to form a lintel beam over the opening. If this is not possible, the top 3x12 of the box should be doubled to form a beam.

Fig. 7

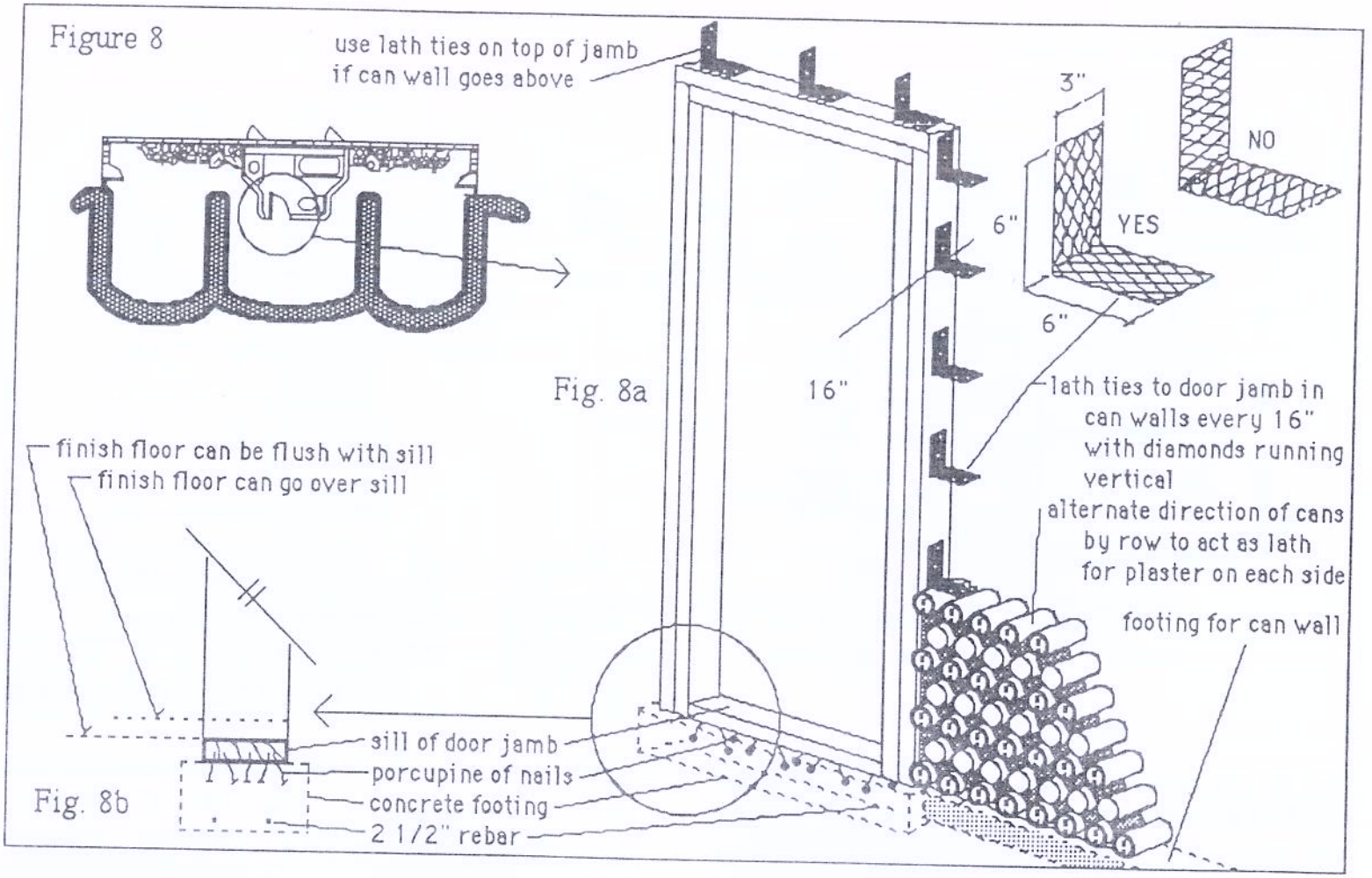


4 "U" PLAN



SHORTENED "U" WALL

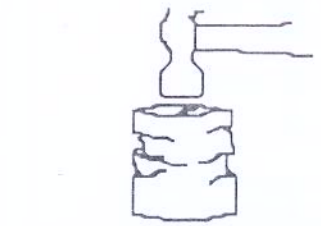
Often it is desirable to let one "U" space flow into another by shortening one wall in between two "U's". This simply involves a column to receive the 2x12 plates and using the shim blocking as a beam to span the opening. In this case the shim beam would want to be an 8x8 to provide more strength. If your span is longer an 8x10 would be needed. Get some advice for the size of this beam. Let the beam extend 2'-0" beyond the opening. This beam will be notched over the 2x12 plates and pinned to the plates in six places (Fig. 7). This will join it to the plate for continuity. Allow for a concrete foundation under the column. This is usually 3'-0" x 3'-0" square, 10" thick, with (4) 1/2" rebar each way. Consult a local builder for any concrete foundations as they will need to be typical to requirements for your area. The column can be pinned to the foundation with a 1/2" rebar pin set in the concrete foundation and extending up 5-1/2" into the column. The column is simply drilled with a loose sloppy hole 6" deep to slip over this pin.



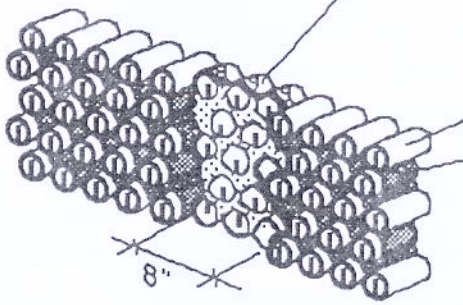
INTERIOR DOOR JAMBS IN CAN WALLS

Bathroom and closet walls are made of aluminum cans layed in cement mortar. Specifications of how to lay cans have already been discussed on pages 155 & 156. Door jambs in these walls are made of 2x6 stock and are always doubled on the sides and top (Fig. 8a). They are always porcupined on the bottom (Fig. 8b). The porcupine technique has been discussed on page 154. The sill of all jambs can be recessed to allow floor materials to go over the sill. Laying cans in single walls must be done with a level used horizontally and vertically. You can only go about four courses in a "hit" and then wait a couple of hours for the mortar to set up before going

Fig. 9

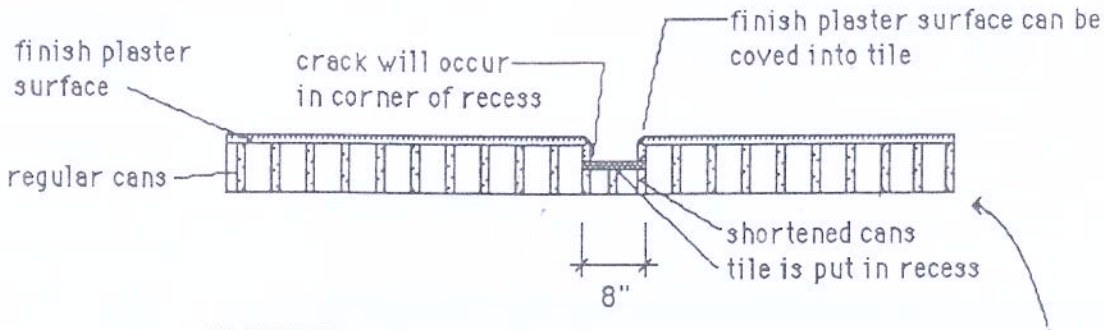


shorten cans to half size
and lay in expansion joint



PLANTER WALL EXPANSION JOINT

Fig. 9a



PLAN VIEW OF CAN PLANTER WALL WITH EXPANSION JOINT

Fig. 9b

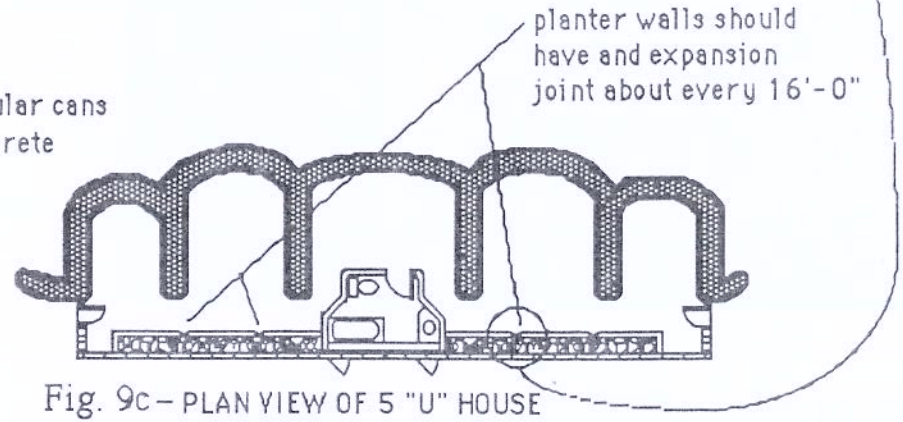


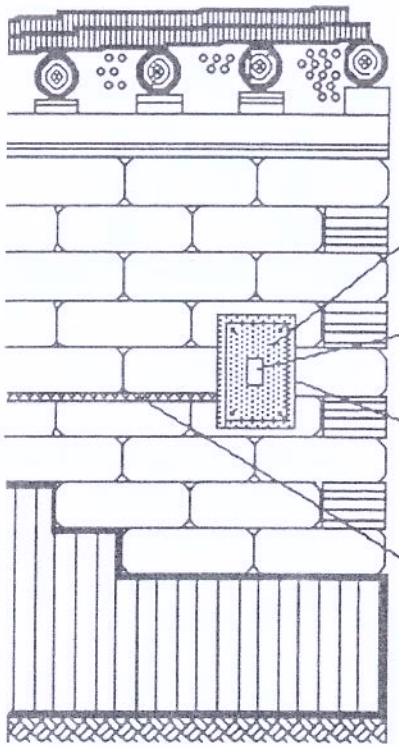
Fig. 9c – PLAN VIEW OF 5 "U" HOUSE

higher. Metal lath, as explained on page 154, should be used where ever can masonry walls touch another material. This includes all jambs, ceilings, tire walls etc. Metal lath ties can be screwed to tire walls for tying in the can wall.

PLANTER WALLS

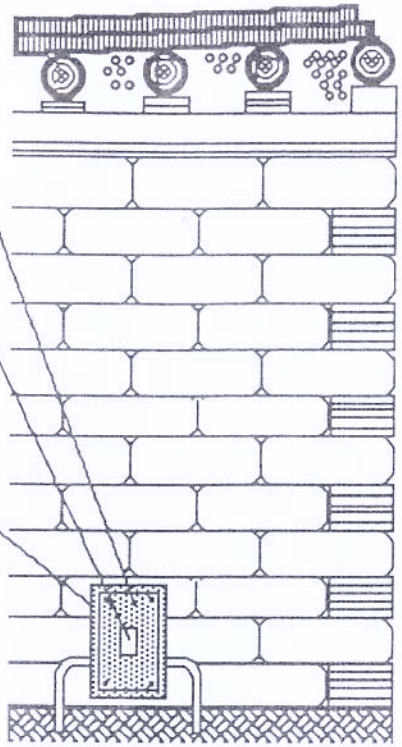
Planter walls are built with aluminum cans laid as described before. Lay them with the mouth pieces out to allow an irregular surface to hold whatever finish plaster is applied. They are usually 2'-0" high and should not go over 16'-0" in length without an expansion joint. Expansion joints are made with shortened cans. Tap them with a hammer (Fig. 9) and lay an 8" space with shortened cans (Fig. 9a). This will cause the expansion crack to occur in the corner of the thinner space (Fig. 9b). This recess space is usually filled with tile.

Fig. 10



SWITCH BOX ROUGH IN

Fig. 10a



OUTLET BOX ROUGH IN

ELECTRICAL ROUGH IN - TIRE WALL

Electrical boxes for plugs and switches can be mounted on plywood plates and screwed to tires as shown in Fig. 10 & Fig. 10a. This establishes the plane of the mud plaster (or other plaster) wall at the same time. Plasters will be explained in chapter 10. Be sure to locate the plywood plate over a void between two tires. This allows room for the box itself behind the plywood plate. The electrical box is then anchored to the plywood plate with conventional means. Wires can be run along channels between tires in conduit sized to code requirements. The plywood plate is covered with 6 mil plastic and metal lath extending 3/4" around the plate to provide a surface for the plaster to overlap onto the tire wall and thus prevent a crack in the plaster immediately around the plate.

Fig. 11

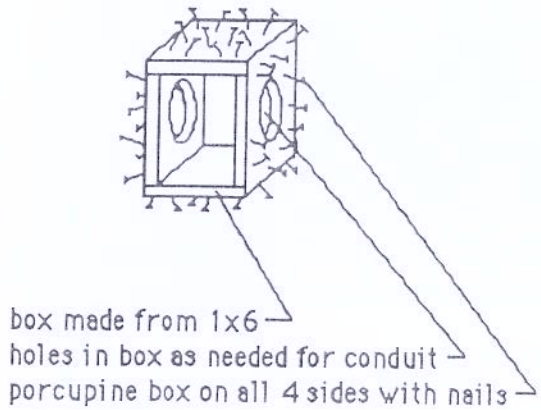
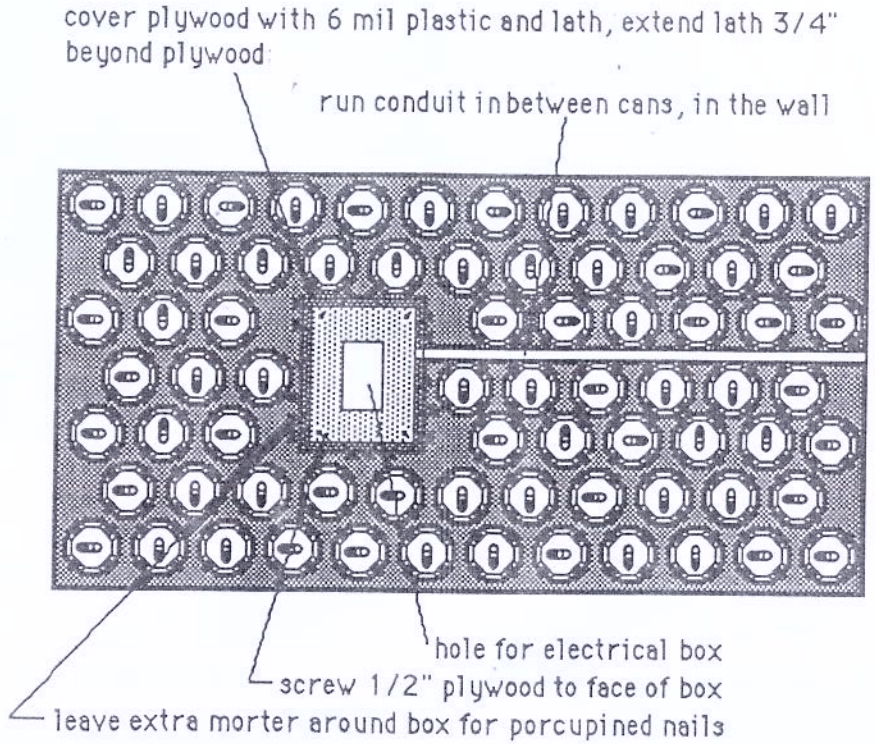
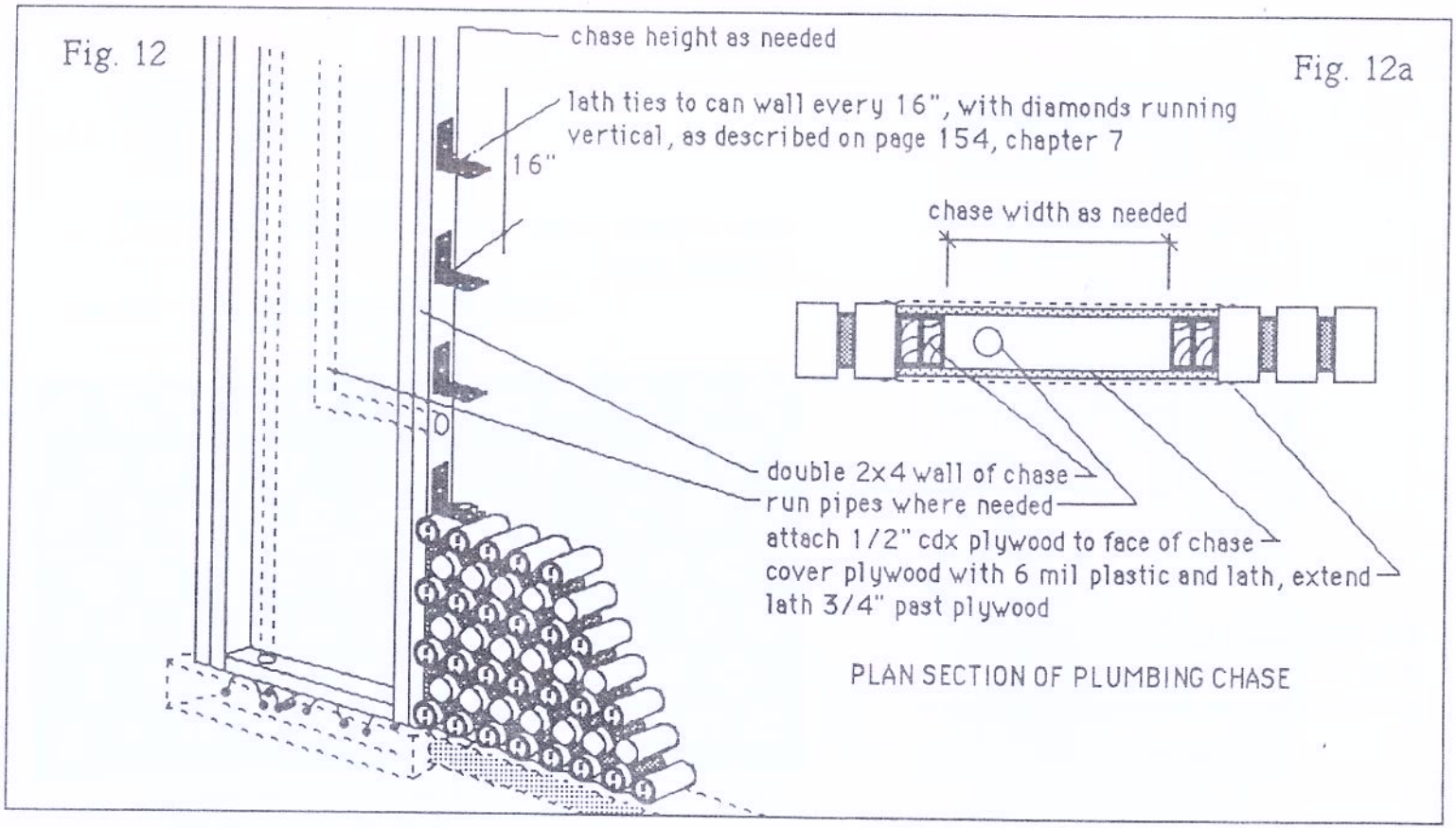


Fig. 11a



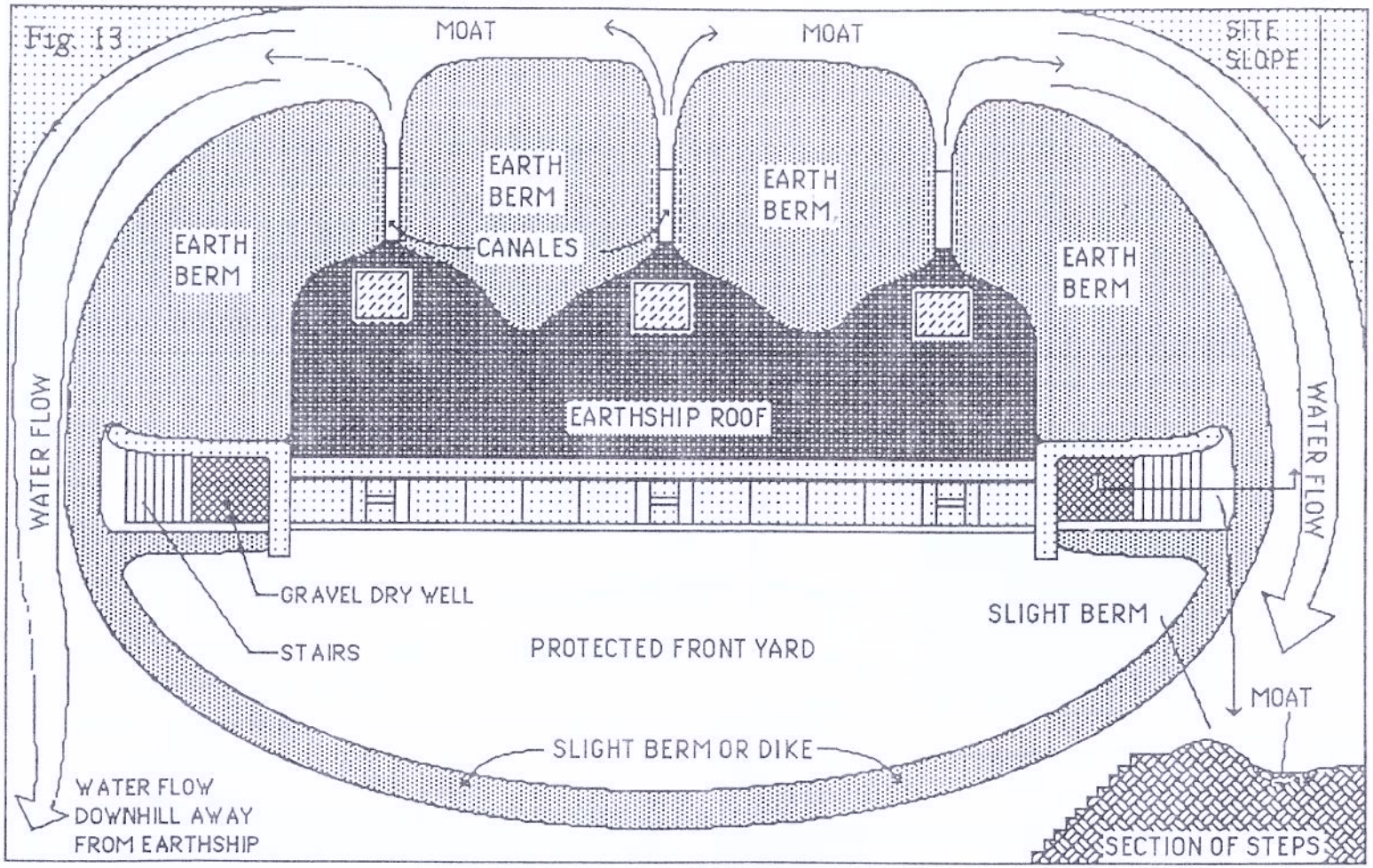
ELECTRICAL ROUGH IN - CAN WALL

Wherever electrical boxes are required in can walls a wood box made from 1x6 stock and porcupined (Fig. 11) must be provided to lay into the can work. Wires are then run in the can work as it goes up to feed the boxes. Again wires can be in conduit or layed directly into the can work as code allows. A 1/2" plywood plate is screwed into the 1x6 boxes to provide conventional anchoring for the electrical boxes. Again this plywood plate must be covered with 6 mil plastic and metal lath extending 3/4" all the way around to prevent a crack in the plaster immediately around the plywood plate (Fig. 11a).



PLUMBING CHASES

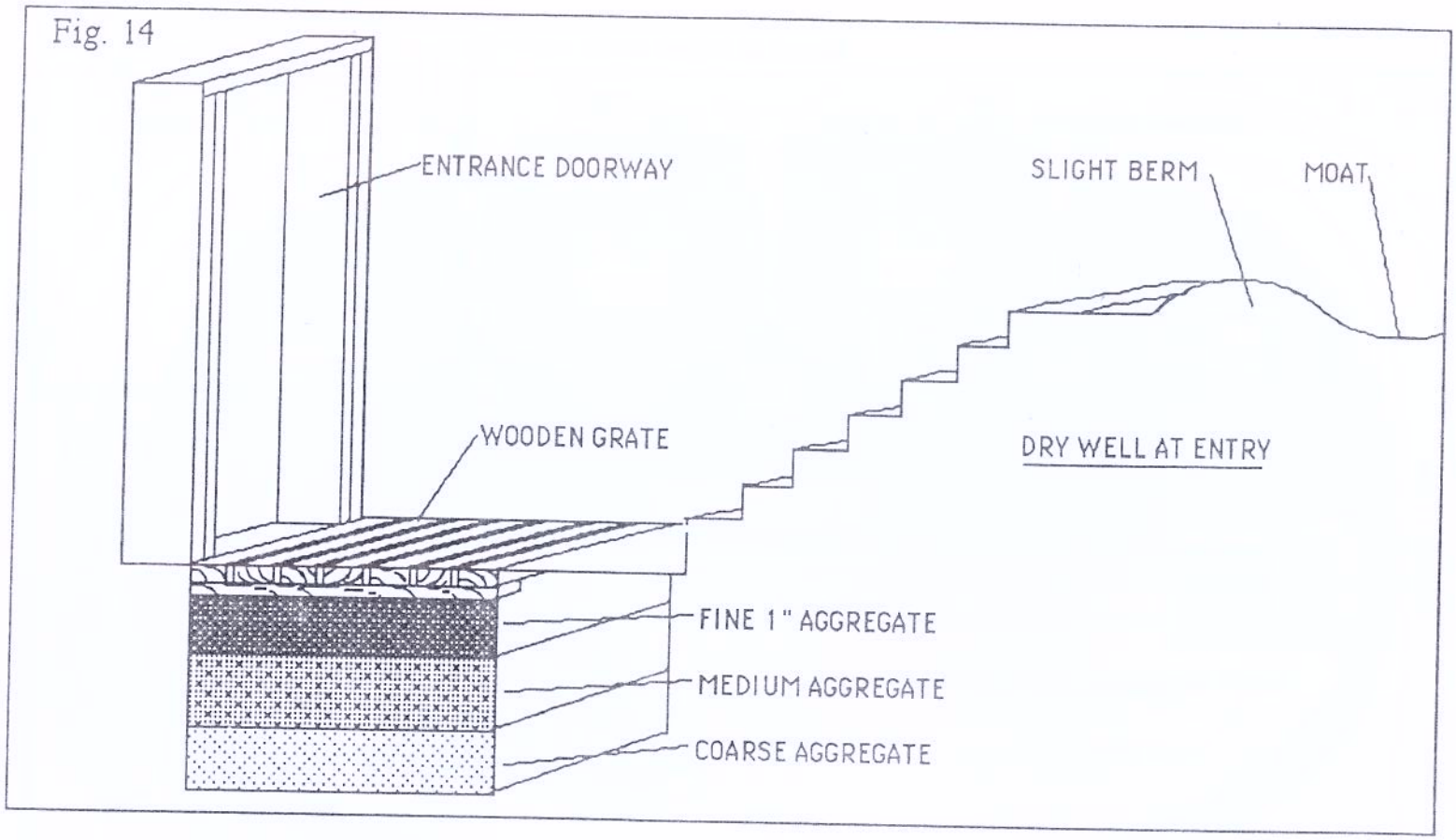
Plumbing vent and water pipes are located in 2x4 frame chases in much the same way as conventional frame houses. These chases are built into the can walls similar to door jambs (Fig. 12). They are made of 2x4 stock doubled on the sides with lath masonry ties every 16". They can be as wide or as tall as the condition calls for (Fig. 12a). Can masonry walls are then layed up to and around these chases as required. The chases are then covered with 1/2" CDX plywood, 6 mil plastic and metal lath extending 3/4" around the plywood to prevent a crack between the plywood and the can wall. Plumbing usually occurs in can walls. If your plan calls for plumbing against a tire wall simply build a 2x4 chase against the tire wall. Tire walls are never interrupted for plumbing.



FINAL BURIAL AND SITE WORK

Immediately after your building is roughed out the site shaping must be done to create proper surface water movement and drainage. Above is a typical drainage plan for a slightly sloped site. Water is taken around (east and west) the building via slight dishes or "moats" on the surface of the earth (Fig. 13)(also see page 40, ch. two). Canalies drain roof water into this dish. The steps going down into the building have a slight berm between them and the moat to keep water from running down the steps (Figs. 13b and 14). In this case all water is running south. **All earth should slope away from building.** A slight berm or "dike" on the south side keeps water from coming back in towards the building.

Fig. 14



DRY WELLS AT ENTRY

If your site shaping is done properly the only water that will collect at the bottom of the stairs going down into the building is the water that rains on the steps themselves. This is handled with a dry well. This involves a 3'-6" deep pit right in front of the door filled with large rock on the bottom, finer rock in the middle and very fine (1") aggregate on the top.

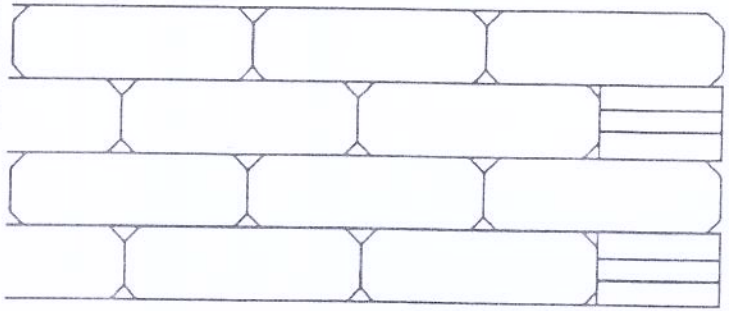
A wood grate can be built over the gravel if desired. This collects what little run-off is caught by the steps and takes it below floor level of the house.

9. FINISHES

THE FORMULAS AND TECHNIQUES FOR VARIOUS FINISHES

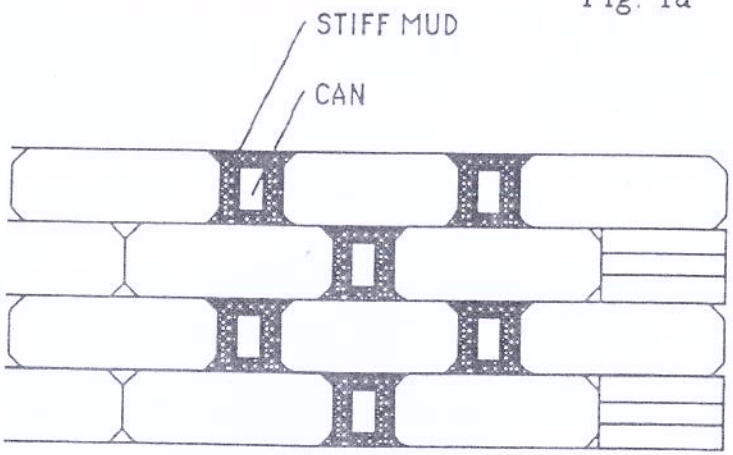
The finishing techniques involve some do-it-yourself methods and some professional plasterer methods. The do-it-yourself methods are presented step-by-step with referrals to professional plaster contractors when applicable.

Fig. 1



TIRES BEFORE PACKING

Fig. 1a



STEP 1

PACKING TIRES - STEP 1

Packing of the voids between the tires can begin very soon after the tires are laid. Step 1 is simply to throw a big double handful of stuff-mud in the void between the two tires and then stick an aluminum can in the mud. The can acts as a spacer to reduce the amount of mud needed and to facilitate its' drying.

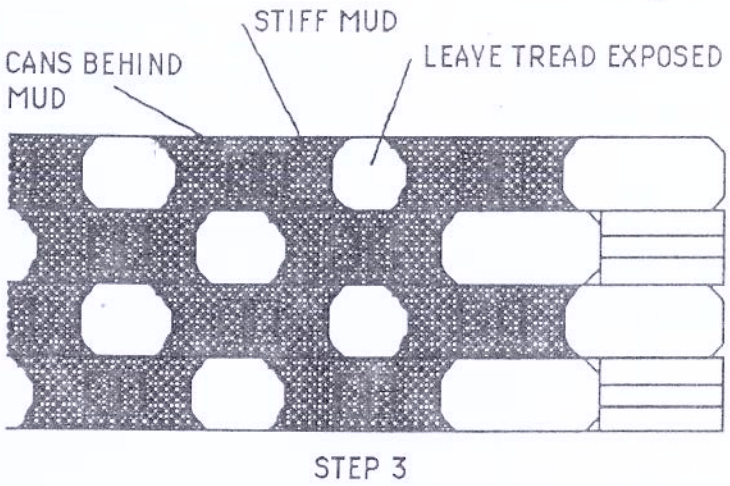
This job can be very easy or very hard depending upon the consistancy of the mud. The mud is mixed with half dirt from the site and half concrete-sand (course) and four large, double-handfuls of chopped straw per average electric concrete mixer load. This is equivalent to about one wheelbarrow load. Mix the sand, dirt and water in the mixer until it is soupy, then add straw until it gets so thick that it will hardly fall around in the mixer.

Wet the tires and throw on the mud.

The straw for this job is simply bailed straw run through a hammer mill. It comes out in 1" long straw fibers. Check your local feed or grain store for someone with a hammer mill. A leaf shredder will also work for chopping up the straw.

If the mud is too loose and runny this job will be next to impossible - **YOU NEED STIFF MUD.**

Fig. 2a



PACKING TIRES - STEP 2 + 3

First allow Step One to dry. New mud should never be applied over wet mud, but always wet the surface of dry mud when applying new mud. Misting the dry mud with a hose works well. Now use the same consistancy of stiff-mud as in step one. Slam two more double-handfulls of stiff mud into the voids you have left over from step 1. Cover the aluminum cans with mud and then stick on two more cans. (Fig. 2a)

Allow this to dry and with your hands push on more stiff mud (this may take two coats) until you bring the mud-filled voids out to the surface of the tire treads. You should end up with a mud wall with little sections of tire tread showing through (Fig. 2a). This wall should now be almost all in the same plane.

Electrical wiring rough-in should go in between Step One and Step Two.

Fig. 3

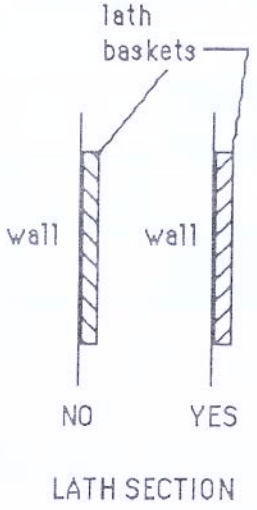
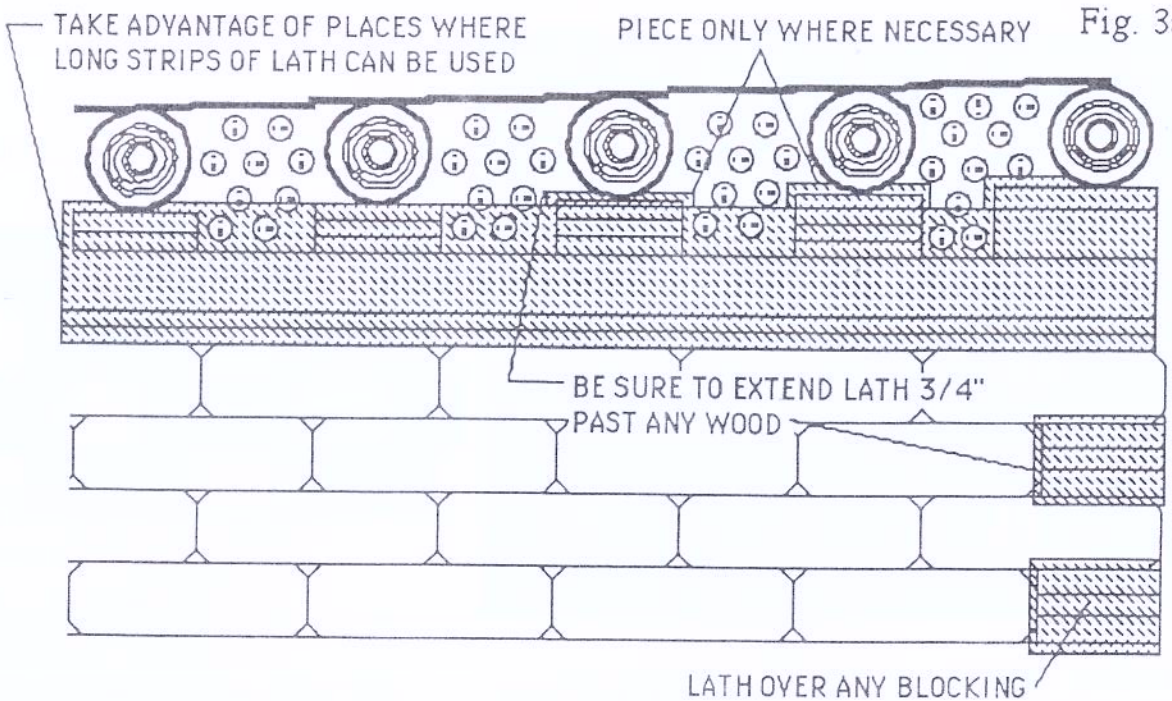


Fig. 3a



PREPARATION FOR SCRATCH COAT

The shelf above the tire walls where the blocking shims and can infill is should now be prepared for scratch mud. The cans should have been laid with mouth ends out. This provides a natural lath for receiving the scratch plaster. The wood should all be covered with 6 mil plastic stapled over it. Over this, nail on metal lath with 1 1/2" roofing nails. If you look closely, the holes in the metal lath are at an angle. One way they create little "baskets" that hold plaster. The other way angles down and allows the plaster to slide off. Angle the "baskets" up whenever possible (see lath section above) and the plaster will stick to the lath much better. Remember to allow the lath to overhang around the wood. Lath should always overlap joints between two different materials.

Fig. 4

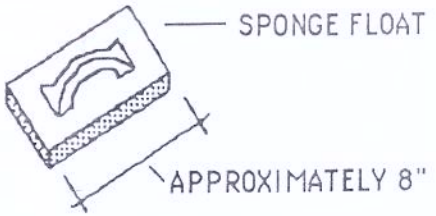


Fig. 4b

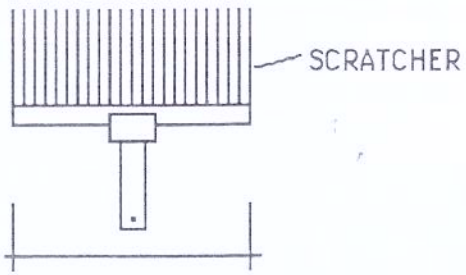


Fig. 4d

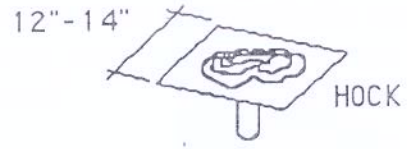
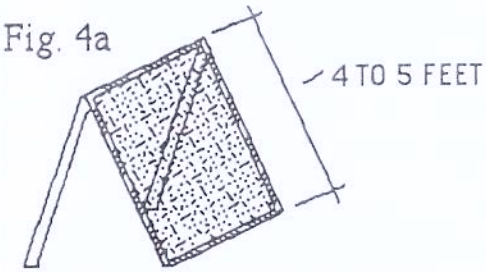


Fig. 4a

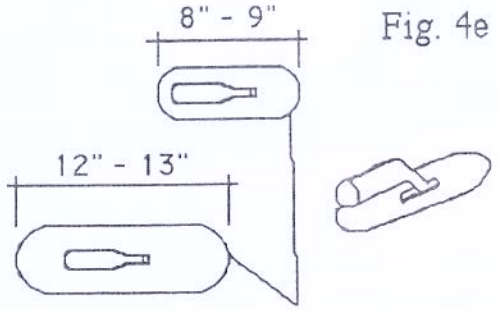


SITE CONSTRUCTED 1/4" HARDWARE CLOTH SCREEN WITH FRAME AND STAND

Fig. 4c

SMALL TROWEL

Fig. 4e



SWIMMING POOL TROWELS COME IN DIFFERENT SIZES BUT MUST HAVE ROUNDED EDGES

SCRATCH COAT

Now that all surfaces are prepared, you are ready to apply the scratch coat of mud. This coat is applied with swimming pool trowels that have rounded ends (Fig. 4e). It is also good to have a hock (Fig. 4d) to hold the mud. The mix is still half dirt from the site and half sand. However, the dirt must now be sifted through a 1/4" screen (Fig. 4a) and the sand must be plaster sand. Still mix a soup with these proportions and add chopped straw until it gets thick. This mix is not as stiff as the fill-packing mud. It must be able to be applied and spread with the trowel.

Sometimes two scratch coats are needed to get the shape one desires for the wall. Make sure the first coat is dry before applying the second. Never apply new mud over wet mud. Scratch the mud horizontally with a scratcher (Fig. 4b) after it is applied and is still wet. This makes the surface rough enough to receive the final coat. Make sure all surfaces are scratched while they are wet before moving on to finish mud.

Fig. 5

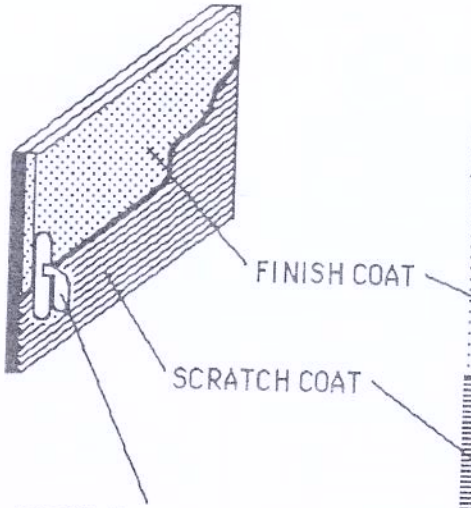
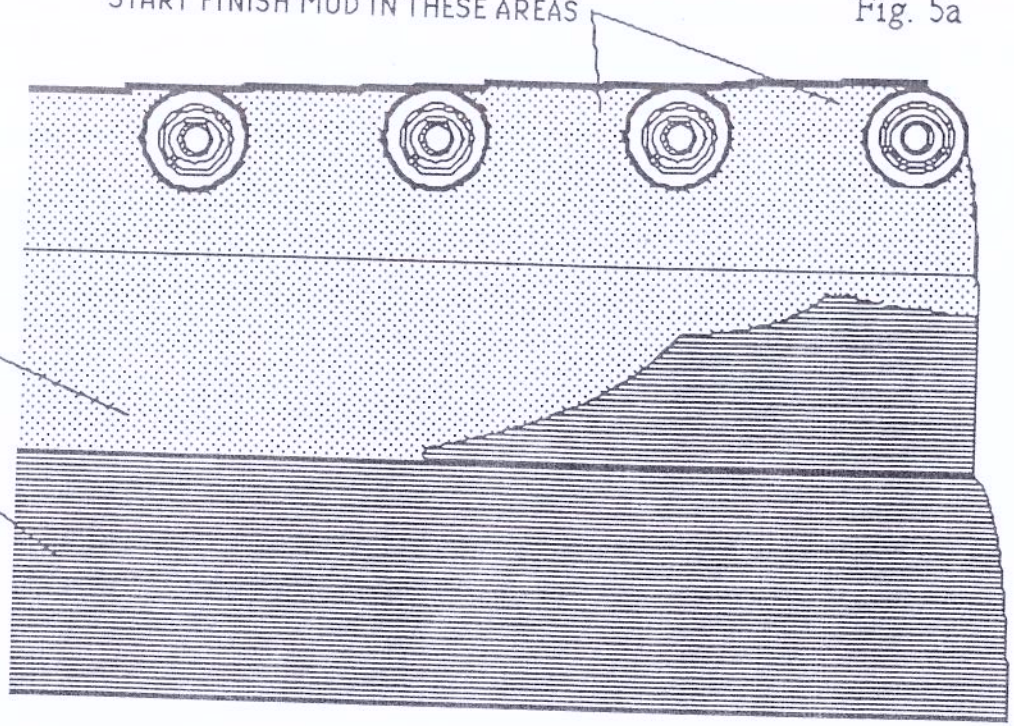


Fig. 5a



FINISH COAT MUD

Finish mud is a different proportion of sand and dirt. The proportion is usually two sands (plaster sand) to one dirt (sifted) with the same amount of straw. However, this varies relative to the clay content of your site-dirt. Several 3'-0" square test patches should be done with varied amounts of fine plaster sand in the mix starting with two sand to one dirt. You are looking for a finish that has no cracks. When you obtain the formula that works, you are ready to do an entire wall.

It is best to start with the high areas around the beams. These are small, more obscure areas with which to learn the nature of the mud. First, wet the wall thoroughly with a fine spray from a hose, then trowel on the mud using a small trowel in small areas. After you obtain the shape you want on the wall, you can get a smooth surface by spraying the mud with a plant-mist bottle. Spray (to make the suface slightly wet) and trowel until you get a smooth surface. Do this over and over, smoothing the

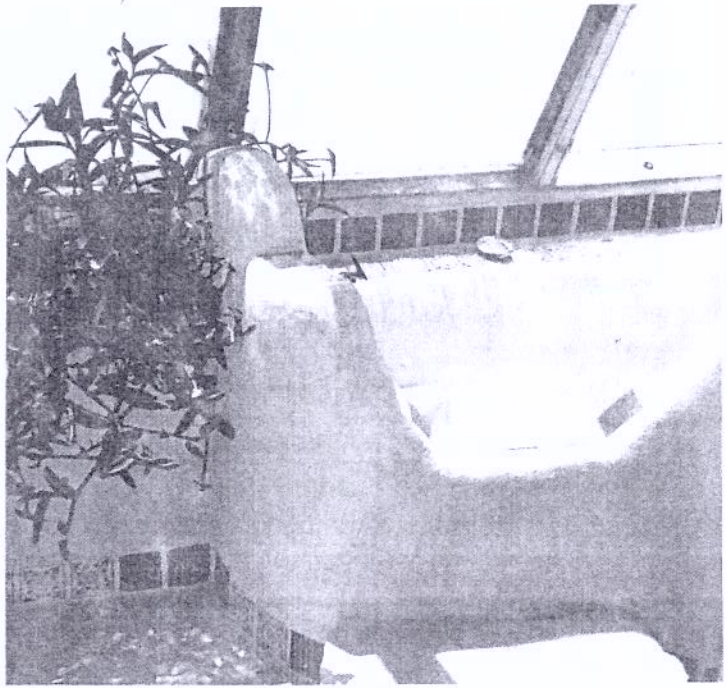
mud with very controlled, regular strokes of the trowel. Spraying the surface with the mist brings out the fine grain and allows you to work the surface until you achieve the look that you want. Never apply finish mud more than 1/2" thick since it will crack. Never let the finish mud dry in direct sunlight. Put a tarp over the windows if necessary to provide shade. If you are not going to paint the mud, you must "design where you place the seams" (where you start and stop a mudding session) since the seams will be visible. Plan out a wall section to mud so that the seam will be in a corner or hidden by something.

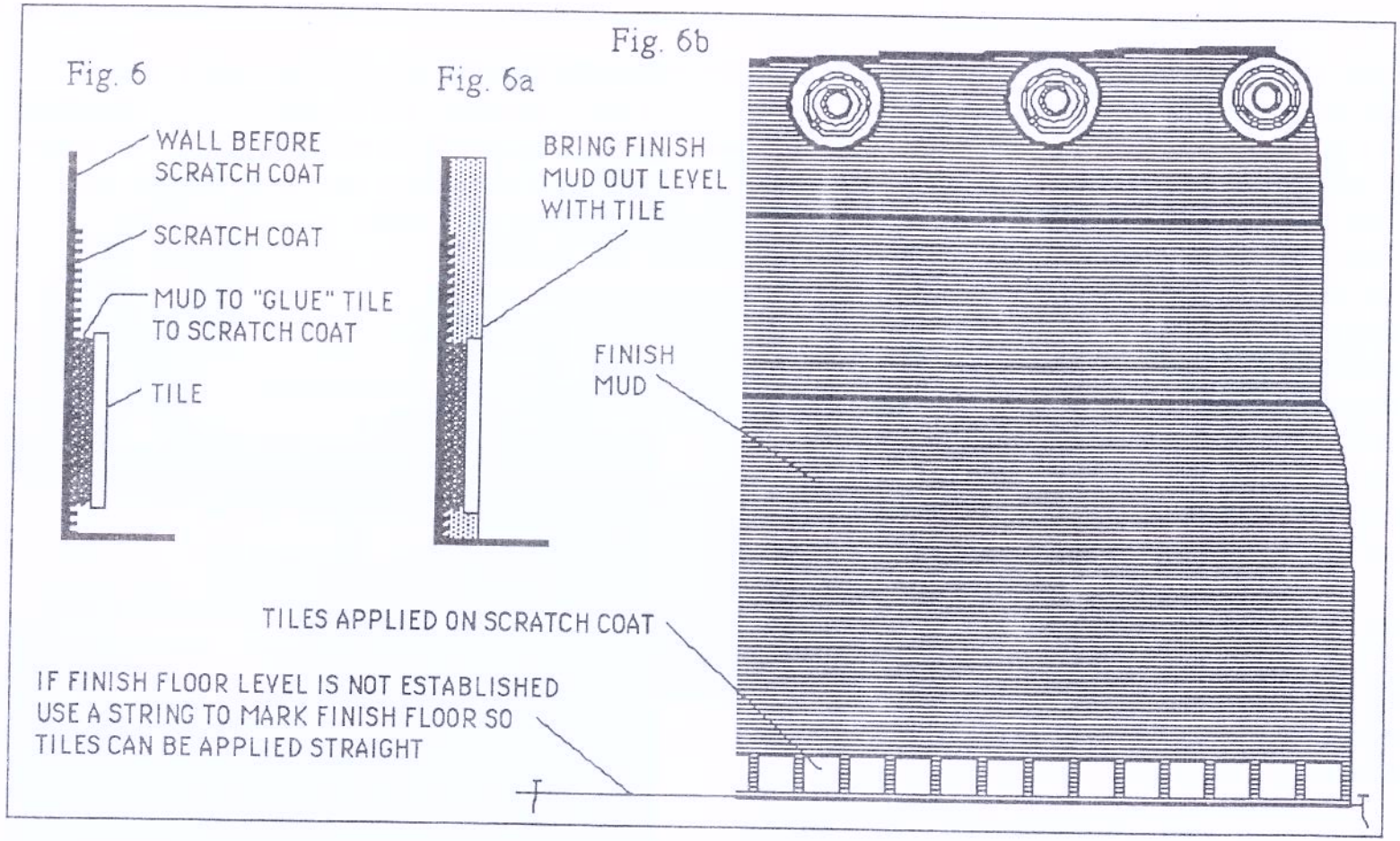
ALTERNATE FINISHES

Finish mud plaster can be painted with any latex , enamel, or epoxy paint. Cracks can be spackled and painted. Painting makes the mud more durable and refines the finish, however, it can also reduce the amount of sunlight absorbed by the wall.

There is a product available through builder's supply stores called "Structolite". It is a hard plaster that can be applied over scratch mud. It provides a more durable surface than mud plaster, however, it would most likely require a professional plasterer to apply.

Stucco companies now have many different acrylic products that come in any color and can be painted, troweled, or sprayed on. Consult your local building supply store. All of these products can be applied over Finished Mud. The idea here would be to get the shape you want with mud and then use an acrylic product for the finish.

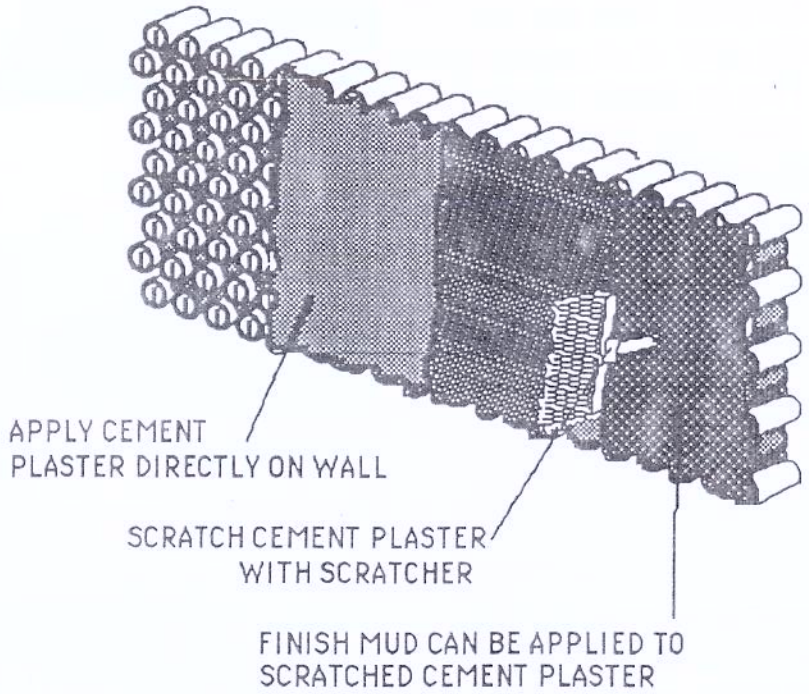




BASE TILES

After you get your scratch coat on, it is time to decide whether or not you want to have tiles at the base of your walls. This is a good idea since it acts as a baseboard and protects against mopping, brooming, and vacuuming, which all tend to scratch up the base of the wall finish. Tiles are installed by establishing a finish floor level with a string, unless you already have the floor installed, and "gluing" the tiles on the wall with a mud-mix. Soak the tiles in water and wet the wall surface, then apply mud to the back of the tile and press it on the wall (Fig. 6). Space the tiles about a fingers thickness apart. Finish mud plaster can now be brought out to the face of the tile (Fig. 6a + b).

Fig. 7



PLASTERING ALUMINUM CAN WALLS

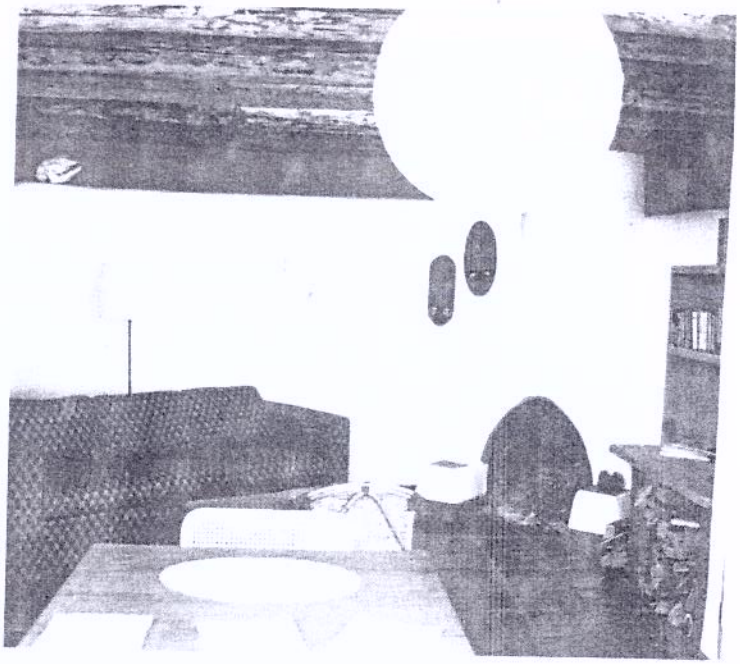
Aluminum Can Walls are laid with the mouth opening pointing out. (Fig. 7 above and 43a, page 155) This creates a natural lath surface for the plaster. When aluminum can walls are finished on both sides (as with a partition wall) then alternate the direction of the mouth openings as you build the wall (Fig. 8a page 162). This allows for the "lath surface" on both sides and provides for a good plaster connection on both sides of the wall.

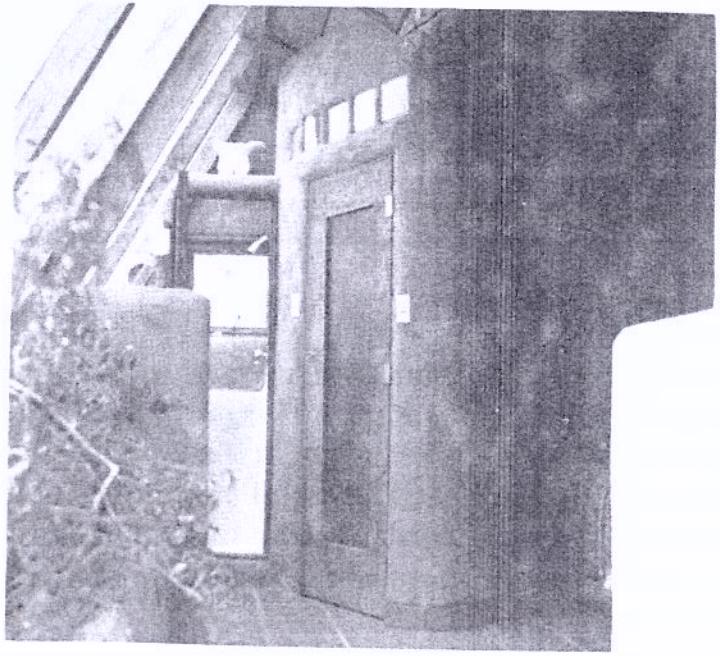
The can walls are scratch-plastered with cement plaster in order to add strength to the wall since the cement IS the strength of the wall. A mix of one part Portland cement to three parts plaster sand is used. Wet the wall and apply the plaster with a swimming pool trowel, then scratch it horizontally with a scratcher (Fig. 7). Finish mud can be applied over this cement-scratch coat if you wish to match the finish of the tire walls.

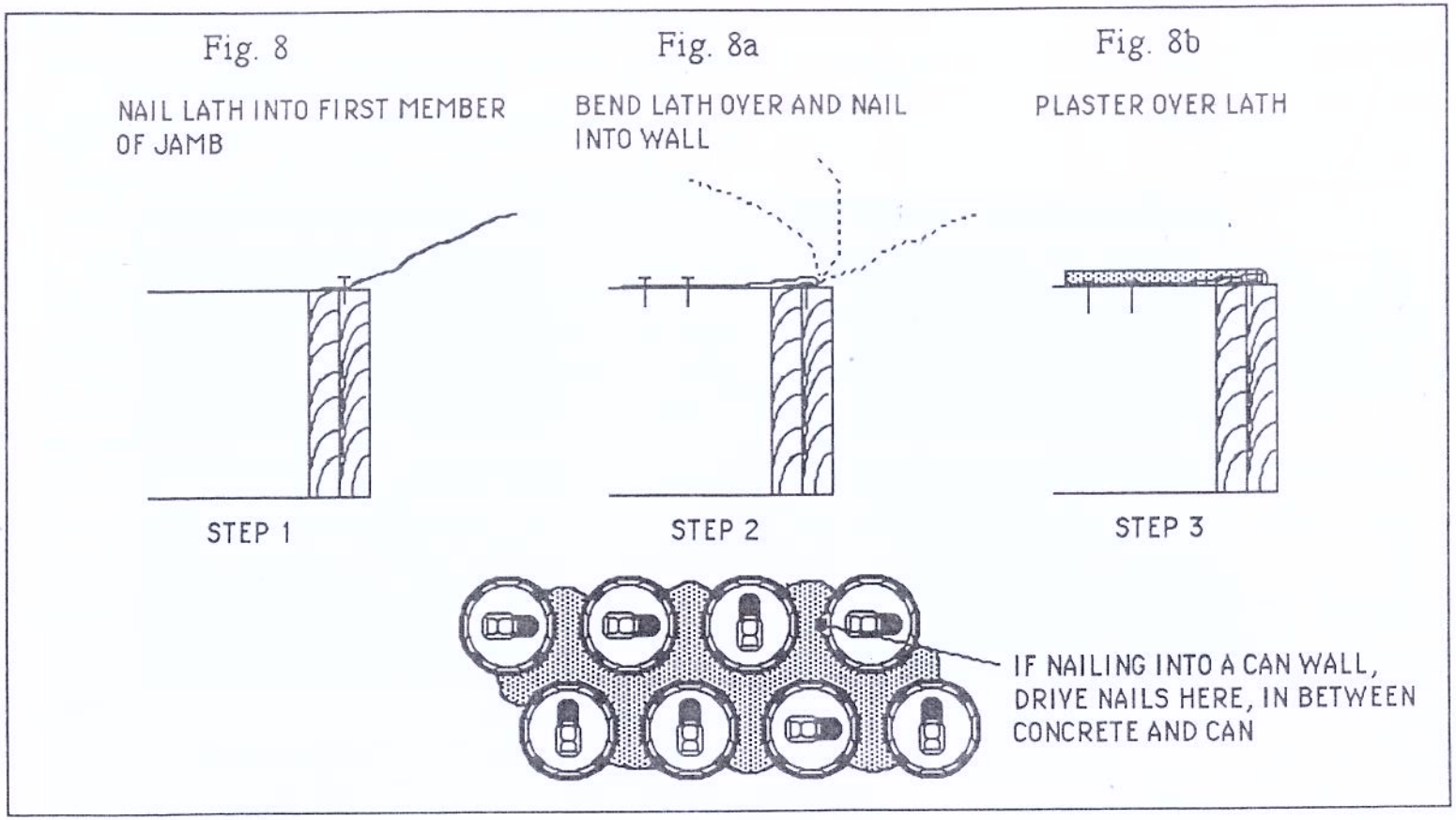
If you are finishing the wall with something other than mud, (i.e. stucco) if the wall is in a bathroom or is an exterior wall, then the next step after cement-scratch coat is to apply a "floated-brown coat". This is simply another coat of the same mix (one part Portland to three parts sand - though, some people add a 1/2 part of masonary cement to the formula). This coat is for shaping the wall, thus, after it is troweled on, it is "floated" with a sponge float (Fig. 4, page 177). This is a standard building technique and any plaster contractor can help you with it. All plaster of any kind should be allowed to dry out of direct sunlight in order to avoid cracking due to quick drying.

After the brown coat is applied, conventional stucco, Structolite, or any hard plaster can be applied. Consult a plaster contractor if you do not want a mud finish.

Internal mud finishes are not limited to the southwest. They are quite durable - especially with paint - and can be easily applied by the average do-it-yourselfer. Different regions of the country require some experimentation with the proper formula.



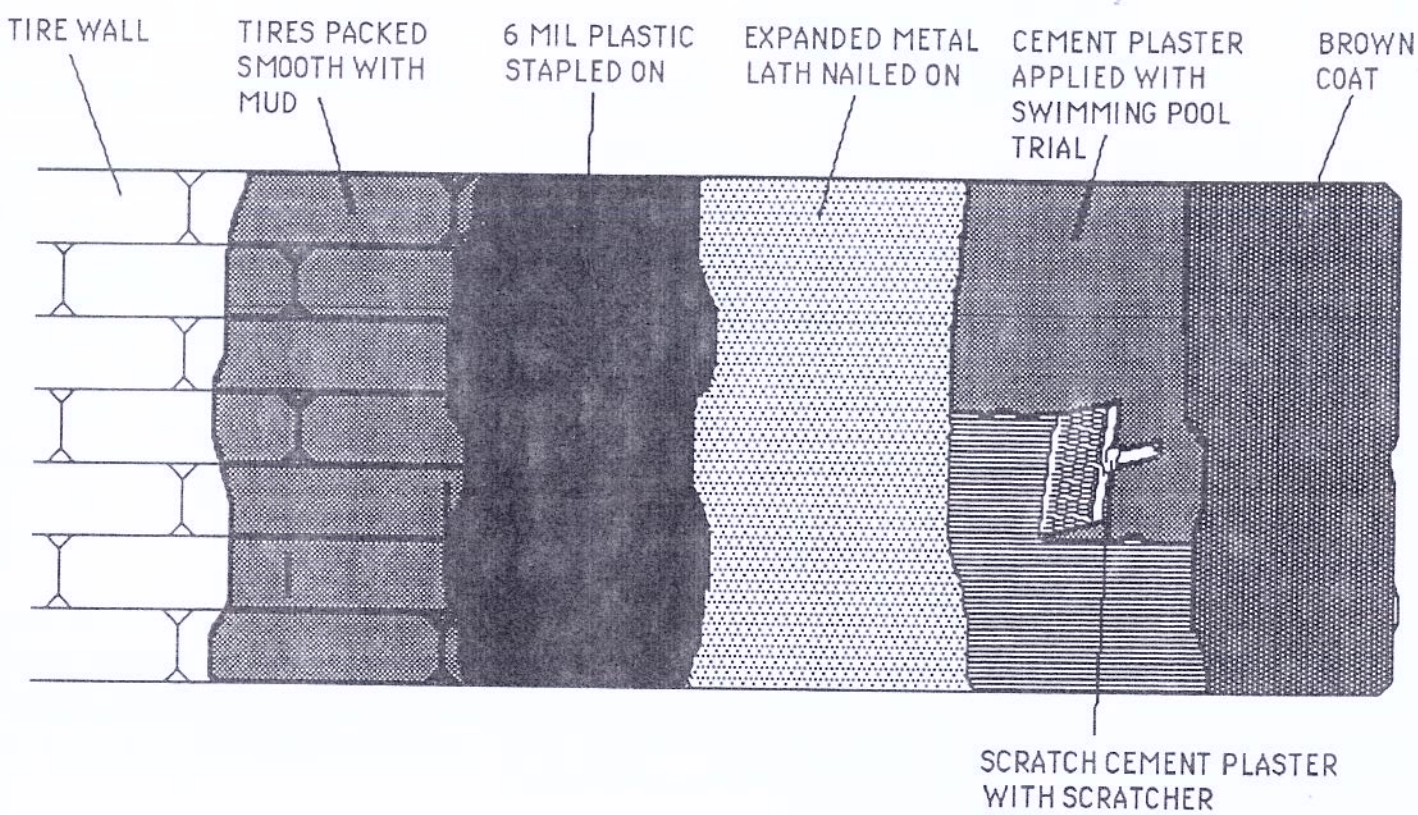




PLASTER PREPARATION AROUND DOOR JAMBS

Any mud plaster or cement plaster that comes in contact with a window or door jamb must have a "bull-nose" metal-lath detail applied in order to "tie-down" the plaster to the wood. Since, otherwise, it will simply crack and fall off around the woodwork. The bull-nose detail is done by nailing four to five inch wide strips of expanded metal lath to the corner of the outside jamb member (Fig. 8), then bending it back over the wood against the adjacent material - cans or tires (Fig. 8a and 8b). The overlapping flap must then be nailed into the other material. If the adjacent material is a can wall, use 16 cc nails and nail in between the cans and the concrete. Nails won't hold in cans and they won't go into concrete, but they will hold if they are driven in between the two. This detail is often forgotten, but it is a very important detail in finishing your building. Any wood, window, or door-jamb must have a bull-nose lath detail.

Fig. 9



EXTERIOR PLASTER

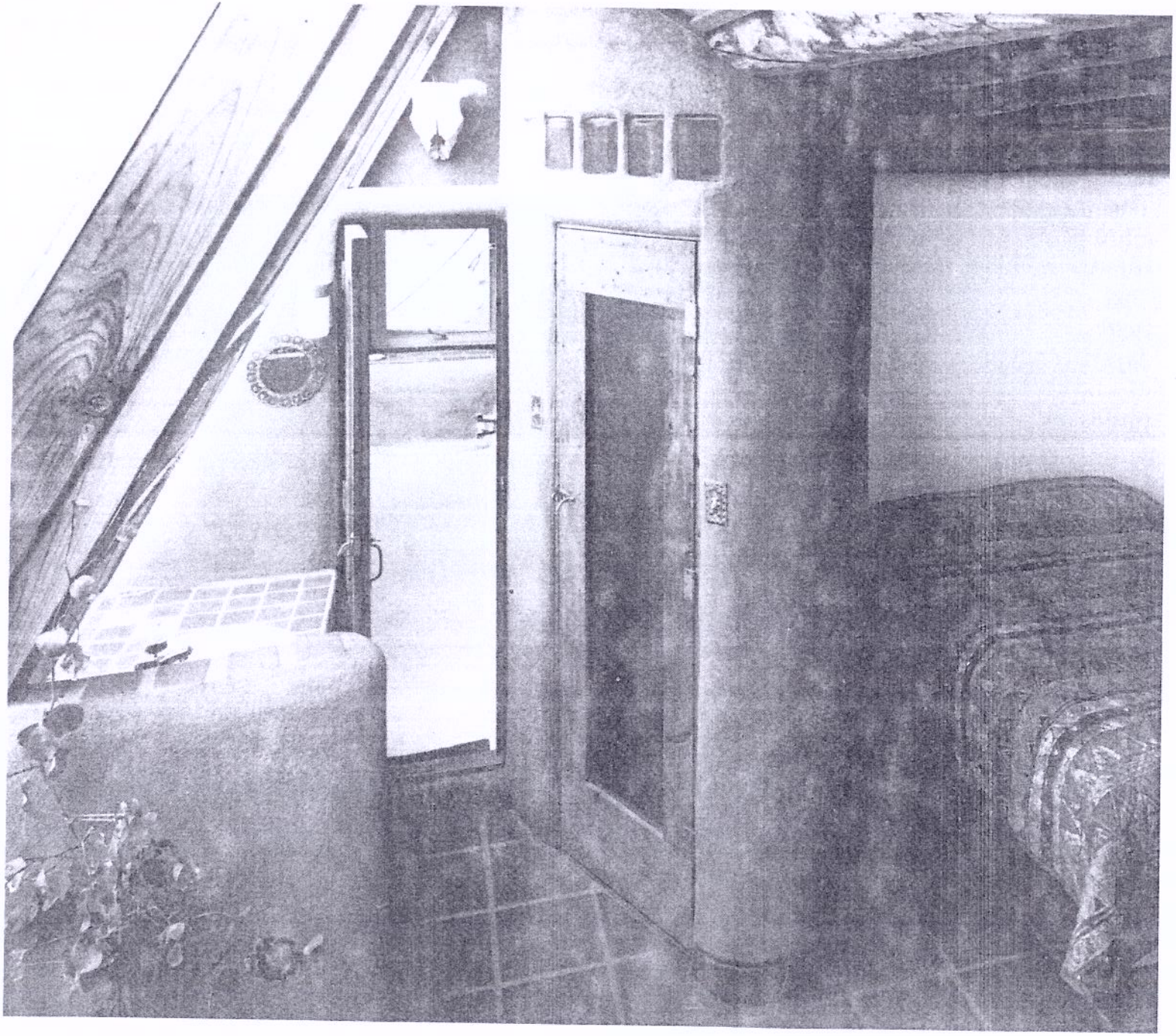
Anytime wing walls on the exterior are packed out to a smooth plane with mud (Pages 174-175), they should be covered with 6 mil plastic that is stapled on. This is then covered with expanded metal lath, baskets up (Fig. 3, page 176). Aluminum can parapets have their own "built-in" lath. Any other odd details or materials should have metal lath installed in preparation for scratch plaster. Conventional scratch plaster can then be applied, one part Portland to three parts plaster sand.

Exterior plaster takes much abuse due to weather changes. For this reason, small synthetic fibers are added to this mix. There are different brand names for these fibers. Usually about two handfuls per wheelbarrow load is enough. The fibers are known as "structural concrete fibers" and can be bought

at your local builders supply store or concrete company.

After the scratch plaster has cured, a "floated brown coat" is applied in order to achieve the desired shape and provide a surface for stucco. This is a conventional technique and therefore a professional plasterer can be consulted. The fibers should also be included in the brown-coat mix. Sometimes plastic cement is used instead of Portland cement. It is more expensive, but it helps prevent the formation of cracks. See your builders' supply store or professional plasterer.

Conventional stucco or one of the new acrylic stucco products can be applied over the brown coat. The brown coat can have many additional applications if you do not obtain the shape you want right away. Just don't put it on too thick since it is better to build up through many layers. Consult a local plasterer for stucco products and applications in your area.



10. OWNER'S MANUAL

HOW TO OPERATE YOUR "EARTHSHIP"

In that Earthships are a new concept in living techniques as well as construction, some specialized knowledge regarding operation and maintenance of an Earthship is required. This chapter will help you derive the most comfort and performance from your Earthship.

TEMPERATURE

Too Hot

If you are too hot, it could be from air temperature, direct sun or both. If direct sun is involved, see the shading section. To cool the air temperature down, you must create a "chimney" for hot air to leave and an inlet for fresh, cooler air to come in. Often, the air movement itself has a cooling effect. This, in a subtle way works like a windchill factor. All "U"s should have an operable skylight. Simply open the skylight in the "U" that is too hot, and open the nearest front face window and/or door to that "U". This creates the chimney and the inlet and breeze. Each "U" has the potential for individual temperature control this way.

If your Earthship is on two or more levels, the entire building can be cooled by opening fully the highest skylight in the highest room and the lowest windows or doors in the lowest level. This creates a chimney effect and gentle breeze throughout the whole vessel. Any combination of venting individual rooms and/or the whole building will have an effect. If the air is crisp and cool outside, you will find that it doesn't take much before you will close your skylights, as you will have exchanged all the air in the space for fresh, crisp air very quickly. If the outside air itself is warm, you may keep the "chimney effect" operational all day long. In this case, the gentle breeze is a factor of the comfort level.

Obviously, weather conditions and local climate are factors of venting, however, it is typical for Earthships to have some venting (even if the windows are just slightly cracked open) almost all year round. Cloudy winter days and winter nights are the only times venting is not typical. For the most part, fresh air is always drifting through the vessel. The tremendous thermal mass allows winter venting since we are not as concerned with heating air as conventional heating systems are. We are living next to a giant warm "body" - the body of the Earthship. Air movement helps keep pests (bugs and white flies) to a minimum and people healthy.

Too Cold

Obviously, if you are too cold, you must close all vents, windows and doors. In winter months, or cloudy weather it is always good to close the vessel up if you are not at home. This allows heat to be stored in the house while you are gone. When you come home, the air will feel stuffy. Simply create a "chimney" effect as described above for a brief time (10 minutes) and you will have changed all the stuffy air. **Do not vent in the winter while you are not home.** This keeps the mass from storing heat. In the winter, always keep the individual spaces unvented (closed up)

if you are not in them. The more heat they are allowed to store, the longer they will be warm without sun or auxilliary heat. The point here is that you must be aware that **you can over-do venting in the winter** and retard your collection of heat storage in your mass. Winter venting should be employed only when comfort or air quality demands. The rest of the time you should be storing heat whenever possible.

In extremely cold climates, with many cloudy days, insulated shades may be necessary. All east and west windows should have insulated shades anyway. The south sloping windows are designed to have insulated shades installed between the struts as shown in Fig 1. These insulated shades are available through Solar Survival Architecture (SSA).

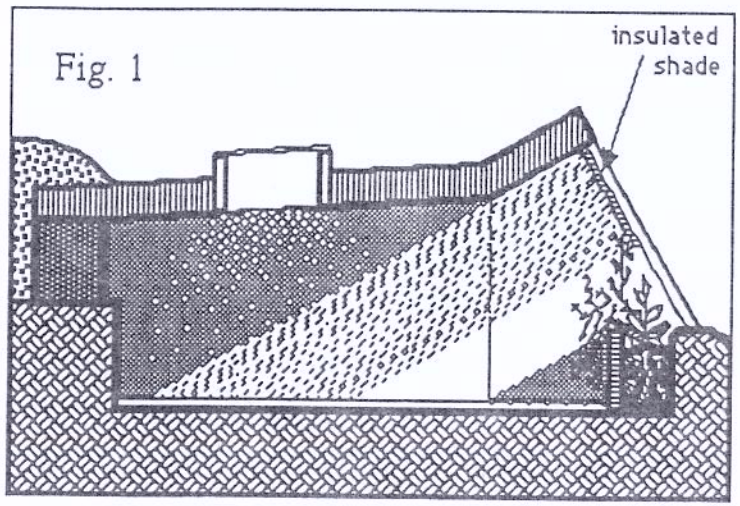


Fig. 1

The shades are closed at night, if needed, to retard heat loss. Earthships have been in operation in extremes as low as -30° fahrenheit, and these shades have not been necessary. However, it is conceivable that there are some conditions where they would be needed.

If control of venting and/or insulated shades does not provide the comfort level you want, a small amount of back-up heat is necessary. This condition would be more likely in high ceiling areas or areas where a large amount of east or west glass has been used. A fire place, small wood stove, small ventless gas heater, or warm floor system is recommended here. Earthships are so massive and well insulated that a very small input of heat from any source goes a long way.

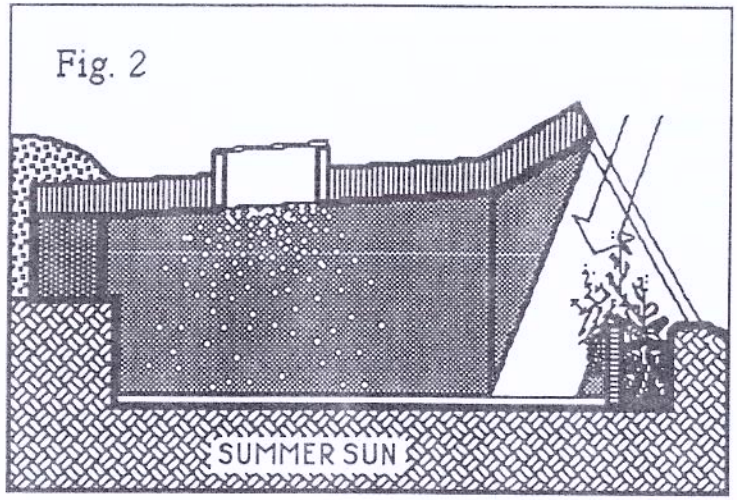
Bathrooms that are not directly on the solar face often require a blast of heat after a shower. This can be achieved with instant electric heaters with fins or small gas units. Wherever the possibility of back-up heat exists, it should be roughed in first with electric wiring and gas lines. Add the actual heating unit only if you find that you need it. Very small amounts of heat go a long way in Earthships. Most Earthships have and need nothing but a fireplace for back-up heat.

SUNLIGHT

Too Much

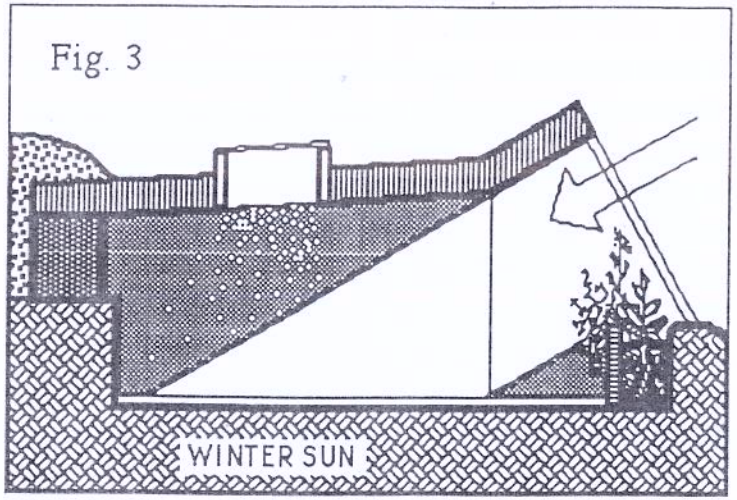
The Earthships are designed so that the sun does not come into the living spaces in the summer (Fig. 2), while it floods them in the winter (Fig. 3).

Fig. 2



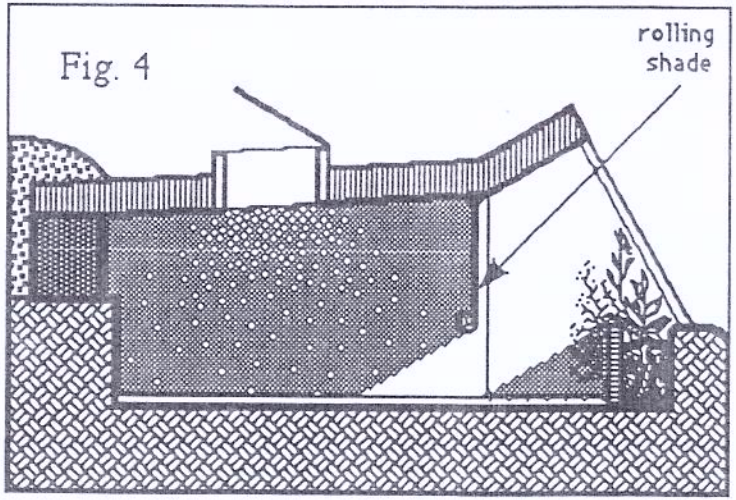
Summer sun doesn't go any further than the greenhouse hallways. If you have developed any seating areas in the greenhouse hallway, you may want to shade them in the summer. Shading is also necessary occasionally in the winter when the sun enters the living spaces. There are two specific ways to deal with shading in the Earthship.

Fig. 3



The first way is done with drop shades or drapes (Fig. 4). **This method can totally shade the "U" while still allowing the Greenhouse Hallway to heat up and collect heat.** It is the most economical and

Fig. 4

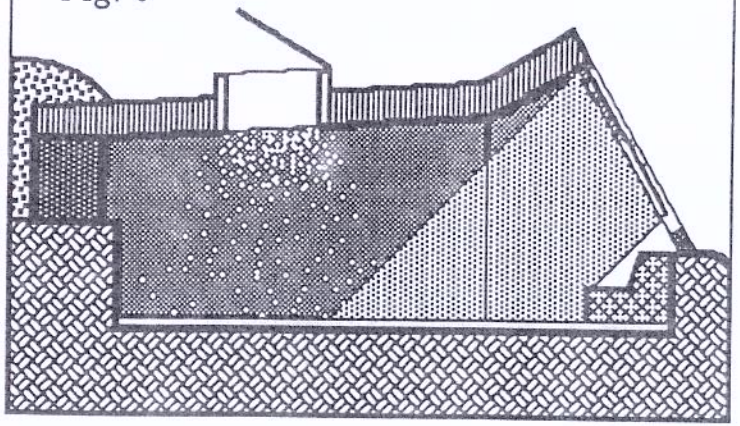


easy way to have some sun control. It is rarely used in the summer, since the sun doesn't come

in any further than the greenhouse hallway. Any type of roll-up shade or drape will work. Roll-up shades have the advantage of not being dropped all the way down, thus allowing winter sun to still heat the floor while you are in shade.

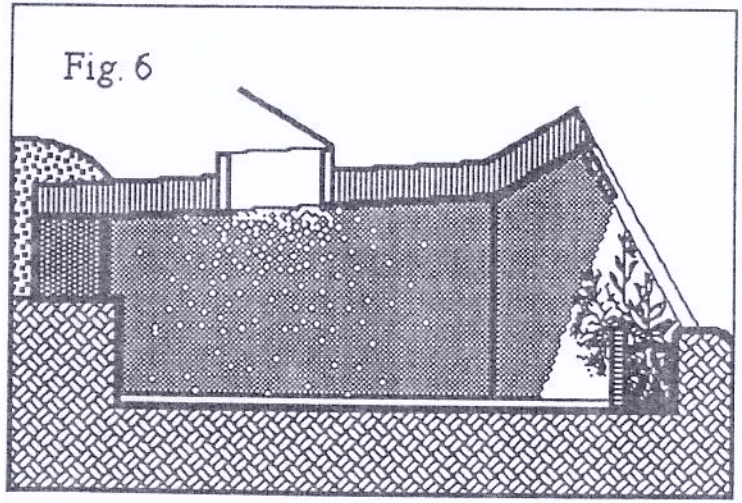
SHADING ON THE FRONT FACE

Fig. 5



Front face shading is only recommended if you have built seating areas instead of a planter under the glass (Fig. 5). There are times when this will be a delightful place to be and times when the sun here is too much. To have some control over this situation, you would need a front face shade. There are many shades available that will fit between the 60° sloped struts, and will slide up and down on the guide rails, thus keeping them against the front face. SSA is a dealer for a very lightweight shade that will work here. They come in white and a variety of colors. The disadvantage of this type of shading is that it cuts off **all** sun to the area - hallway included - so that you are cutting off your heat absorption by fully shading against the glass. Therefore, this type of shading should be used sparingly in the winter - perhaps by only letting it down two or three feet when in use (Fig. 6).

Fig. 6



This lets the sun into the greenhouse hallway and floor, but shades the bulk of the "U".

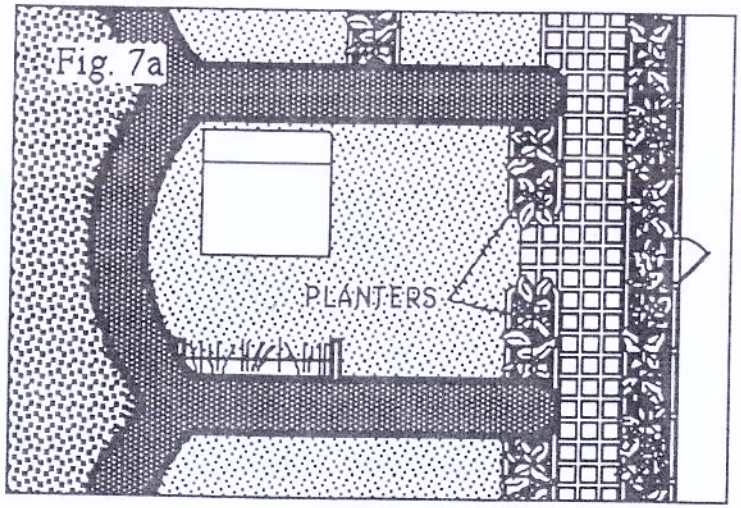
NOT ENOUGH SUN

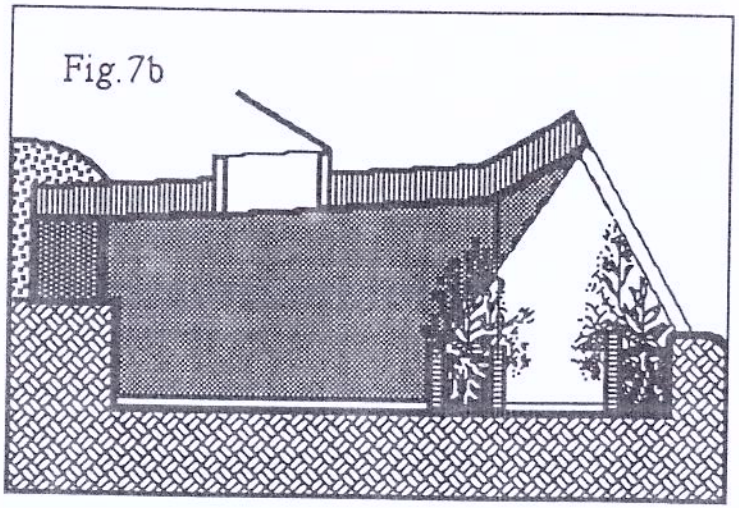
An advantage of front face shading up against the glass is that in extremely cold climates with very little sun, these types of shades could be let down at night to insulate the south windows from heat loss. In areas where there is a lot of sun, this is not necessary due to the tremendous gain and storage capacity of the Earthship, however it is an advisable device in cold cloudy climates.

The bottom line with shading is to know what you are trying to do with it and what the consequences are, so that you can select the proper method.

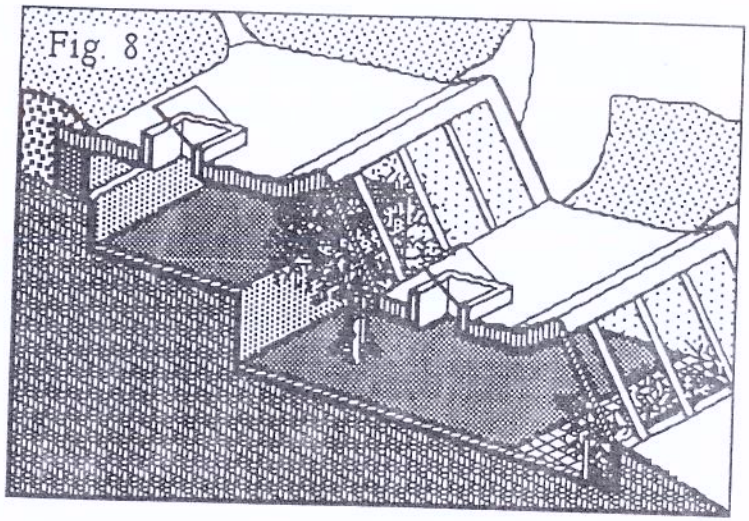
PLANTS

The greenhouse hallway heating duct is the major place for planting because it gets full light all the time. Another very good place for plants is between the "U" and the hallway (Fig. 7a and 7b). This area gets full sun most of the time. Planters in this area can be open on the bottom to tap into uncontained earth.





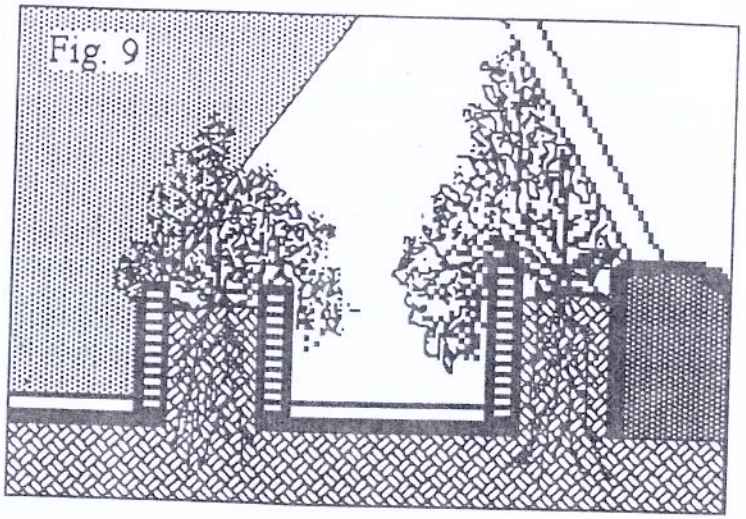
Here the plants can act as a partition to give some shade and/or privacy to the "U".



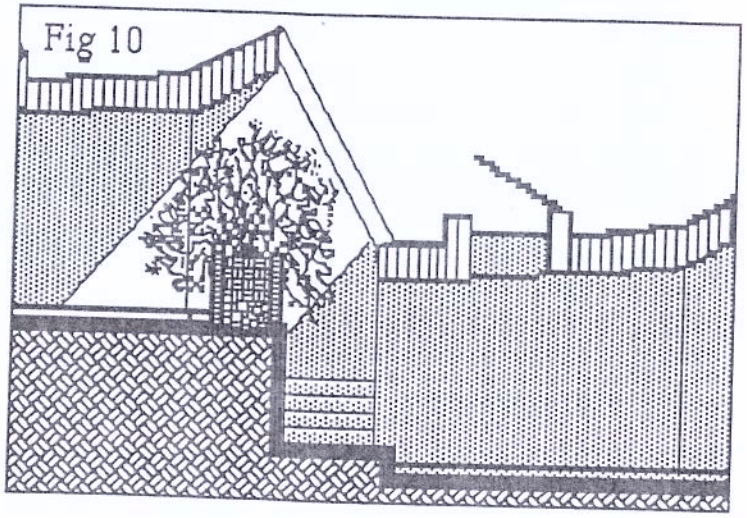
In some step arrangements of "U"s, two story spaces are created which allow trees to grow (Fig. 8). The Earthships are thus designed for maximum living with plants. The reasons for this are for food, beauty, oxygen/CO2 exchange between people and plants, and for convenience. It is very easy to tend a garden if it is on the way to your bedroom.

Living with plants to the extent we are talking about in an Earthship does require some understanding of the nature of plants themselves. There are many opinions and theories about how plants should be cared for. The instructions in this section are those of the author, based on 15 years of living with large amounts of plants.

Planters on single level Earthships go directly to the ground.



That is, the planter has no bottom (Fig. 9). Planters that are on upper levels of a stepped arrangement are contained, drained and have a rock and gravel bottom to facilitate drainage (Fig. 10).



Planters are filled with topsoil from the site up to the last 6 inches. The last 6" is topsoil from

the site mixed with sand, vermiculite and peat moss. Any soil that is used over and over has to be fed. Household grey water should be directed or caught and poured into planters whenever possible. This is a "natural" way to feed your soil with your own by-products. All plants love dirty bath water and the food particles in the kitchen sink water. Mild soaps like Ivory Liquid, when diluted, are actually good for plants in that they help to immunize plants against pests. Grey water systems will be discussed in depth in Earthship Volume II.

There are some plants that require almost no care, grow fast and are very hardy. These are the best plants to "establish" your green areas with. You can come back later and clear out areas for more delicate plants that require more time and care. The hardy plants will practically take over and there are very few bugs that will harm them. Even later, when you plant more delicate plants or food producing plants, which are more vulnerable to bugs, it is best to leave "patches" (sometimes as much as half the area) for these hardy plants since a large area of delicate plants is easy prey for bugs. When there are strong hardy plants on either side of delicate plants, vulnerability is somewhat reduced.

These hardy plants are:

Wandering Jew - There are many varieties ranging from green to purple leaves. All have blooms. All need almost no care and they simply take over. Bugs never bother the Wandering Jew and plants can be started from a trimming stuck directly in the soil. Keep it very wet until it takes hold - about one week.

Geraniums - There are many varieties, all of which have beautiful blooms in many colors. They spread rapidly and bloom often. They get no bugs and fill planters with foliage up to 3' high. They can be started with a clipping stuck directly into wet soil - keep it wet until it takes hold and starts growing.

Bulb plants like Amaryllis, lilies, iris, etc. all do very well with no care.

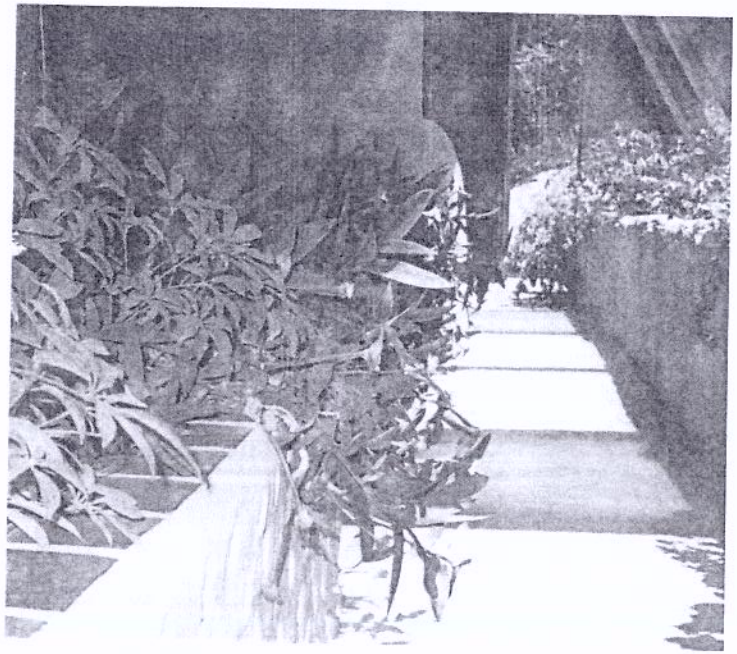
Grapes - Grapevines take over and vine up the windows providing shade in the summer. They are cut back all the way in the winter and have very few problems. They also provide grapes!

Aloe vera - Aloe is a good plant to have around for medicinal purposes (see a medicinal plant book). It spreads, needs little or no care and gets no bugs.

Any succulents - Succulents can take the sun and grow rapidly in the Earthship environment.

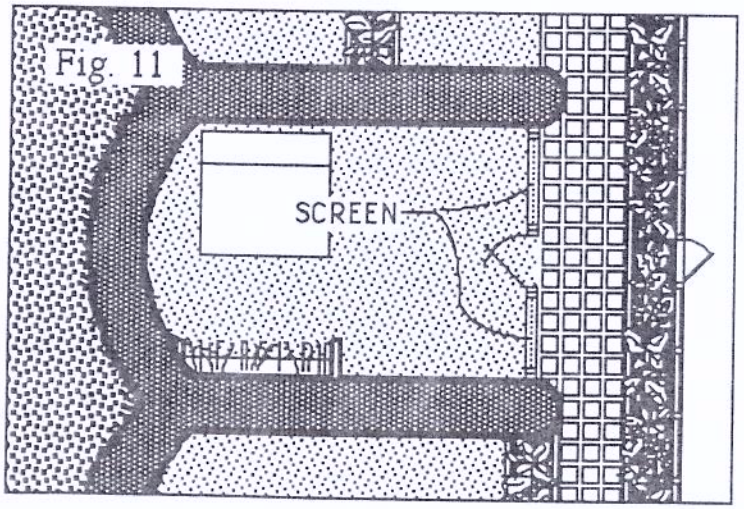
All of the above plants are easy to obtain, easy to start and are resistant to bugs. They will

establish your green areas. After you fill your green areas with these plants, you can come back and clear out certain areas to plant more vulnerable plants that require more care. You will have too much to care for until you slowly program plants into your life. It is strongly recommended that you start with plants that require little care and slowly integrate plant care into your life. It is very depressing to have a greenhouse full of sick, screaming dying plants that you have no time to care for. This experience will dampen the whole idea of living with plants. Start with an easy situation and work into more variety. Large amounts of plants can take much time, work, and money to care for - more than you may realize.



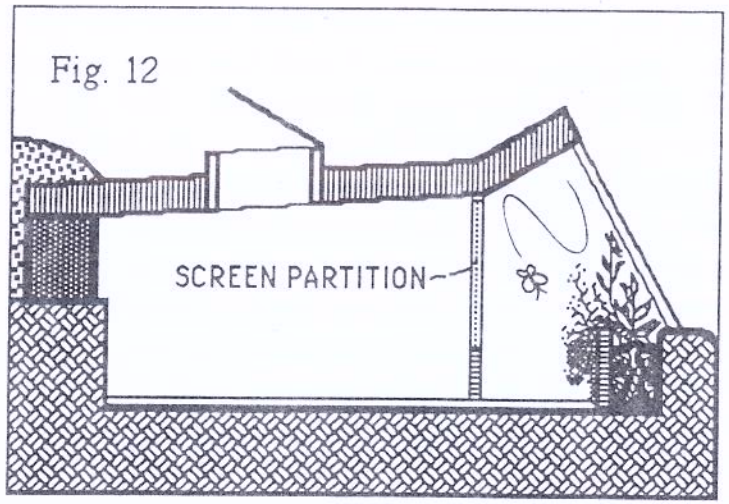
BUGS

Most food-producing plants are vulnerable to various pests. Common pests are white flies, aphids, and pill-box bugs. There are other insects that appear around large planted areas that aren't necessarily pests. The idea is to keep pests to a minimum, and simply allow some insects to exist with the plants. To try and create a sterile environment is not healthy for plants or humans, and is a very expensive, time-consuming, loosing battle. Plants will have some bugs since this is natural. Ideally, the greenhouse area should get much fresh air, and have some bees and butterflies passing through.



If bugs completely scare you, some "U"s could be closed off or screened off from the growing areas (Figs. 11 and 12).

Fig. 12



The point is that plants require some insects for pollination and policing for harmful insects. For instance, lady bugs are often turned loose in greenhouses for the purpose of eating aphids. If you want to live with plants, you must accept some bugs. One of the most common mistakes made in living with plants is the struggle for a sterile (no bug) environment. **The solution to the bug problem is control, not annihilation.** Many methods can help control bugs. One easy way is to mist vulnerable plants often with water that has a few drops of Ivory Liquid in it. Anything yellow with something sticky on it will attract and catch white flies. Lady bugs eat aphids. Misting with water that has tobacco soaked in it causes many pests to run. Don't try to get rid of all of them. Just don't let them take over. This will keep you from frustration. This is another reason to start with "bug free" hardy plants as discussed above, and gradually work into the more vulnerable food producing and flowering plants. One of the best defenses against pests is strength. Strong plants have their own resistance. Grey water is one of the best ways to make plants strong. The more watering you can do with grey water, the happier and healthier your plants will be. There are many ways to capture and distribute grey water. These will be discussed in Earthship Volume II.

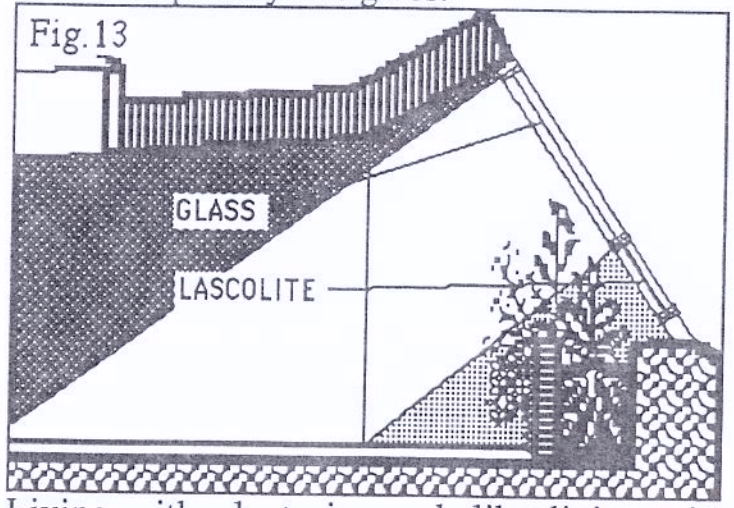
FOOD PRODUCING PLANTS

Food production is a major reason for living with plants. To be able to stagger crops and harvest a little at a time (as opposed to massive harvests, canning, etc. of a conventional garden) is a luxury and a convenience available to Earthship owners. Easier plants to start with are tomatoes, zucchini, romaine lettuce, and bell peppers. All can get bugs, but if the bugs are kept to a minimum, via the techniques mentioned previously, you can get much produce that is far better in quality than any store bought produce - organic or not. Almost any vegetable, herb-citrus product, or root crop can be grown inside. Serious production would definitely demand grey water use.

Conventional glass does allow plants to produce; however, in areas of serious food production, the plastic and acrylic glazing

products produce a diffused light with more of the ultraviolet light that plants like. Serious food production is more successful under Lascolite or a similar product. (See your local solar supply store for obtaining Lascolite or similar products). If you can live without a view in certain areas (you can't see through Lascolite), Lascolite glazing would be recommended for optimum food production. Regular glass glazing units could be installed every third window to get the best of both worlds for intense production areas. Or, another method is to make the bottom 2'-0" of glazing Lascolite (or equal) and then make the top 6'-0" out of regular glass (Fig. 13). This requires a little more detailing but gives you the best of both worlds. Some people also like the added privacy this gives.

Fig. 13



Living with plants is much like living with other people, i.e. a family. You must relate to their needs as well as your own and try to integrate the two. You can't ask plants to adapt totally to your world if you want them to produce. This is how we get some of the inedible foods we find in stores. Plants like grey water, some bugs, fresh air, strong friends, (neighboring bug resistant plants) and, in serious production areas, a plastic (Lascolite or equal) type of glazing.

Food crops produce longer inside an Earthship, but they do have to be ripped out and replanted as they get old. Some tomatoes produce for as long as a year if they are happy. Plants should be considered and provided for just as another "member of the family." Pets have this status - why not food producing plants?

MAINTENANCE

Any building or vessel requires maintenance. Since Earthships are mostly covered with earth on the north, east, and west, maintenance is basically limited to the south face which is mostly glass. Whatever wood you use on the south face should be oiled once a year for longer life.

Site drainage should be inspected and reinforced annually. **Make sure surface water is always rapidly running away from your vessel.**

Interior mud finishes can be touched up once a year. Many Earthship owners will opt for

acrylic or hard plaster finishes over the mud fill on the tire walls. These finishes do provide more durability than natural mud or painted mud. However, cracks, movements, or changes do appear over time (as they will in any building due to settling), and so the more modern products require more expensive and involved methods of patching and in some cases, require entire walls to be replastered. Mud finishes, however, even if they are painted, can simply be patch-mudded and/or spackled and repainted. Mud finishes allow easy maintenance executed by the owner. This obviously has advantages if you are a do-it-yourself type of person. The point is that there will be some cracks, scores, and in some areas around wood detailing, movement in the finish plaster no matter what material you use. How much relates to how well your detailing and plastering techniques were executed. Mud, while not as durable, is easier to patch and maintain than other products. The result is you may have to police your mud plaster once a year yourself as opposed to having someone every two or three years professionally retouch and/or redo your hard plaster or acrylic walls. Most major expansion and contraction (thermal movement) in a massive Earthship will occur within the first three years. The bottom line is to expect some plaster cracks during this time. They will diminish as the Earthship finds it's thermal cycles and seats itself into the seasons of your site. We are talking about one day of mud patching once a year for the first three years in an average sized house.

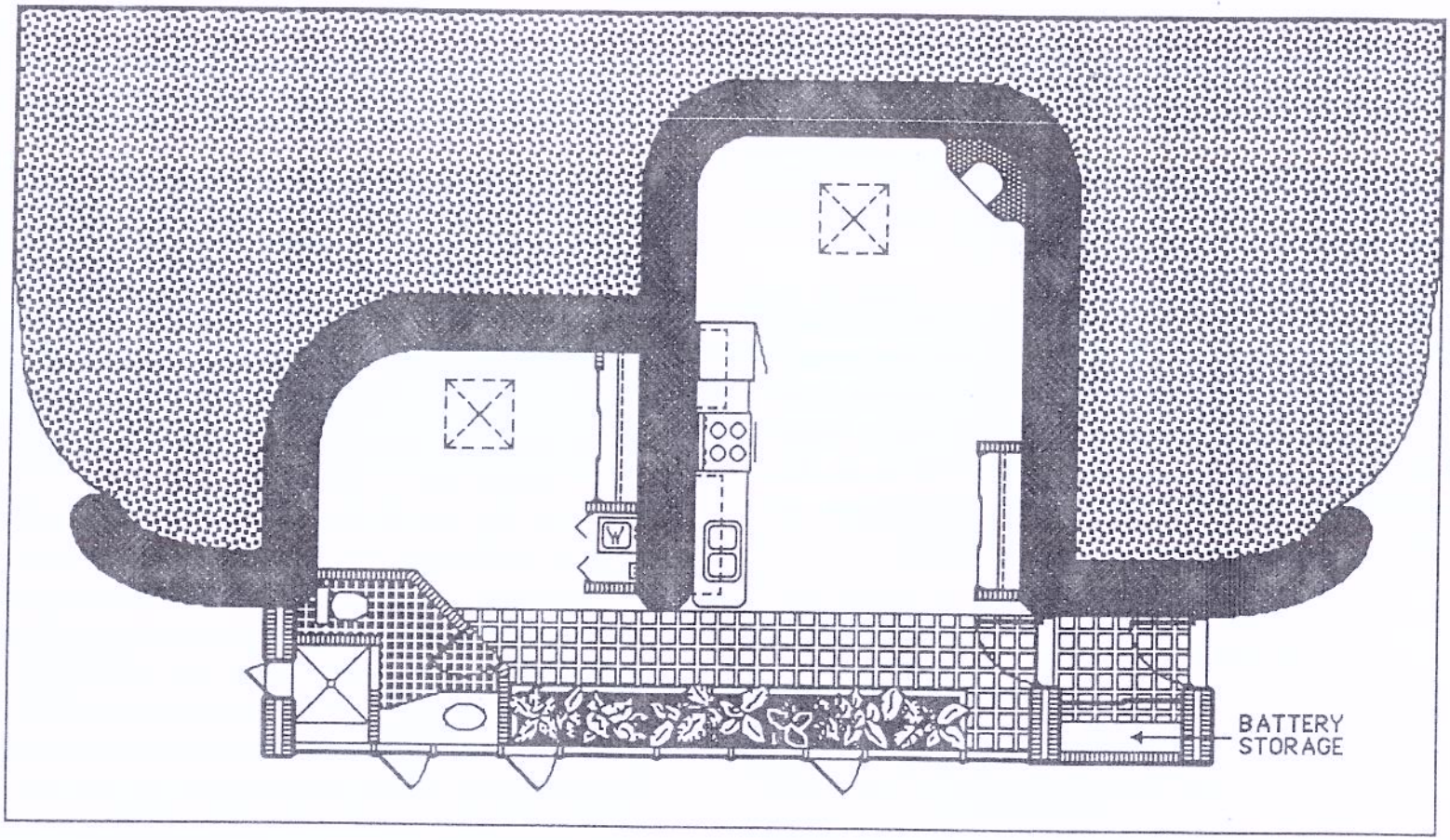
Other than systems operation, which will be outlined in Earthship Volume II, this is all you need to know to operate your Earthship.

Bon Voyage!

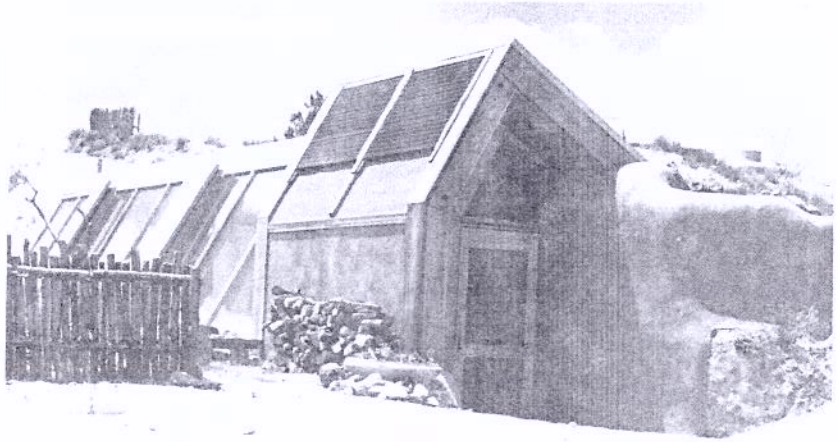
11. EXISTING EARTHSHIPS

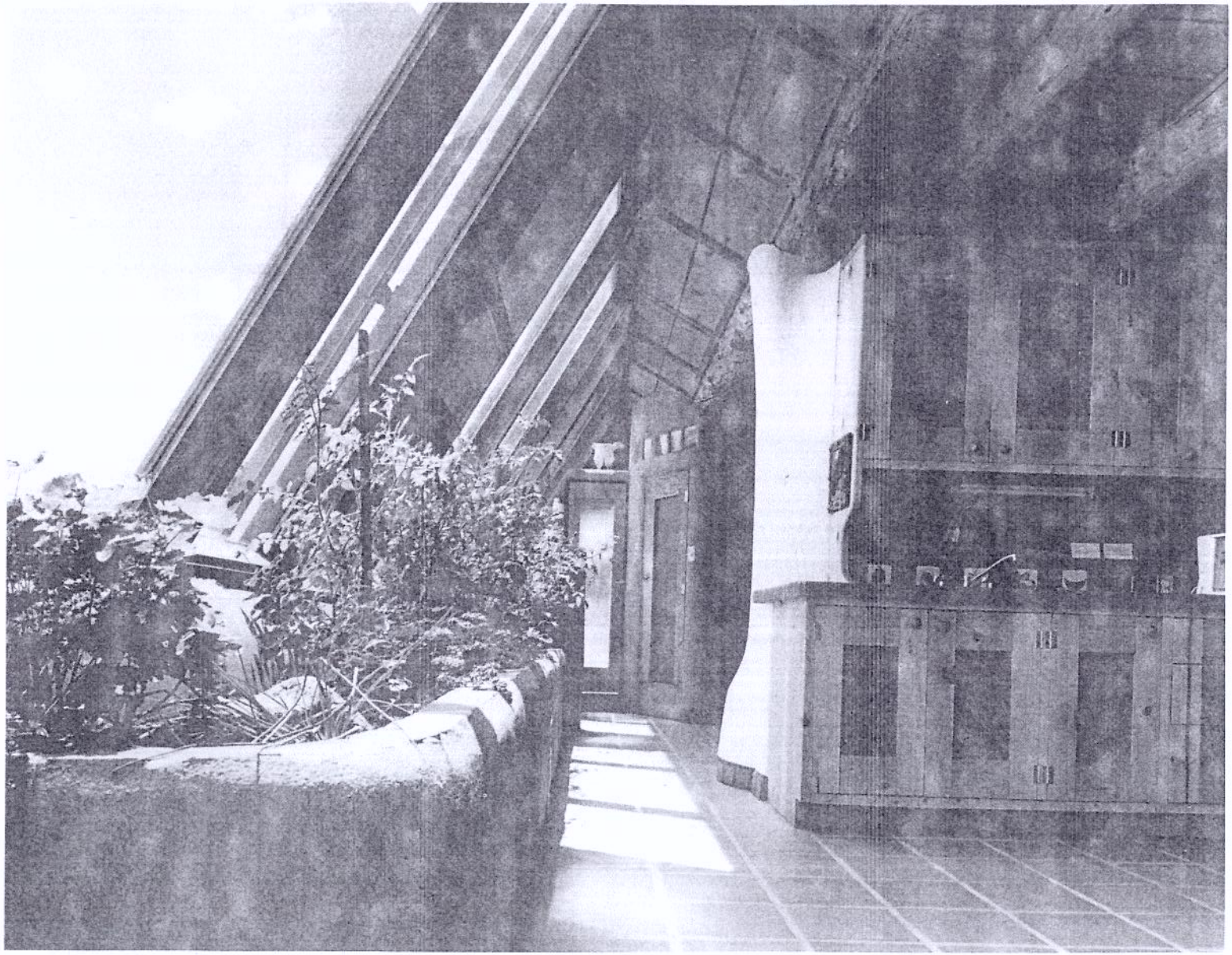
THE PROTOTYPES

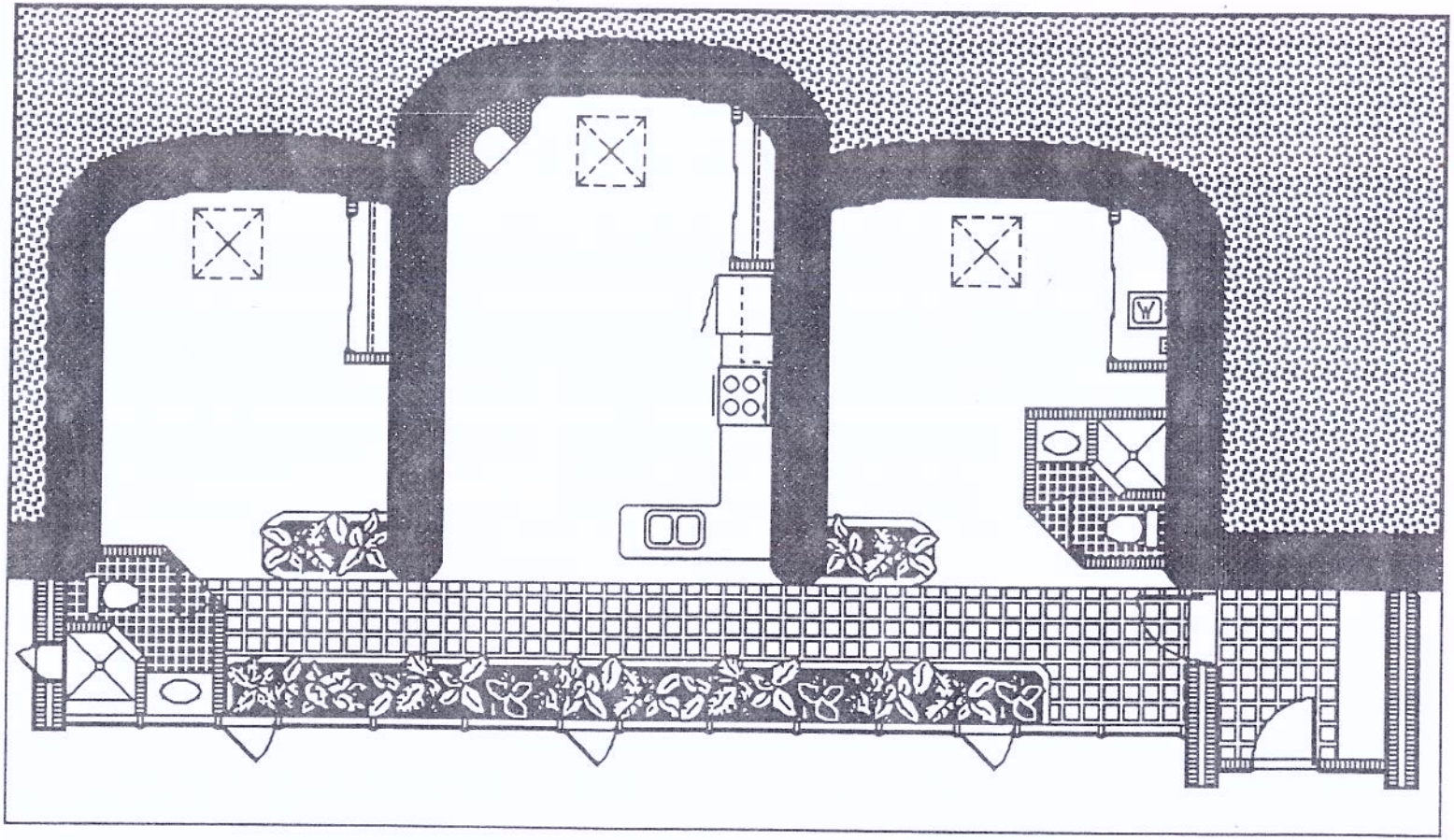
Photographs (finished and during construction) and plans of existing Earthships are presented here. Costs range from $20.00 per square foot to $90.00 per square foot. Sizes range from 600 square feet to 10,000 square feet to an 80 unit destination lodge. A wide spectrum of uses of the concept are illustrated here.



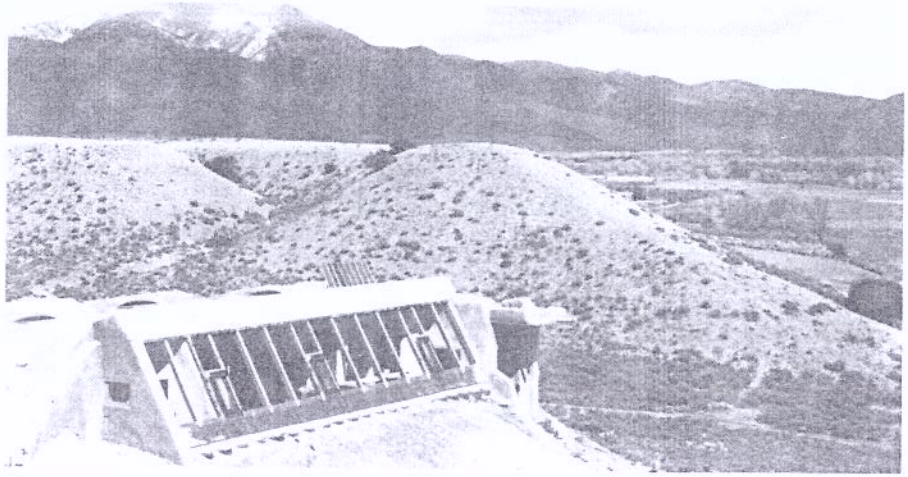
Owner: Pat Habicht
Taos, New Mexico
675 square feet
Owner worked on job
Cost- $45.00 per square foot
Job managed by Joe Hoar

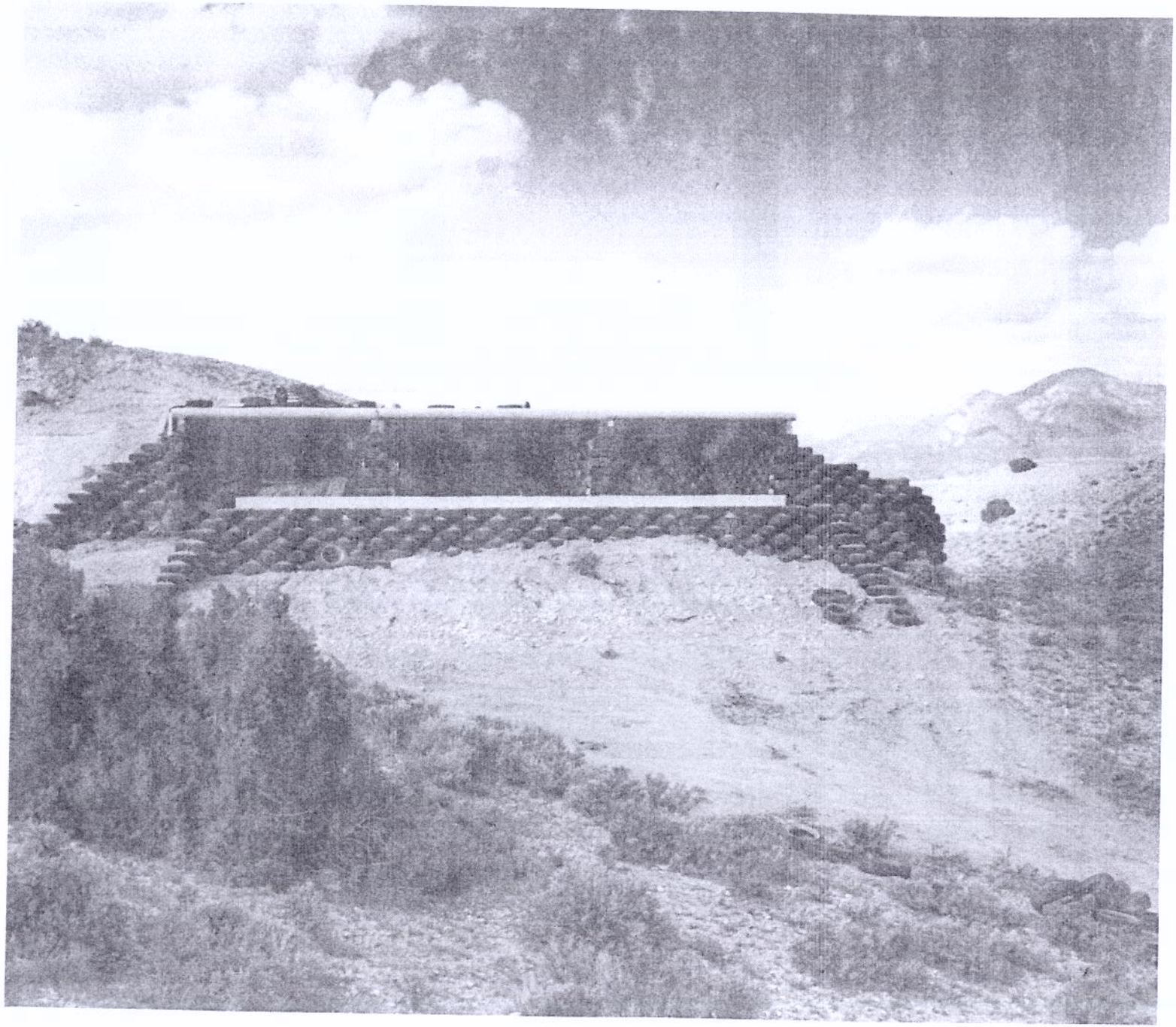


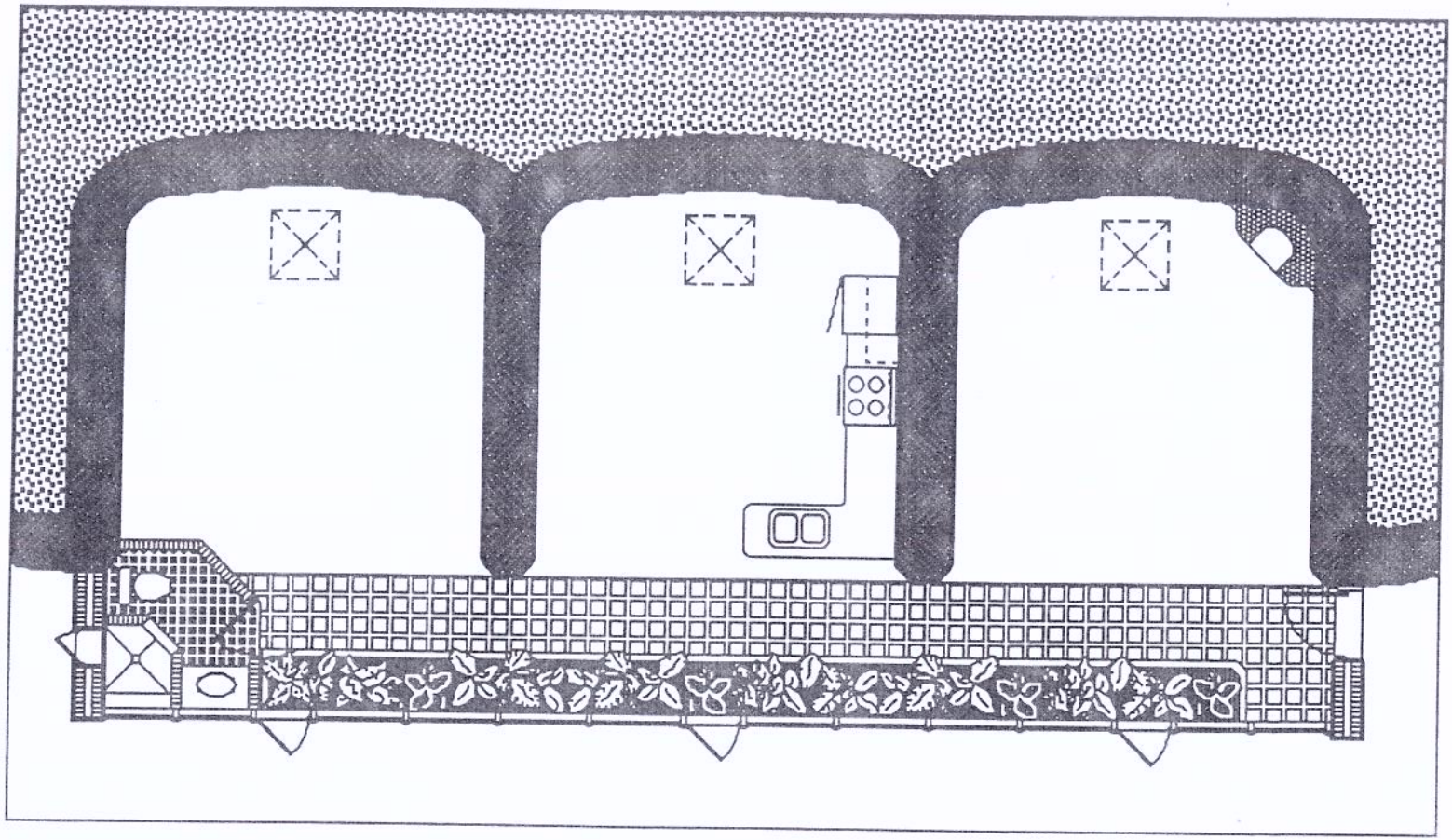




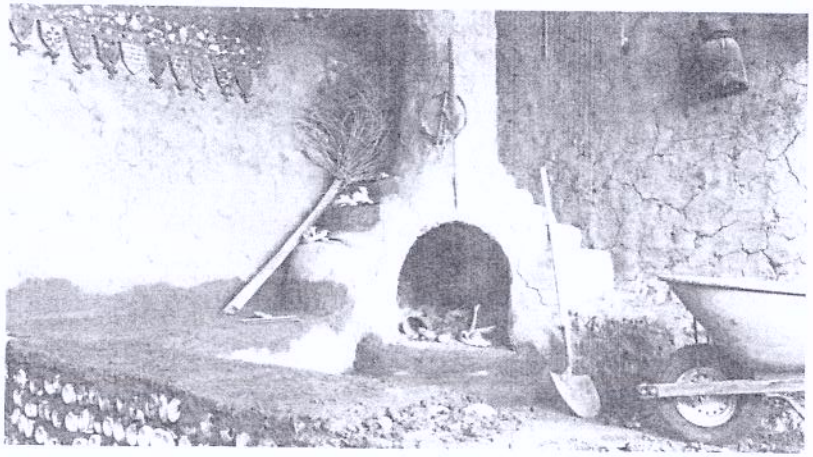
Owner: Steve Trujillo
Taos, New Mexico
1250 square feet
Owner-builder
Cost- $50.00 per square foot
Job managed by Justin Simpson

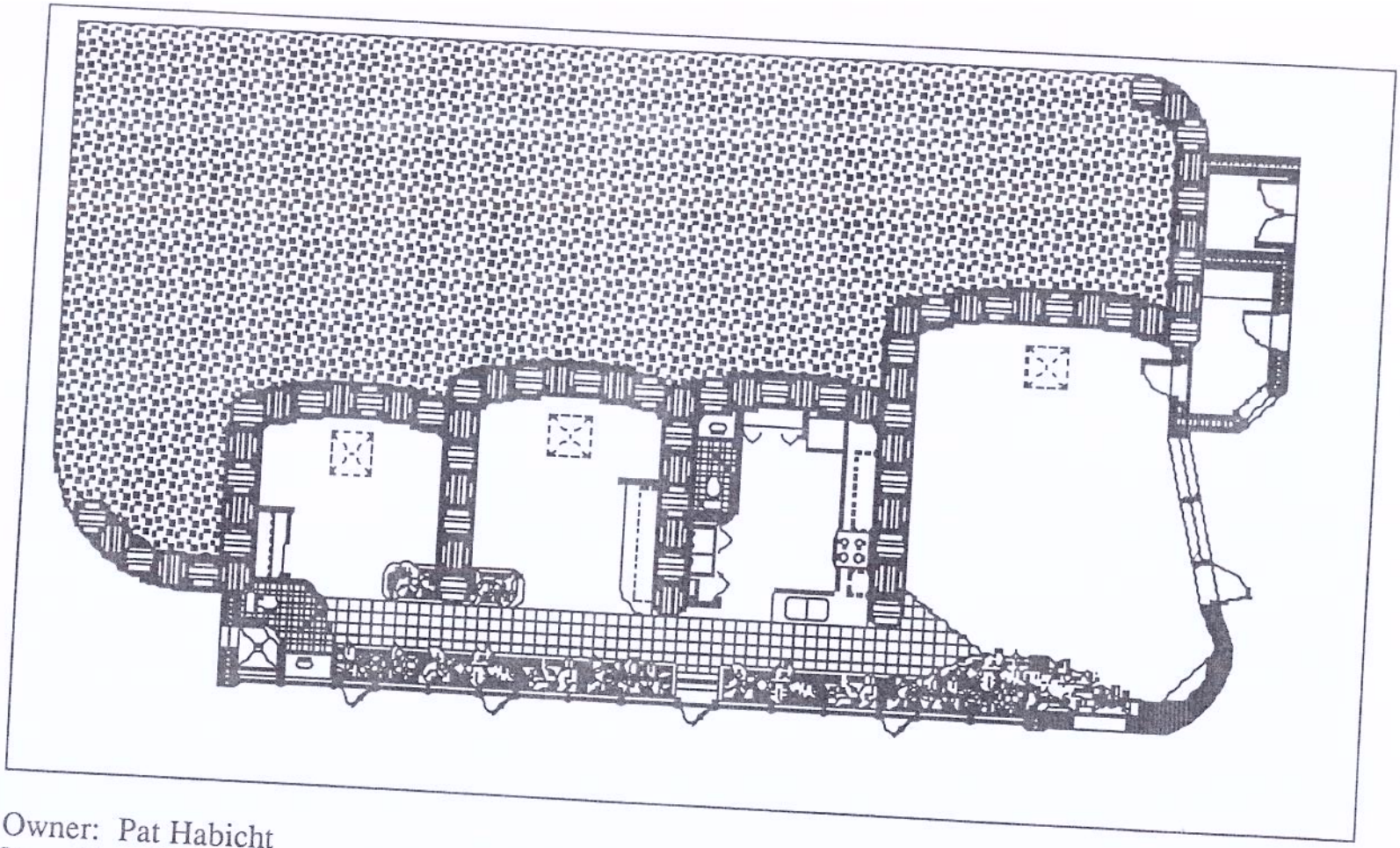




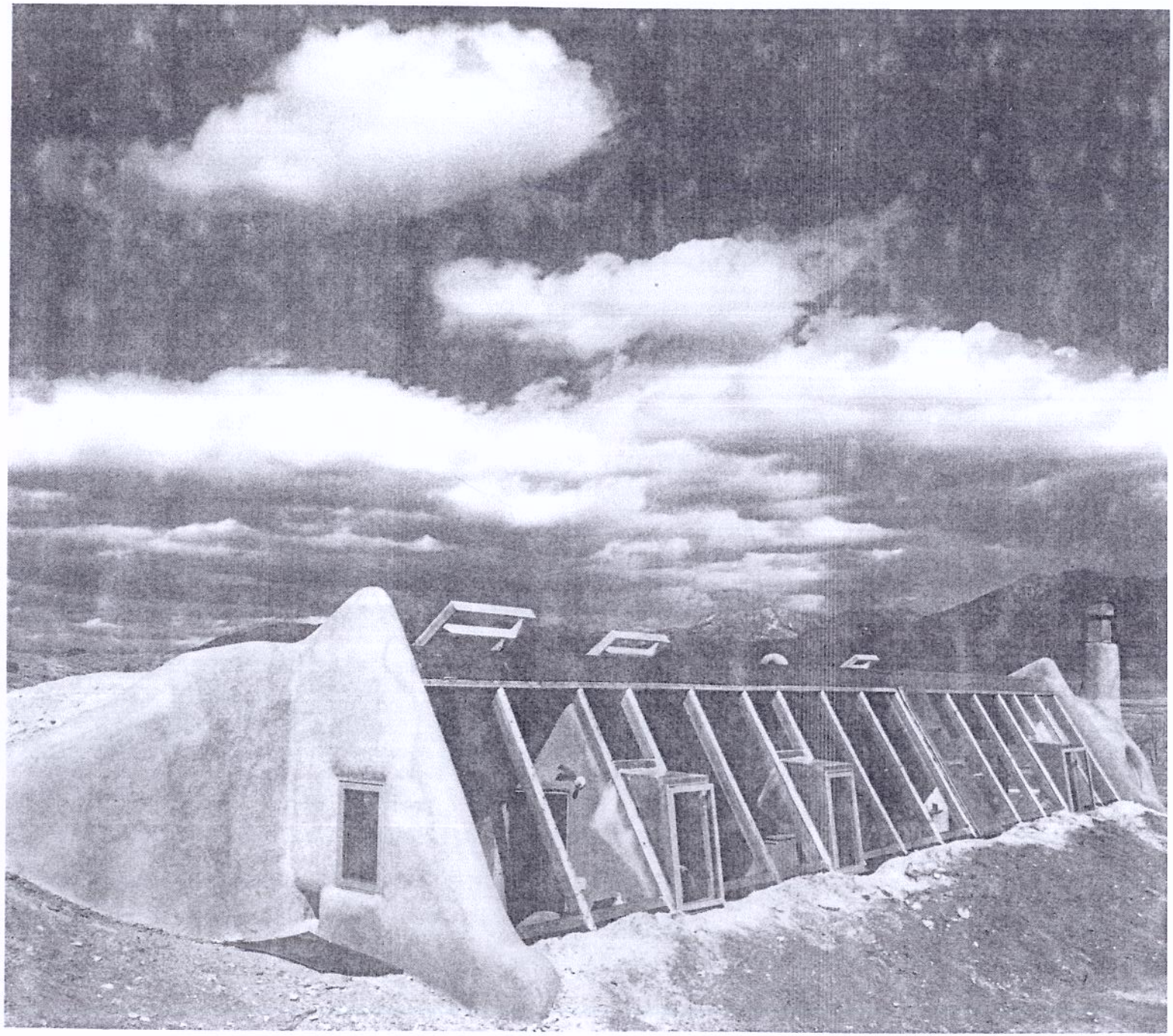


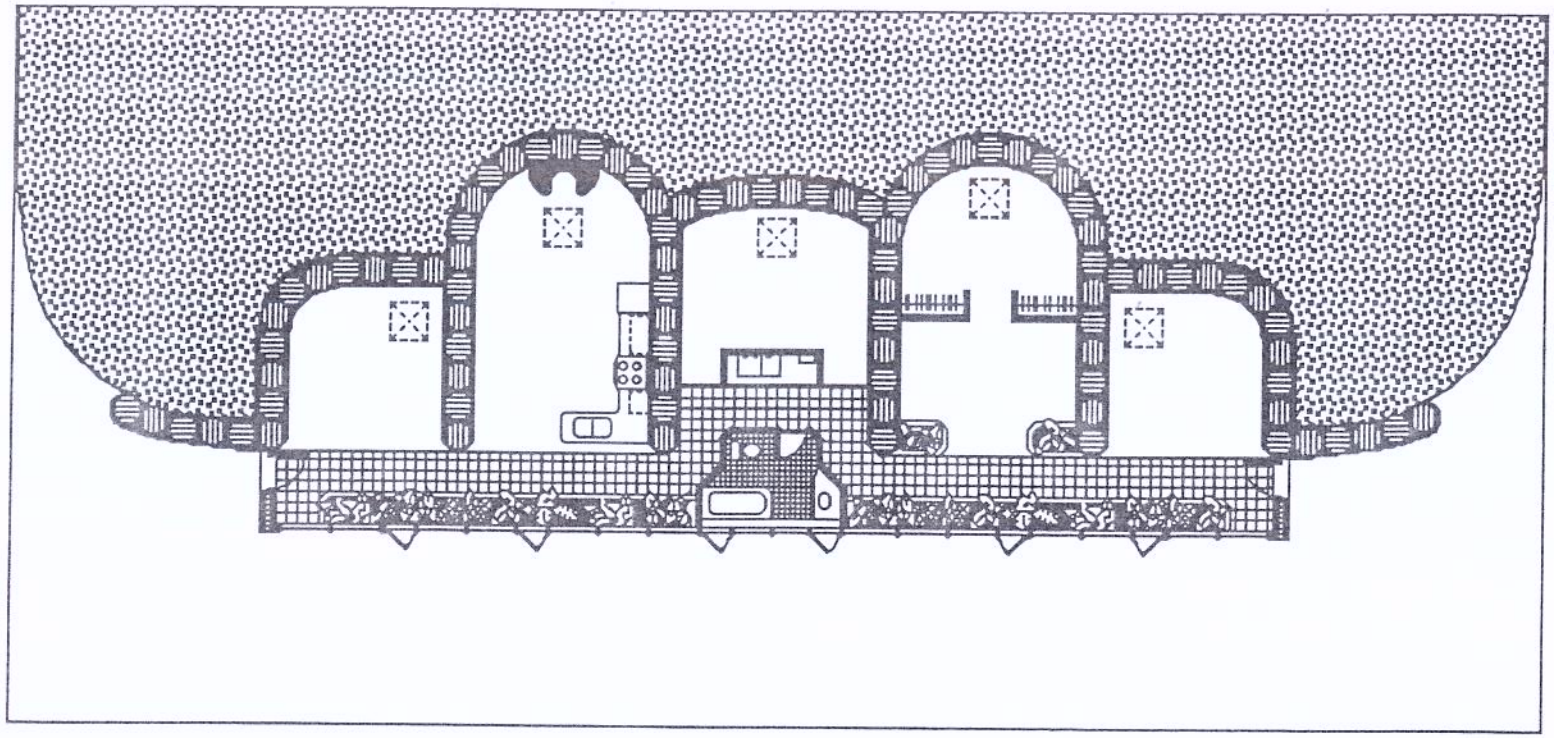
Owners: Me'l Christensen
and Sam Bascom
Taos, New Mexico
1000 square feet
Owners built project
Cost- $30.00 per square foot
Job managed by owners



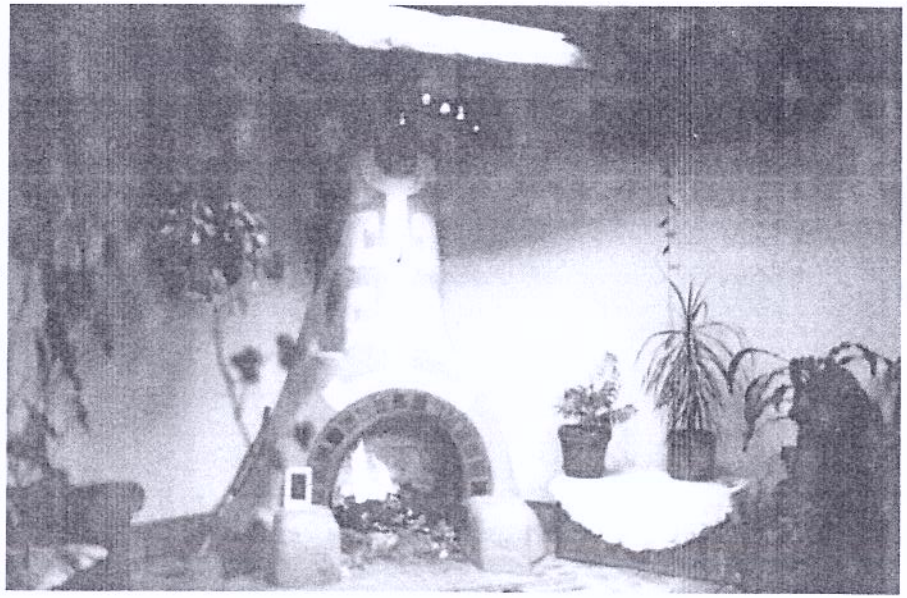


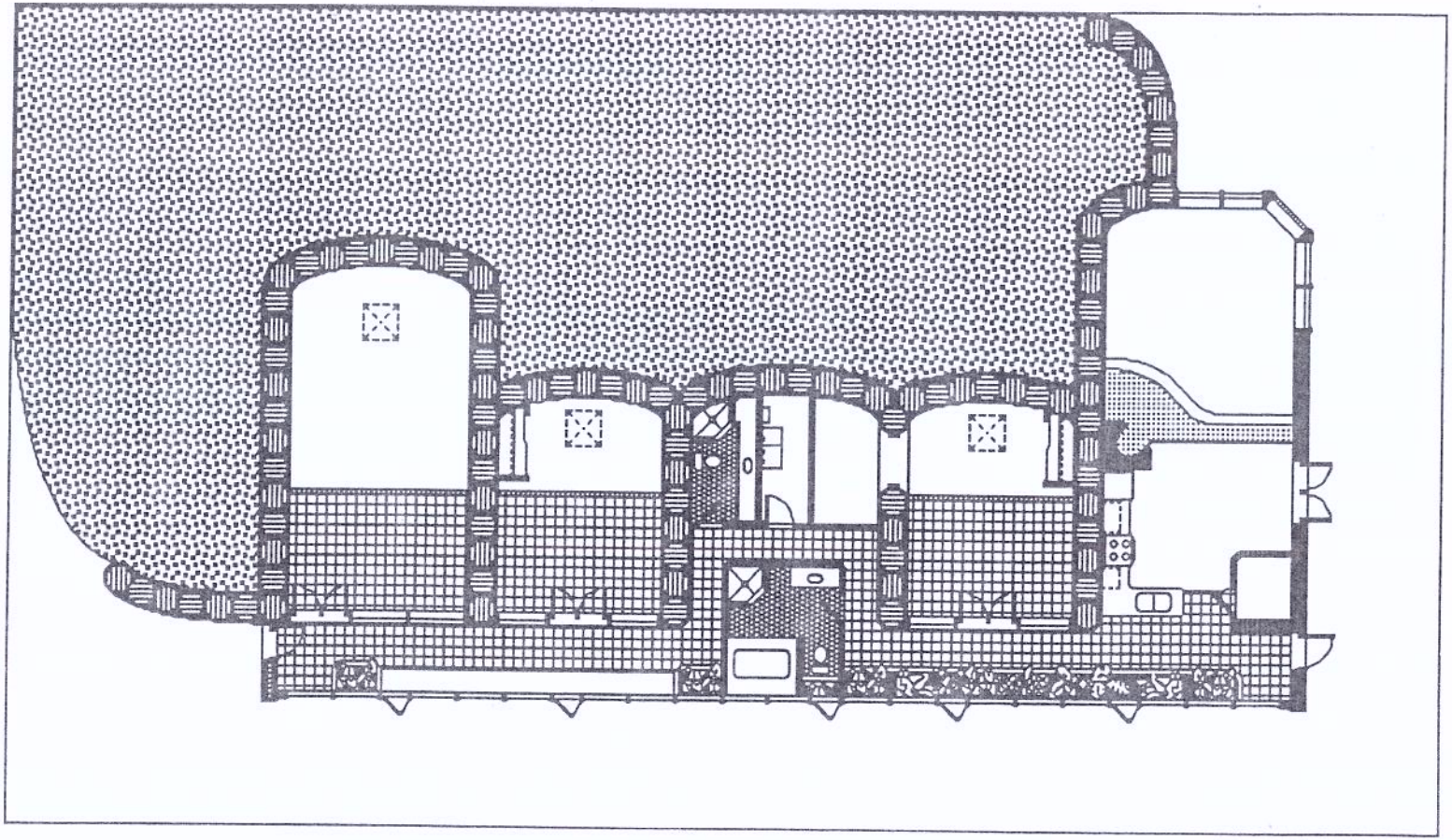
Owner: Pat Habicht
Taos, New Mexico
1600 square feet
Owner worked on job
Cost- $50.00 per square foot
Job managed by Peter Kolshorn



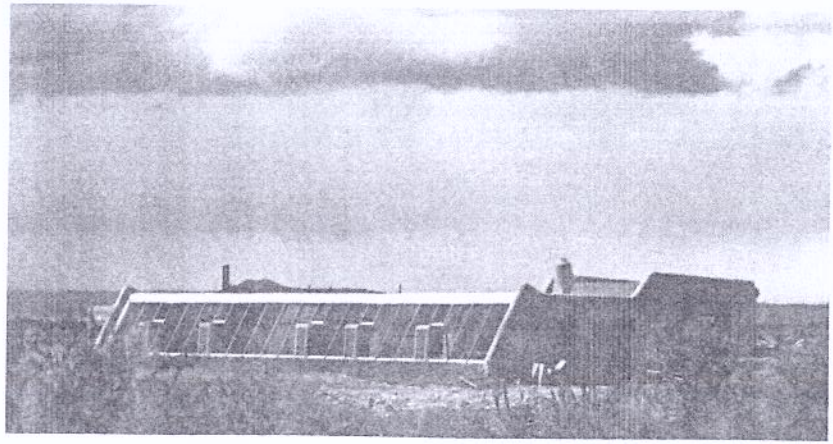


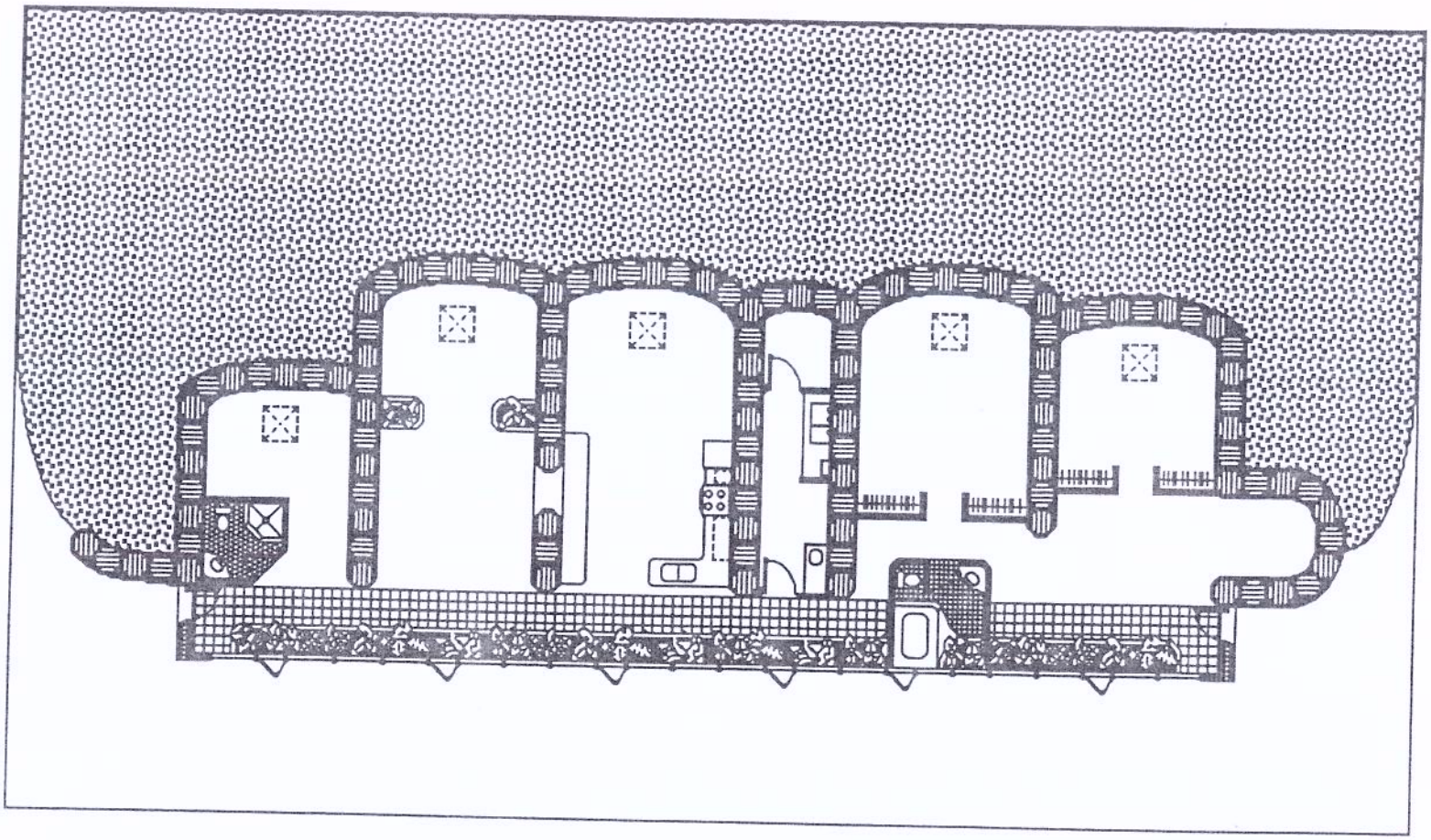
Owners: Michael Reynolds
and Chris Simpson
Taos, New Mexico
1600 square feet
Owners built project
Cost-$20.00 per square foot
Job managed by Michael Reynolds



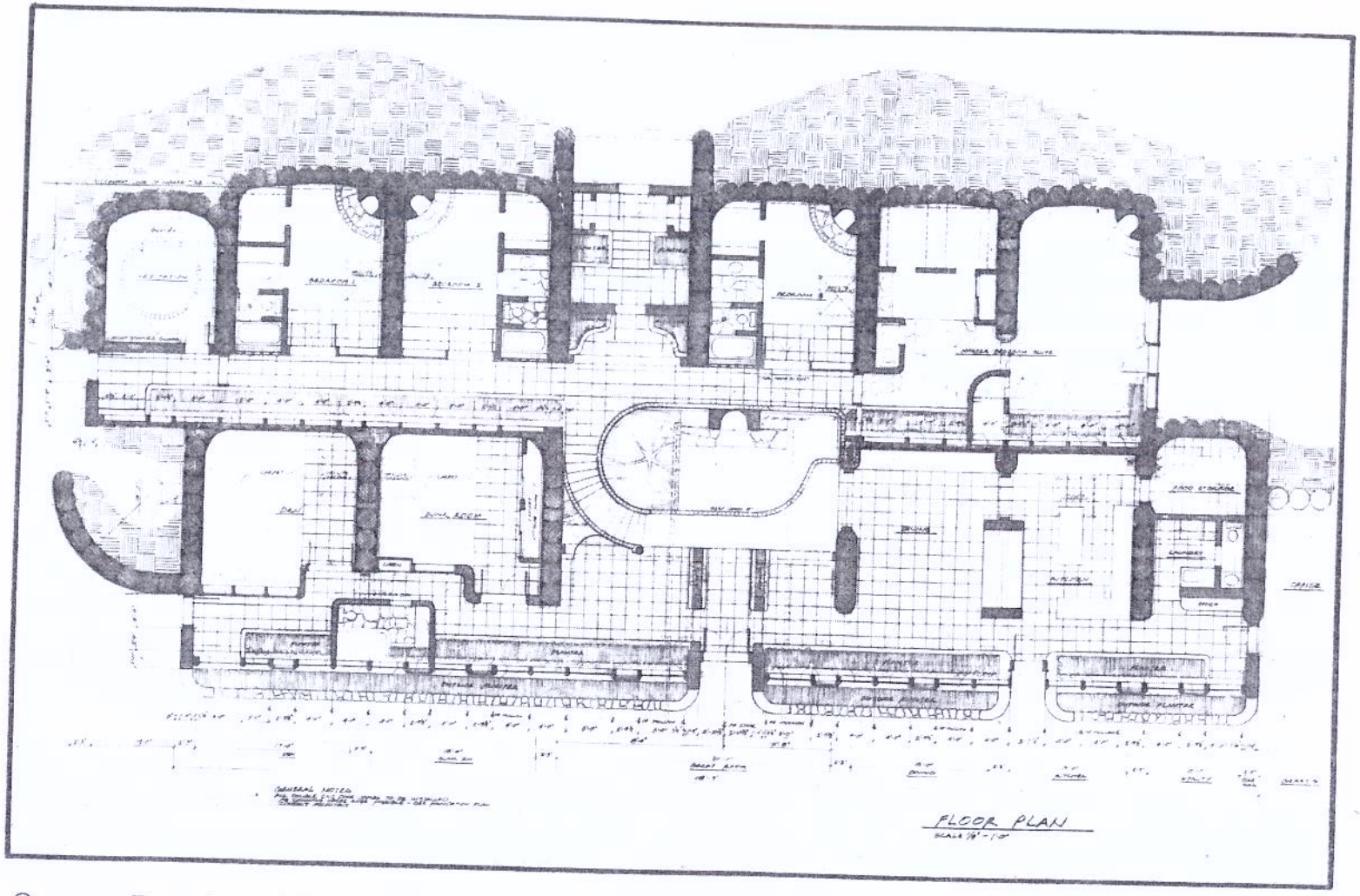


Owners: Carolyn Lake and Joy Franklin
Taos, New Mexico
2800 square feet
Owners worked on job
Cost-$55.00 per square foot
Job managed by Joe Hoar

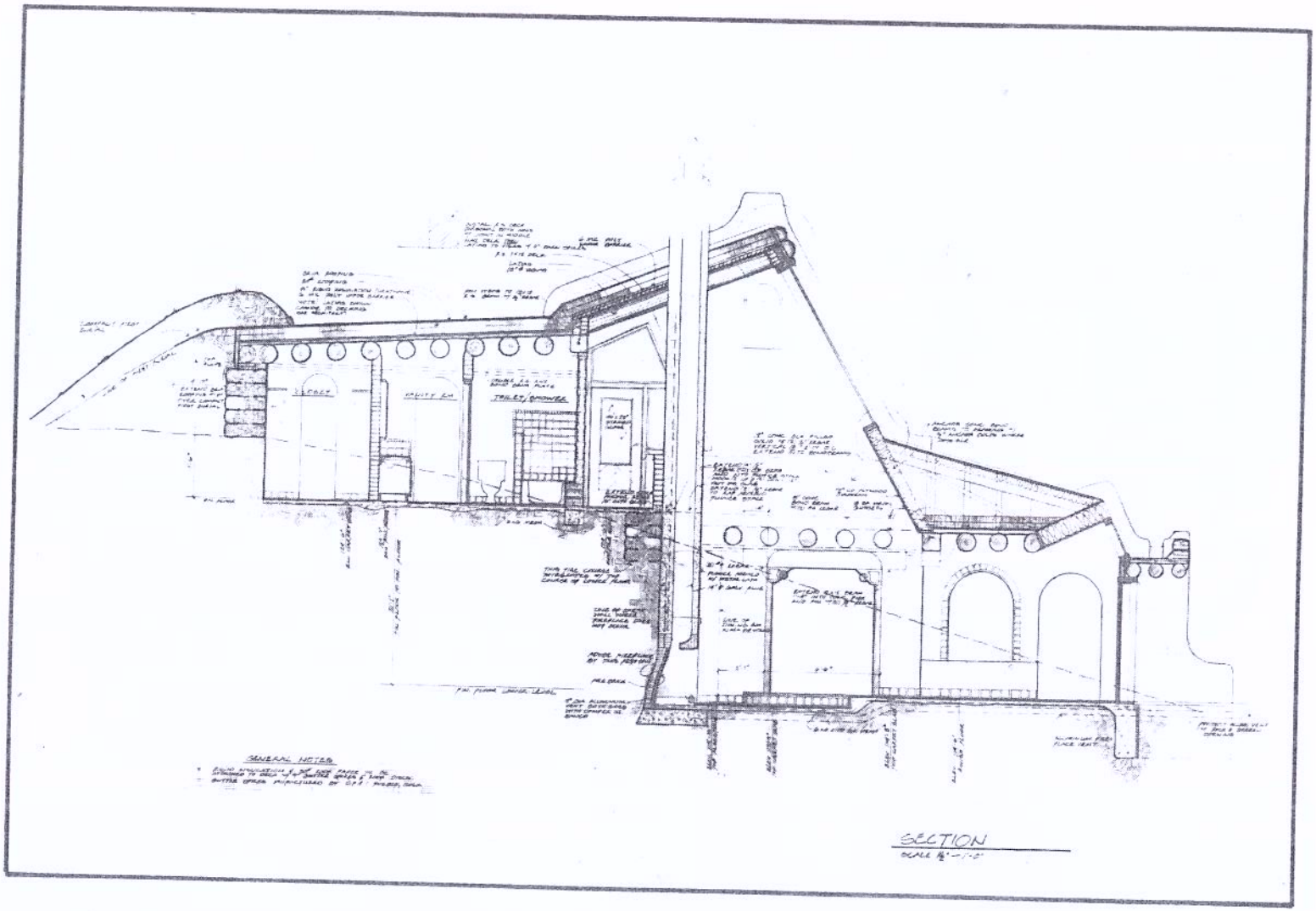




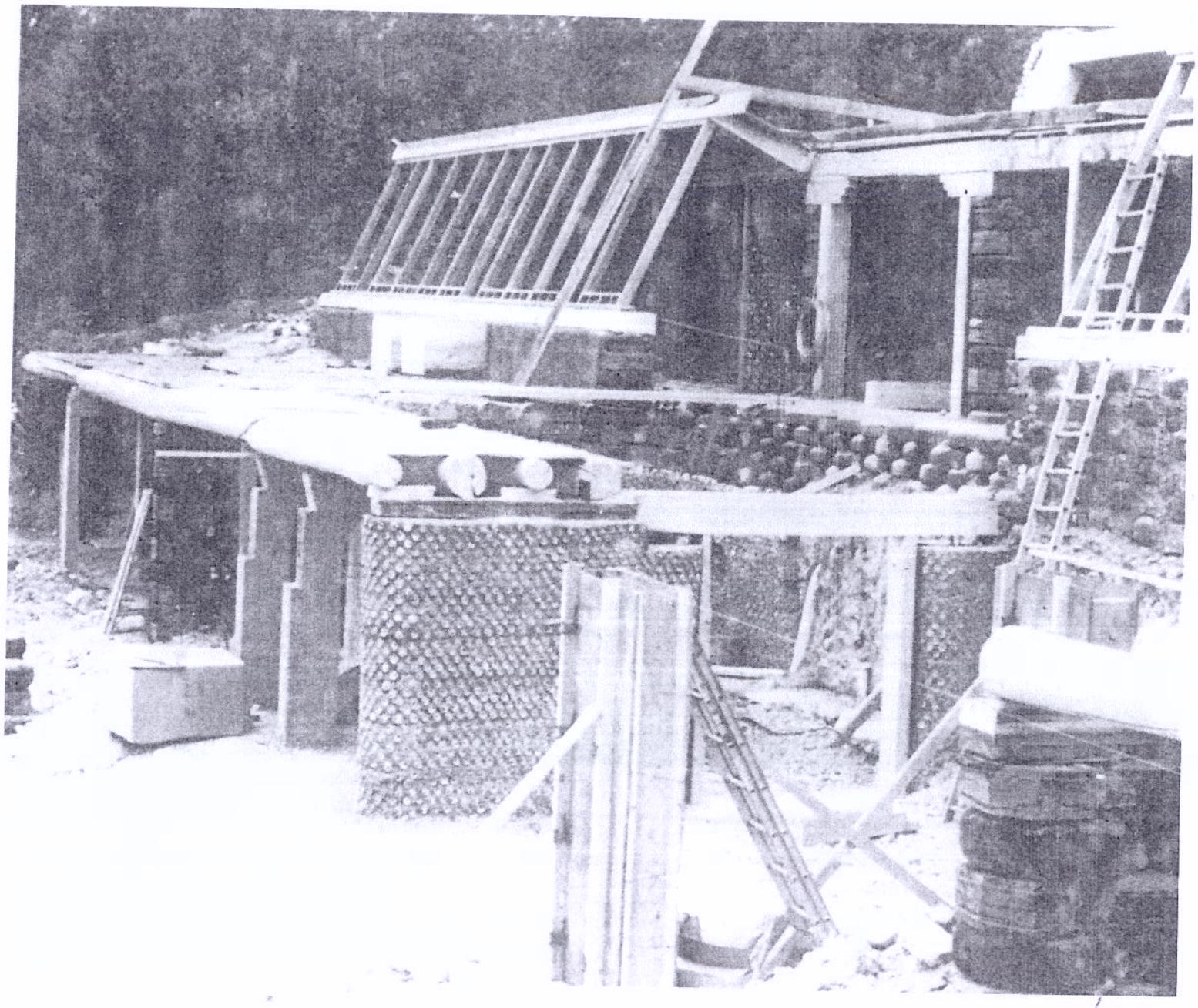
Owners: Susan and Eric Henley
Albuquerque, New Mexico
2600 square feet
Owners worked on job
Cost-$60.00 per square foot
Job managed by William Stoddard
Construction Company and Dan Reardon



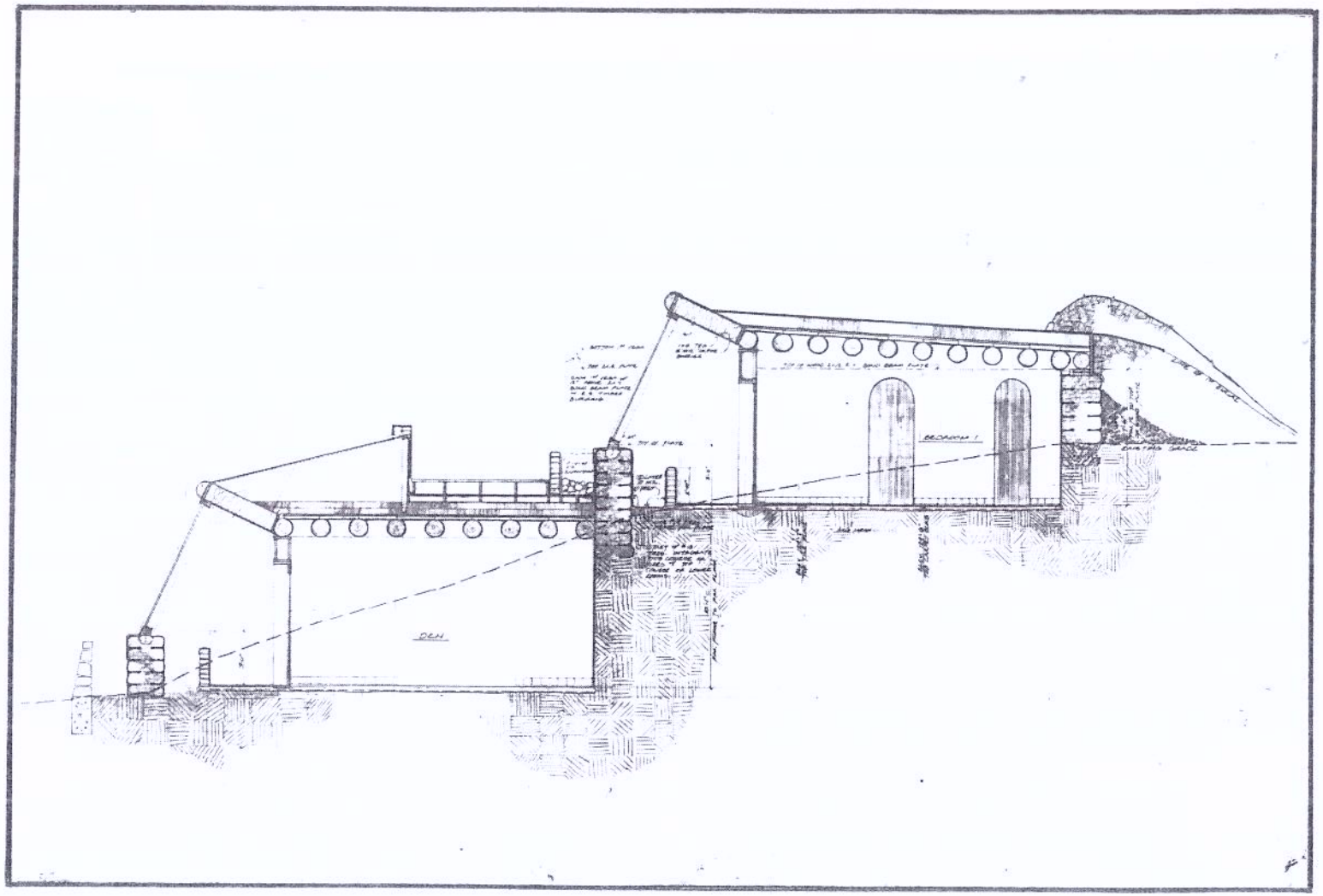
Owners: Dennis and Gerry Weaver
Ridgway, Colorado
7000 square feet plus garage
Owners worked on job
Cost-$90.00 per square foot
Built by Allison Construction Company



Weaver Section



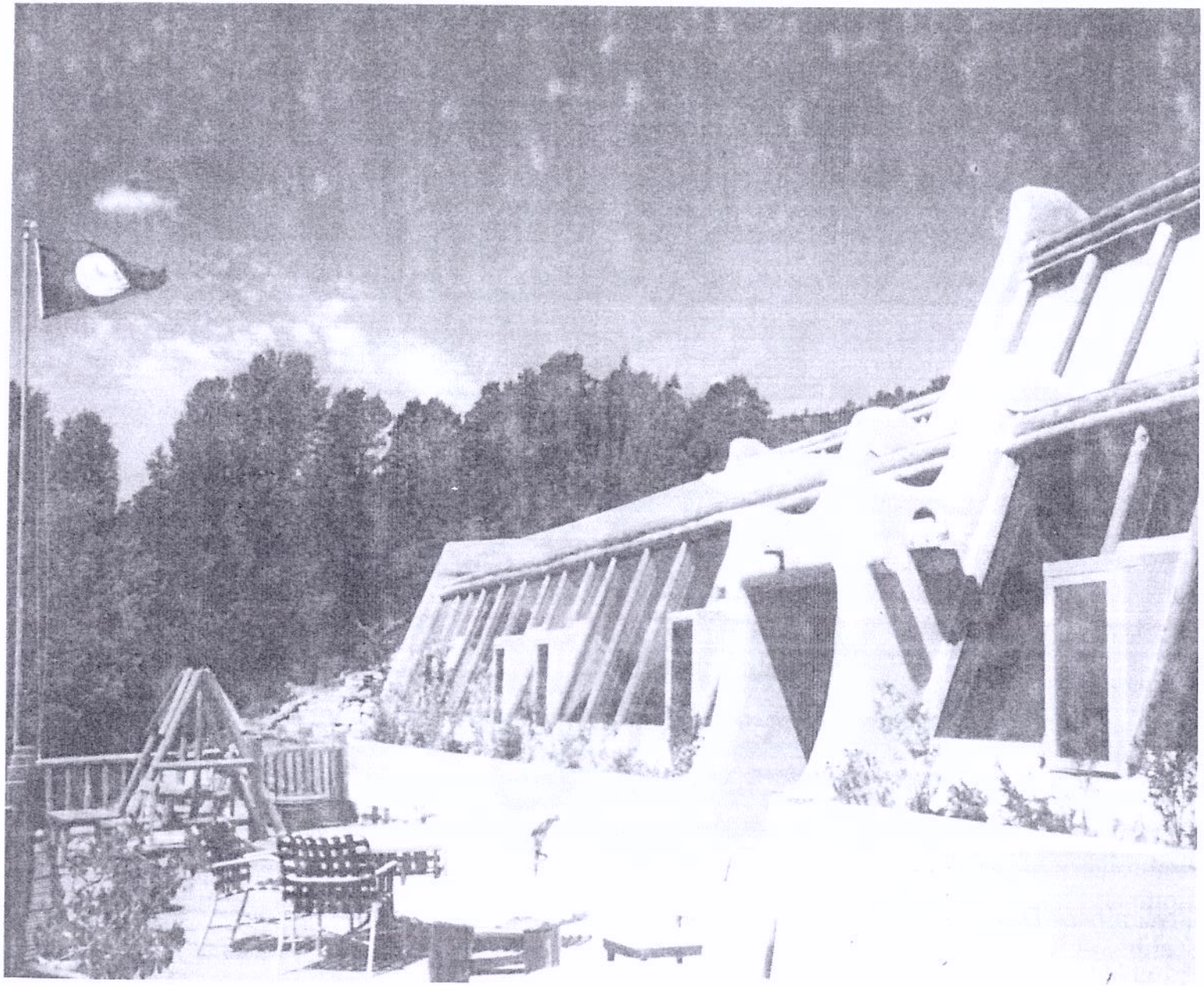
Weaver Construction



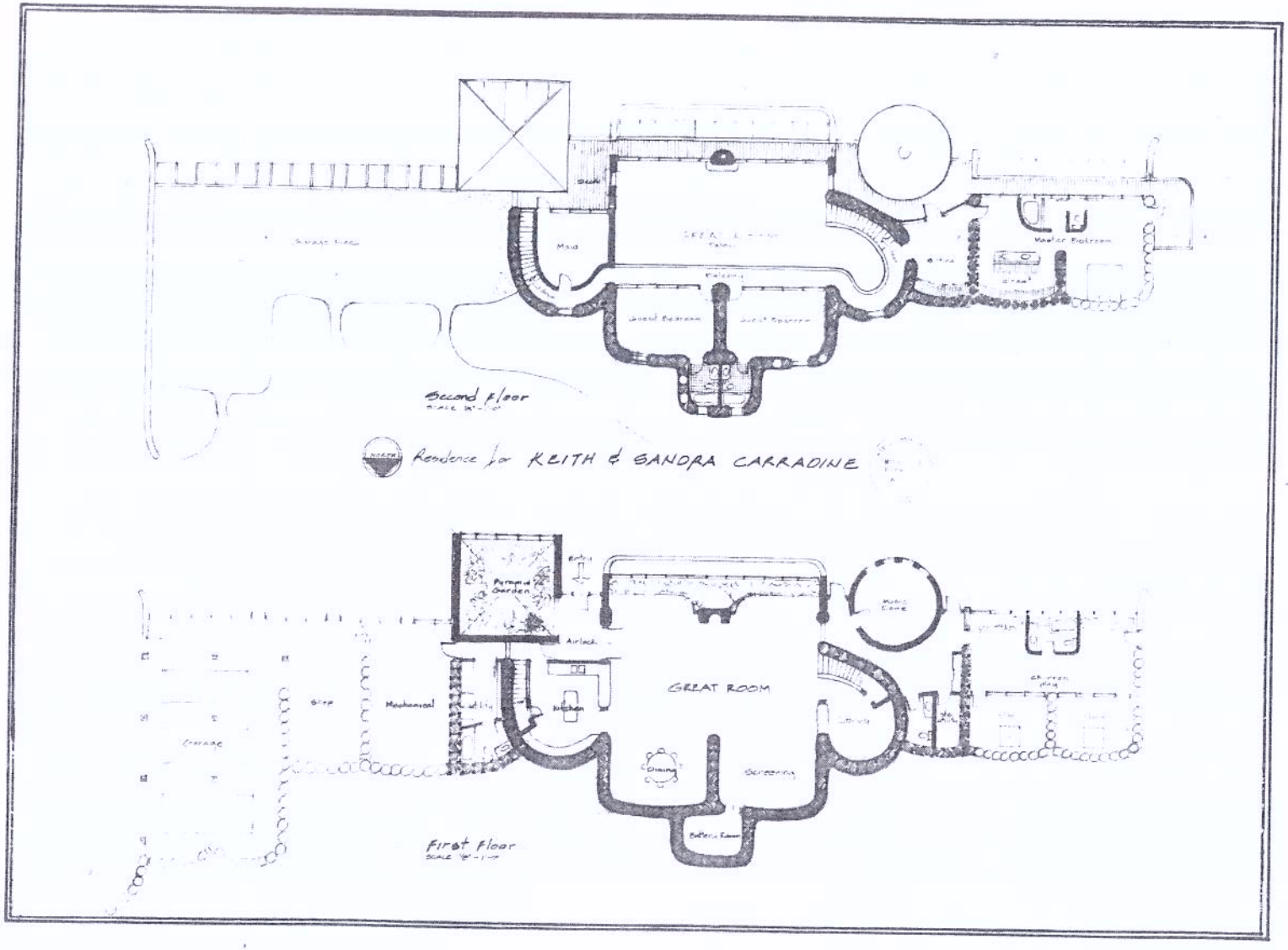
Weaver Section

Weaver Tire Wall on Rock Cliff

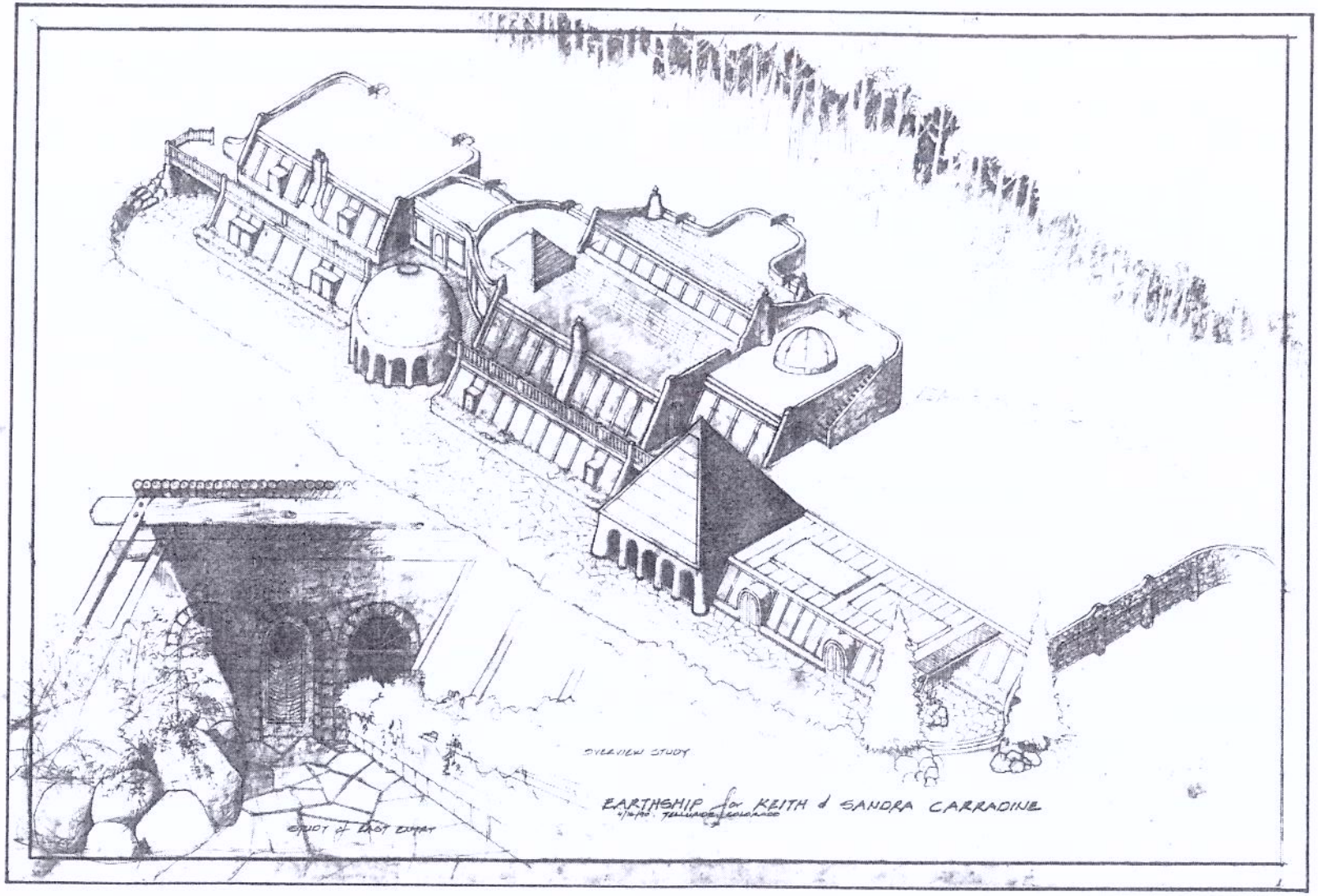
Weaver West End



Weaver Overview



Preliminary Design
Keith and Sandra Carradine
Telluride, Colorado



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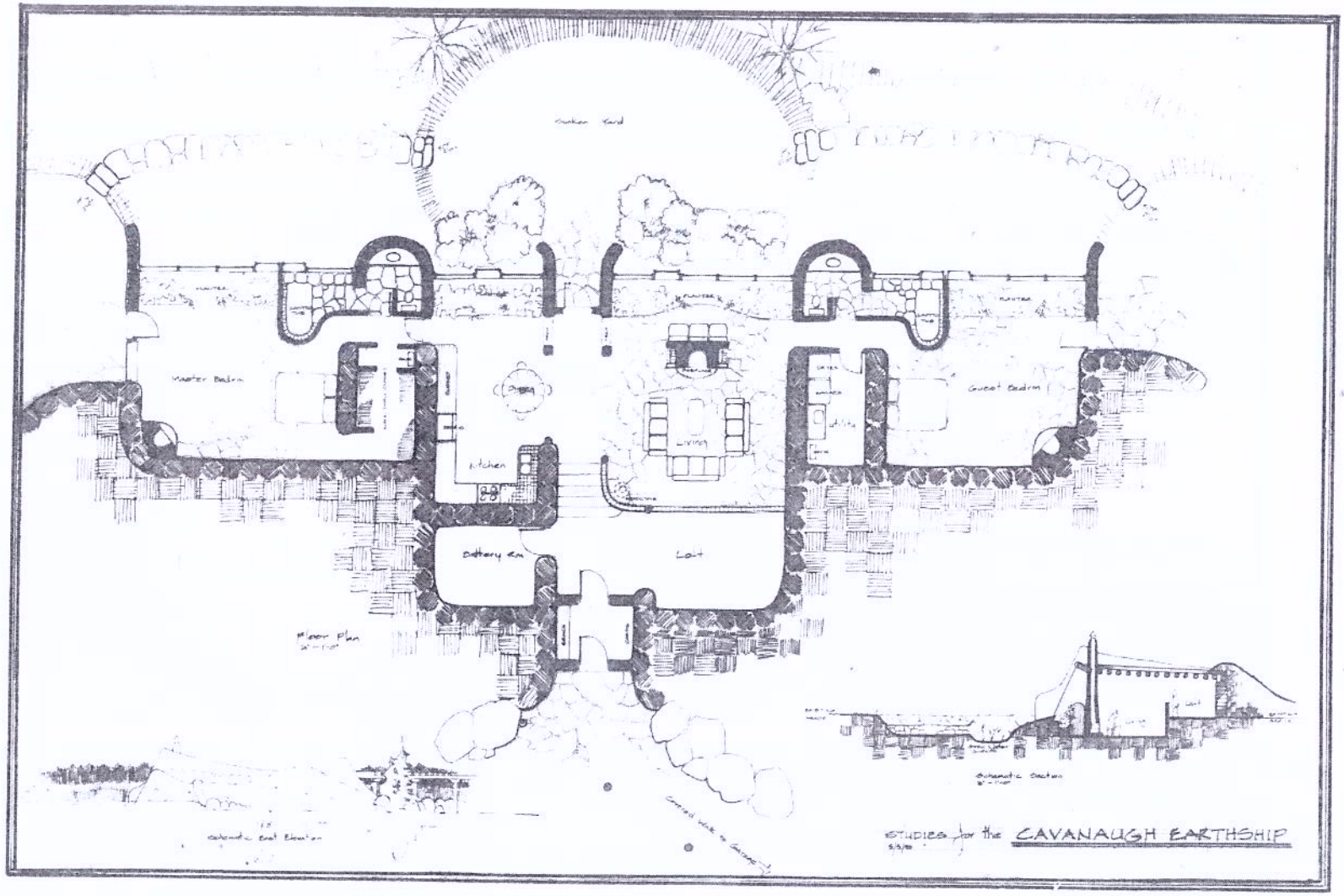
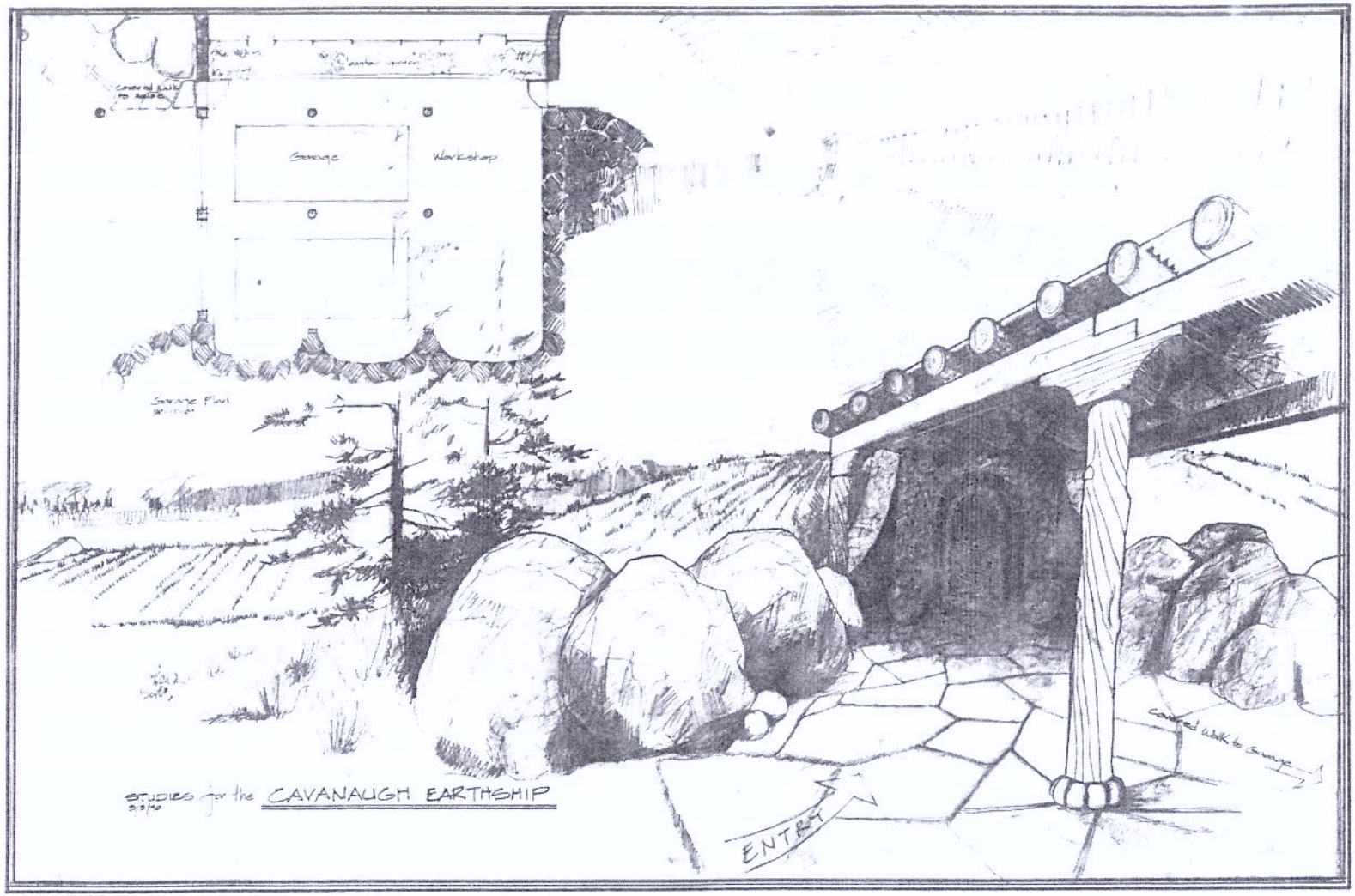
Keith and Sandra Carradine
Telluride, Colorado



Preliminary Design
Tom and Peggy Cavanaugh
Ridgway, Colorado



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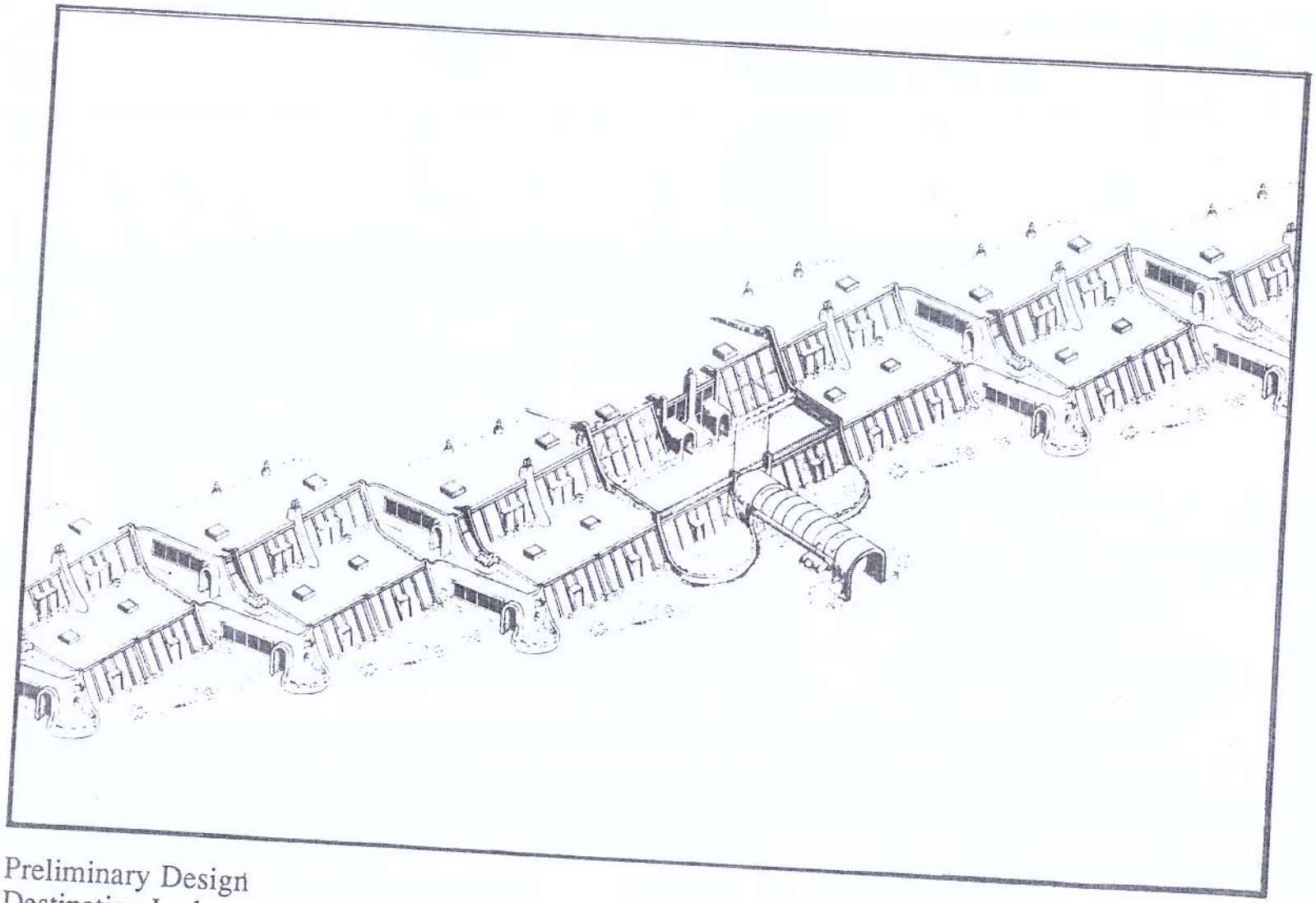
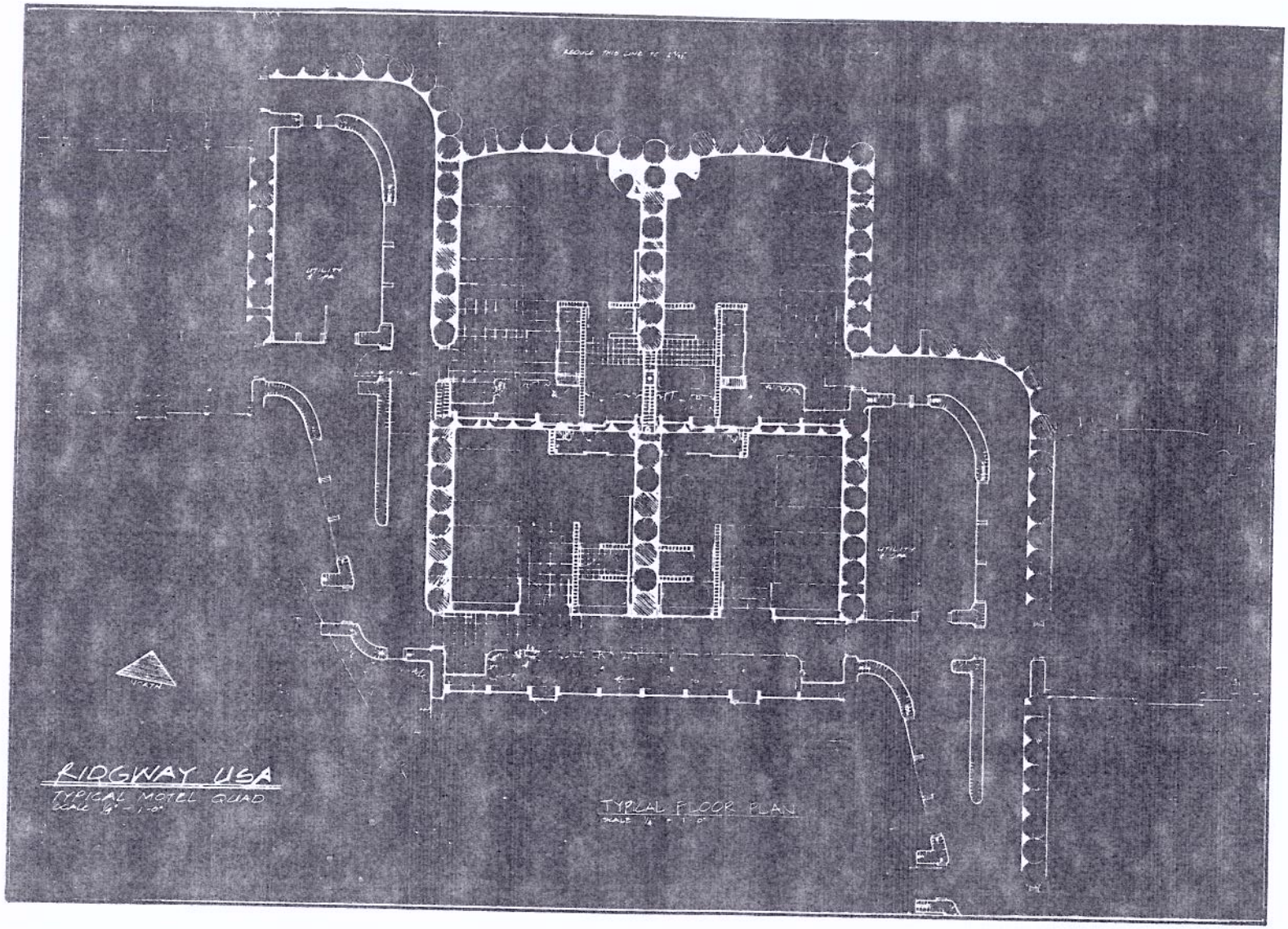
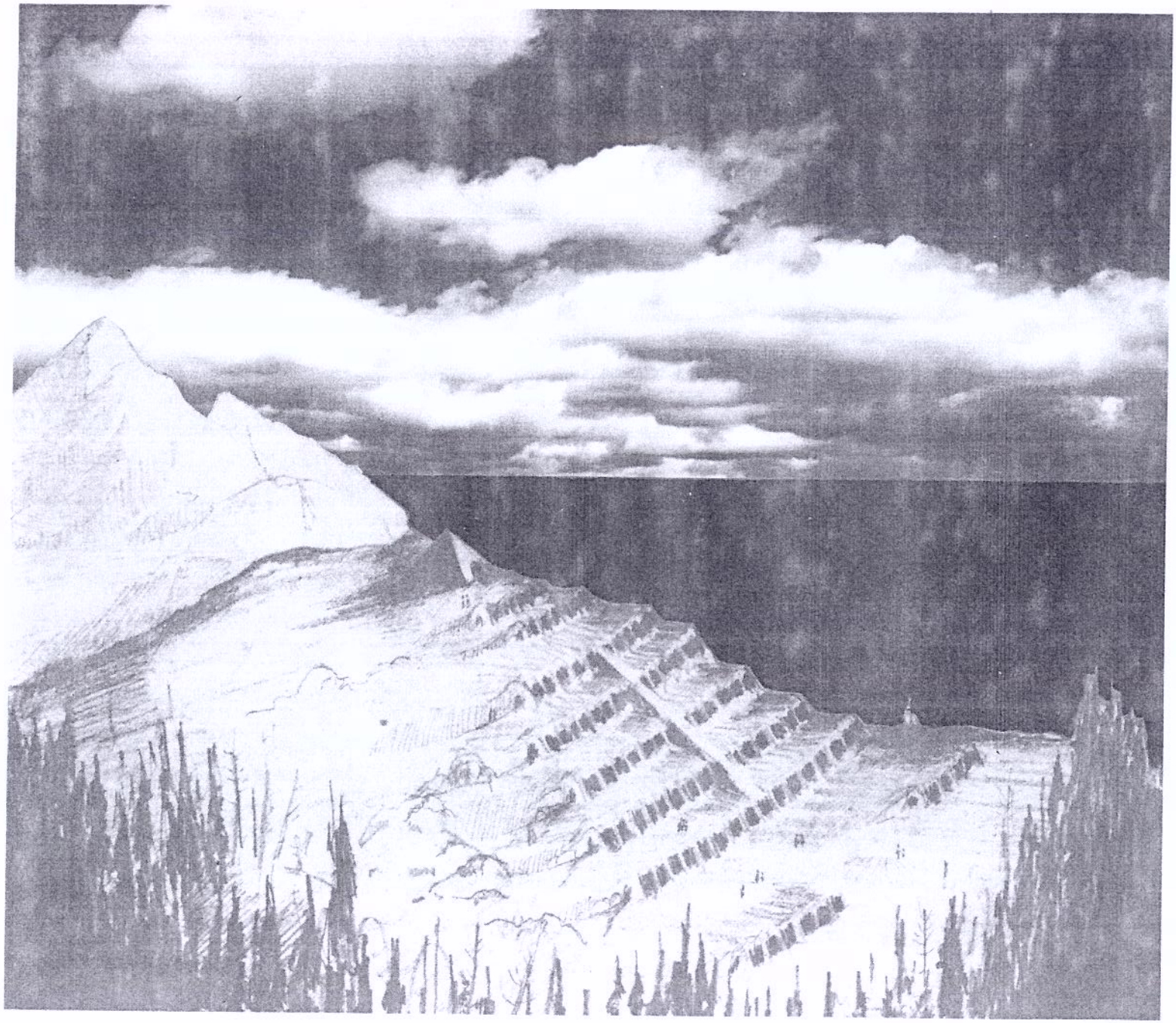
Tom and Peggy Cavanaugh
Ridgway, Colorado



Preliminary Design
Destination Lodge
Ridgway, USA
Ridgway, Colorado



Preliminary Design
Destination Lodge
Ridgway, USA
Ridgway, Colorado



EPILOGUE

Having been involved in building homes and other structures out of tires for 20 years, I get very excited when I see the giant tire piles that exist in almost every populated area. Knowing how easy and inexpensive it is to construct energy efficient homes from these tires, I begin to see the tire dumps **as a solution to other problems** (housing, energy, employment), **not a problem in themselves.** These tire dumps are potential communities, towns, and even cities of Earthships. We have unknowingly been mass-producing and stockpiling ideal building materials for the future. The time has come to begin using them.

A major factor in establishing the proper frame of mind for "voyaging" in an Earthship is that an **Earthship is not a house.** A house as we know it is an out-of-date concept, no longer appropriate for human life on Earth. With this understanding, we will not be trying to make an Earthship into a house. An Earthship is a vessel to take care of us in the world of tomorrow, when population and global abuse will be realities to reckon with. This tomorrow is coming fast. We will be more concerned with self-sufficient comfort and food production than with "style" and "tradition".

When one buys a mobile home, one accepts certain factors about mobile home that allow it to be different than a house, because it is a given that it is mobile. When one buys an Earthship, there are certain factors relative to performance that one must accept as givens to allow it to be a vessel that will "sail on the seas of tomorrow" where common housing will surely sink. The point is that human dogma is the only thing between us and a harmonious future on the Earth.

Michael E. Reynolds

CONSULTATION – SCHOOL – ARCHITECTURAL SERVICES

There are many levels on which the concepts and techniques put forth in this book can be applied. It is the aim of this book to guide people through the use of this concept with as little outside help as possible. However, there will undoubtedly be questions and additional expertise needed in many cases.

SOLAR SURVIVAL ARCHITECTURE holds a contractor's license and an architectural license under the name of Michael E. Reynolds. We offer minimal consultation all the way to full architectural services, and in some cases we actually do the construction.

We also have regularly scheduled seminars and an ongoing school to teach these methods and concepts to home owners, builders, and architects. Please contact us if we can help take you farther on your voyage.

Earthship Volume Two will be available in late winter of 1991. It will include how to build fireplaces, skylights, stairs, doors, cabinets, greywater systems, solar electrical systems, mud relief sculpture, domes and vaults, and more.

REBEL

let the world fall away
i am not boundaried by
your boxy repetition
i am not living under your fashion magazine
my bullets are hidden for later
i have deceived you
i have no microwave ha ha
i have not eaten for 8 days
my children are illegal aliens
my american car has no engine
i wear boots with formal wear
i don't care i just don't care

let the world fall away
to snowfalls of dust
and institutions of clutter
demanding dirty dishes and laundry
leave it all along the asphalt
there is lots of jungle left
the birds are blue and green
trees are truer than television
the sky holds a million sparks
for each of us

we are withering in our darkness
under electric light
our bleached sheets and blankets
will never be clean
we will not survive
until we set ourselves free

— anonymous, 1982

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