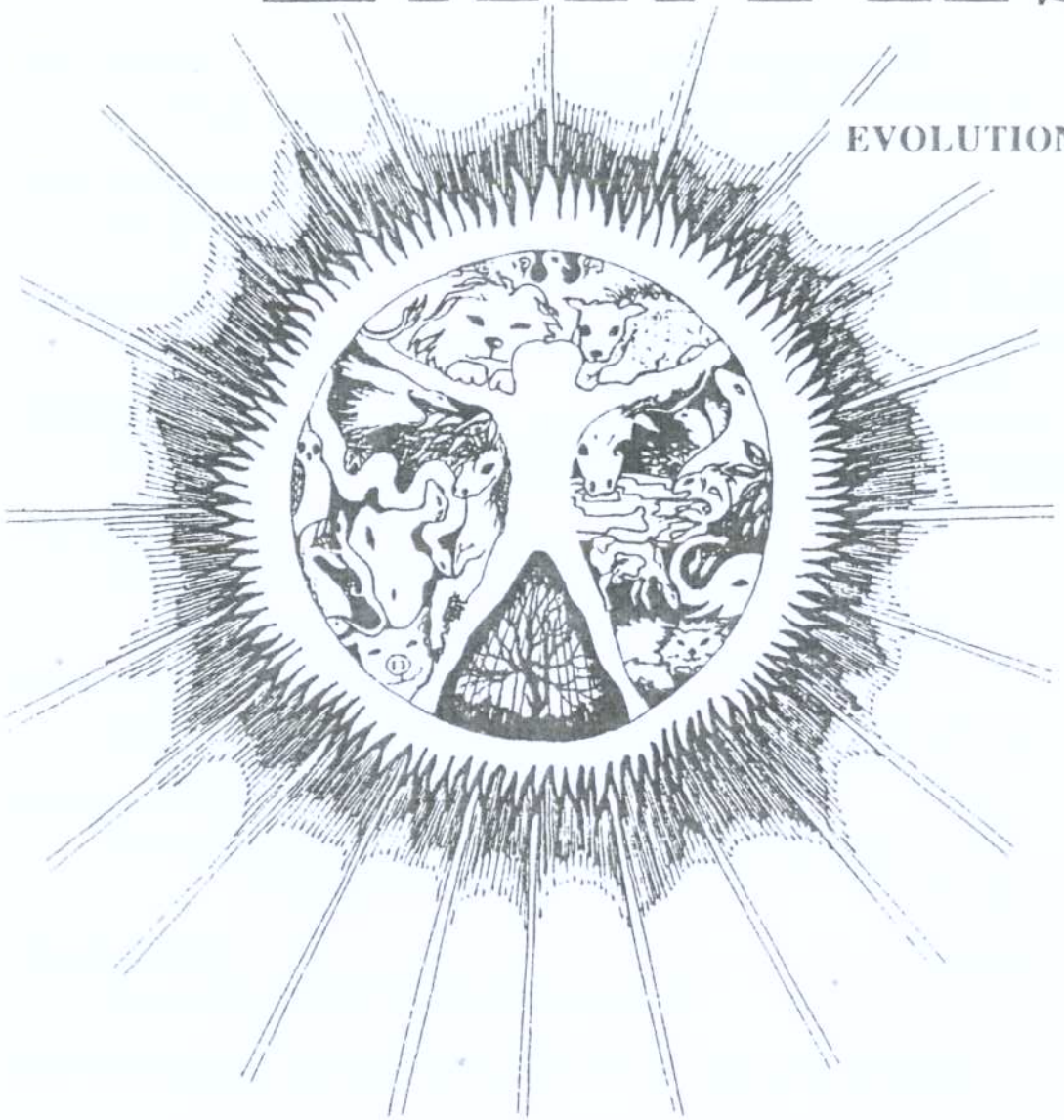

EARTHSHIP
VOLUME III
EVOLUTION BEYOND ECONOMICS
BY MICHAEL REYNOLDS

EARTHSHIP

EVOLUTION BEYOND ECONOMICS



Michael E. Reynolds

ISBN 0-9626767-2-1

First Printing July 1993
Revised Printing April 1996
SOLAR SURVIVAL ARCHITECTURE
PO Box 1041
Taos, New Mexico, 87571
earthshp@taos.newmex.com
http://www.taosnet.com/earthship/

SPECIAL THANKS

Claire Blanchard
for grinding out this production from start to finish

Mary Stone
for office support during production

Tom Drugan and **Marty Remaly**
for graphics

Peter Kolshorn
for rear cover photograph and running construction crews during production

Jonah Reynolds
for computer graphics and photography

Joe Hoar and **Justin Simpson**
for contributions to component design.

Nick Stallard
for electrical design and production of POM

Gerry and **Dennis Weaver**
for ongoing involvement in the Earthship concept

Tanya Parks
for running Solar Survival Press and

Chris Simpson, my wife for continuing to deal with a fanatic.

EARTHSHIP VOLUME III

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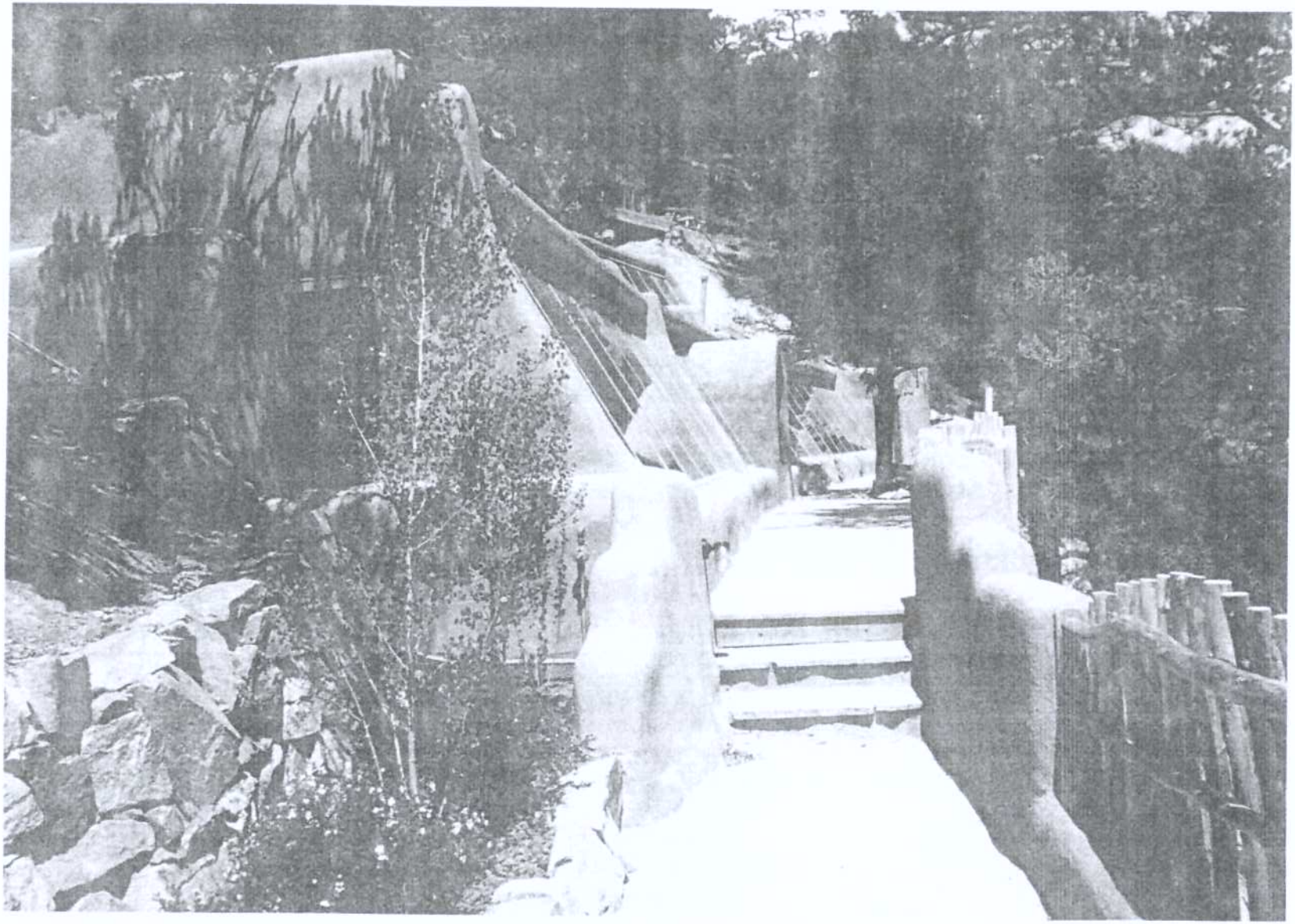


ENTRY OF THE WEAVER EARTHSHIP AT R.E.A.C.H., NEAR TAOS, NEW MEXICO

JUST AS THE SUN ALLOWS NO DARKNESS
THE LAKE ALLOWS NO DRYNESS
THE WIND ALLOWS NO CALM
THE RIVER, NO SILENCE...

THE EARTHSHIP ALLOWS NO POVERTY

EARTHSHIP AT BEAVER SPRINGS, MONTANA

INTRODUCTION

Global observations continue to show that the earth and its inhabitants are in a precarious situation. Politics, economics, and religion all present shallow solutions to a confused, disenchanted global populace. Politicians promise jobs. Economists analyze markets and play games while religious leaders perform crystalized ceremonies that have little to do with today's world. Meanwhile people are jobless, homeless, starving and dying, or if they are lucky, just unhappy and apathetic.

Why make jobs? Why should our lives (our existence) depend so much on a thing called the economy? Even religions which were founded on a spark of inspiration have now become dogmatic institutions that function with money. The all-encompassing economic dinosaur is too large to be changed or significantly influenced by *anybody* or *anything* and doesn't even notice the people it is supposed to serve. It eats everything in its path (including the souls of men) and then leaves excrement so physically and emotionally vile to both people and planet that life itself is beginning to look questionable. What if we slowly abandoned this dinosaur, using it for what it's worth as we sail into another dimension of existence? This thought will not be too exciting for those who want wealth and power. But then what is wealth and power and do these words have anything at all to do with **living**?

Let's imagine we are going to give all people all the necessities of life. This thing called economics need not be so much a part of this.

The extras of life should be the fuel for the economy - <u>not the necessities.</u>

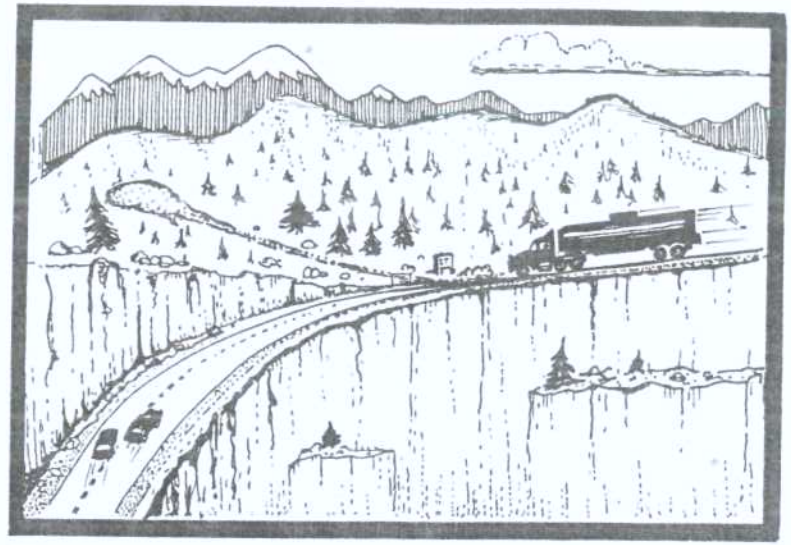
What are the necessities? **SHELTER, ENERGY, FOOD, WATER, AIR.** These necessities should not be subject to the perversions of the economic dinosaur. The capitalist game can still be played with VCR's, lawn mowers, hair dryers, clothes dryers, etc. but the necessities of life should be made easily available to all, <u>independent of economics</u>. Education should be aimed at this, politics could be aimed at this, even religion can guide us toward a survival that transcends the economic dinosaur.

We spend our time and money developing faster cars, taller buildings, better TV's, and so on while people are freezing, starving and shitting in the streets of our polluted and dying cities. Is there a bee in any hive that is not provided for? Is there a tree in any forest that does not have soil for its roots? Is there an elk in any herd that cannot graze (well actually all of these are on their way out with the rest of us!). But humans have no <u>system for all</u> like these other creatures. It is still possible for us to achieve this however. ***A system for all would manifest the necessities of life for <u>all</u> while perfectly interfacing with the planet that we are <u>all</u> traveling on.***

One conceptual approach to this *system for all* is a single vessel, available to all, that independently provides the necessities of life. Somehow every adult human should get one of these. The Government could provide them; foundations could provide them; even the wealthy could provide them, but this is a dream. These factions all are slaves

themselves of the economic dinosaur. ***We must invoke the necessities of life for ourselves.*** We must take what is "out there" and build ourselves vessels that will provide the necessities of life - SHELTER, ENERGY, FOOD, WATER, and AIR - survival beyond economics. This is what the ever evolving Earthship concept is after - a survival guide for a civilization that has turned on itself. Is it possible for all people to have the necessities of life without pollution, politics, or economics (all of which are synonymous)? Yes it is. We must continue to evolve the vessel and to help others get it, for there is no peace in a world of haves and have nots.

In the Colorado mountains, the steep downhill grades have built in safety spurs off of the main road. These spurs (or runaway truck ramps) are short uphill unpaved diversion lanes that occur every few miles. Often, large semi trucks experience brake failure and find themselves rolling down the hill at an increasing rate of speed, at some point getting out of control and crashing. The uphill safety spurs are there to absorb the out of control momentum of the truck and bring it to a halt without a catastrophe. The driver only has to be aware enough to change the direction.



Hence, life on this planet is much like a giant semi truck rolling down a hill. We are trying to put on the brakes. Examples of this "braking effort" are: auto emissions control, industrial emissions control, waste dump clean up efforts, recycling etc.

All of the above are genuine efforts of "putting on the brakes" but unfortunately the momentum of the giant truck is too much for any braking effort. *We are out of control.* No braking effort by any politician can stop us. We must steer the "truck" ourselves into another direction that (like the runaway truck ramp) *absorbs the momentum of our current downward plummet* and avoid catastrophe.

How close are we to catastrophe? Mexico City has air four times dirtier than that which makes healthy people sick. Eastern Europe has thousands of starving people. The USA has thousands of homeless people. Political corruption is as rampant as any plague that history records.

How do we change that direction? We have discovered that a little fire can warm us and cook our food. So we move toward fire. We make more and more fire. Then we learn that too much fire can burn our house down and kill us. A little fire is helpful, too much fire destroys.

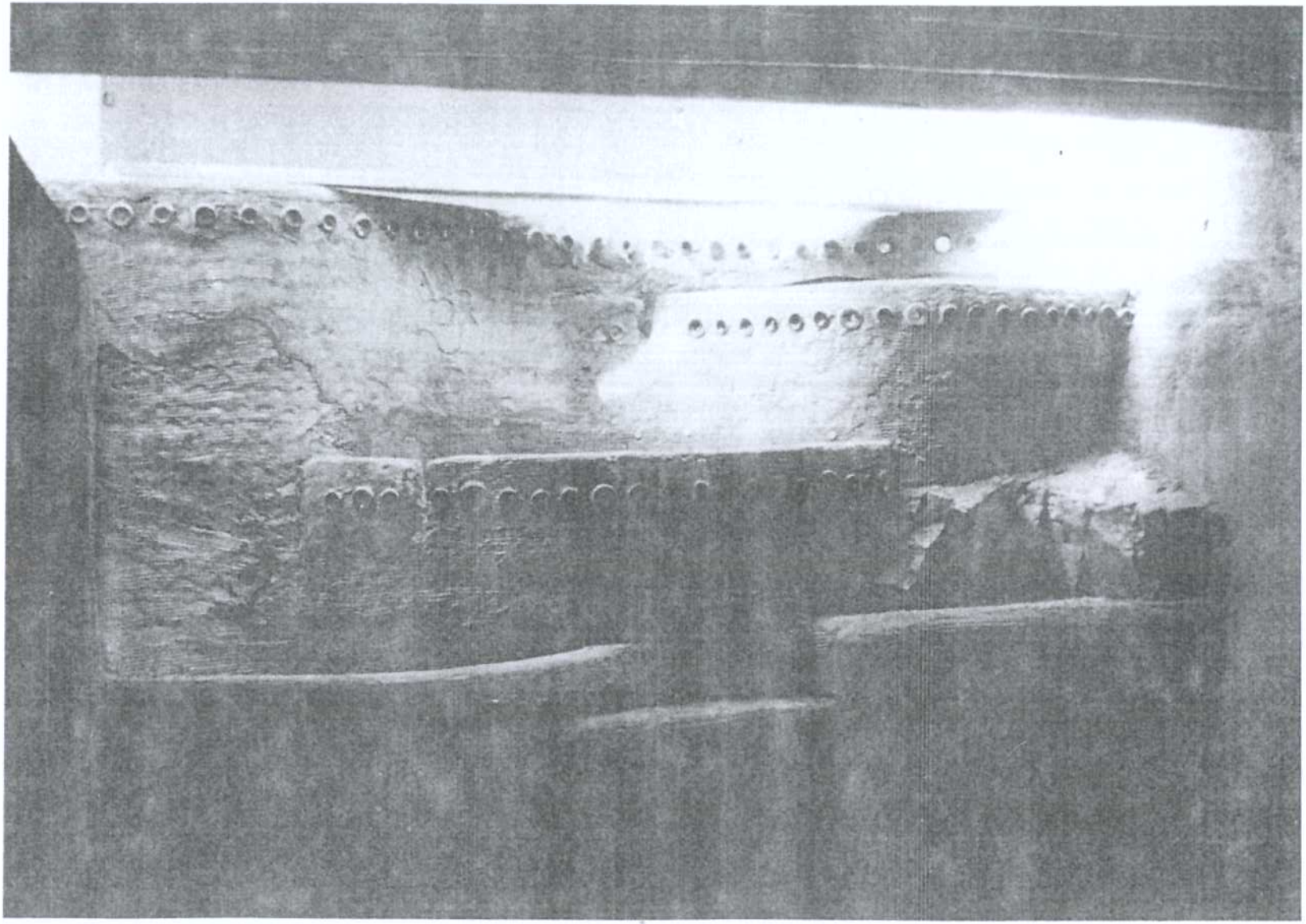
We know that a little water is good to drink, bathe in, and cook with, but too much water washes away our houses and drowns us. We have learned these lessons about basic phenomena like fire and water. Our economic and political systems are much like fire and water. A small amount of each can be an asset to our lives. A large amount can devour us. People all over the world are drowning in economic turmoil and being burned alive by political corruption. Why must these phenomena stand between us and our existence? Can't we steer ourselves in another direction without the permission of our failing economic and political systems? We are relying on them to put on the brakes but they are failing. We are unaware of the fact that we can steer the giant truck into another direction ourselves. **We can take the steering wheels of our world and change the course.** As with the truck, a sharp turn would be tragic but a slight turn in another direction, little by little, absorbing the momentum of our current direction, can save us from catastrophe.

There are things we must take charge of. There are a few defined necessities of life that we must pull out of the fire and flood of the political and economic turmoil. SHELTER, ENERGY, FOOD, WATER, and AIR.

No political or economic system should stand between a human and her/his right to the above necessities. We must invoke these necessities for ourselves and we must show and help our "relatives" to have the same. We are talking about a global human partnership for survival. Look at a bee hive. Are any bees not provided for? Look at a tree. Are any leaves not allowed to tap in to the branch? Why are some humans on this planet provided for and others left to starve? If you are naked in 10 below zero weather and you have a very expensive warm glove on your right hand, that hand will be very comfortable until the rest of your body dies. We must realize that the globe is one body much like the human body. If the people on one small elite part of

the planet are happy and well cared for, they will be very comfortable until the rest of the planet dies. **The whole body must be equally cared for to avoid specific damage *that will ultimately affect the whole body*.** The bottom line is that *all the people must help all the people.* We cannot wait for or rely on politics or economics to do it for us.

With these thoughts in mind we present Earthship Volume III.

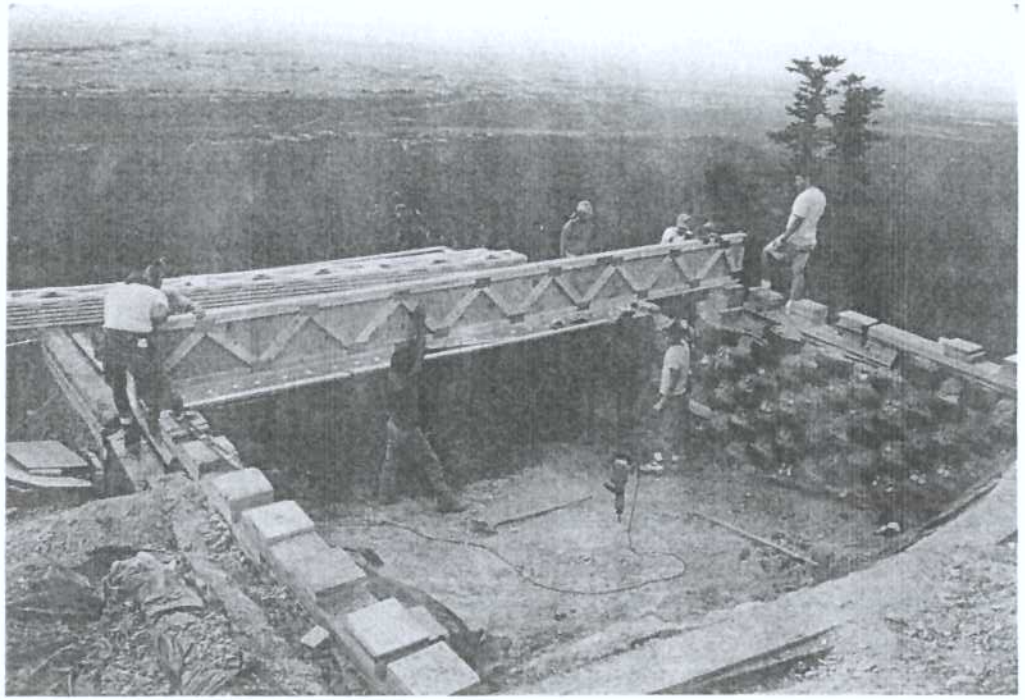


DEGAN AND SEAGAL EARTHSHIP, SANTA FE, NEW MEXICO

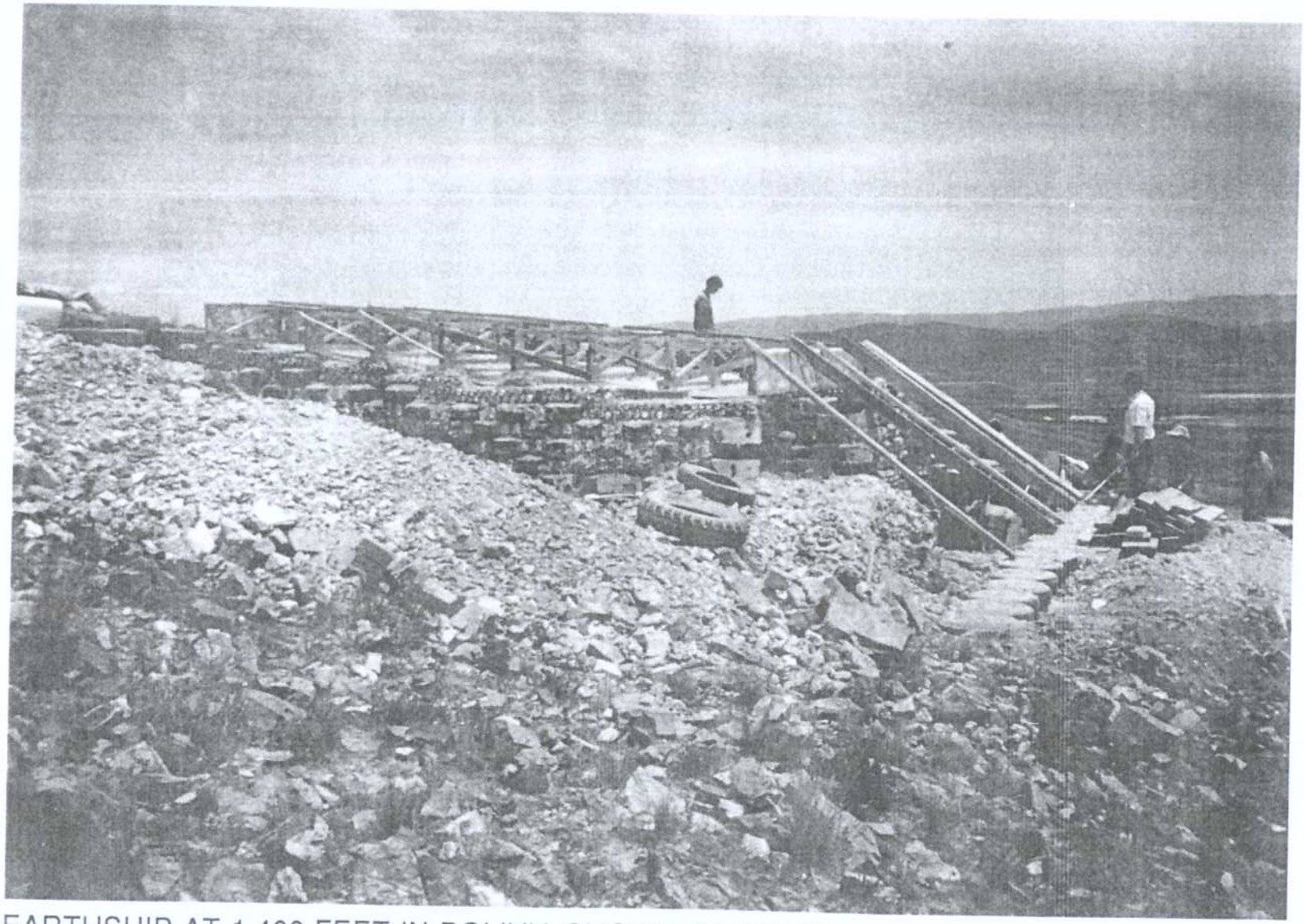
ONLY AFTER THE LAST TREE HAS BEEN CUT DOWN,
ONLY AFTER THE LAST RIVER HAS BEEN POISONED,
ONLY AFTER THE LAST FISH HAS BEEN CAUGHT,
ONLY THEN WILL YOU FIND
THAT MONEY CANNOT BE EATEN.

CREE INDIAN PROPHECY

PART ONE
EARTHSHIP EVOLUTIONS



EARTHSHIP AT REACH - TAOS, NEW MEXICO



EARTHSHIP AT 1,400 FEET IN BOLIVIA SHOWING THE DIFFERENT GREENHOUSE ANGLE FOR THE HIGHER SUN NEAR THE EQUATOR

1. STRUCTURAL EVOLUTIONS

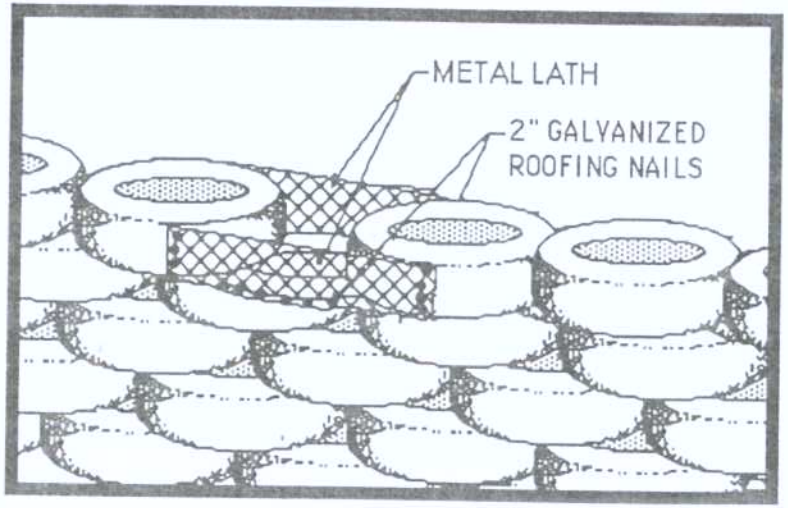
AS EARTHSHIPS ARE BUILT ALL OVER THE USA AND OTHER PARTS OF THE WORLD, WE CONTINUE TO EVOLVE THE TECHNIQUES, DETAILS AND PERFORMANCE. THESE EVOLUTIONS ARE DISCOVERED BY OWNER/BUILDERS, CREW MEMBERS AND ARCHITECTURAL STAFF MEMBERS. WE THANK EVERYONE FOR HELPING US CONTINUE TO MAKE EARTHSHIPS BETTER AND EASIER TO BUILD. AT THIS POINT WE SEE NO END TO THE EVOLUTION AND IMPROVEMENT OF THE EARTHSHIP BOTH IN TERMS OF STRUCTURE AND SYSTEMS. WE ARE JUST SCRATCHING THE SURFACE OF A CONCEPT THAT WILL SAIL US THROUGH THE FUTURE AT PEACE WITH OUR ENVIRONMENT. STRUCTURAL EVOLUTIONS ARE PRESENTED IN THIS CHAPTER ALONG WITH OTHER TECHNIQUES AND INFORMATION THAT WE HAVE BEEN REQUESTED TO PROVIDE TOWARD MAKING ALL ASPECTS OF THE EARTHSHIP MORE EASILY WITHIN THE GRASP OF THE OWNER/BUILDER.

graphics by .....Claire Blanchard
photos by .....Chris Simpson, Ken Anderson, Tom Woosley

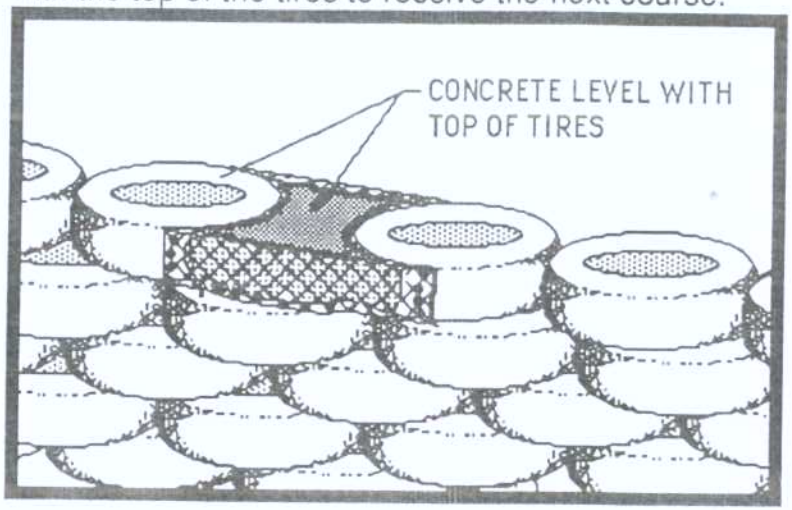
CONCRETE SPACER BLOCKS

Earthship Volume I (page 95) shows half blocks made of treated wood covered with plastic. There are two conditions where these blocking situations occur. Both of these conditions can be executed with concrete rather than wood as an alternate and sometimes easier method of forming blocking. *We must point out that a planned arrangement of empty tires before pounding can avoid most blocking.*

A half block that occurs in the middle of a row can be made by nailing a double thickness of metal lath to the tire on either side of the space to be filled. 2" galvanized roofing nails are used as they are long enough to get a good grip into the tires well yet still short enough to drive into the tires very easily. If there are any spaces where the concrete can fall through, fill them with cardboard before pouring the concrete.

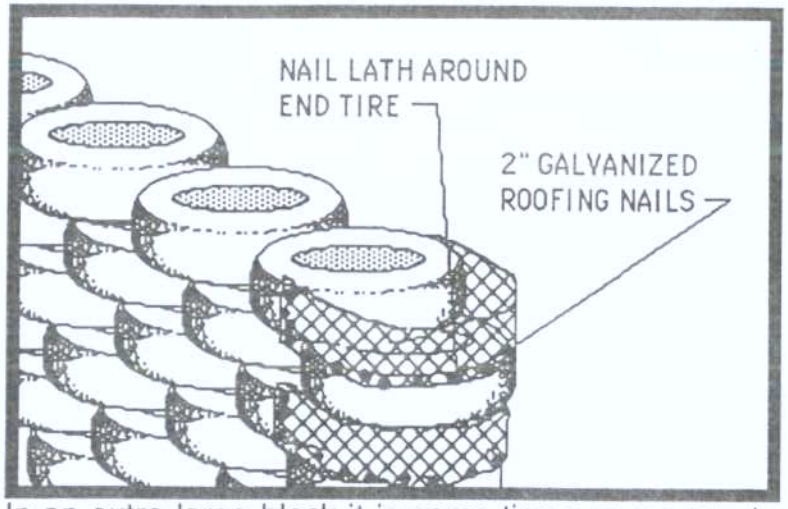


Once the lath is secured to the tires you can begin pouring in the concrete. The concrete is a 3-4-5 mixture of 3 parts cement to 4 parts sand and 5 parts gravel plus a small handful of engineering fibers which we recommend for all concrete. The engineering fibers can be obtained from a local redi-mix dealer. The concrete should be poured level with the top of the tires to receive the next course.

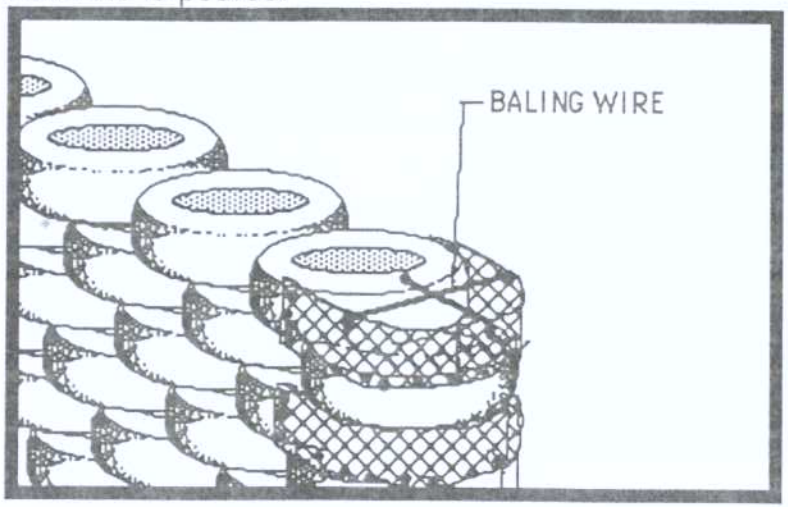


CONCRETE HALF BLOCKS

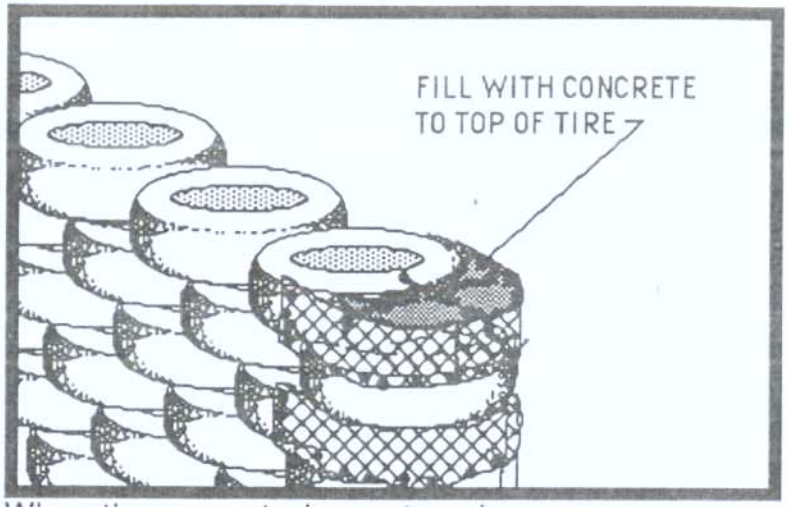
Half blocks on the ends of the tire walls can be formed with a similar procedure. The metal lath is nailed on one side of the tire with 2" galvanized roofing nails, wrapped around the tire below, and then nailed to the other side of that same tire. The lath is also nailed to the top of the tire below to hold the concrete in as shown in the following diagram.



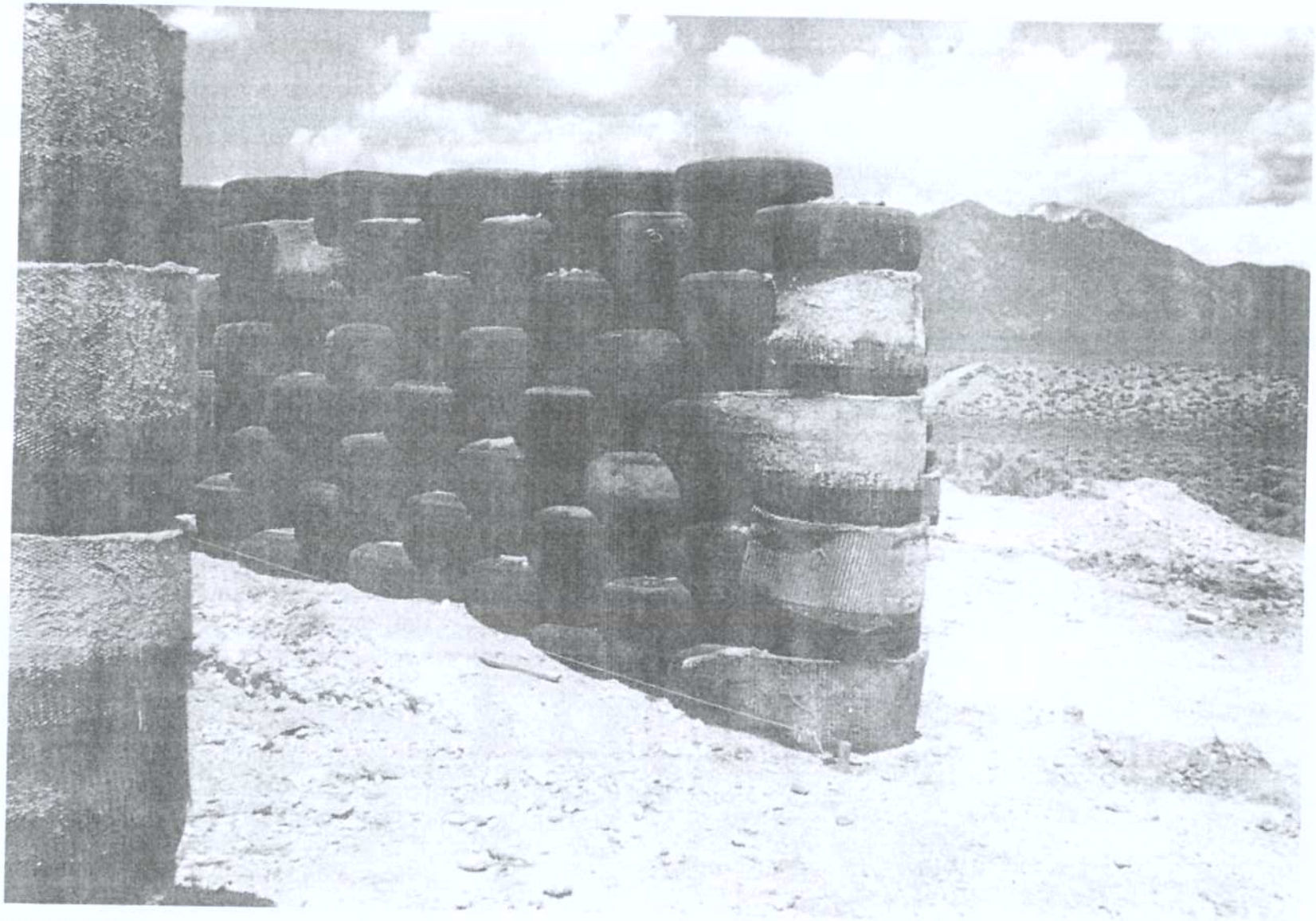
In an extra large block it is some times necessary to use baling wire added as shown below to strengthen and keep the shape of the lath as it can sag when the concrete is poured.



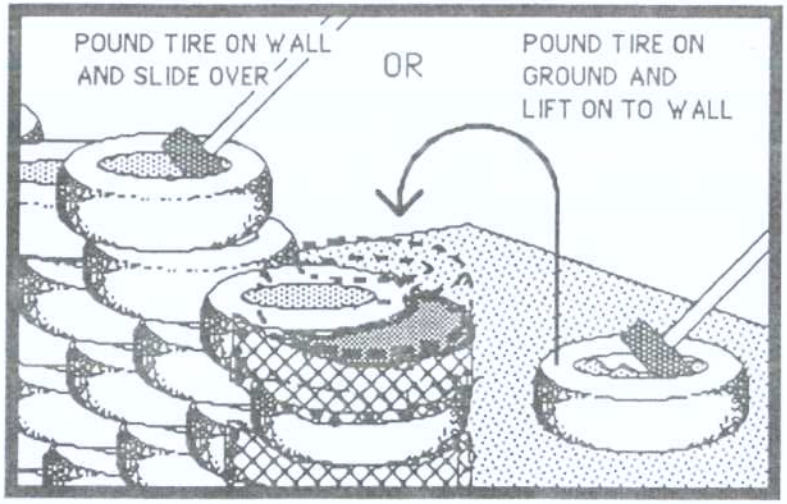
Now the form is ready to be filled with concrete.



When the concrete has set up (usually overnight) you can begin pounding the course of tires above. If you stop tire pounding an hour or two before the end of the day, you will have time to form the lath, and pour all the concrete blocks so that they can harden overnight and be ready for more tire pounding the next morning. The advantage of concrete is that it is faster, cheaper, and uses less tools and materials than the wood technique. The advantage to the wood technique is that you don't have to wait a day for the concrete to set up in order to pound tires on top of it. This is really the only advantage of wood, therefore we recommend the new concrete blocking technique wherever time allows. If time is a factor and you still want to use concrete blocking, there is a trick to continue pounding tires with a wet concrete block. It requires that you pound the tire at another location such as further along the tire wall or on the ground next to the tire wall and then lift or slide the tire into place gently over the wet concrete (see page 5).



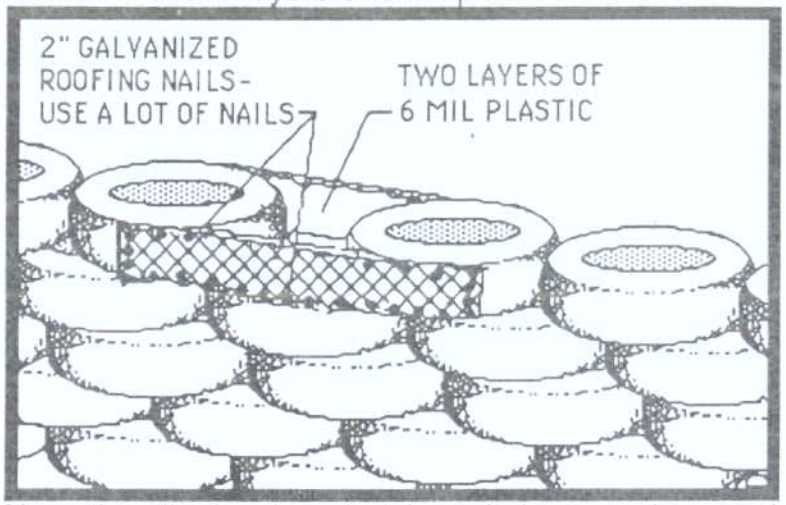
GREG AND MARJORIE HARFORD'S EARTHSHIP SHOWING CONCRETE HALF BLOCKS.



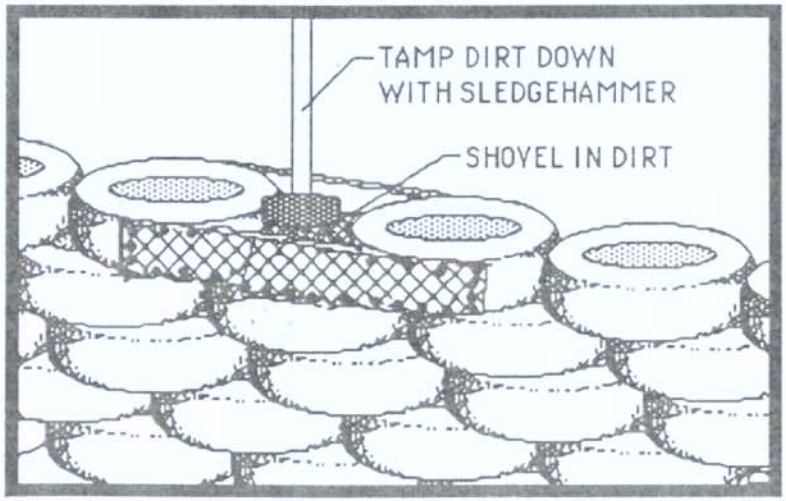
RAMMED EARTH SPACER BLOCKS

We have also developed a rammed earth spacer block. The advantages of this method are cost and environmental factors relative to less use of concrete. The only cost is a double piece of lath, 6 mil plastic and a handful of nails. The earth is free. Compare this to the concrete block where you have to purchase sand and cement in addition to the lath and nails. The basic difference is in the strength of the two materials. In situations where strength is a major concern, such as an extreme load (or half blocks at the end of a tire wall) we recommend the use of the concrete blocking. In many situations though, the rammed earth block is cheaper, quicker and easier, and is constructed as follows.

A double layer of metal lath is nailed on to the tires as shown for the concrete blocks with additional nails at the bottom of the lath to the tire below. Use plenty of nails to withstand earth ramming. Then the inside is lined with two layers of 6 mil plastic.



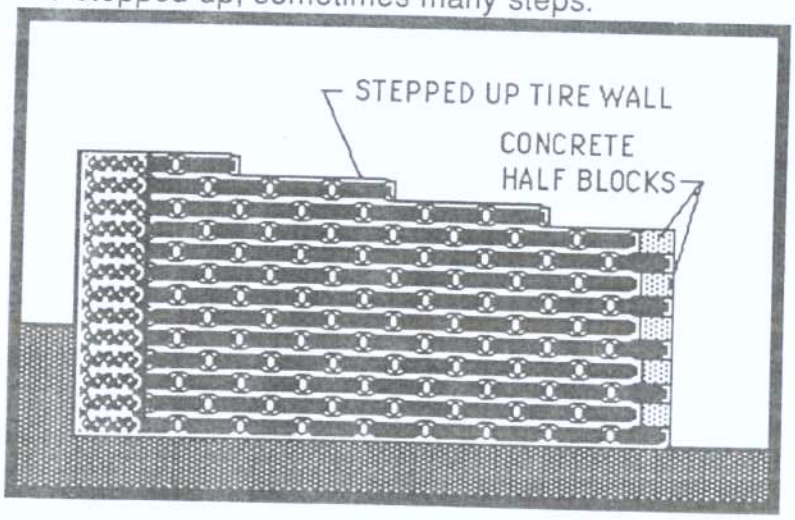
Now the dirt is shoveled in a little at a time and tamped down with the sledge hammer. It is best if the dirt is slightly damp. This process of filling and tamping is repeated until the block is full and level with the tires on either side of it.



Rammed earth spacer blocks require a much more serious and conscientious job in forming and nailing the lath than on concrete spacer blocks as the lath must withstand the ramming of earth. *We do not recommend rammed earth half blocks on end walls.* Concrete is the best material here.

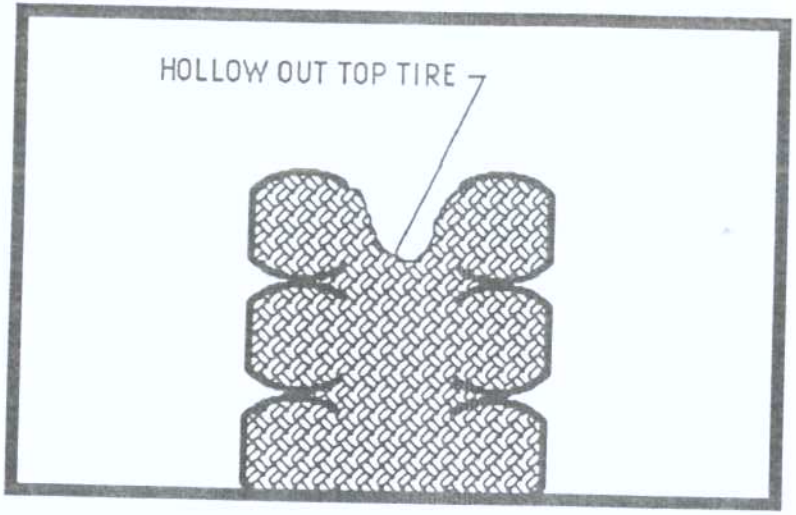
CAN AND CONCRETE BOND BEAM

The can and concrete bond beam is most effectively used on a building that has a steep roof slope. In this situation the tires do not end on a level course but are stepped up, sometimes many steps.

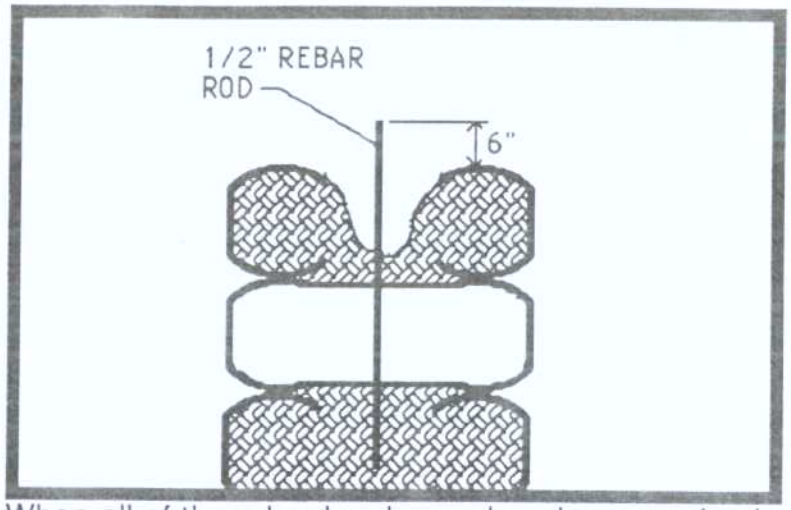


The concrete bond beam connects all the levels together much easier than the stacked wood blocking steps required with a wood plate bond beam. The can and concrete bond beam provides a continuous platform for the roof structure. Another advantage of the concrete bond beam is the reduction of wood used in the Earthship. In many cases concrete is cheaper than wood and requires fewer tools. *Concrete is ultimately a more permanent material than wood.*

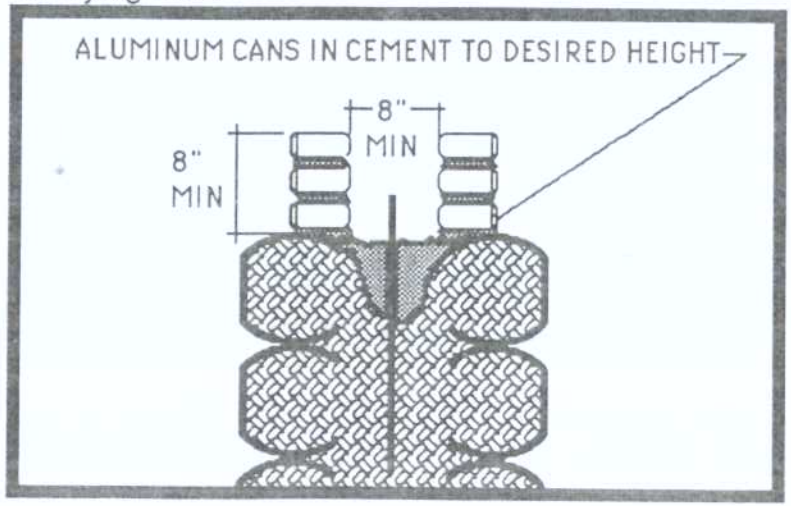
The first step of the bond beam is to hollow out the center of every tire on the top course to receive the bond beam.

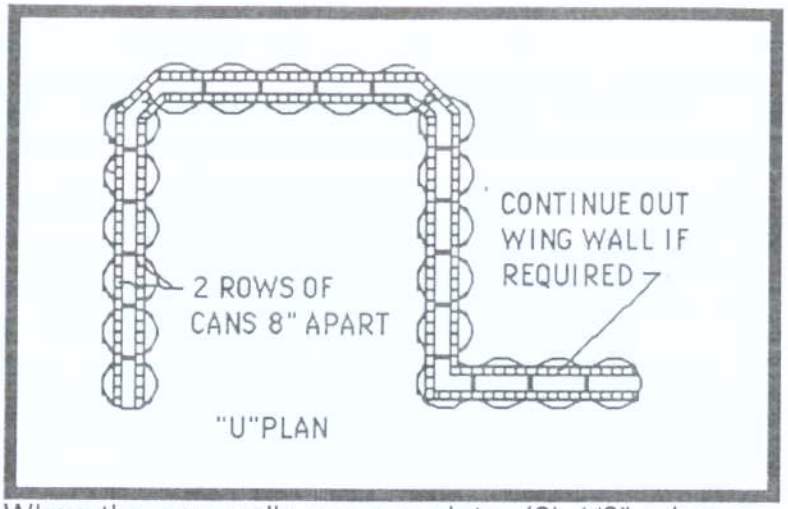


This connects the concrete bond beam to every tire on the top course. Drive a 3'-0" rebar deep into the tire coursing leaving 6" sticking up above the top of the tire. Try to aim the rebar between the tires on the second course down so you don't have to pound the rebar through the rubber casing.

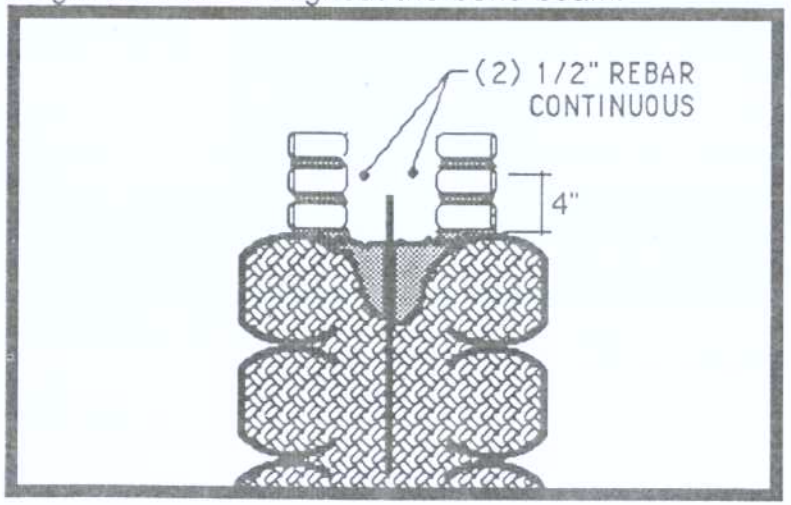


When all of the rebar has been placed you can begin laying cans at the top of the tire wall. Two rows of cans are laid leaving a space between that is a minimum of 8 inches wide. See page 158, Volume I for laying cans.

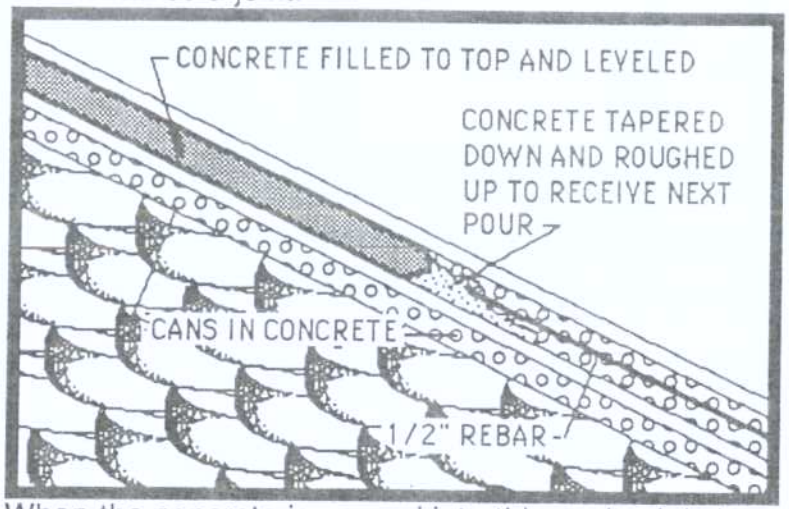




When the can walls are complete, (2) 1/2" rebar are installed horizontally in the space between the cans. This rebar should run continuously. The twenty foot lengths should be overlapped 18" where necessary and joined with baling wire to achieve a continuous length of rebar throughout the bond beam.

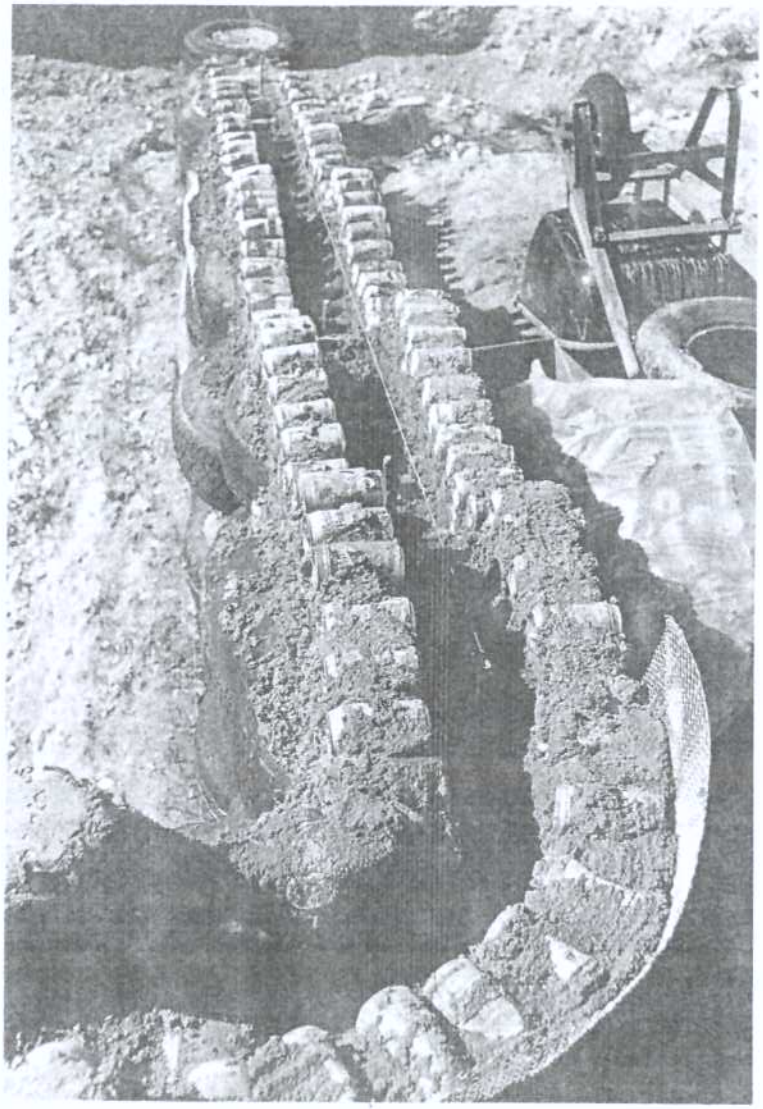


This horizontal rebar should be installed at 4" above the top of the tire. This can be achieved by wiring it in place with baling wire or by pouring the bond beam 4" thick, laying the rebar on the wet concrete and then continuing the pour. Never leave a horizontal cold joint.

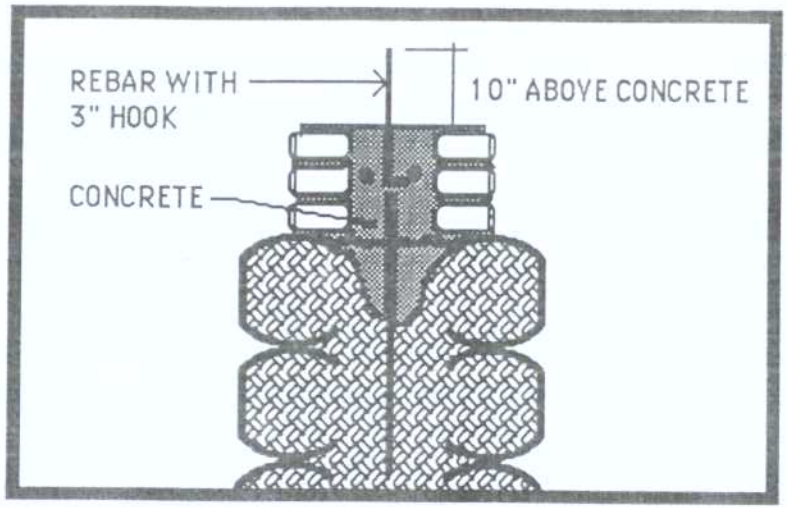


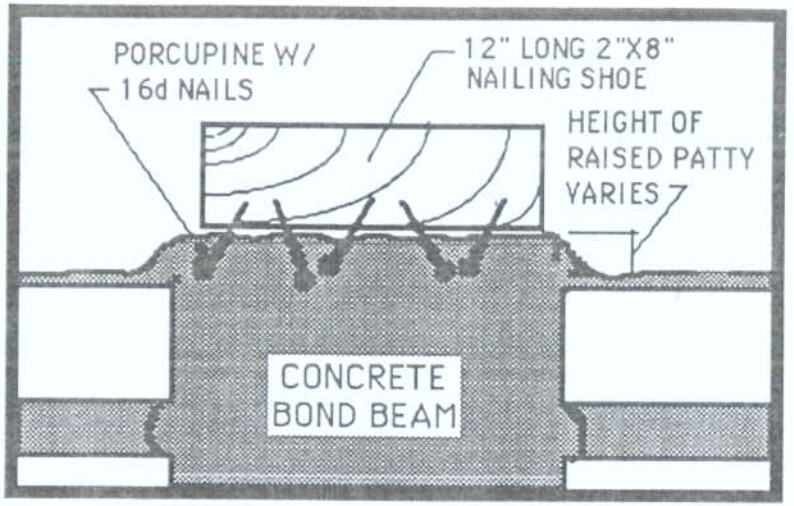
When the concrete is poured into this cavity, it is best to pour the beam all at once as any cold joints in the concrete will weaken this structure. If cold joints do occur, taper the pour off and rough it up to receive the new pour.

After the concrete is poured and while it is still wet, provisions must be made for roof structure. If vigas are used, a vertical rebar with a 3" hook on the end is placed in the wet concrete at the required viga locations. The rebar must be left sticking up about 10" to allow roof slope shimming for vigas (see Earthship Vol. I, pages 104 - 109).



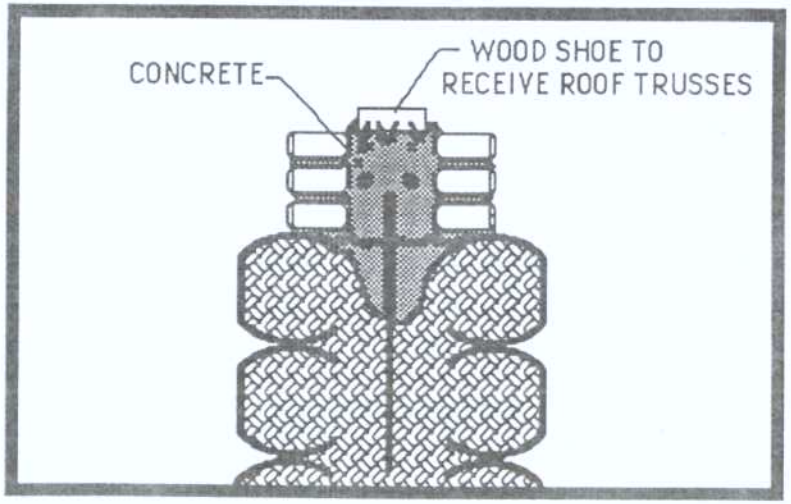
Notice that the top of the concrete bond beam is level and stepped. Never attach vigas to a sloped bond beam

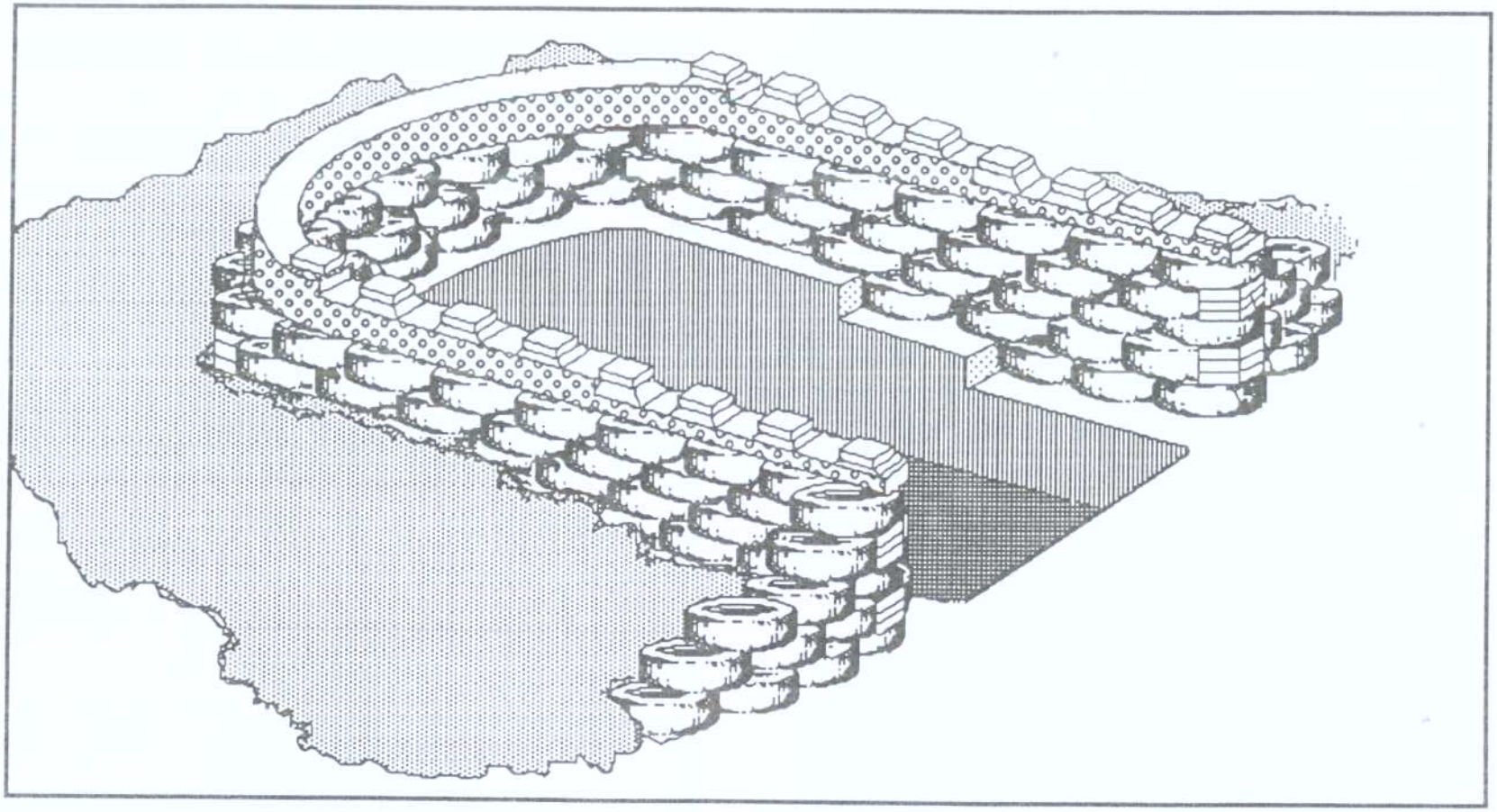




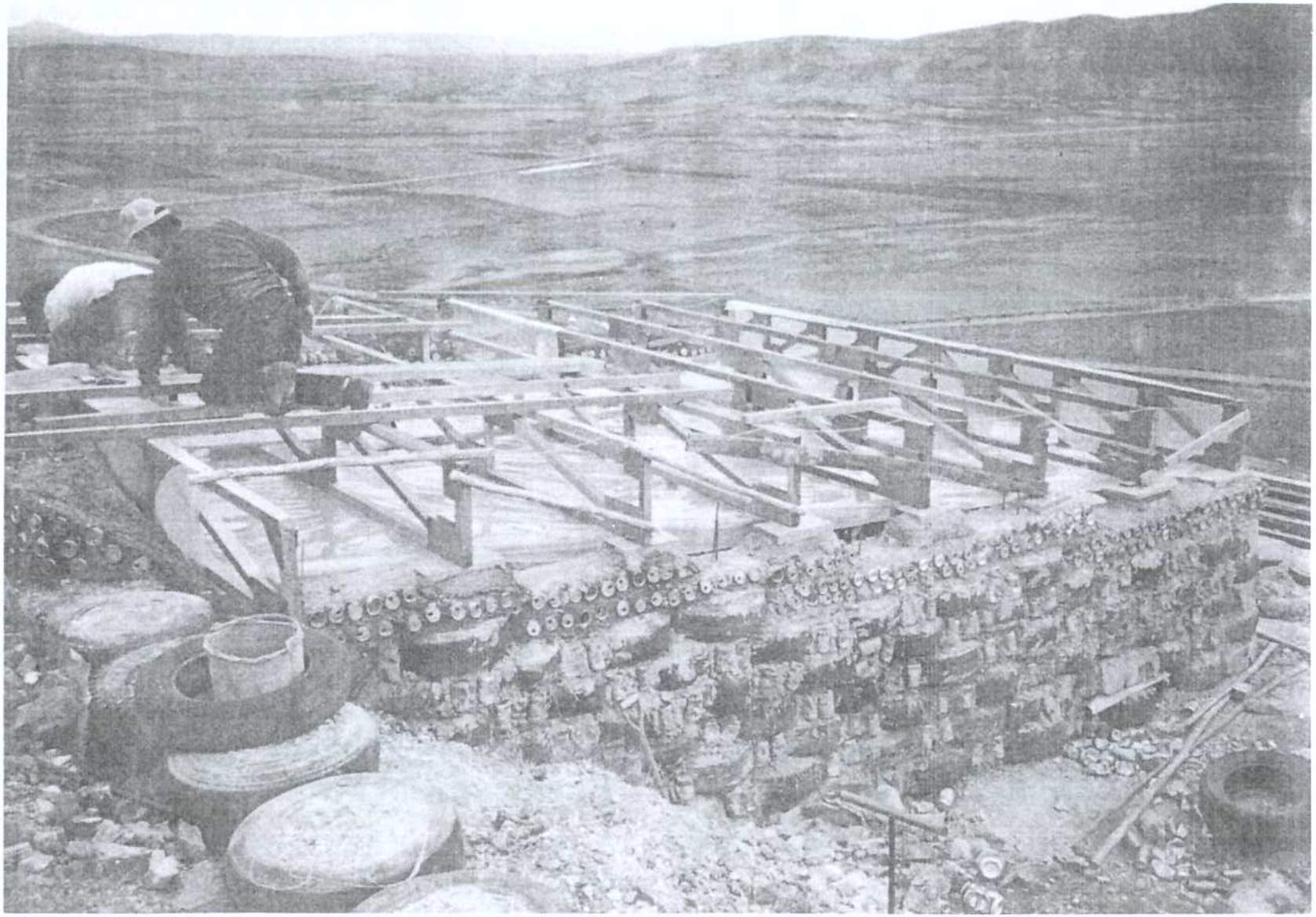
Vigas are not available in many places so we have evolved a truss system that can be used when heavy timber is not available. If trusses are used, a wood nailing shoe is cleated into a raised patty on the wet concrete bond beam. The shoe is made from 1-1/2" thick pressure treated 2" x 8" lumber and is 12" long. It is porcupined (see Earthship Vol I. page 157) with 16d nails and set into the wet concrete.

These wood "shoes" allow anchoring and shimming of the trusses to an appropriate slope. Be sure that these shoes are installed level and not sloped. Never install trusses on a sloped shoe. See photograph oposite page one.



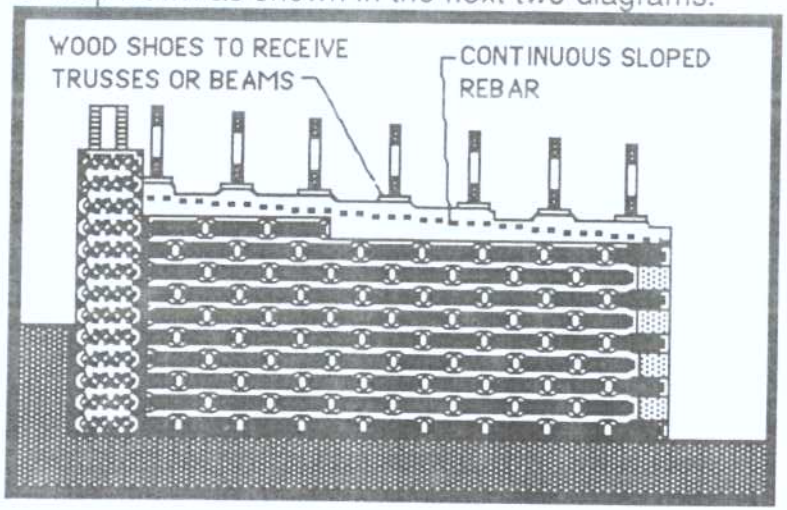


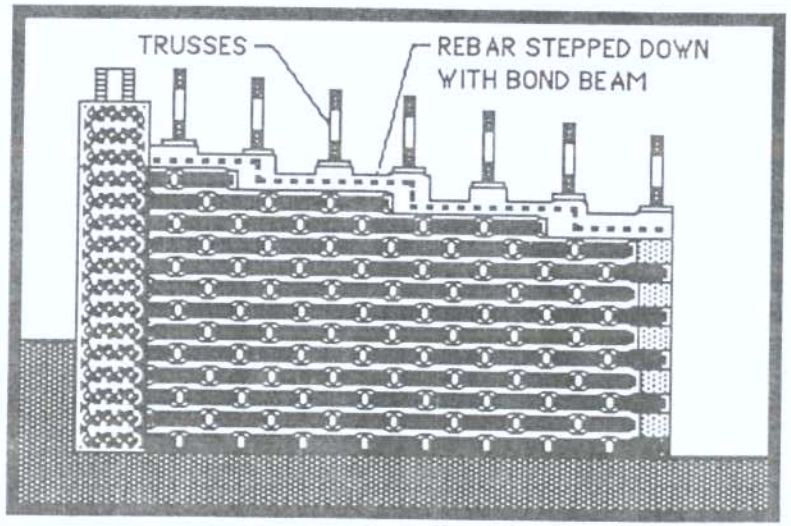
TYPICAL EARTHSHIP "U" WITH CAN/CONCRETE BOND BEAM AND WOOD NAILING SHOES FOR TRUSS MOUNTING.



EARTHSHIP AT 14,000 FEET IN BOLIVIA SHOWING THE DIFFERENT GREENHOUSE ANGLE FOR THE HIGHER SUN NEAR THE EQUATOR

Depending on the conditions of the tire wall, the horizontal rebar will either slope down continuously or step down as shown in the next two diagrams.

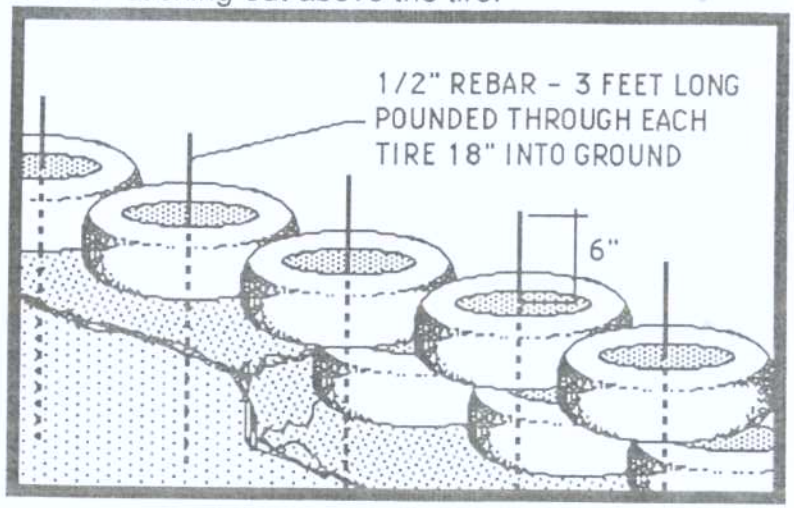




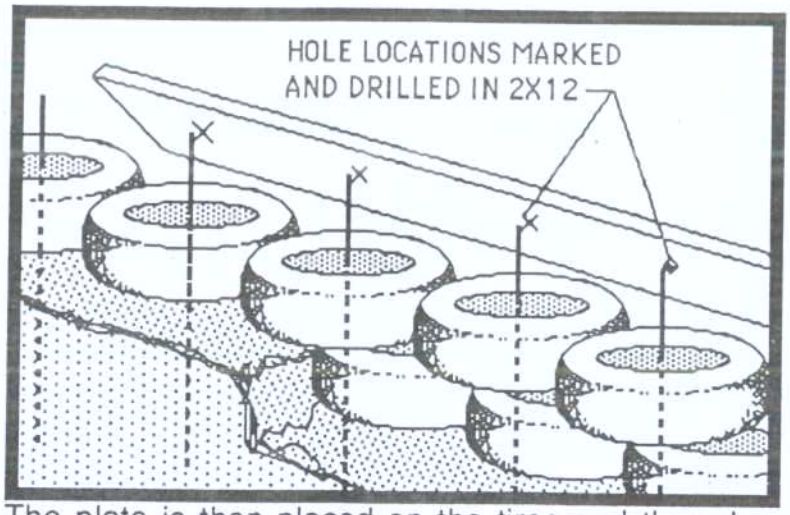
REBAR PINNED PLATES

In some situations, Earthships are built with only one to three courses of tires on a gentle slope. For these Earthships we have an alternate method of anchoring a wood bond beam plate to the tires - the rebar plate anchor (See Earthship Volume I p. 101-103 for wood bond beam plates). This method can save time and money since it does not require any concrete.

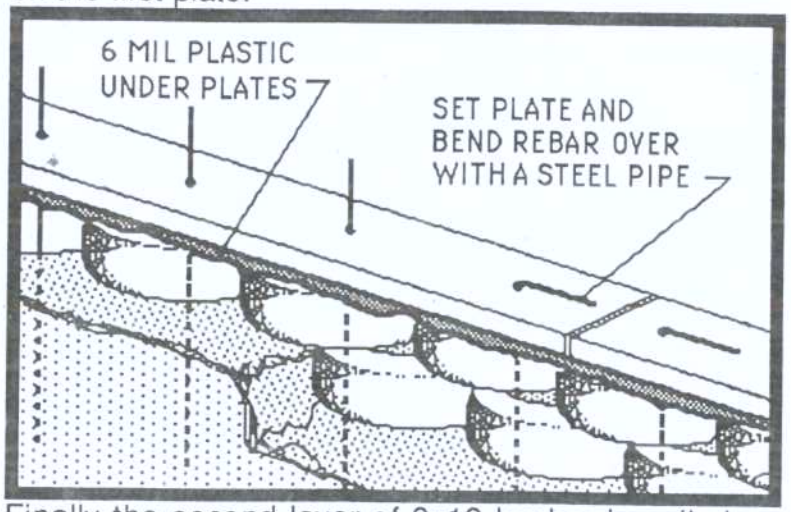
3 foot lengths of 1/2" rebar are hammered down through the pounded tire with a sledgehammer at least 18" into undisturbed soil (or 3 tires deep), leaving 6" to 8" sticking out above the tire.



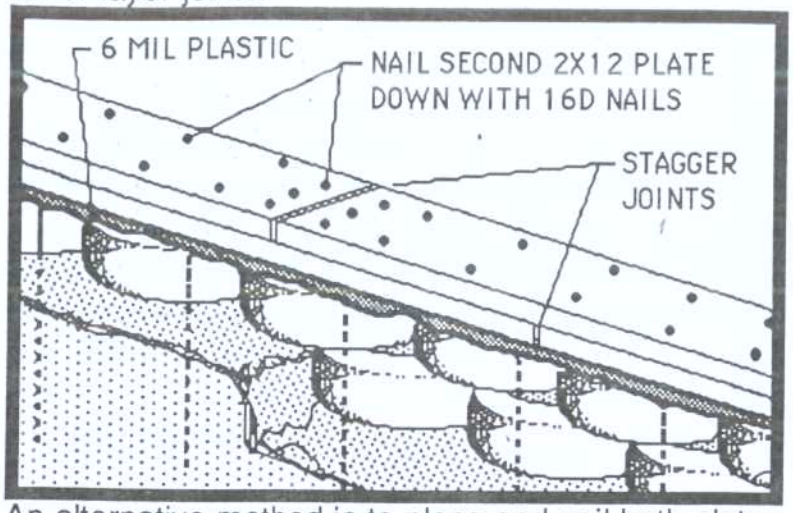
Then the first layer of 2"x12" pressure treated lumber is set over the tires and rebar. *Be sure to lay down 6 mil plastic over the tires first.*. Marks are made, where holes will be drilled, at the location of the rebar anchors by placing the 2x12 plate over the rebar stakes and tapping it with a hammer. Make pencil marks where the dents are.



The plate is then placed on the tires and the rebar that is sticking up from the plate is now bent over with a steel pipe and snugged up with a sledgehammer. Make notches in the second 2 x 12 with a chainsaw where the bent rebar is so the second plate lays flat on the first plate.



Finally the second layer of 2x12 lumber is nailed on with 16d nails. Keep upper layer joints away from lower layer joints.



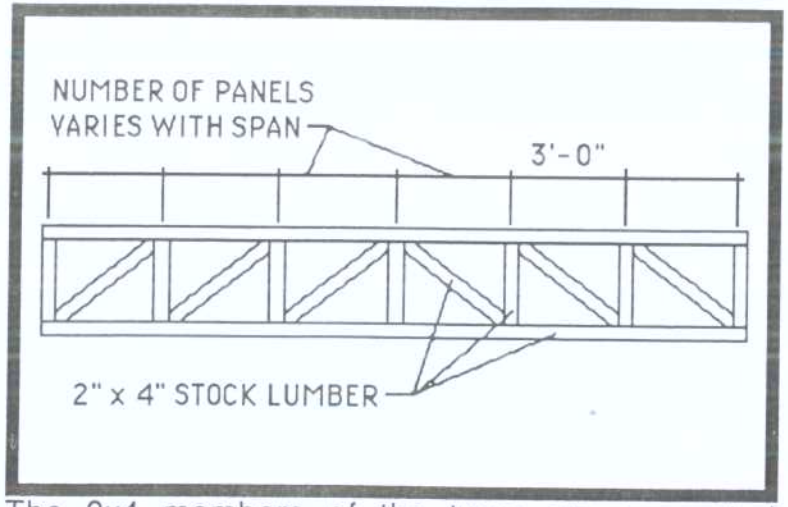
An alternative method is to place and nail both plates and install rebar pins through them afterwards.

HOMEMADE TRUSSES

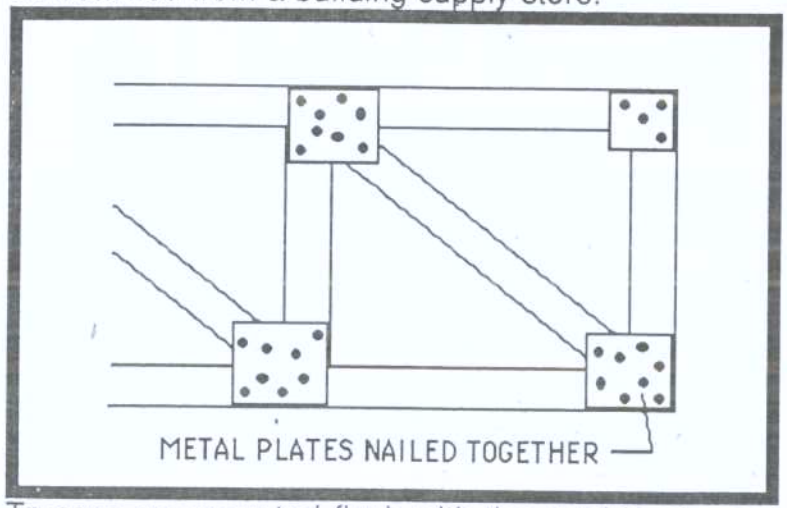
PANEL TRUSS

The truss as a roofing system has several advantages. Trusses are lighter and easier to handle than a viga or beam. Some areas do not have access to timber for vigas or beams so trusses are a must in these areas. Trusses also allow an increased depth of insulation in the roof. Custom trusses can be constructed with minimal tools on the job site or purchased from a local building supply store. The truss is a flat box type and is constructed of panels made from 2"x4" stock lumber. The depth and number of panels in the truss will depend on the span of the room and the roof loads to be carried. 3'-0" is an average size of the panels. If large snow or wind loads are possible in your area, trusses should

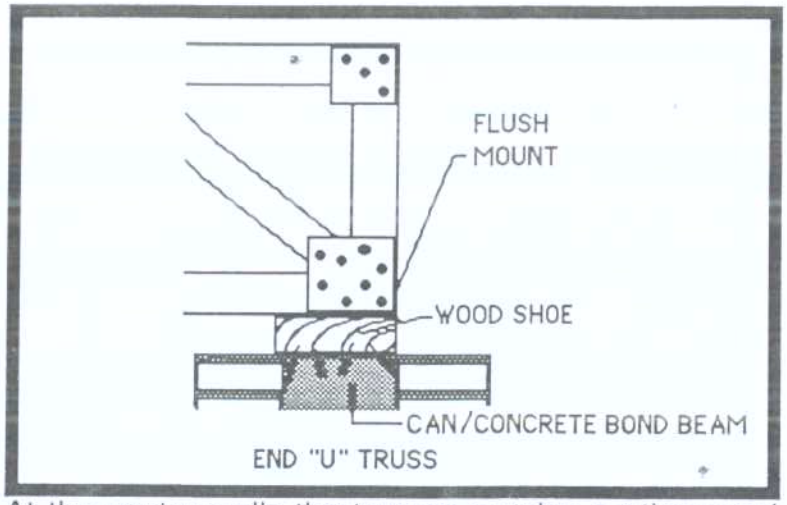
be checked out with a local engineer, truss manufacturer or SSA.



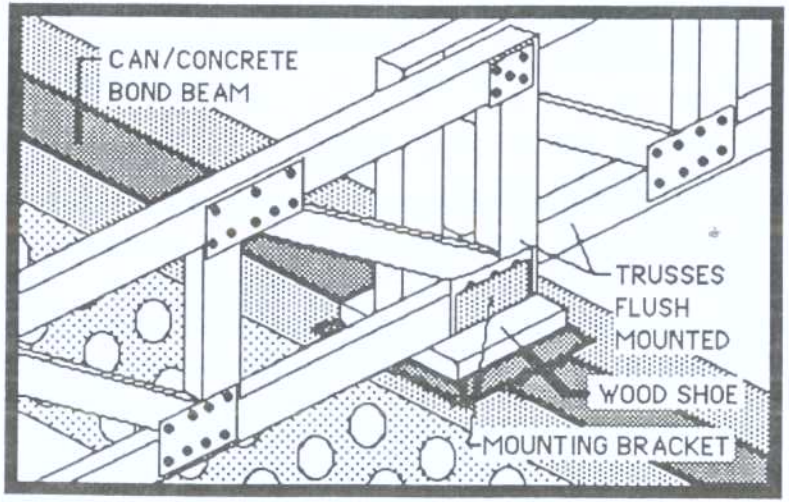
The 2x4 members of the truss are connected together with metal plates nailed into the lumber. These metal plates are called truss plates and can be obtained from a building supply store.



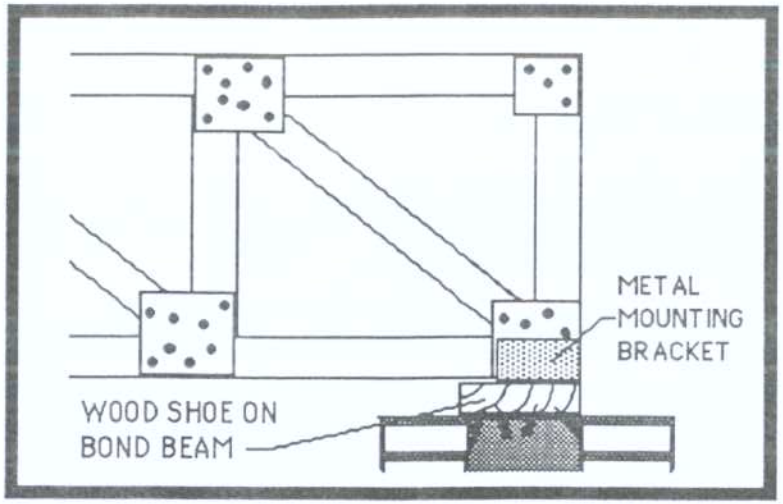
Trusses are mounted flush with the outside of wood shoes.



At the center walls the trusses overlap on the wood shoe.

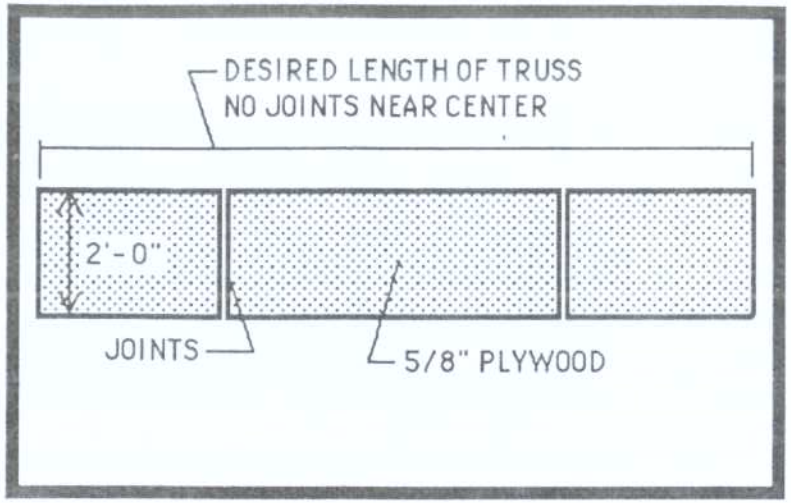


The truss can be mounted on the prepared shoe block (previously set in the bond beam) with metal brackets available at a building supply store.



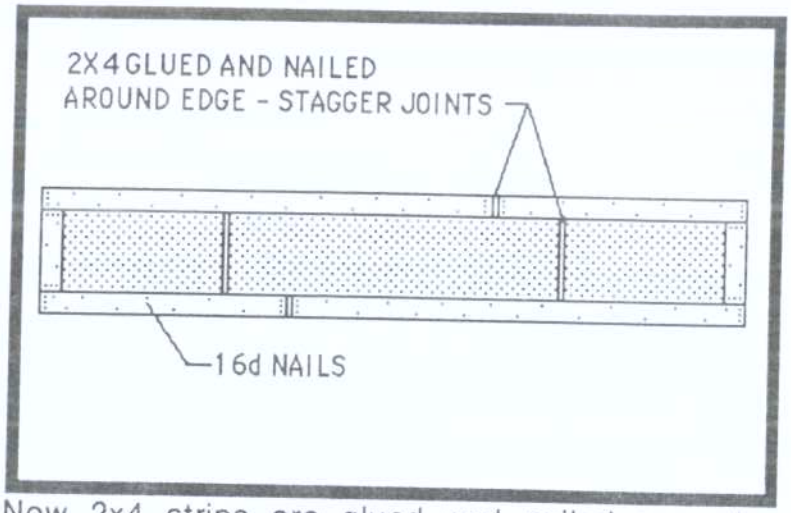
If you are in an area that may receive heavy snow or wind, or if your span is more than 18'-0", you may require additional reinforcing of the trusses. It is important that you consult your local structural engineer or SSA for assistance.

Although this panel truss design is simple, it does require some carpentry skill and quite a few tools. An inexperienced builder can make a dangerous mess of this truss. Therefore we have a second truss design that literally anyone can make. We call it the "idiot truss". It is actually much safer and stronger. It does cost a little more in materials. This truss is constructed of 2x4 stock lumber and 5/8" CDX plywood. It should be constructed on a flat surface and requires minimal tools such as a circular saw, square, and hammer along with nails and liquid nails. First the plywood is cut in half so that you have (2) 2'x8' sheets of plywood. Cut the length so that joints in the plywood do not occur near the center of the truss.

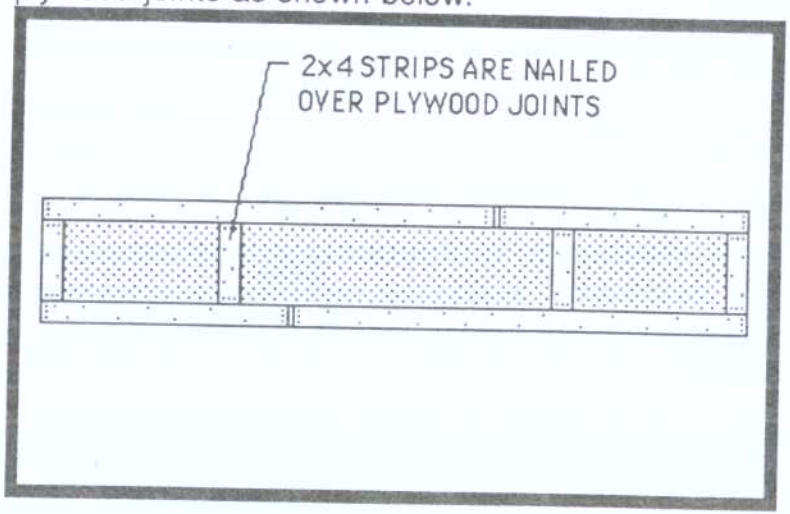


Then 2x4 stock lumber is glued and nailed around the edge of the plywood as shown on the following page. The bottom and top 2x4's should be continuous and if possible should be one piece of wood. If joints are necessary they should occur away from the center and away from other joints. **No joints of any kind occur within 3'-0" of middle.**

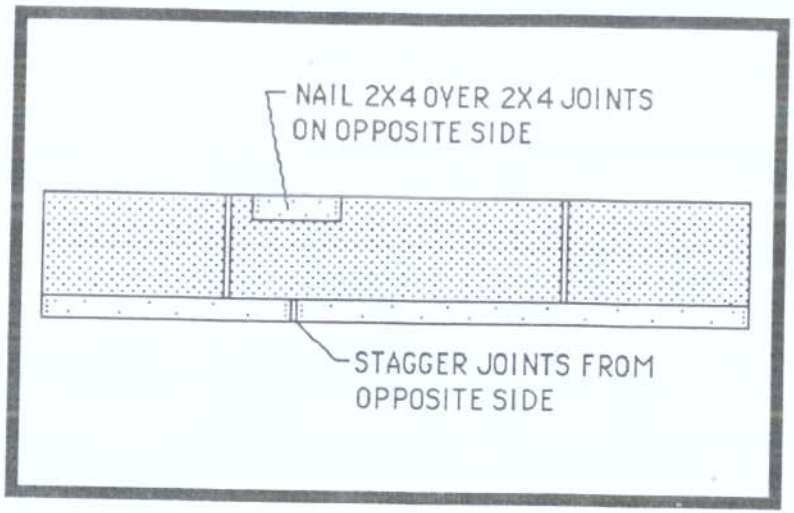
Use 8d nails for the top 2x4 plate. Tack the bottom plates on with 8d nails but use 16d nails staggered every 6" to secure them permanently. Use Liquid Nails on all 2x4 plates.

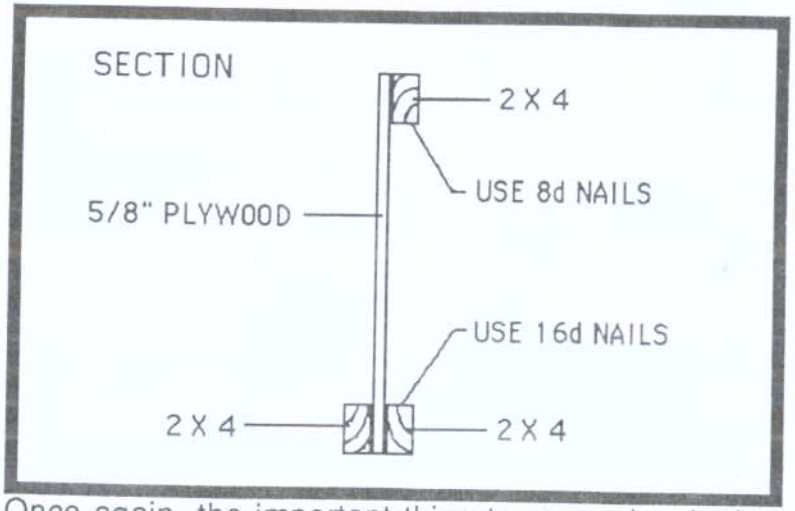


Now 2x4 strips are glued and nailed over the plywood joints as shown below.

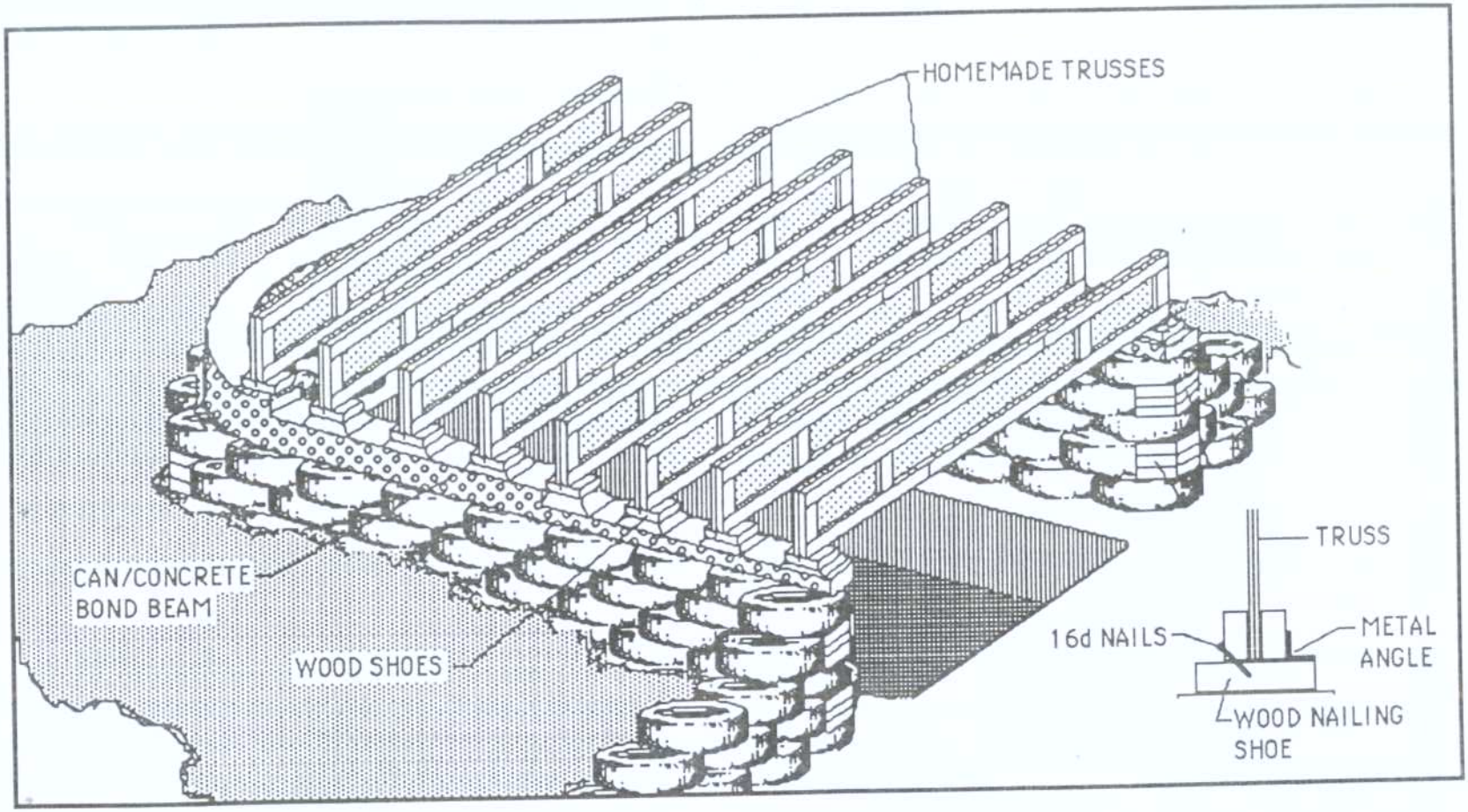


Now the truss is turned over and an additional 2x4 is glued and nailed along the bottom only, plus a small (2'-0" min.) piece of 2x4 nailed where the joint in the 2x4 on the other side occurs.





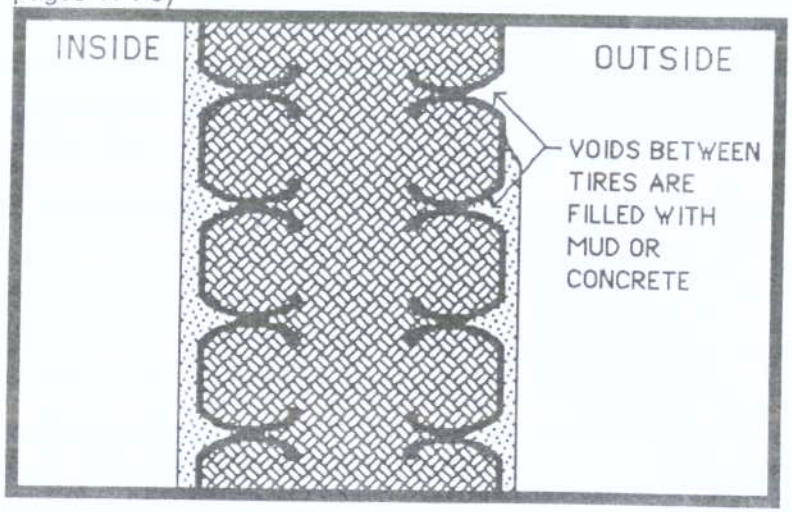
Once again, the important thing to remember is that *none of the joints in plywood or 2x4 occur next to each other.* Now the truss can be installed as shown on opposite page. These trusses will span up to 22' at 2'-0" O.C for loads up to 50 PSF. For longer spans or larger loads check with SSA or an engineer.



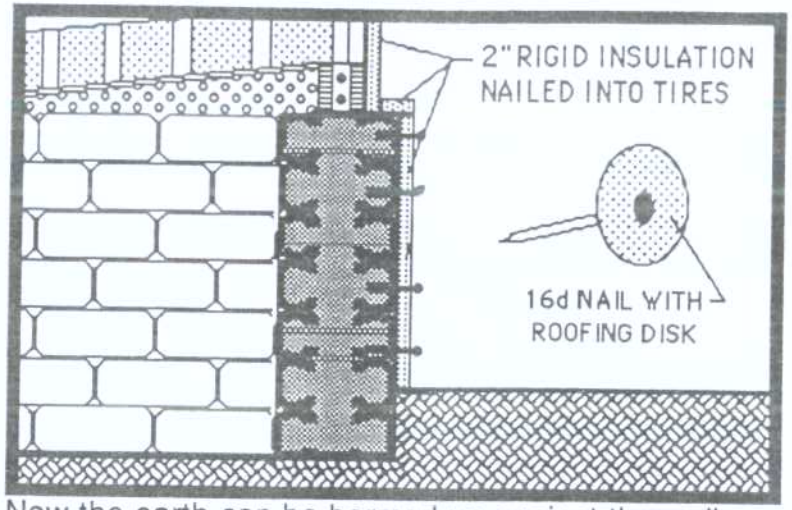
TYPICAL EARTHSHIP "U" WITH CAN/CONCRETE BOND BEAM AND HOMEMADE TRUSSES. TRUSSES CAN BE ANCHORED TO NAILING SHOES WITH 16D NAILS AND/OR METAL ANGLES NAILED TO TRUSSES AND TO NAILING SHOE.

COLD AREA GROUND INSULATION

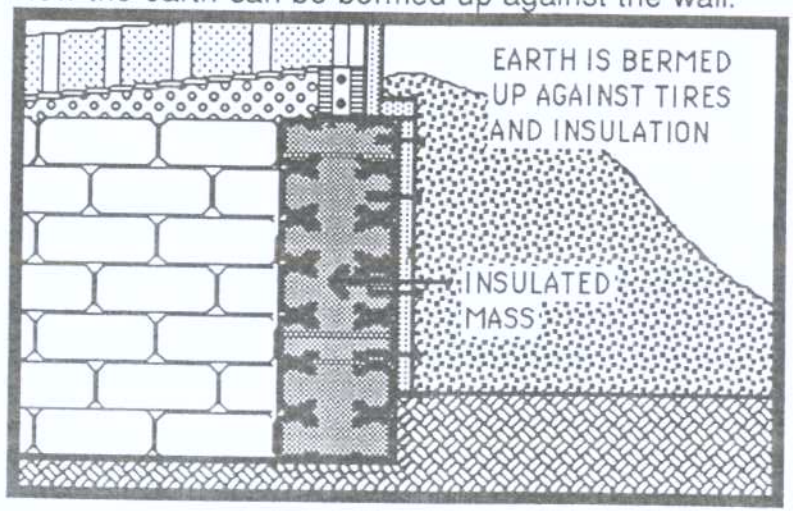
In areas where the tire structure of the building is above the frost line or where the frost line is very deep (4'-0" or more), additional insulation may be required around the perimeter. In this situation, the tire wall is completed and the voids between the tires *on the outside of the building* are filled with mud or cement the same as the interior. (see Earthship Vol. I pages 174-5)



Then, before the earth is bermed up against the tires, a layer of 2" rigid perimeter insulation is nailed (with 16d nails and roofing disks as washers) to the tires as shown in the following diagram.



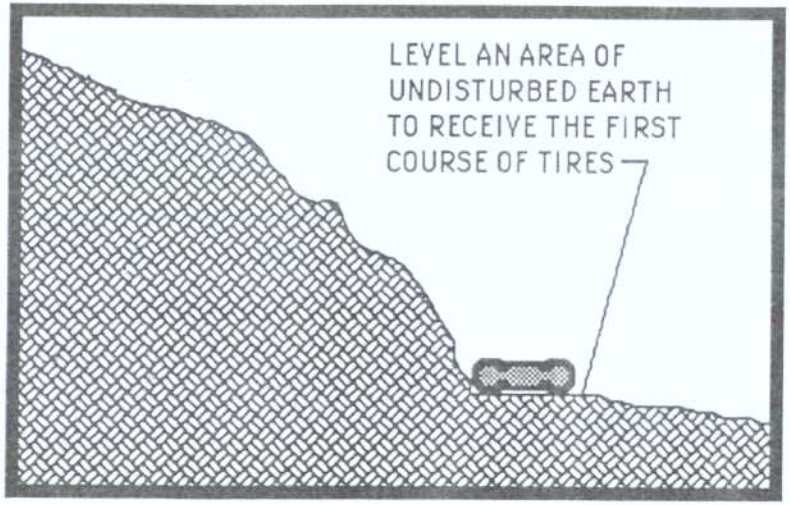
Now the earth can be bermed up against the wall.

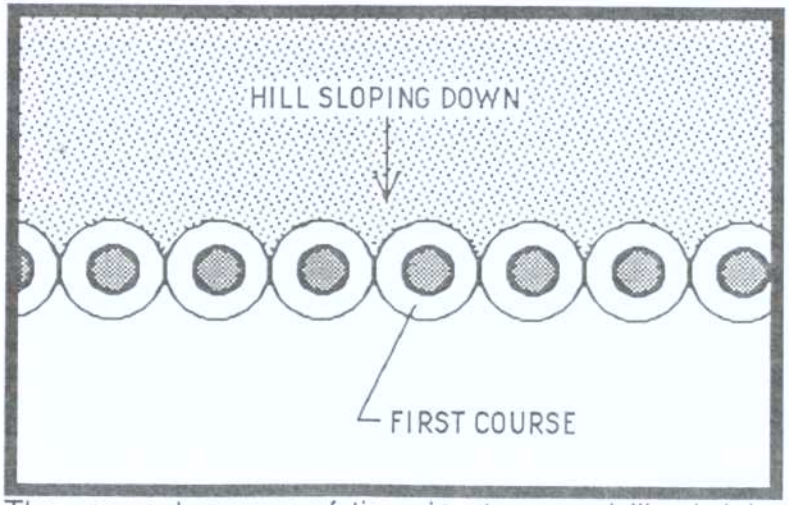


BATTERED TIRE RETAINING WALL AND WING WALL

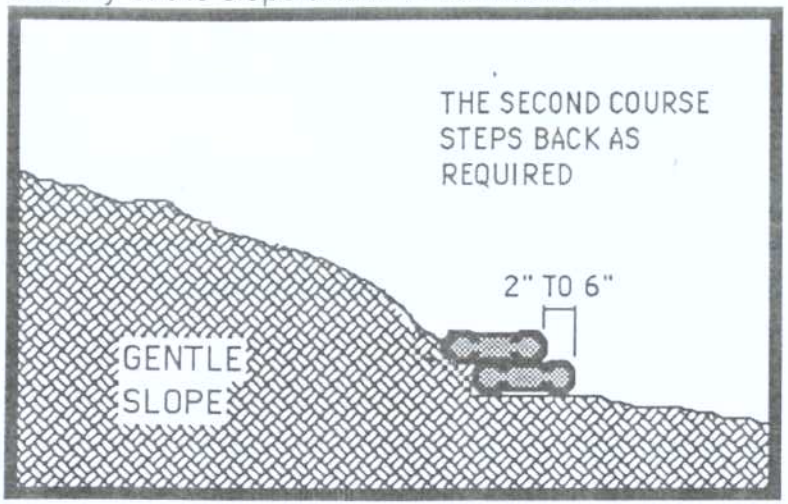
On some steep sites or where Earthship walls are well below normal grade, a retaining wall may be necessary to hold back the surrounding earth. The

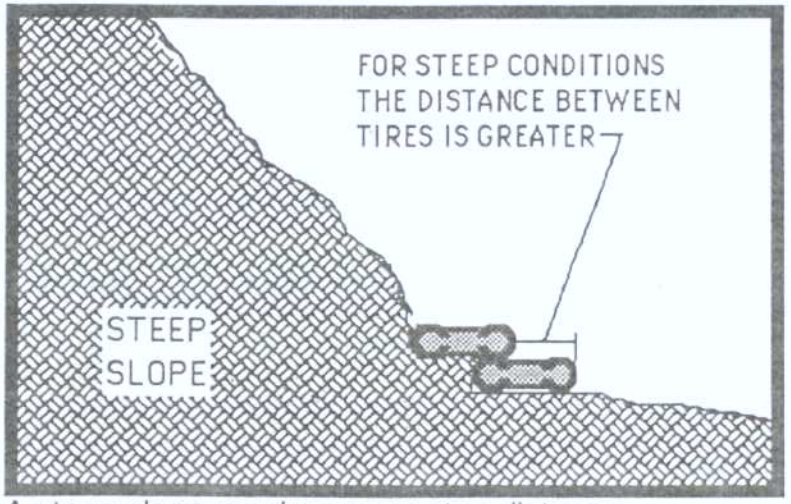
construction of the leaning or battered tire retaining wall is as follows. The first course of tires is pounded at the base of the area to be retained. A flat area of undisturbed earth must be cleared for these tires to rest on.



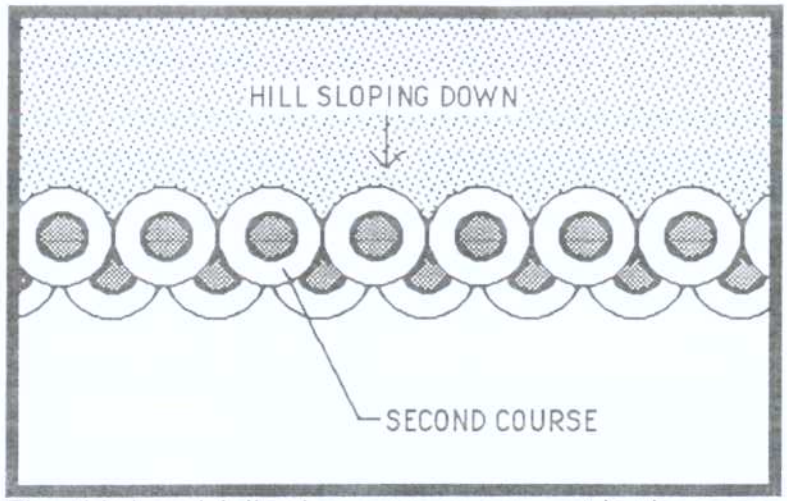


The second course of tires is staggered like bricks the same as building a vertical tire wall, but it also steps back. An arc can be added for strength but is not always necessary. The distance the tires are stepped back on each course depends on the severity of the slope that is to be retained.

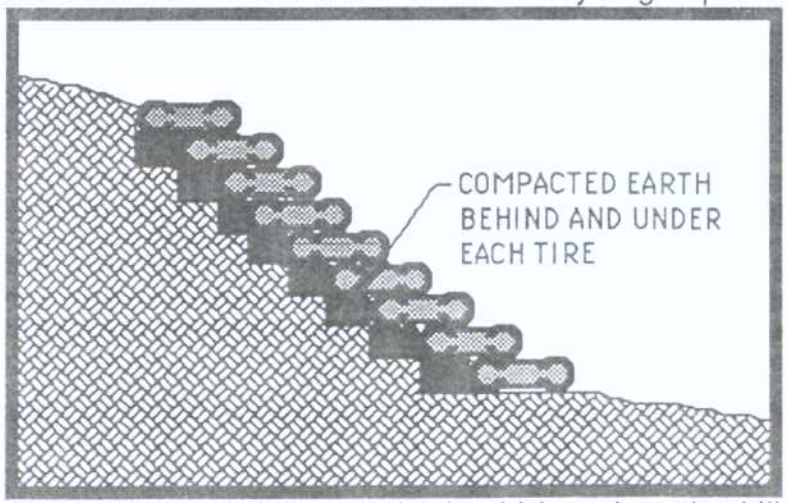




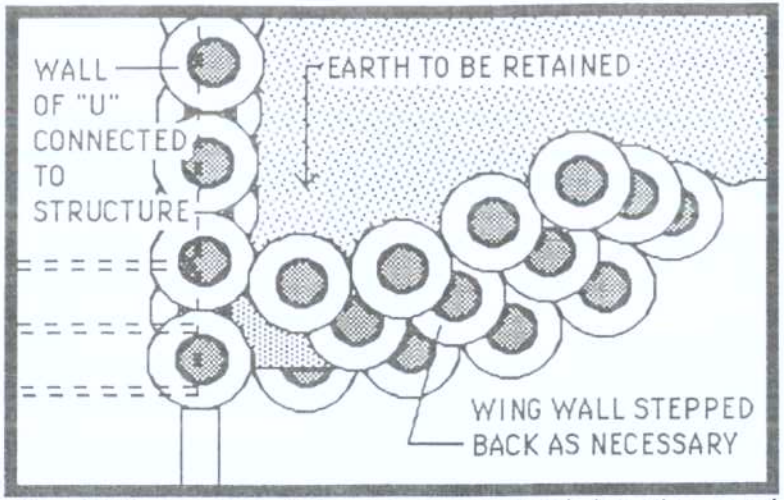
A steep slope requires more step distance.



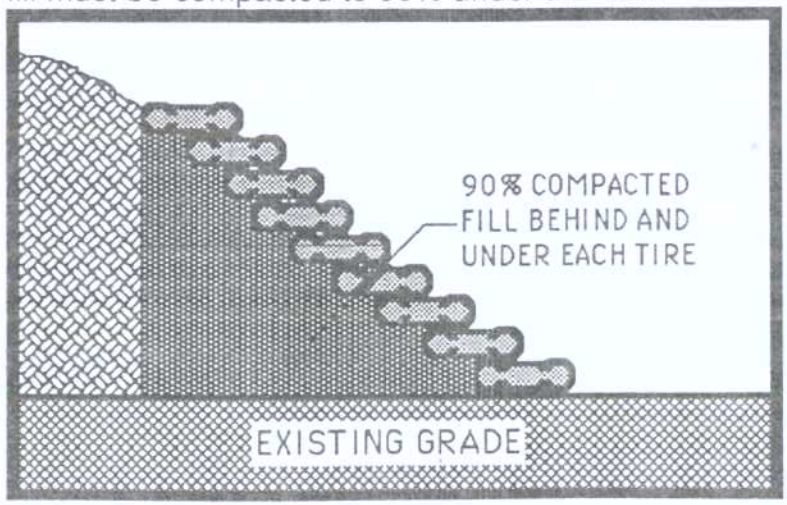
The third and following courses are set in the same manner of leveling and stepping back until the desired height is reached. Make sure you compact the earth behind and under the wall as you go up.



All tire walls retaining earth should lean into the hill they are retaining. This is true for all wing walls as well.



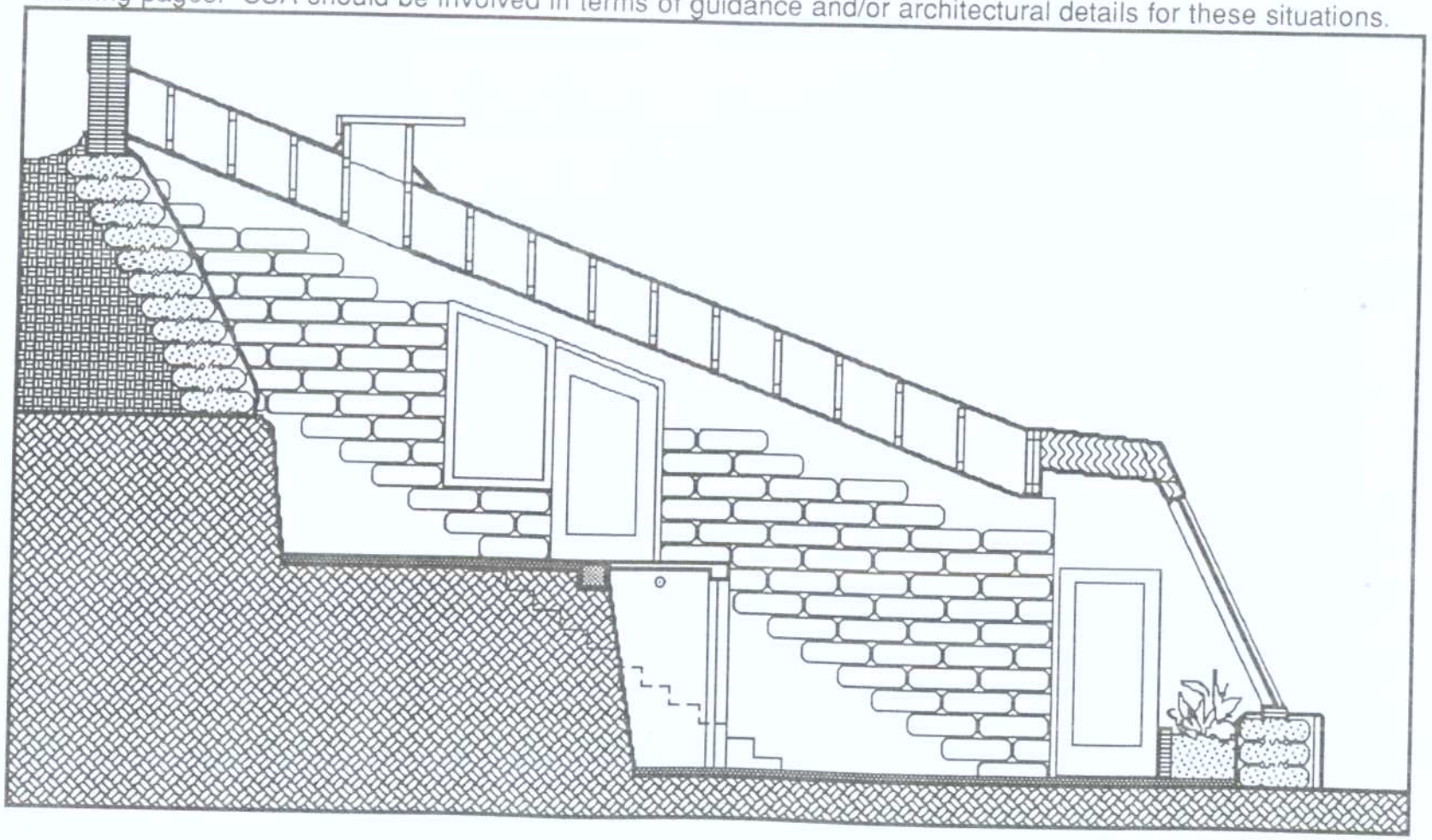
The wall of the "U" is supported by the roof diaphragm and does not have to be arched or battered like the free unsupported walls that are not connected to structure. If the wall is retaining fill, the fill must be compacted to 90% under the wall.



TIRE RETAINING WALL BEHIND EARTHSHIP IN JAPAN.

STEEP SLOPE SECTIONS

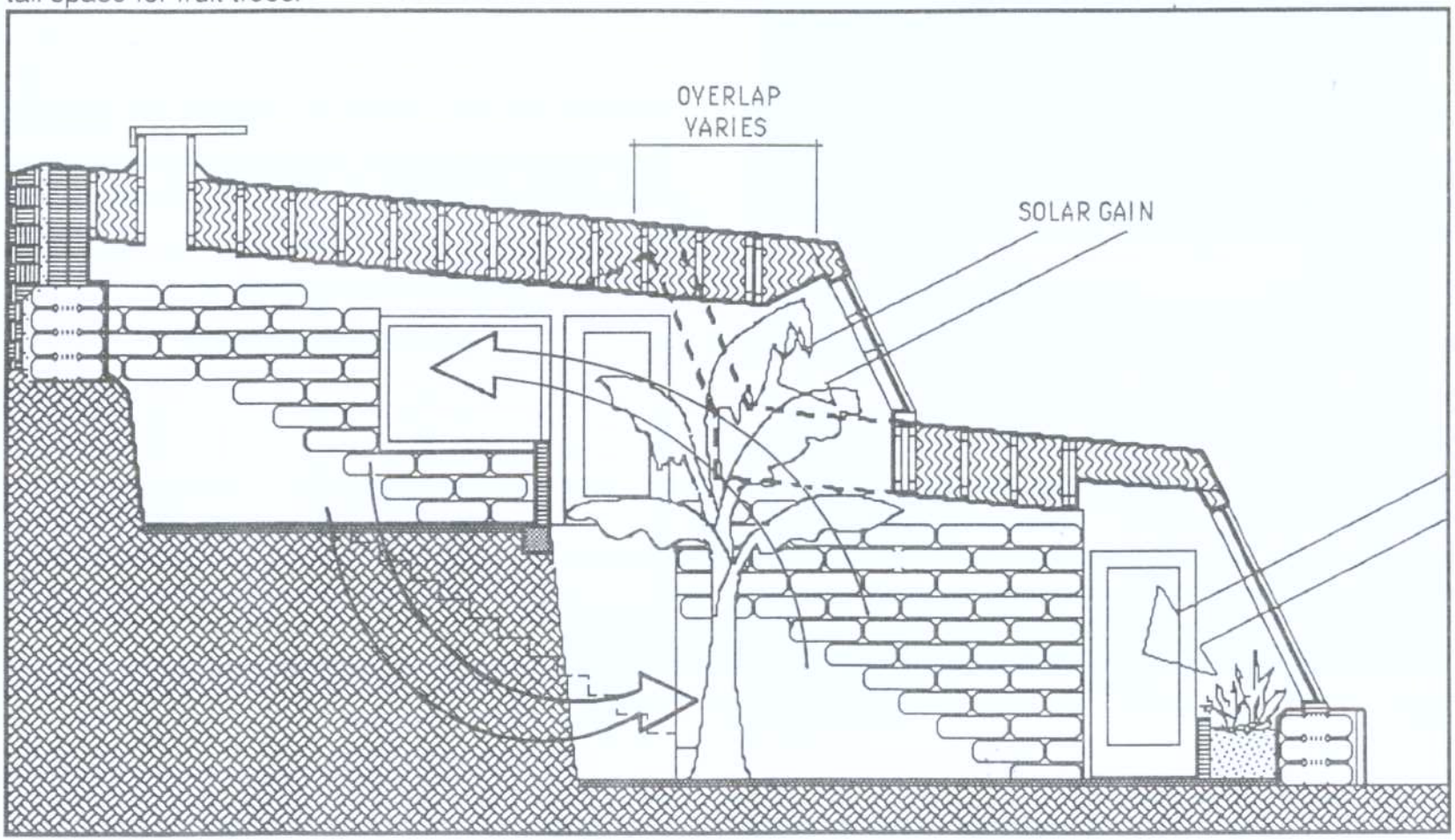
For those sites that have a steep slope, we have designed two level Earthships that can accommodate the steep terrain. These are not two story structures but rather two levels stepping back into the hill as shown on the following pages. SSA should be involved in terms of guidance and/or architectural details for these situations.



THIS CONFIGURATION IS MORE ECONOMICAL AS IT DOESN'T REQUIRE GLAZING ON THE SECOND STORY.

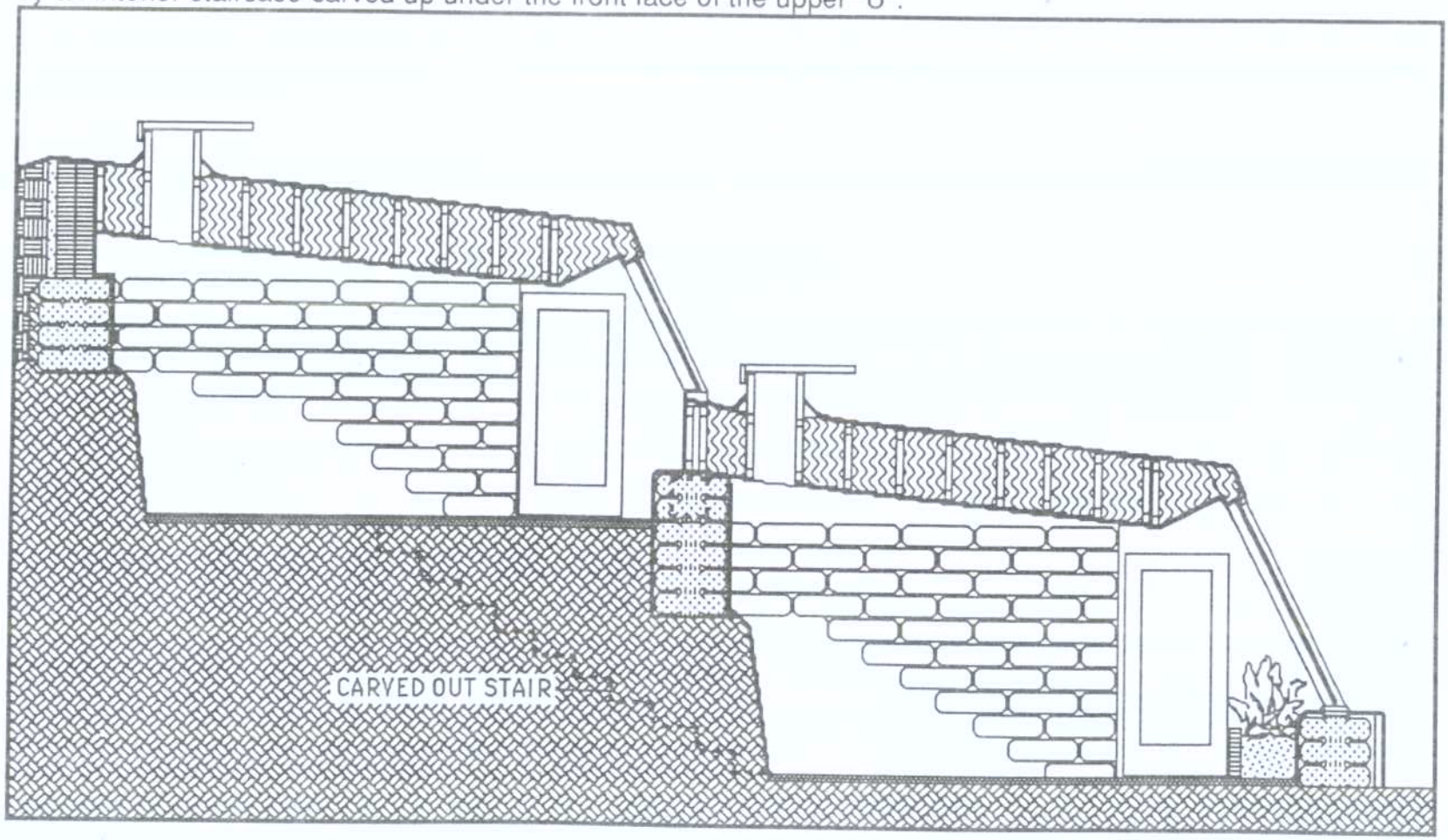
These structures require more money in terms of architectural drawings and more money in terms of construction. Also the warmest rooms tend to be on the upper level since heat rises. This sometimes requires ducts for air movement.

The overlap can be very small or large as the following diagram suggests. A large overlap can accommodate a tall space for fruit trees.



THE CONFIGURATION OF THIS ROOF PROVIDES FOR A SECOND ROW OF SOUTH FACING GLASS TO HEAT THE UPPER LEVEL.

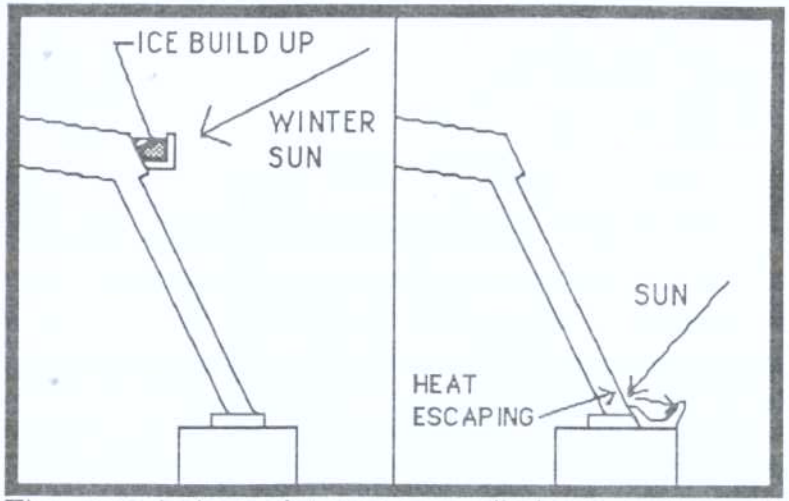
Two typical sections can be stepped up a hill without any unusual details as shown below. They can be joined by an interior staircase carved up under the front face of the upper "U".



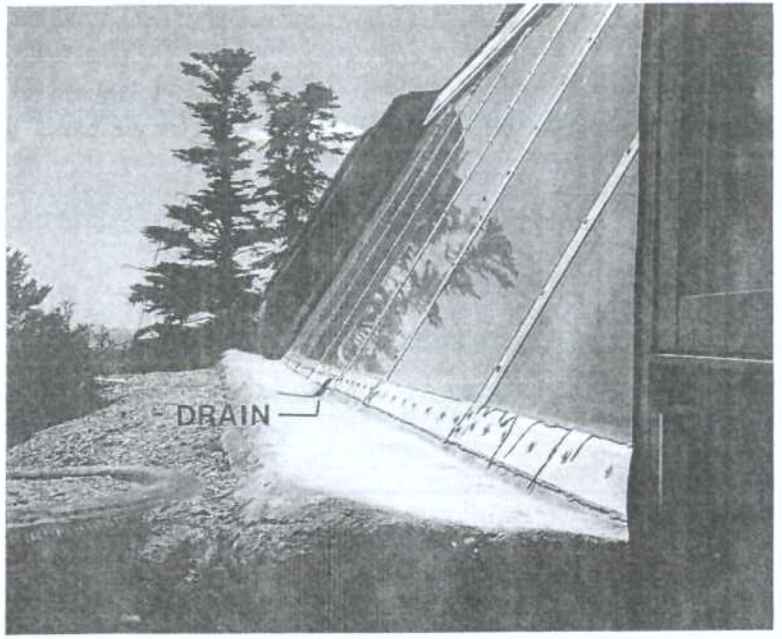
NEW GUTTER DETAILS

In areas with very cold winter temperatures the gutters, presented in Earthship Volume II, located at the top of the front face shade themselves and for that reason are prone to freezing and ice dams.

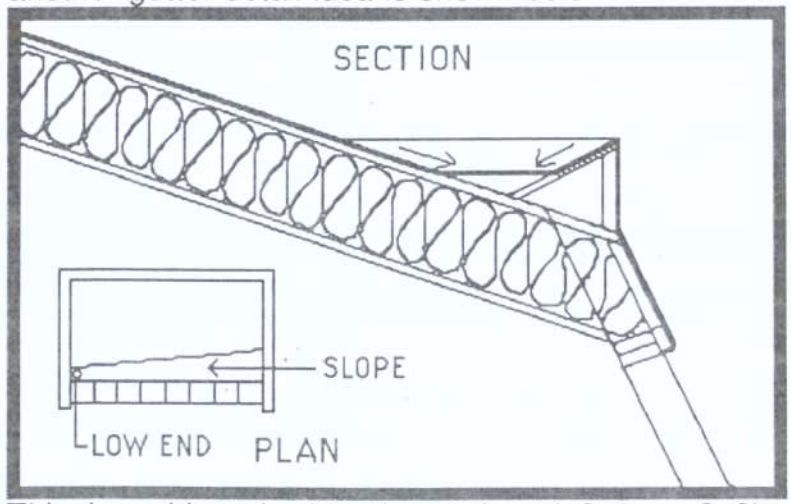
A new gutter detail, located at the bottom of the front face alleviates this problem as sun can reflect off the glass face and melt the ice dams. Also this is where the house loses heat so it is a warmer place than the location of the upper gutter. This gutter works best for south sloping roofs that do not have a kick up in the front.



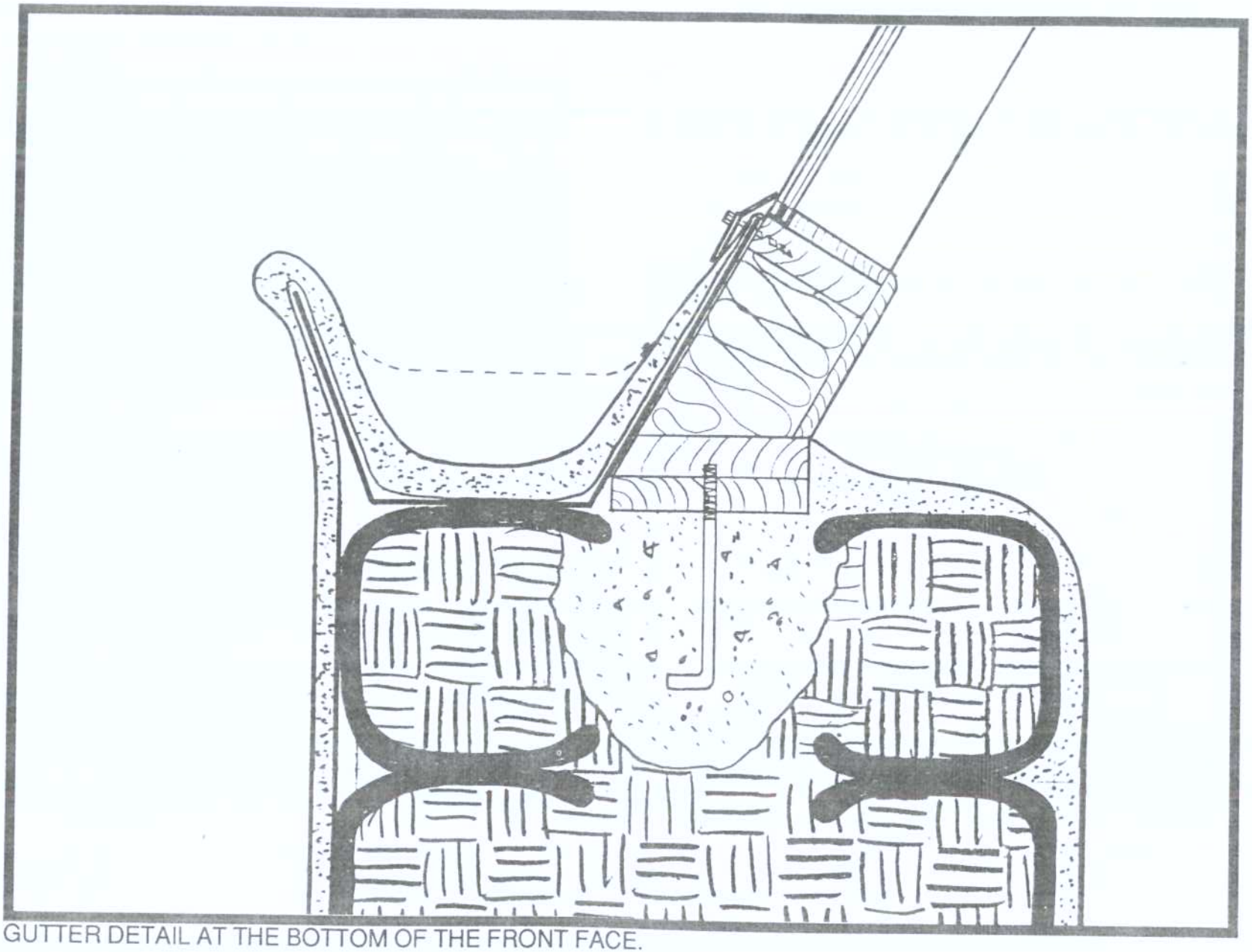
The new indoor cisterns can eliminate gutters all together. In many cases this is easier and cheaper. See chapter 2, pages 44 to 47.



If you don't want water running down your front face, another gutter detail idea is shown below.



This is achieved with plywood and 2x6 or 2x8's. Making it higher at one end will direct the water.



GUTTER DETAIL AT THE BOTTOM OF THE FRONT FACE.

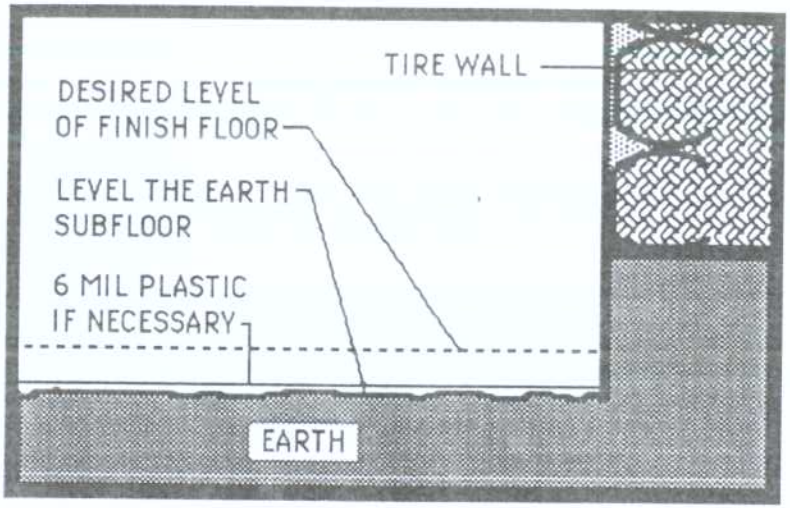
FLOORS - MUD AND FLAGSTONE

Both flagstone and mud floors are laid directly on an earth subfloor. In arid climates this is fine. If there is a possibility of dampness, lay down a 6 mil plastic vapor barrier on the earth subfloor before starting your mud or flagstone floor.

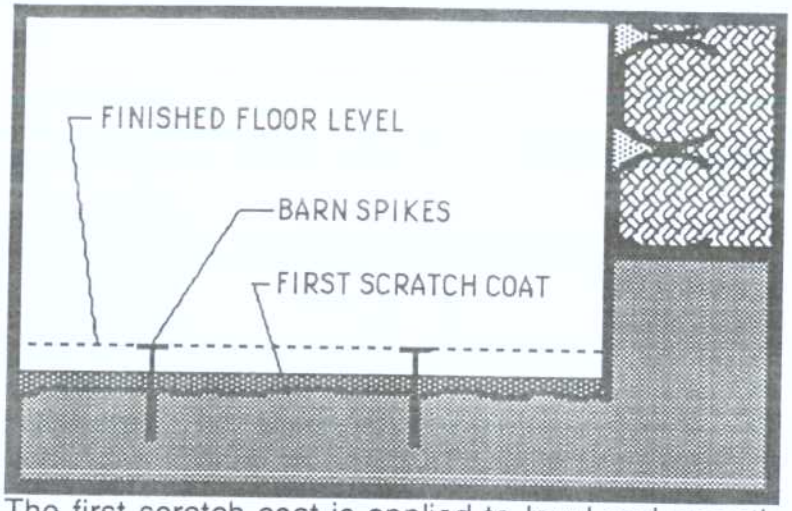
MUD FLOORS

A mud floor is very similar in construction and finishing to an adobe mud wall finish and with the addition of oil coatings or sealers can be very durable. It is not, however, recommended for use in high traffic areas near exterior doors or wet areas like bathrooms. The process of applying the mud floor will usually occur in three steps which should correspond to the finishing of the rest of the building. In general the floor is the last part of the building to be finished so it is important to make sure that when you are ready to do your last coat of mud on the floor that the rest of your finishing has been done.

The first step in applying a mud floor is to level the dirt subfloor to a reasonably smooth surface. Make sure all areas of fill (such as plumbing trenches, low spots, etc.) are tamped and compacted before starting your floor. You will want to establish the desired height of finished floor. The subfloor is leveled about 2 1/2" below the proposed finish floor height.



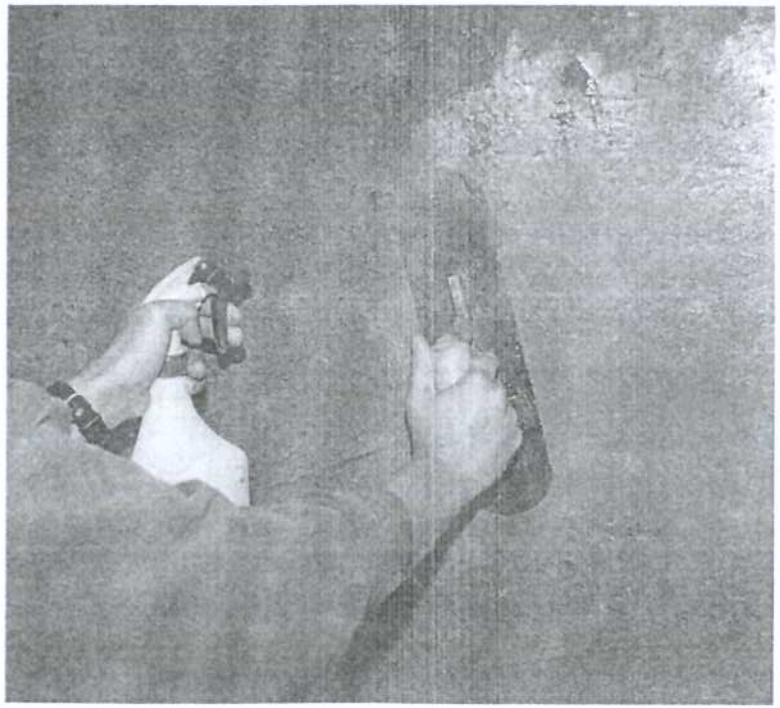
The floor can now be covered with the first of two scratch coats of mud. The mud is typically a mixture of one part sifted dirt to one part sand, 4 or 5 large double handfuls of chopped straw per wheelbarrow load and water to a fairly thick consistency. For the scratch coat, the sand can be course or fine. If you use the dirt from your site you will have to sift it through a 1/4" hardware cloth screen for the scratch coats. This hardware cloth can be attached to a simple frame of 2x4 lumber for easier sifting. You will have to vary the quantity of sand added depending on how sandy or clay your soil is. The dirt is the "glue" for the mixture. The sand keeps the mud from cracking and the straw makes a structural web throughout. You will find the correct proportioning by trial and error as you work through the mud in the building. If you get cracks in your scratch coats, add sand to the mixture.



The first scratch coat is applied to level and smooth the surface of the subfloor. The mud can be poured or shoveled on and is then troweled flat with a square trowel and leveled. After the mud is level, it is scratched to roughen the surface for receiving the next coat (see Earthship Vol. I, p. 177 for scratcher). The thickness of the first coat will vary because of irregularities in the subfloor. Sometimes it is necessary to drive barn spikes into the subfloor and level them all with each other (with a builders level) to establish a level surface at the height of the finished floor. These spikes are removed during the final coat. After the first coat is completely dry, the second coat is applied in the same manner but should be about 1" in thickness.

The final or "finish" coat has a slightly different mixture. The quantity of sand should nearly double the quantity of dirt so it will be 2 parts sand and 1 part dirt and a slightly larger quantity of straw can be added. The sand for this coat should be fine plaster sand. It is during this coat that you remove your grade stake spikes. Again it is troweled with the square trowel as smooth as possible and left to set up until it is firm to the touch but still damp. It is best to keep this coat between 1/2" and 3/4" thick.

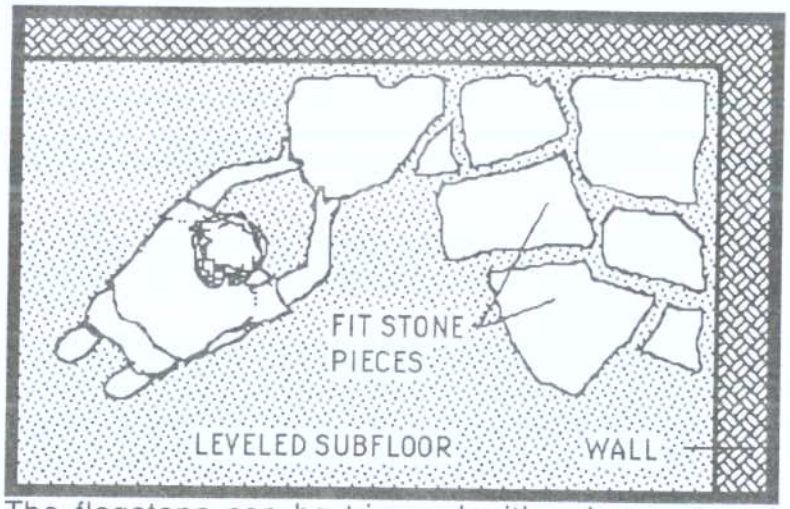
The last step is to retrowel the mud by first misting it with a plant spray bottle filled with water and then troweling until it is slick (see Earthship Volume I, P. 178 for misting mud). For this step a "pool" trowel that is more flexible and round on the ends is recommended. This step can be repeated the following day if cracks begin to occur.



When the mud is completely dry it can be sealed to create a very durable surface. The most commonly used sealer for mud is boiled linseed oil mixed half and half with mineral spirits. This thin mixture soaks into the mud 1/2 to 3/4 of an inch and dries quickly. It is applied with a brush like paint and usually takes three coats to cover and soak in evenly. Each coat soaks deep into the mud floor giving you a thick 1/2" layer of hard oiled mud. A fourth coat of two thirds oil and one third mineral spirits can be added for more durability. *Make sure every coat is totally dry before applying another.* If a pool of oil does not soak in, wipe off the excess. Compared to other floor sealing products, the linseed oil is a fairly organic way to seal. Another product that can be used after 3 coats of the oil mixture is satin finish Varathane which, unlike the linseed oil, gives the mud a more shiny finish. These floors are very beautiful and reasonably durable for areas that aren't exposed to wet muddy shoes and grit. Heavy furniture should have coasters to keep pointed legs from denting the mud floor.

FLAGSTONE FLOORS

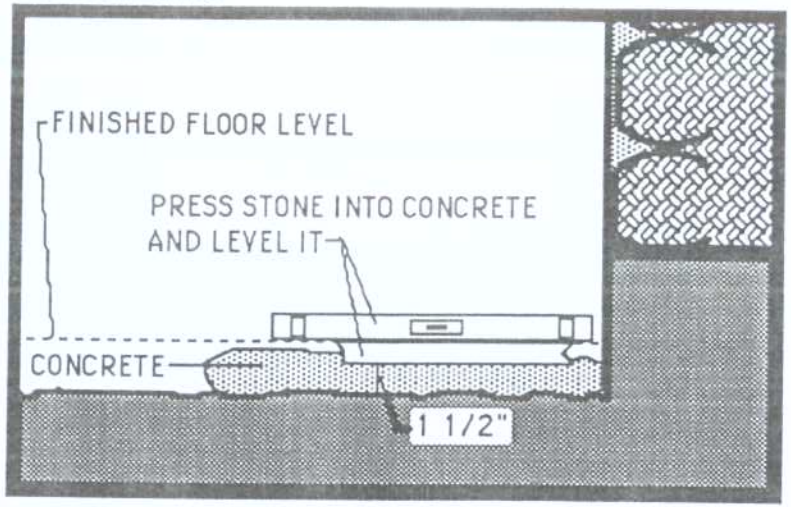
Our method of laying a flagstone floor begins the same way as a mud floor. You must first level the subfloor reasonably flat as shown in the previous discussion. Allow 3" to 3 1/2" for the total thickness of the floor. Then you will want to lay out your stones, cutting and fitting a small area at a time.



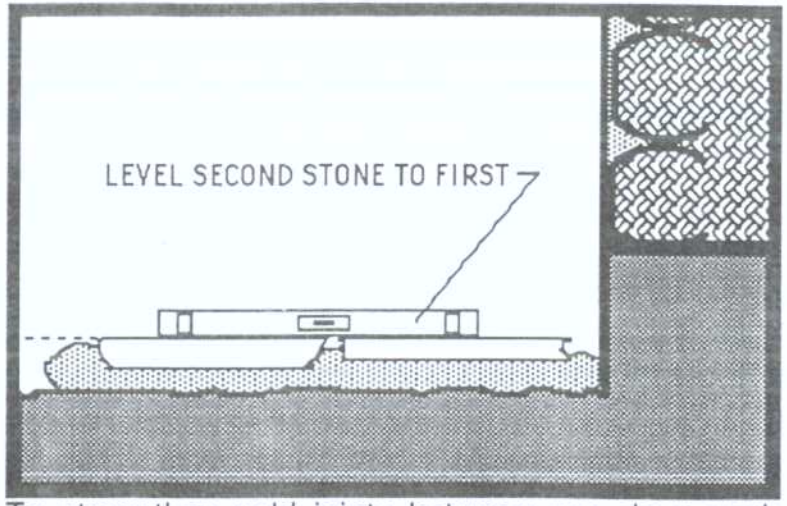
The flagstone can be trimmed with a hammer and cold chisel or scored on the back side with a circular saw and masonry blade and then chipped off. If you take the time to work out a good "puzzle" you should have very little cutting.

The joints between the stone can vary between 1/2" and 1-1/2". Once you have laid out a small area, you can begin setting the stones in concrete. The mixture for concrete is 1 part cement to 3 parts concrete sand plus the addition of a hand full of structural engineering fibers. The brand of fibers you purchase will recommend the correct quantity to add. Fibers can be purchased at a concrete and gravel yard. Concrete sand has particles (aggregate) up to 1/2" diameter, whereas plaster sand has very fine particles. Concrete sand is cheap but not good for plaster or grout. ' Plaster sand is more expensive and is not necessary for laying the stone.

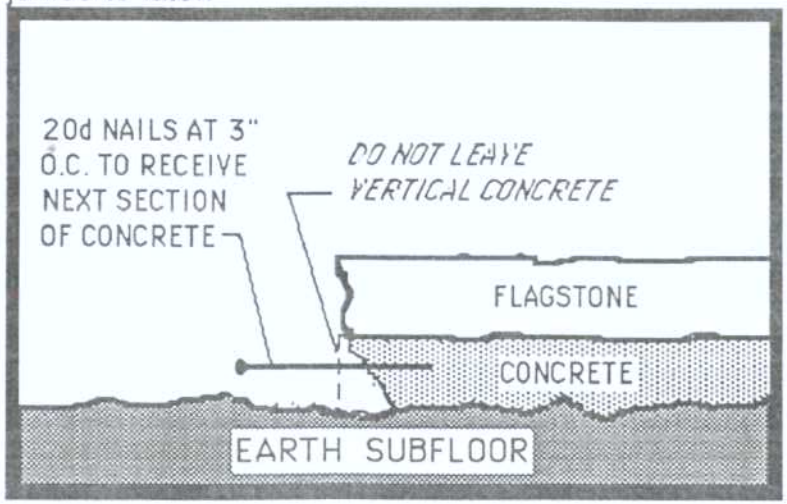
Next pour out the concrete onto the subfloor at least 1 1/2" to 2" thick and set the flagstone, one piece at a time, in the concrete. Wet the stone and push it down lightly into the concrete leveling it in all directions at the same time.



Now set the second and all other stones similarly, leveling them with the first stone. When you are finished with the area for that day be sure to remove any concrete from inside the joints as you will want to fill them with grout later. Hollow out all joints between stones to at least 1" deep to allow for finish grout. Also, you must thoroughly sponge off each stone as concrete is very hard to remove once it dries.



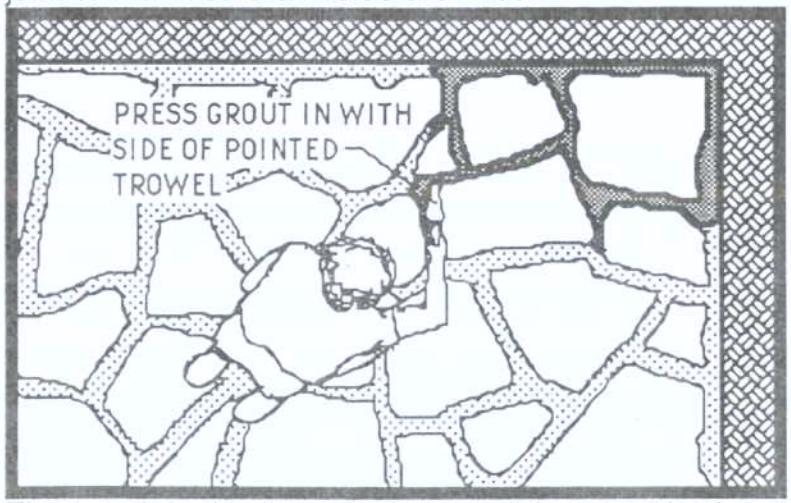
To strengthen cold joints between one days work and the next it is a good idea to set some long 20d nails into the edge of the wet concrete about 3" apart. This will give the new concrete something to grip onto. Never leave a vertical area of concrete to be joined to later.



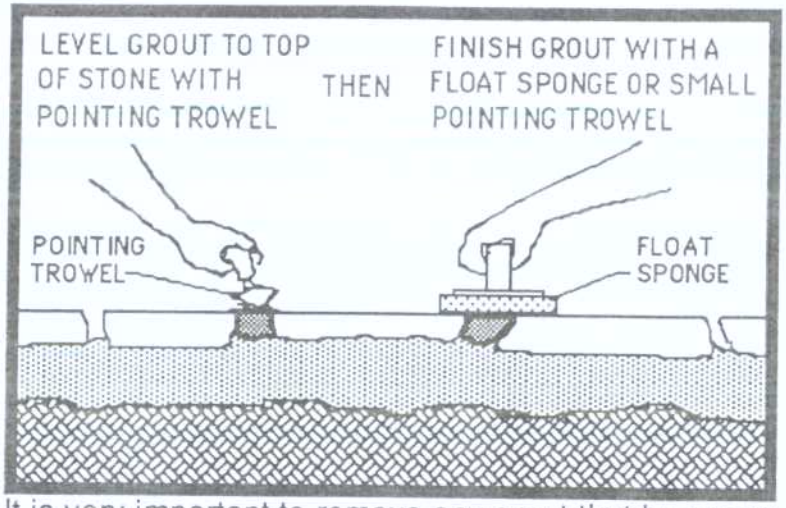
GROUTING AND SEALING

Grouting can begin as soon as the concrete is set up, usually overnight. There are several types of material that can be used for grout, the cheapest being cement. A mix of 1 part cement to 3 parts fine plaster sand with water mixed to a paste. This will be light grey when it dries. Other products specifically made for grout can be purchased at your local building supply and are generally applied in the same manner.

The joint is dampened and grout pressed in with the side of a triangular pointing trowel to fill up all of the voids. It is a good idea to chop the cement into the joint to make sure all voids are filled.



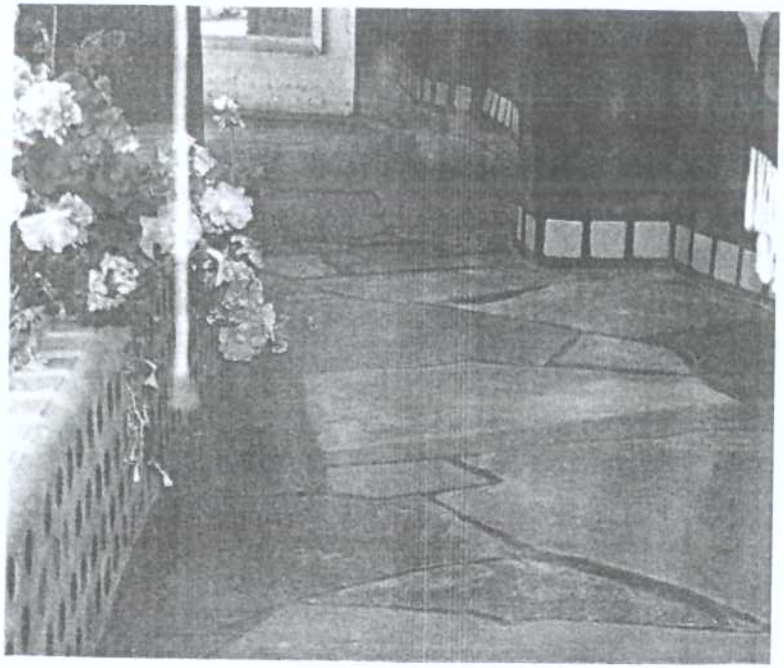
Then, using the trowel, the grout is smoothed out level with the top of the flagstone. When the grout starts to become firm it can either be smoothed out with a sponge float or troweled to a more shiny finish with a small pointing trowel. The latter is a more difficult finish.

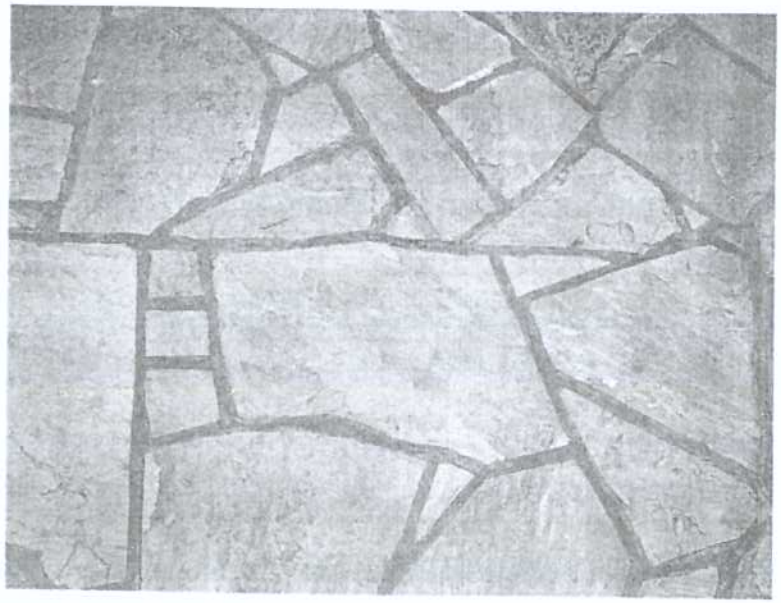


It is very important to remove any grout that has gone onto the stone as it will stain and be very difficult to remove later. This can be done by repeatedly wiping the stones with a wet sponge towards the grout joints.

Once the grout is dry, the flagstone can be cleaned thoroughly with a scrub brush and water to prepare it for sealing. When the flagstone is dry, a mixture of half boiled linseed oil and half mineral spirits is painted on. Usually three coats are necessary. *The oil should dry completely between coats. Do not allow pooling.* Due to the nature of this work we recommend knee pads and a respirator, if desired, during the oiling process.

If you prefer to use large floor tile instead of flagstone the procedure for setting, grouting and sealing tile is identical to flagstone.

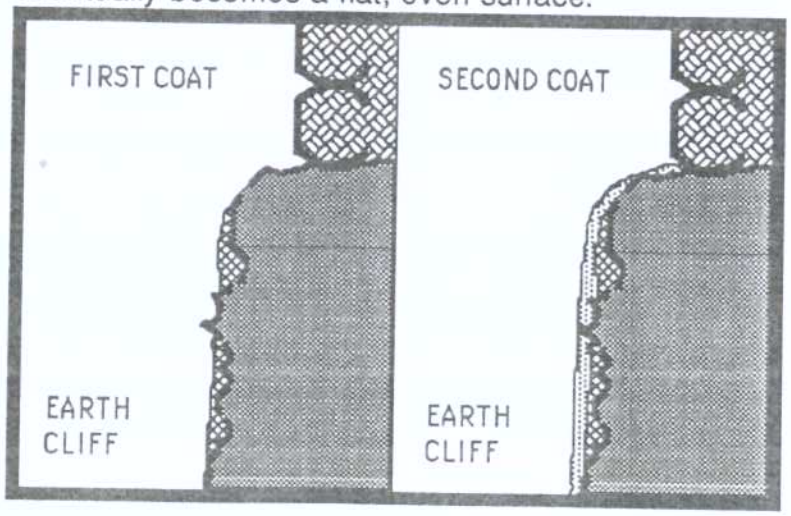


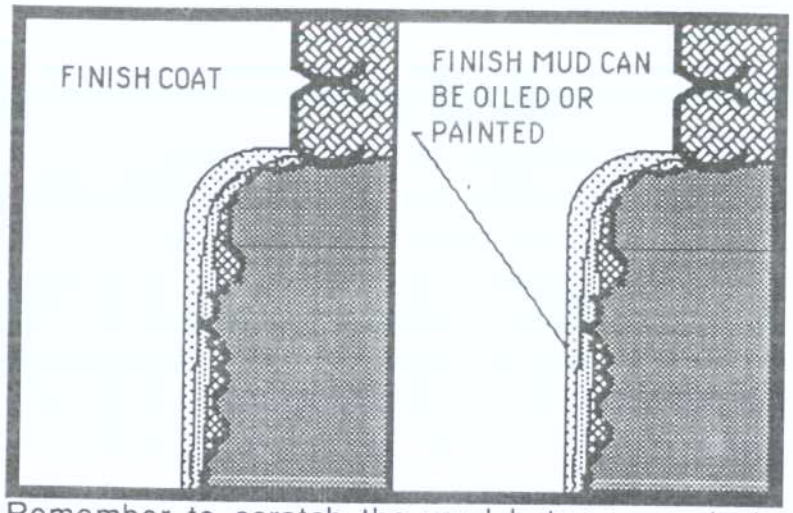


FINISHING EARTHCLIFFS

There are two methods suggested for finishing earth cliffs; a mud plaster finish and a cement plaster finish. The mud plaster finish would be used in areas where you are sure that your Earthship is far enough away from the water table and therefore, will not encounter any moisture or dampness. Like the mud floors, the mud plaster is a mixture of mud, sand and straw with water added. The mix is 1 part dirt to 1 part sand and 4-5 handfuls of straw for usually two coats of scratch mud, then 1 part dirt to 2 parts sand with 4-5 handfuls of straw for the finish coat.

The earth cliff is dampened with a sponge or splash brush and water. Then the mud plaster is applied directly on the earth cliff with a trowel, either square or round pool type. The object of plastering is to fill in the "low" spots or dips in the earth cliff in layers until it eventually becomes a flat, even surface.



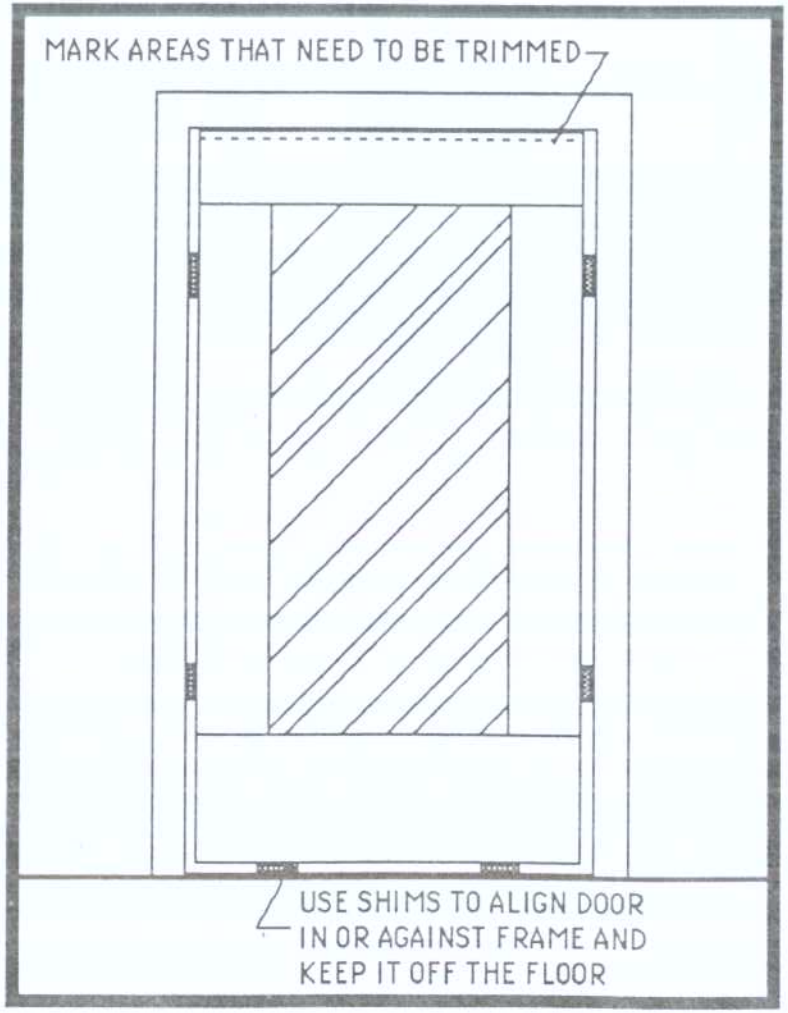


Remember to scratch the mud between coats to roughen the surface. The finish coat is retroweled and misted in the same manner as the finish coat on the mud floor (see page 26 this chapter and Earthship Vol. I p. 178). When the mud is dry it can be sealed with the same linseed oil/mineral spirits mixture as the floors. Another good finish for mud walls that does not effect the light color is called "Z- Seal" by Z- Brick.

If there is any chance of moisture, being close to the water table, or a flaky earth cliff we recommend a cement plaster coat over the rough earth cliff. This will protect the structure of the earth cliff and help seal out moisture. This plaster mix is 1 part cement to 3 parts plaster sand and structural fibers. It is applied with a trowel as shown above, and may take several scratch coats to cover properly. After the cliff is covered with 2 scratch coats of cement plaster you may continue with mud plaster for your finish coat. It will be sealed as above. We have also used stucco (a cement base color finish coat) for a finish in cement

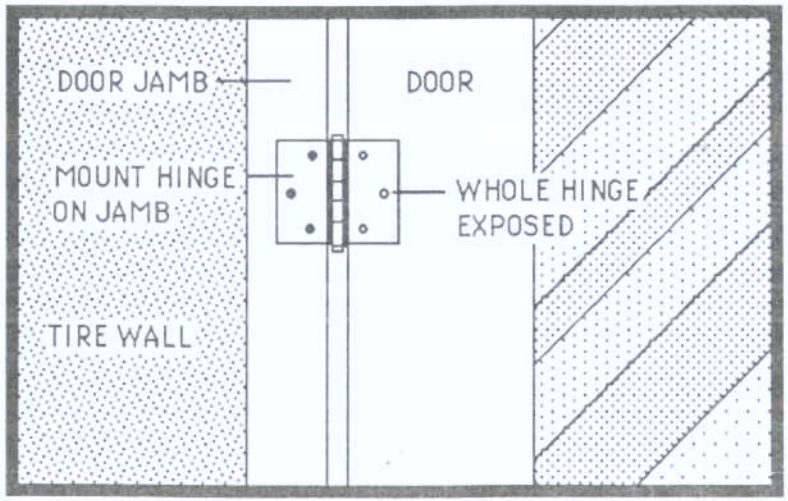
plastered earth cliffs. This provides a moisture resistant finish.

HANGING EARTHSHIP DOORS

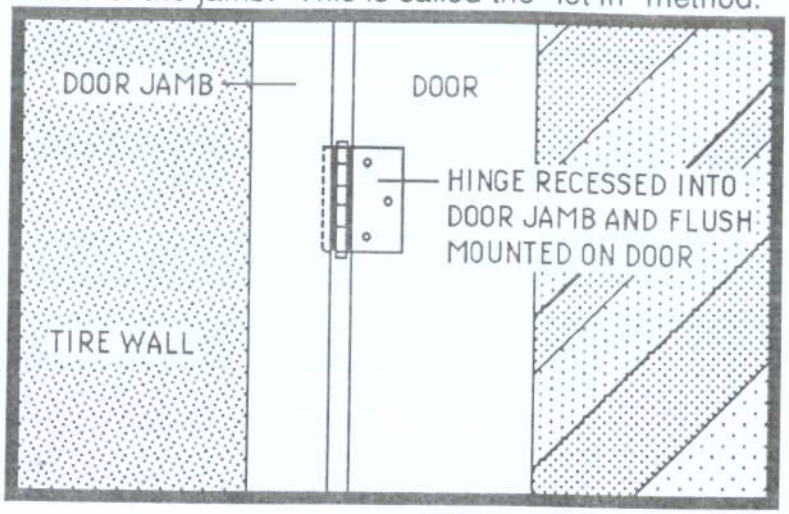


After a door is completed (as per Earthship Volume II pp 163-176) it is ready to be hung. This process begins by fitting the door into or against the frame and marking areas that need to be trimmed for a proper fit. Next, trim the door down as per the marks with a plane or sander using coarse paper. It is best to trim the door a little on the small side as swelling sometimes occurs with weather changes.

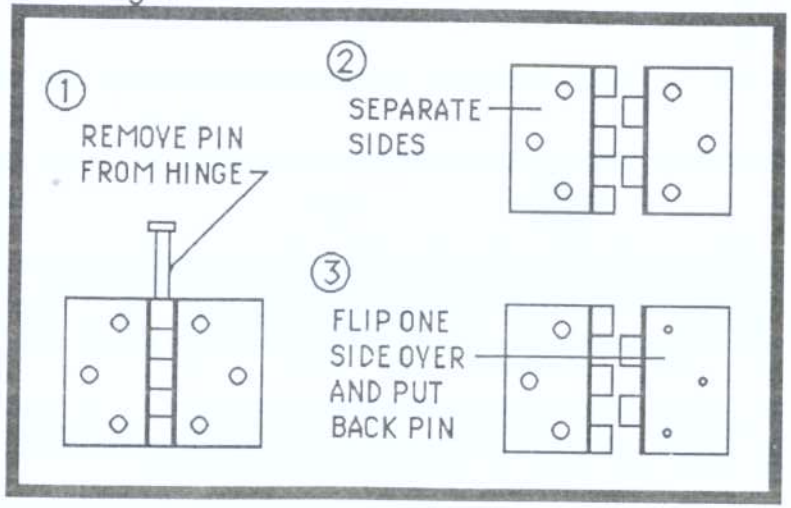
Now you are ready to mark and install the hinges. Be sure that you have purchased the appropriate size hinge for your door as a heavy door can pull a small hinge out. We usually use (3) 3 1/2 inch butt hinges per homemade door. Begin by measuring and mounting the hinges *on the door jamb* in their desired location. There are 2 methods for this. One method exposes the whole hinge and is very easy. This is the flush mount method.



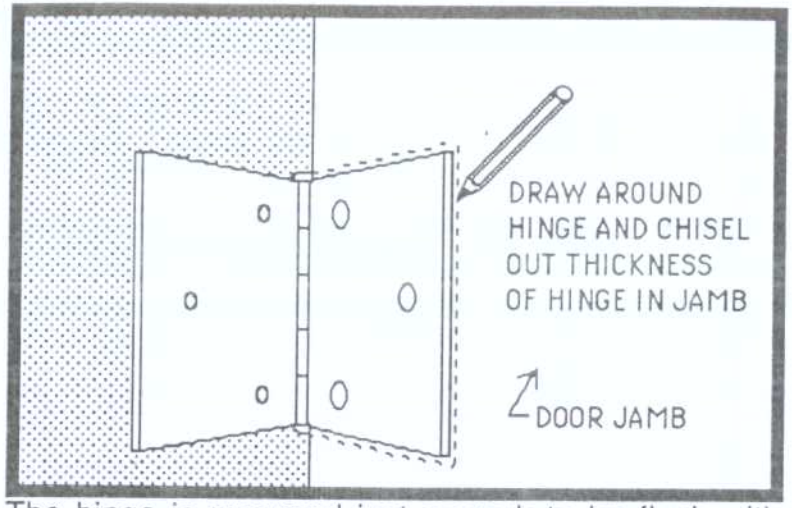
Another method requires recessing the hinge into the inside of the jamb. This is called the "let in" method.



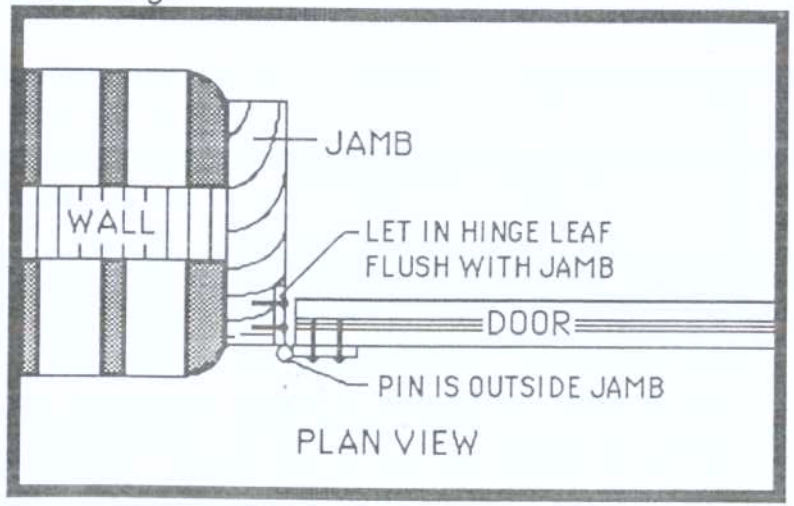
This method requires unpinning the butt hinge and reversing it.

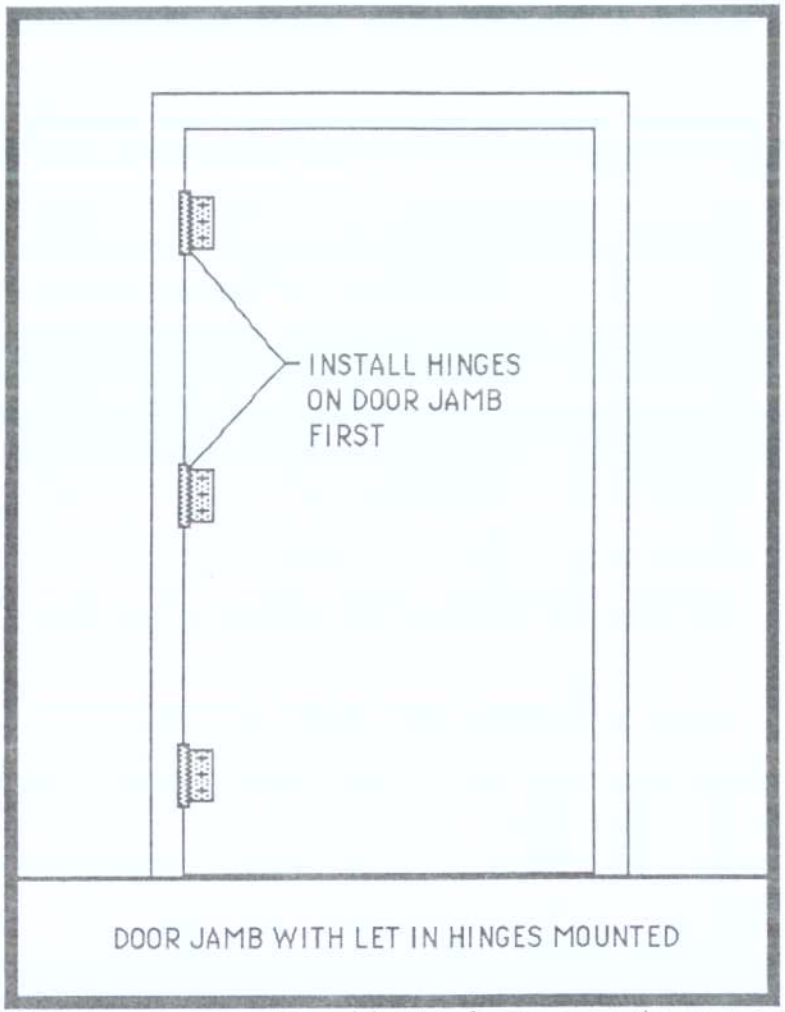


Now the hinge must be recessed into the jamb with a chisel.



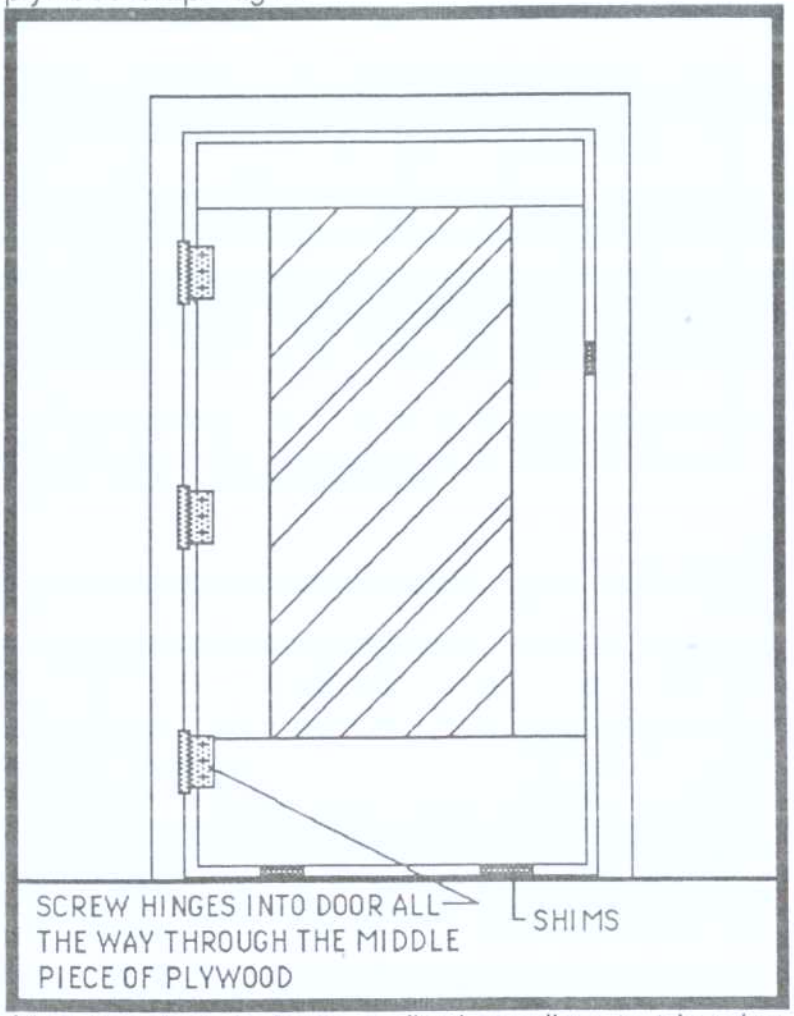
The hinge is recessed just enough to be flush with the jamb. Notice that the pin is not let in - just the leaf of the hinge.





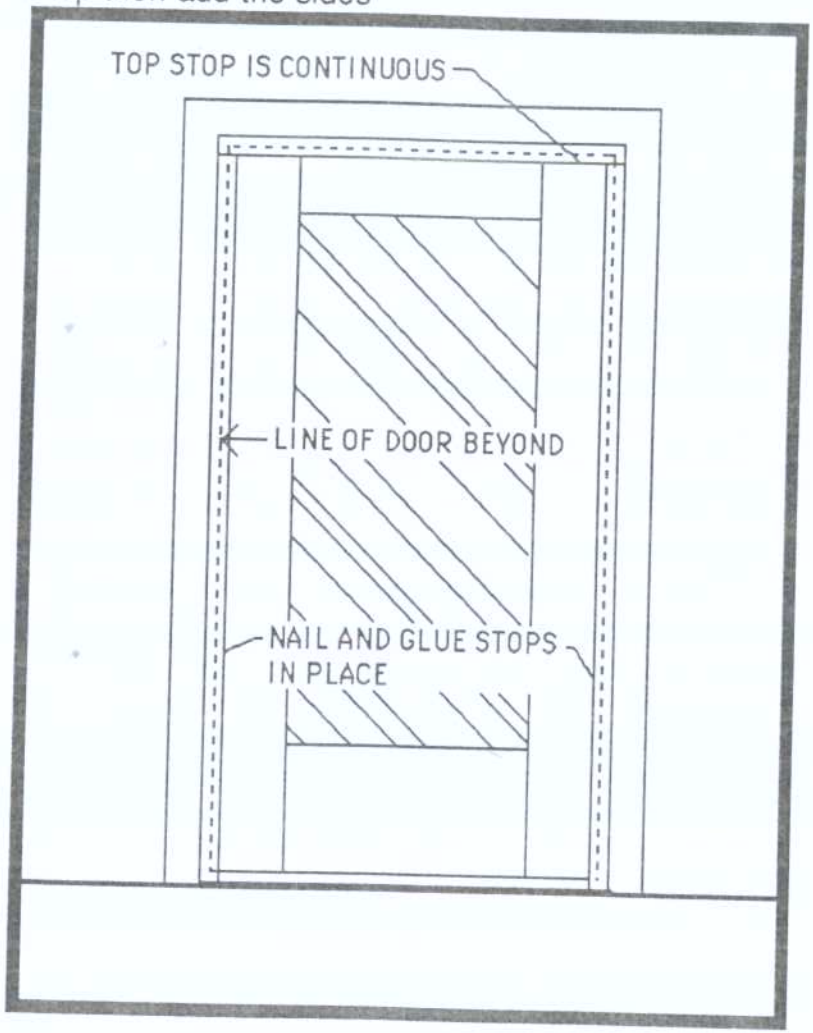
DOOR JAMB WITH LET IN HINGES MOUNTED

The door is now placed in the frame exactly as you wish it to hang. Use wood shims to raise it off the floor to take into account for carpet, threshold and/or weatherstripping where applicable. Make sure it is almost touching the top of the jamb. Then, while holding it in place, screw the hinges into the door. Hinges usually come with short screws. We advise replacing these screws with longer screws of the same diameter. This will work much better for the heavier door. Screws should go through the plywood diaphragm.



After the door is hung, a final sanding or trimming can be done if necessary. Installation of the door stops is done as follows. Begin by selecting the

desired width (2" to 8") of 1" stock lumber and then measure and cut pieces for the sides and top. Now glue and nail the stops in place while another person holds the door steady and flush with the jamb on the opposite side to ensure a flush fit. Start with the top stop then add the sides

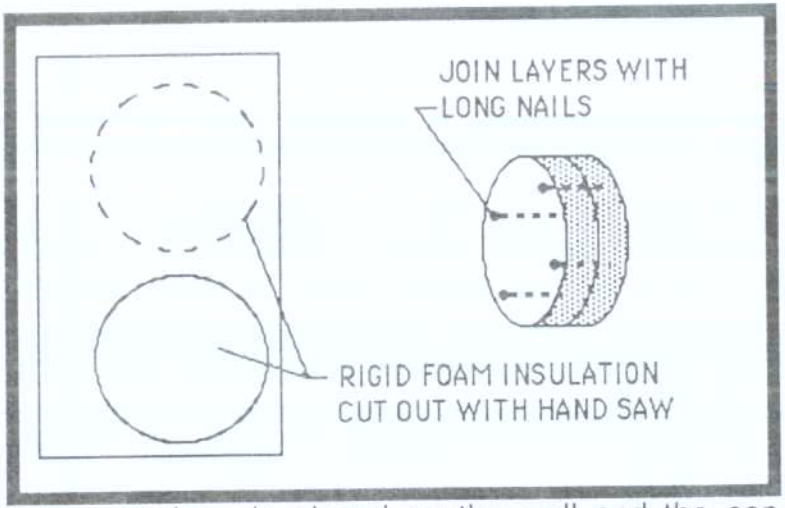


Your door is now ready for handles or other hardware available at your local building supply store. Be sure to measure the thickness of the door before purchasing these supplies as Earthship doors can be slightly thicker than conventional doors.

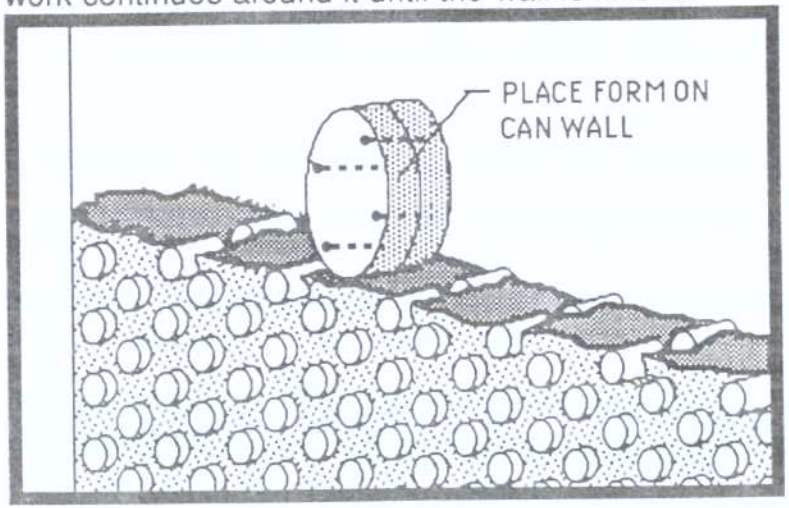
If you are installing cabinet doors the stops are not necessary. A simple magnetic catch installed anywhere opposite the hinged side of the door is all that is required.

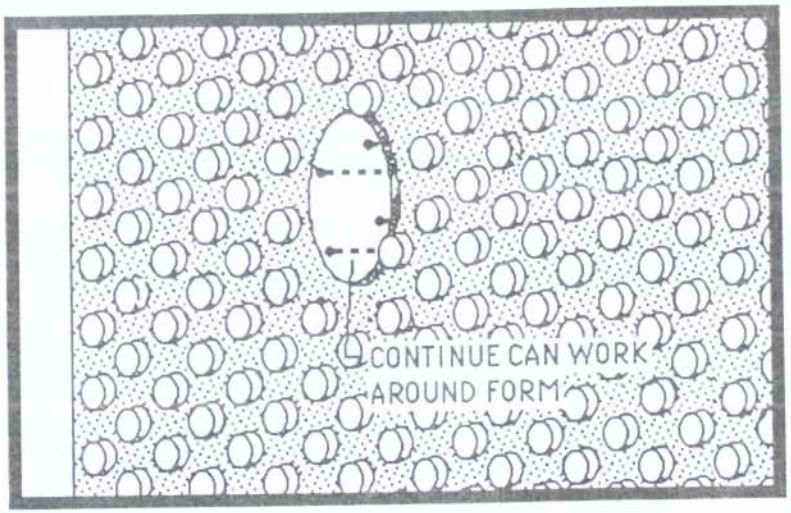
ROUND AND ARCH WINDOWS

The construction of a round or arch window in a single or double can wall can be done by building the can wall up to the desired level and location of the window. Then cut the shape of the window out of a sheet of rigid foam insulation. Cut two or more layers if necessary to get the thickness of the can wall. The layers can be joined together with some long nails like 10" barn spikes from both sides.



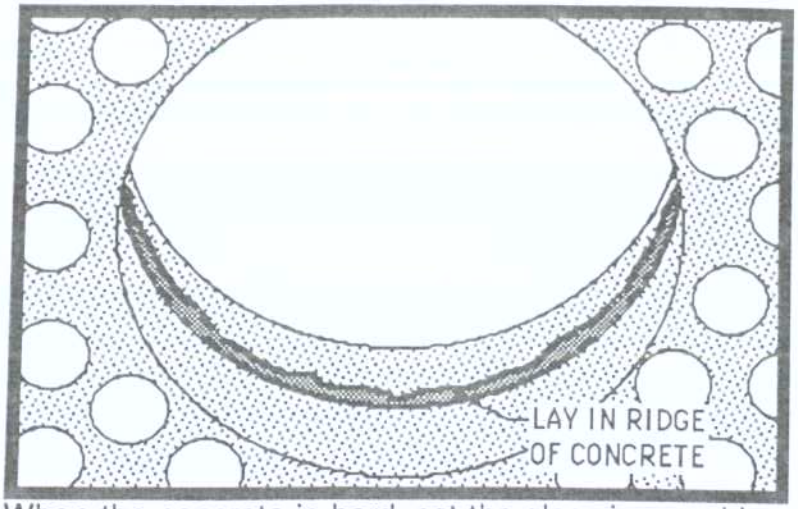
Now your form is placed on the wall and the can work continues around it until the wall is finished.





When the wall is complete and you are ready to install the glass, the form is removed. If the form will not come out by sliding it, then break the foam up with the claw end of a hammer until it comes out. Now you can make a template or take measurements for your glass.

The glass is set into the hole by making a small ridge of concrete around the opening to receive the glass. This ridge serves as a stop and should be on the outside - the glass sets on the inside of this ridge.

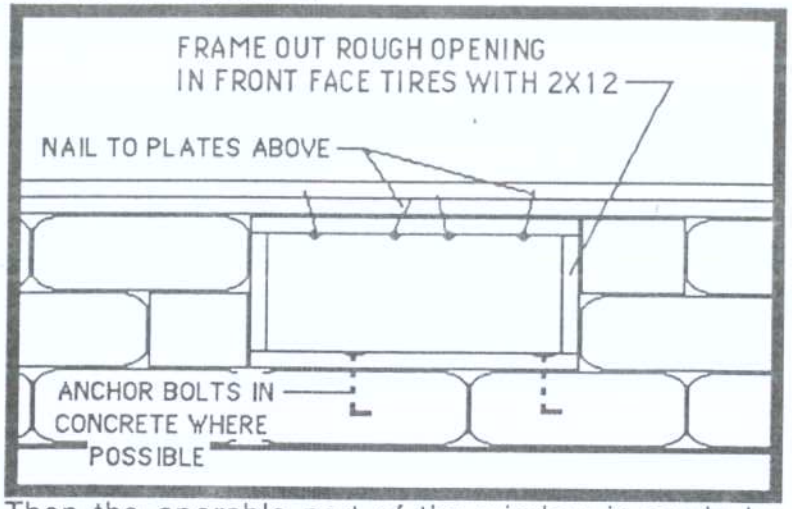


When the concrete is hard, set the glass in on rubber shims and put another ridge of mud plaster all around the *inside* to hold the glass in place. We use mud plaster here so the glass can be easily replaced if broken. Now plaster up against the glass with mud inside and cement plaster outside. Slope the plaster at the bottom so water will run away from the window.

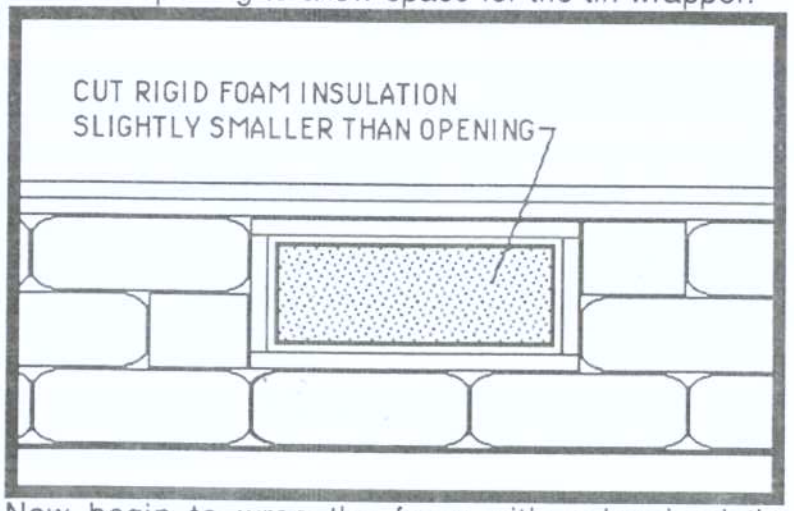
HOMEMADE OPERABLE HOPPER WINDOW

The advantages of this new homemade operable window that fits into the lower front face are many. It is cheaper, it has better insulative value than the commercial hopper window and since it is made on site , it can be any size. The third factor is important because tire coursing varies making standard size windows more difficult to plan for and install.

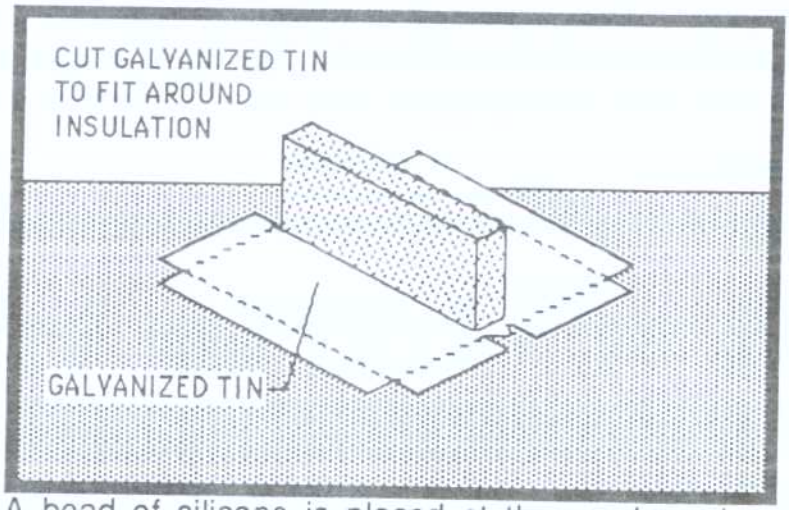
The first step to constructing this window unit is to frame out the desired rough opening in the tire wall. This frame is attached to both the front face plates and the tires below it.



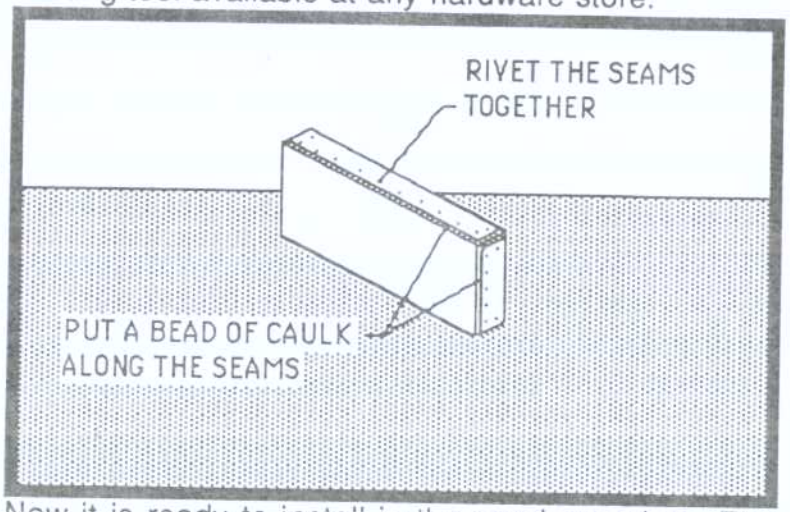
Then the operable part of the window is made by cutting out a piece of rigid insulation, slightly smaller than the opening to allow space for the tin wrapper.



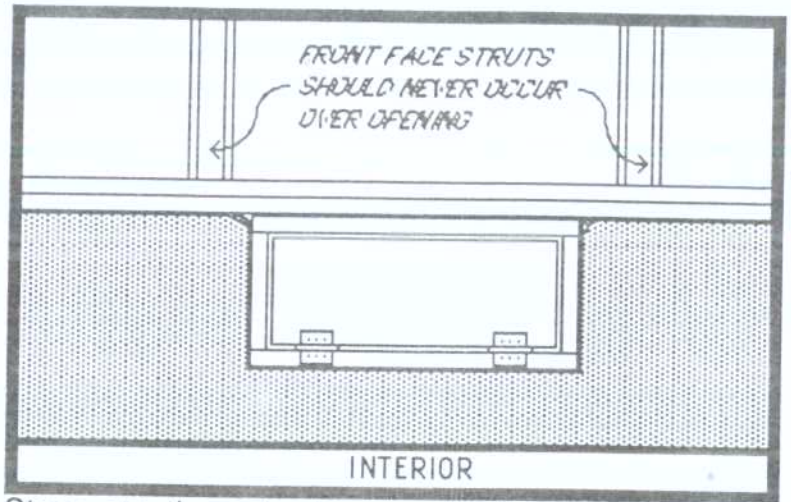
Now begin to wrap the foam with galvanized tin cutting off the excess with tin snips.



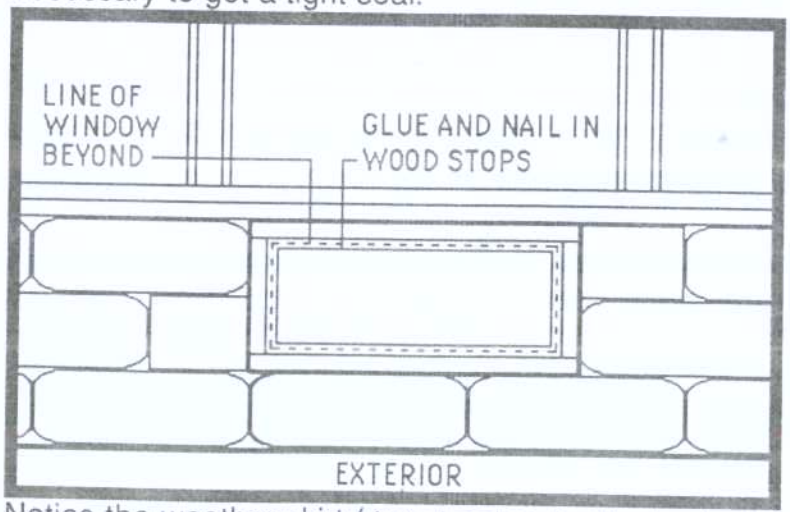
A bead of silicone is placed at the overlaps then those overlaps are riveted together with a simple riveting tool available at any hardware store.



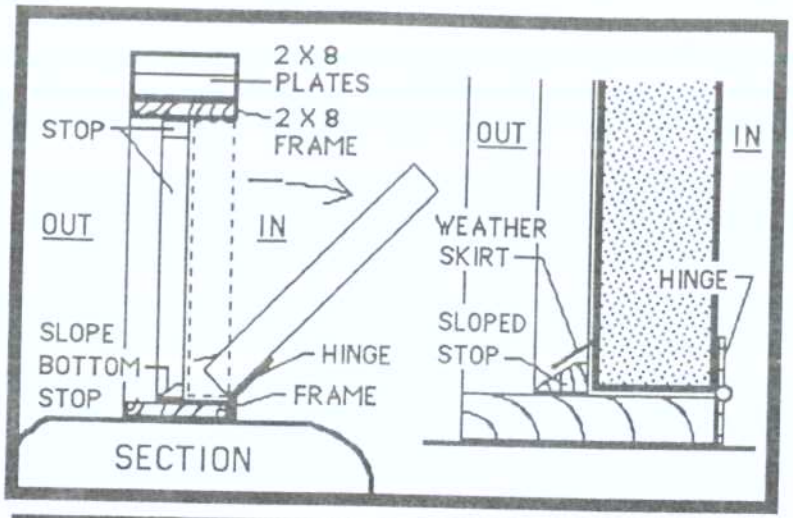
Now it is ready to install in the rough opening. The tin wrapped insulation unit is placed in the opening with the seams toward the inside of the building. Then the hinges are installed.



Stops are then glued and nailed on the exterior of the opening. 1" stock lumber can be used for these stops. Each piece is cut to fit and then glued and nailed in place. Weatherstripping can be used if necessary to get a tight seal.



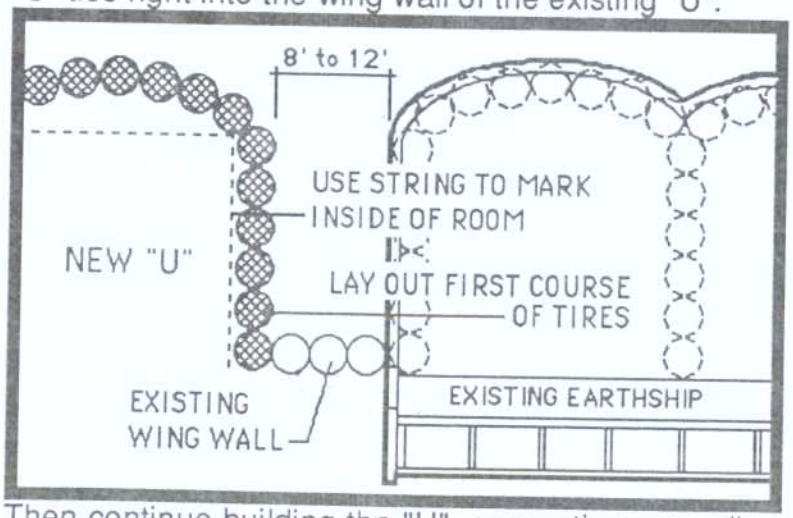
Notice the weather skirt (riveted and caulked in place) and sloped lower stop. These are important to keep the unit from leaking.



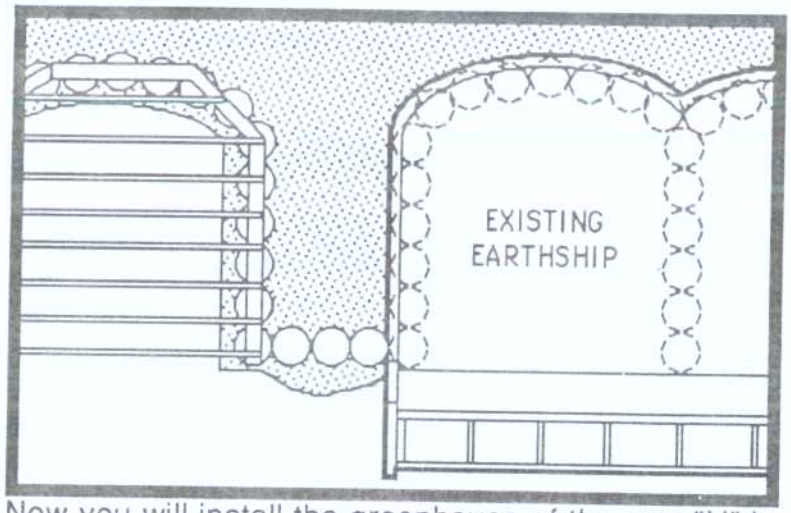
ADDING ON A "U"

There are two methods of adding another "U" on to a completed building. Either of these methods used to add a "U" can be done at any stage of completion of the original Earthship. The first of the two methods does not disrupt or require any alterations of the original structure. You simply add another "U" 8 to 10 feet away from the original "U" and connect the in between space with a short greenhouse hallway. The advantage of this method is that adding another "U" does not have to be taken into account during construction of the original Earthship. The disadvantage is that it leaves a space or hallway between the two rooms but this always has a use and is in most cases desirable.

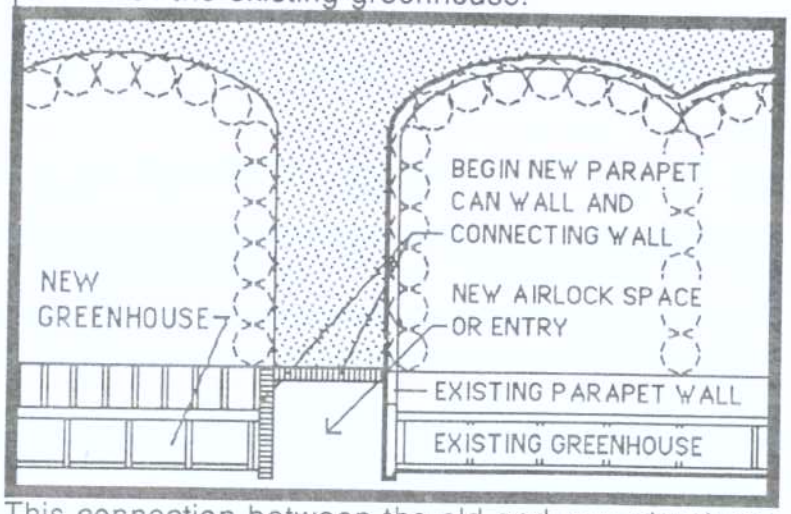
Begin by determining the correct distance away from the existing "U" that you will build the addition. This distance is based on the strength of the soil. If the soil is hard and does not crumble easily, you can build as close as 8 feet. If the soil is crumbly or unstable you will need to build at least 12 feet away. The next step is to mark the perimeter of the room with string and lay out the first course of tires on the ground as per Earthship Vol. I, pp. 90-93. The new "U" ties right into the wing wall of the existing "U".



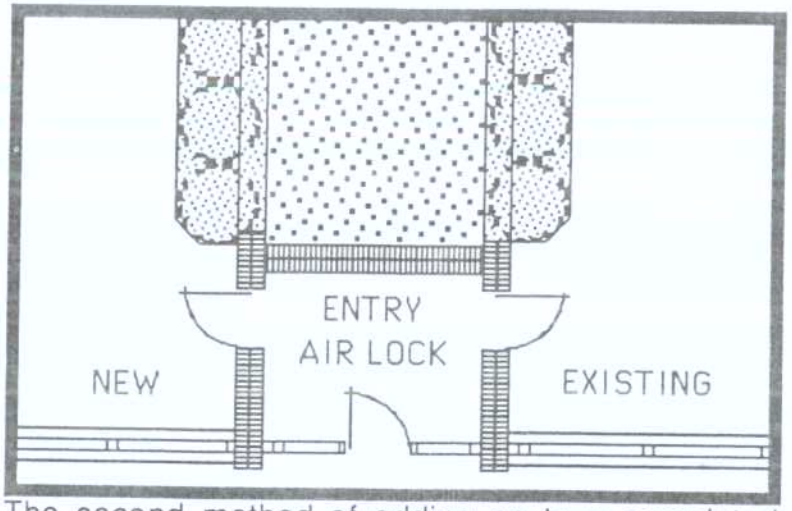
Then continue building the "U", excavating, pounding the tire walls, installing the bond beam and roofing, as you would with any Earthship.



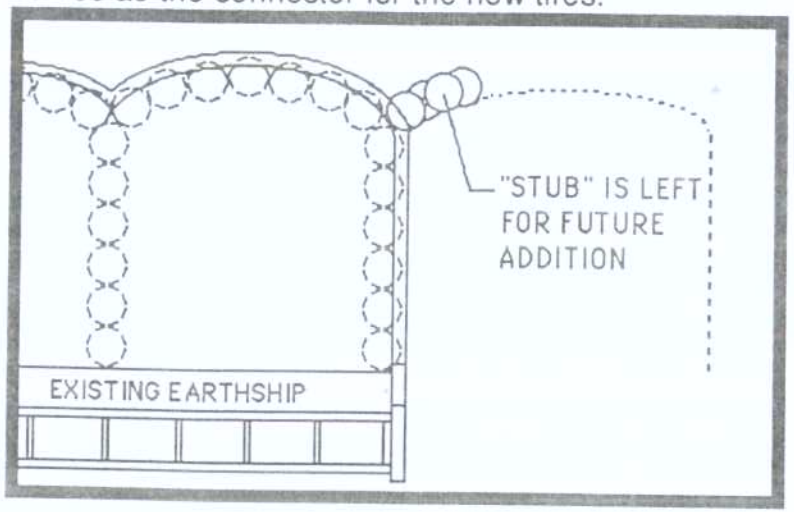
Now you will install the greenhouse of the new "U" in plane with the existing greenhouse.

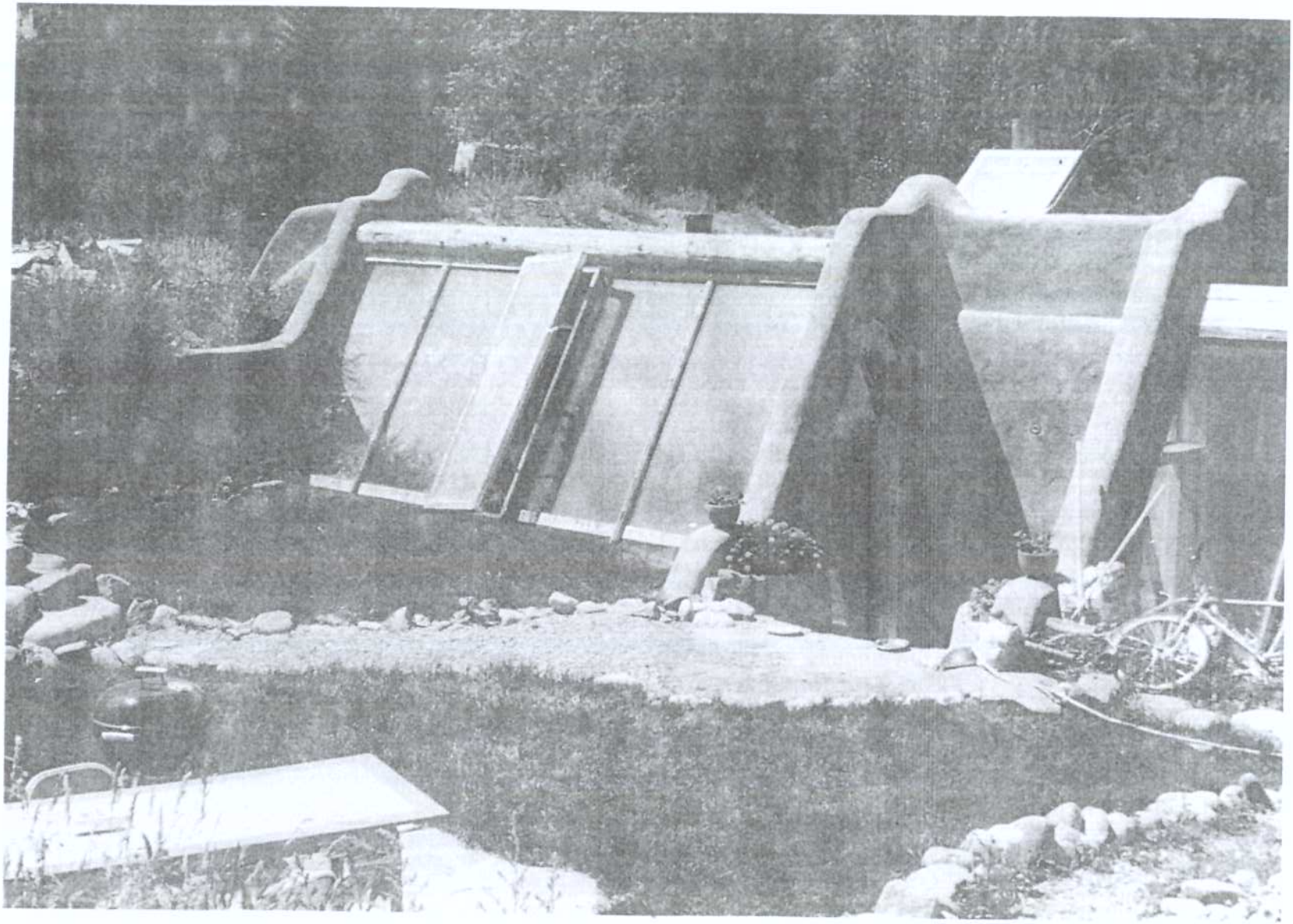


This connection between the old and new structures can be finished and serve as an entry airlock or hallway connecting the two "U"s as in the following diagram. It can also be left open as in the photograph opposite.



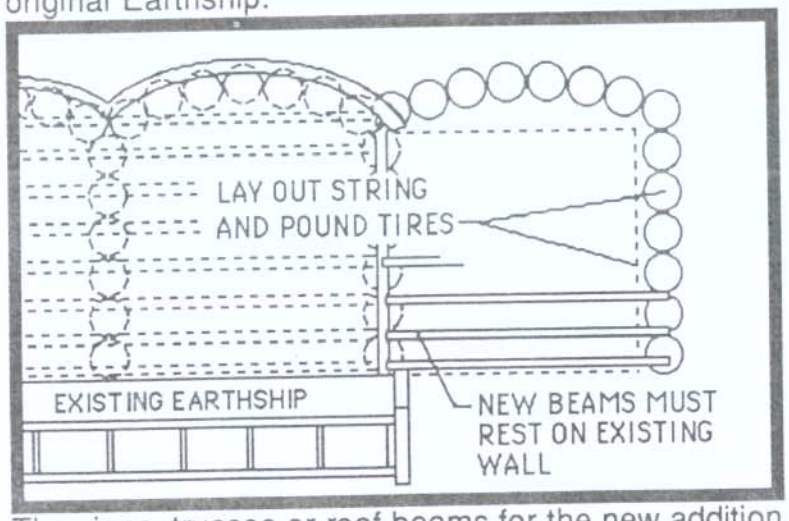
The second method of adding on to a completed Earthship is planned for *in the original structure.* During construction of the original Earthship a stub tire wall is left sticking out of the back of the last "U" where you plan your future addition. This stub serves as the connector for the new tires.





EARTHSHIP IN TAOS, NEW MEXICO WITH A "U" ADDED ON

The stub can be buried during the original construction and re-excavated when and if you do your addition. The addition is laid out and built as per Earthship Volume I. The procedure for tire pounding and excavation are identical to that of the original Earthship.



The vigas, trusses or roof beams for the new addition must rest on the existing wall of the original building. This requires some planning ahead when you originally detail this wall. It must be set up just like a typical wall between two "U"s in the original building. See Earthship Volume I, P. It can be temporarily capped with plywood and roofing paper or plastic and rigid insulation. It can even be buried. You simply have to remove this detailing to get to the bearing plate for the new beams.

As the Earthship continues to evolve, there will be more new details and more questions will arise. Future books will continue to respond to our development and your requests.

2. MECHANICAL EVOLUTIONS

AS THE EARTHSHIP ITSELF EVOLVES, SO ARE THE VARIOUS MECHANICAL SYSTEMS EVOLVING. JUST AS THE HUMAN BODY IS A RESULT OF THE VARIOUS SYSTEMS THAT SUPPORT IT- (CIRCULATORY SYSTEM, NERVOUS SYSTEM, RESPIRATORY SYSTEM, ETC..) SO MUST THE EARTHSHIP BE A PRODUCT OF THE SYSTEMS THAT SUPPORT IT. IN VIEW OF THIS WE HAVE REALLY FOCUSED ON MAKING THE EARTHSHIP SYSTEMS BOTH UNDERSTANDABLE AND AVAILABLE TO THE COMMON EVERYDAY HUMAN AT NO EXPENSE TO THE PLANET. ***WE ARE SIMPLY ADAPTING OUR NEEDS TO THE ALREADY EXISTING ACTIVITIES OF THE PLANET.*** WHY PIPE WATER LONG DISTANCES FROM A CENTRALIZED COMMUNITY WATER SYSTEM, OR UP FROM AN EXPENSIVE WELL THAT NEEDS SIGNIFICANT ELECTRICAL POWER, DEPLEATS AQUIFERS AND LOWERS THE WATER TABLE, WHEN WATER FALLS FREE FROM THE SKY? WHY HAVE A CORPORATE OR POLITICAL "MIDDLE MAN" BETWEEN US AND OUR ENERGY NEEDS? OUR VESSEL MUST BE DESIGNED TO SAIL WITH THE FORCES THAT EXIST ***BEYOND HUMAN CONTROL AND EXPLOITATION.*** THESE FORCES WILL BE THE "MENTORS" OF THE FUTURE.

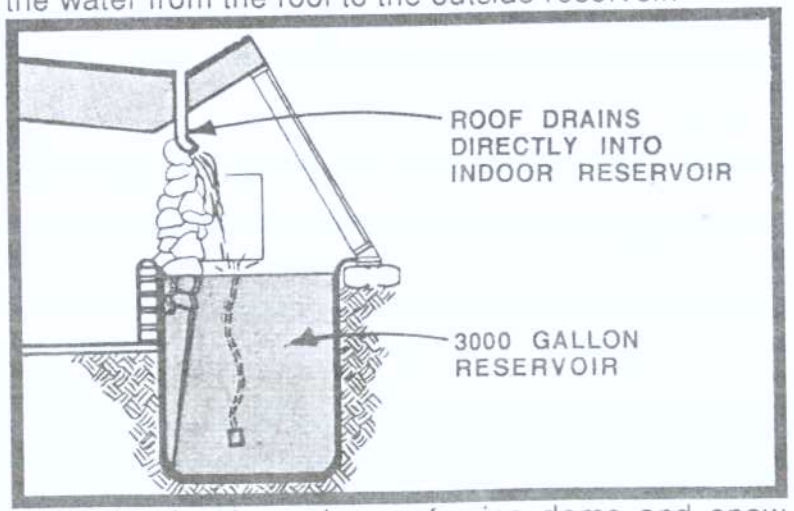
Graphics by .....Tom Drugan, Claire Blanchard
Photos by .....Pam Freund, Tom Woosly

An understanding of mechanical systems for most humans is limited to what is within reach of their fingertips. It is understood that when you flip a switch on the wall, a light comes on. When you turn on the faucet, hot water comes out. When you pull the handle on the toilet, it flushes. Little thought is given to where the electricity comes from or what kind of nuclear waste was produced to generate it. How many of us even know where the power plant is that supplies our power. Few people ever wonder which water table is depleted to bring them water and what chemicals have been added to it. Where does the sewage go after it is flushed and which rivers and lakes are polluted by it?

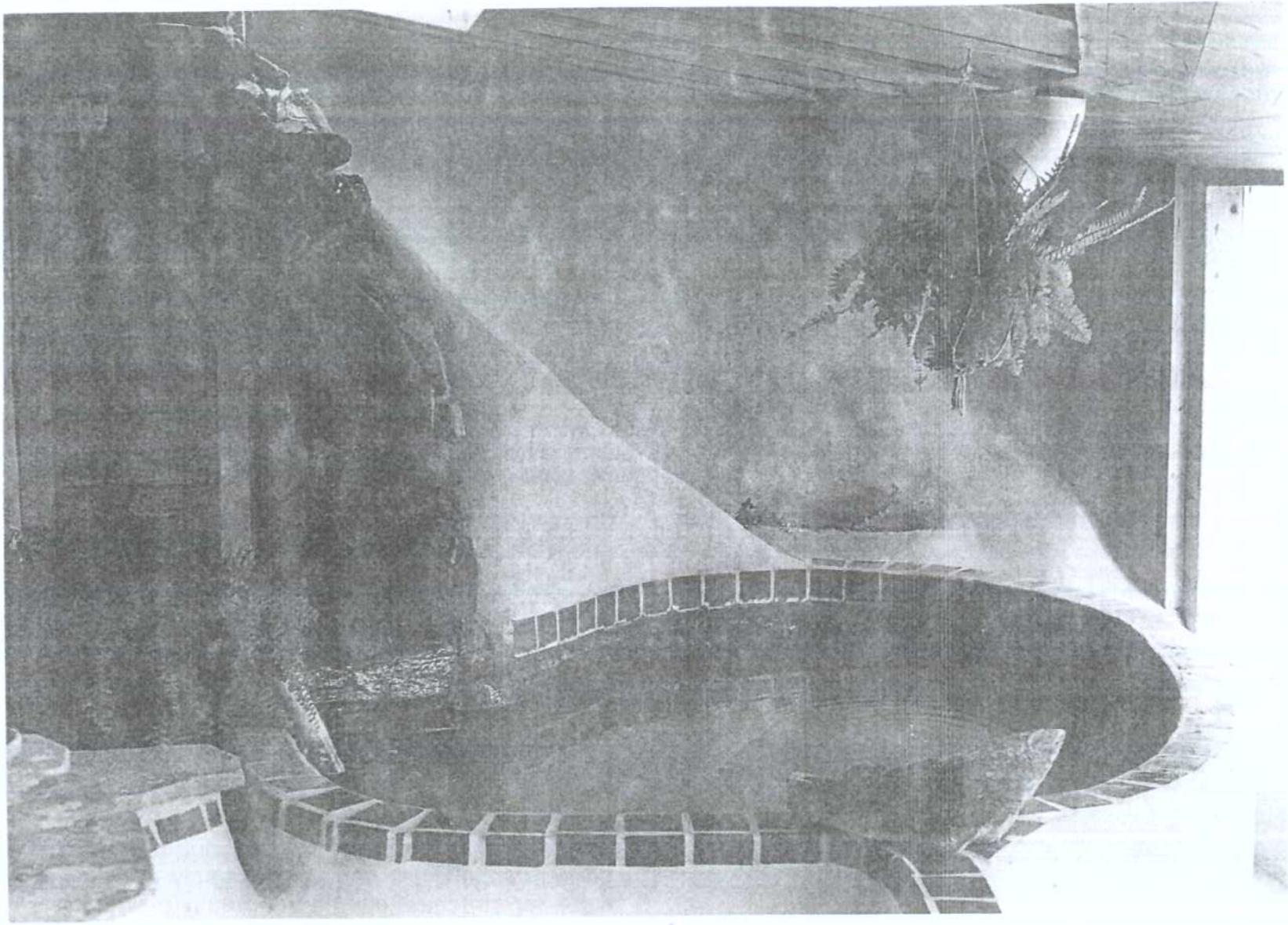
The condition of our planet tells us we must now begin to take responsibility for what happens beyond the reach of our fingertips. We must begin to reconsider the source of these utilities, our access to them, and how we dispose of the waste produced. The mechanical systems of the Earthship confront these issues *directly*. We call this direct living (see A Coming Of Wizards, chapter 5). Source, access and destination are all contained within the Earthship, *within the reach of our fingertips*. There is no mystery involved in Earthship electricity. There is no unknown source of water. There is no magical black hole that sucks up all our sewage. Instead, we work in harmony with the earth to deal with these issues - taking what it has to give us *directly* and giving back what it wants to receive. With this harmony ringing in our minds we evolve the Earthship mechanical systems.

INDOOR WATER CATCH

Water falls from the sky. If your area has more than 8" of total precipitation per year, your roof can catch enough water for domestic use. This is assuming you are using a dry toilet (solar or compost), low flow faucet heads, and reusing your grey water for plants. In Earthship Volume II we discussed the use of holding tanks *outside* the Earthship for storage of water. We found this to work very well but we found something better. The cost of making an *indoor* water catch is less than the cost of buying and delivering the 3000 gallon galvanized storage tanks we have used in the past. The roof can drain directly into this indoor reservoir now and avoid the considerable expenses of pipes and funnels to get the water from the roof to the outside reservoir.



There is also less chance for ice dams and snow blockage when using a direct roof drain. Standard commercial roof drains available through SSA are recommended.

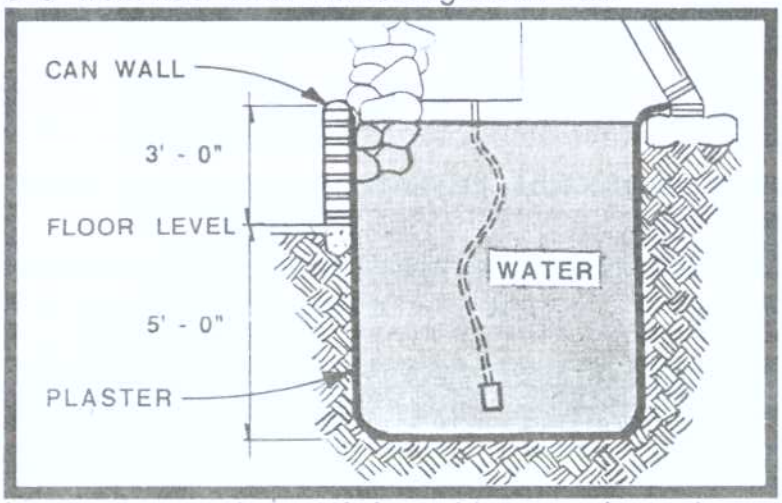


AN INDOOR WATER CATCH AT **REACH** NEAR TAOS, NEW MEXICO

The indoor water catch is both better and cheaper as it also dispenses with the need for underground freeze proof piping from the outdoor reservoir to the inside of the dwelling. Another advantage is the presence and sound of water in the dwelling as a small water fall must be incorporated to keep the water circulating thus keeping it fresh. The roof drain can direct the water to this waterfall so the waterfall becomes the "source" of water for your reservoir. The only disadvantage is that some space is required in the building for the reservoir, usually about 8'-0 in diameter and 8'-0" deep.

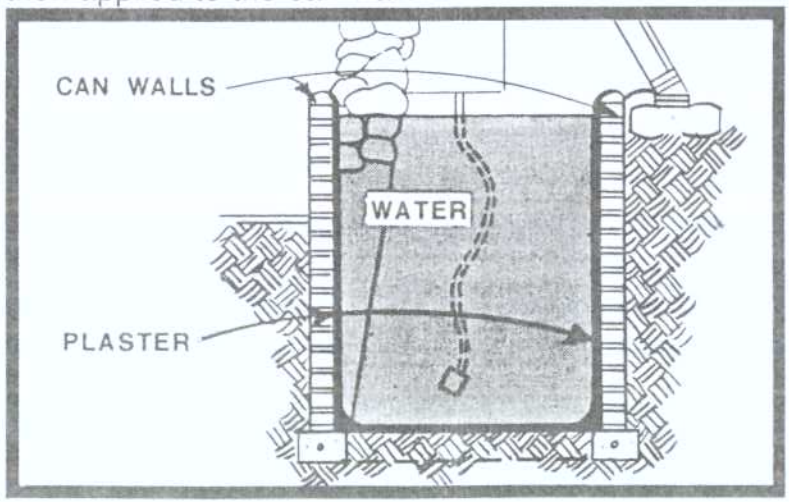
DETAILS AND SPECIFICS

An easy indoor cistern is made by digging into the ground, down 5'-0" from floor level and building up 3'-0" from floor level with a single can wall.



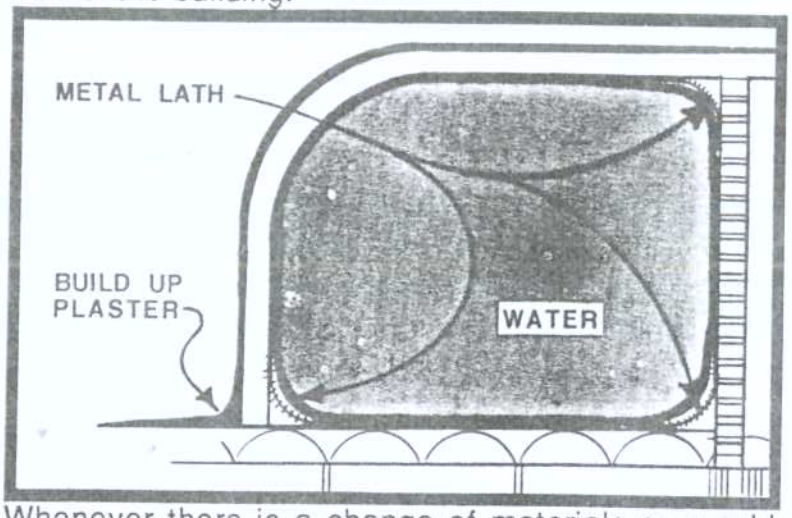
In most cases the earth is stable enough to plaster with a cement plaster (1 part cement to 3 parts sand plus engineering fibers) right on the earth cliff of the hole that has been dug out. It is best to apply about 4 scratch coats so that you have a 1 1/2" to 2" thick *slab* of concrete forming the cistern. Remember that this is a structural situation and that the plaster is just a technique for building up the structural slab. The engineering fibers are a must. *This is not just a plaster job.* After each coat, be sure to scratch it well. Then apply a 5th coat smooth troweled using a swimming pool trowel (see Earthship Vol. I p. 177 for scratcher and trowel). It is important to apply the final smooth coat in one application to avoid cold joints in the final surface.

If the earth is not stable enough to hold a good cliff, then a can wall must be taken all the way down to the bottom. This can wall must set on a small footing with continuous rebar. The same 5 coat plaster job is then applied to the can wall.



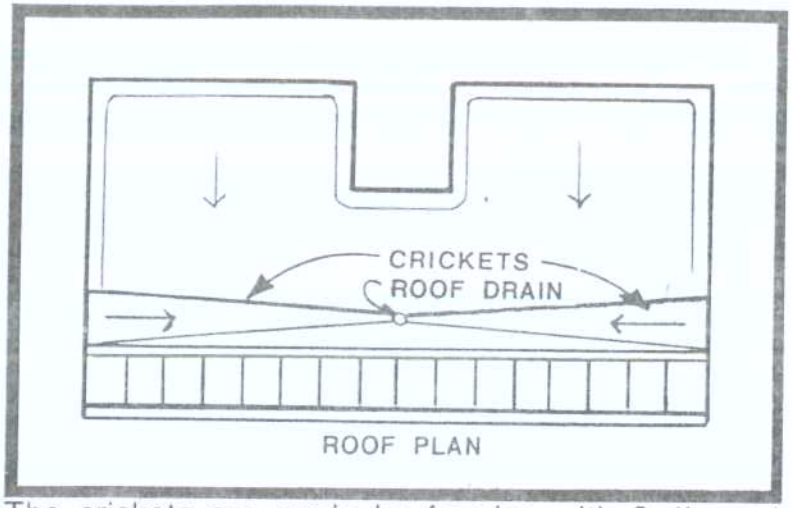
The shape of the cistern does not have to be a perfect circle but it should be slightly curved on all sides for structural integrity and easy plastering with no seams or corners.

Metal lath should be applied to areas where the can wall of the cistern meets the tire wall or another can wall of the building.

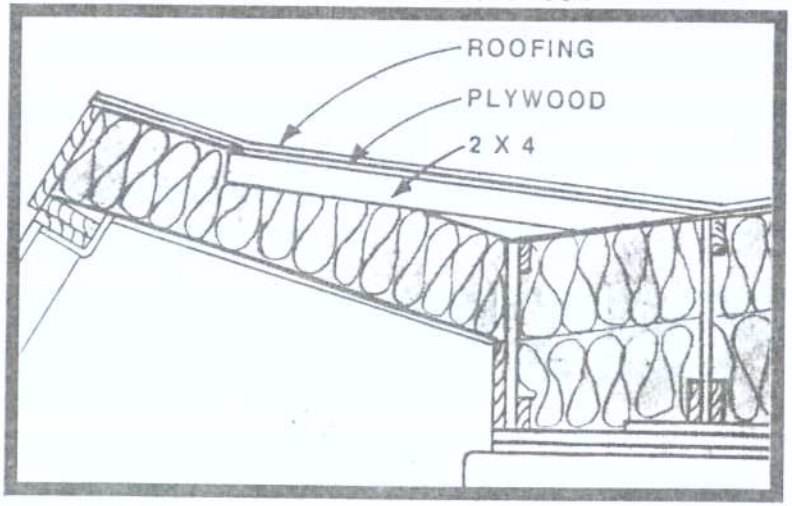


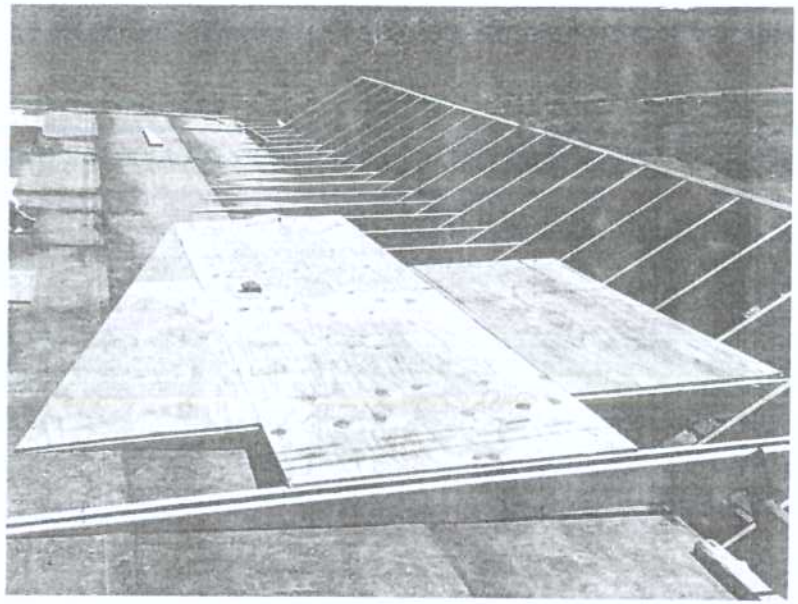
Whenever there is a change of materials or a cold joint, metal lath is always applied lapping well onto both surfaces for plaster preparation. Plaster should be built up on the outside of these areas (where applicable) to work against the force of the water pushing out.

The water is funneled into the cistern from the roof via "crickets" on the roof. A cricket is a term used for added planes on a roof surface to slope water in a specific direction. This is very similar to the water management on the ground surface around the outside of the Earthship.

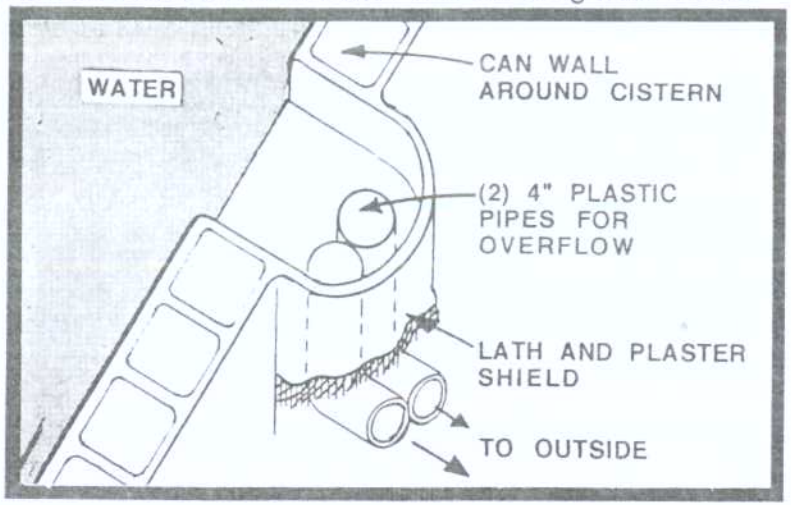


The crickets are made by framing with 2x4's and adding plywood to the roof surface creating a slope toward the drain. The plywood is then roofed with the same material as the rest of the roof.

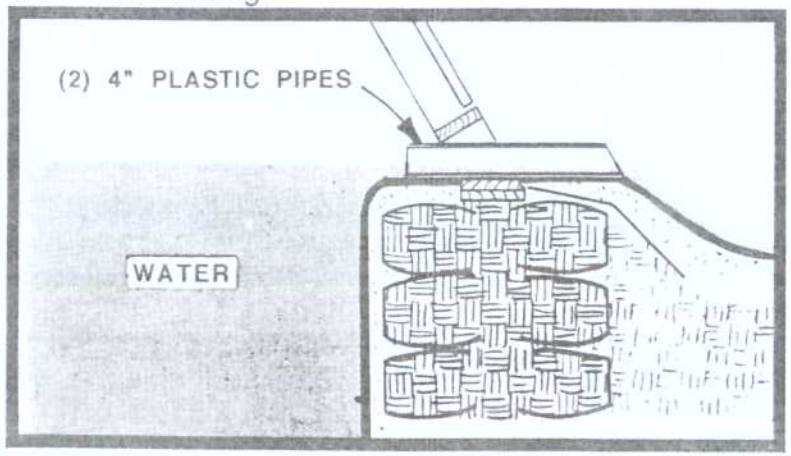


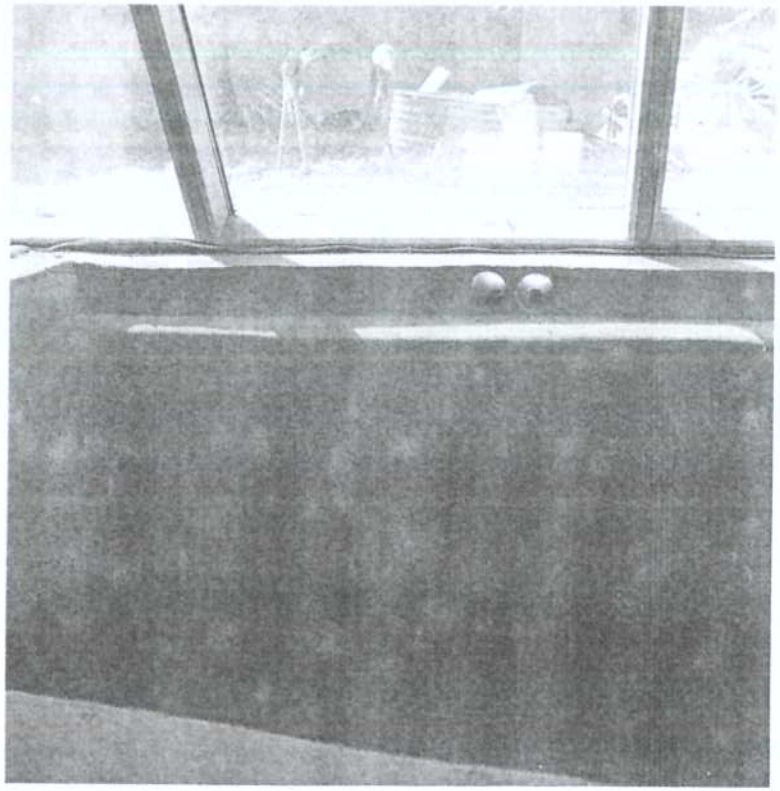


We have not found any material that is as easy to apply and as economical as the Brai or Firestone roofing (two different brands of modified bitumen roofing material) which we recommend in Earthship Volume II. This roofing comes with a mineral surface that protects it from the sun. It also comes without the mineral surface. We call this naked Brai. Both types have to be painted as the chemicals in the roofing can leach into the water. We recommend the naked roofing as it is easier to melt together and easier to paint. We have found an acrylic roof paint that protects the roofing material from the elements and creates a "drinkable" surface, preventing the roofing chemicals from leaching through. This coating is billed as a roofing material also and can be obtained through Solar Survival Architecture. It is applied like paint in three coats - a primer and two finish coats. Regular outdoor latex paint can be applied over this for color. The reservoir must have one 4" overflow for every 6" inlet. The roof must have one 6" inlet for every 1200 square feet of roof surface. The overflow can be detailed as illustrated in the diagram below.

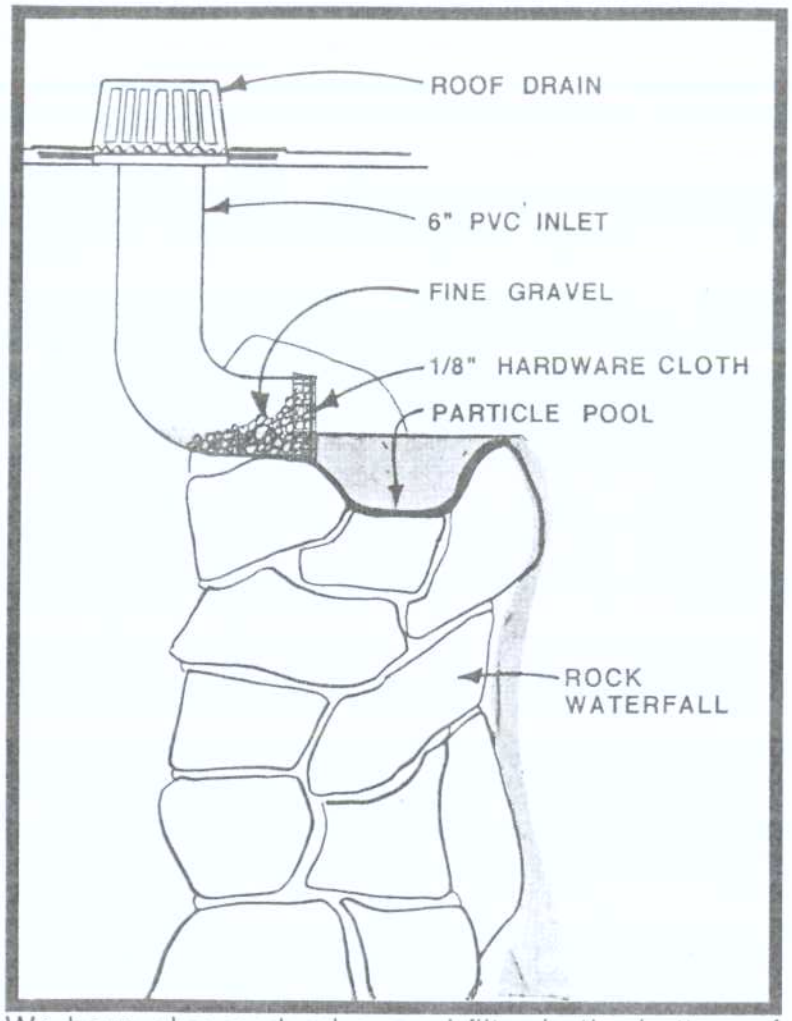


When the reservoir is against the front face an alternate overflow detail can take water out under the front face framing.

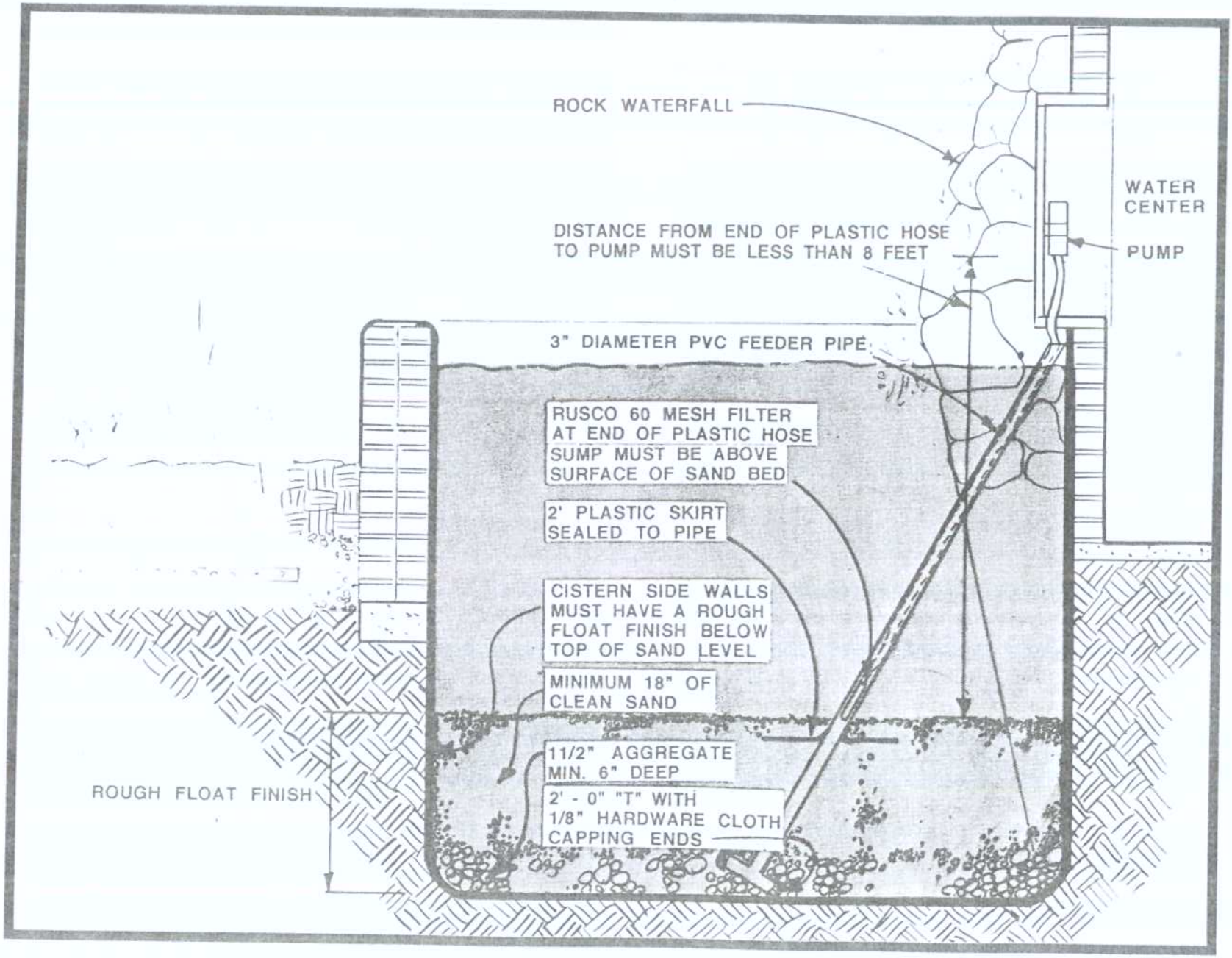




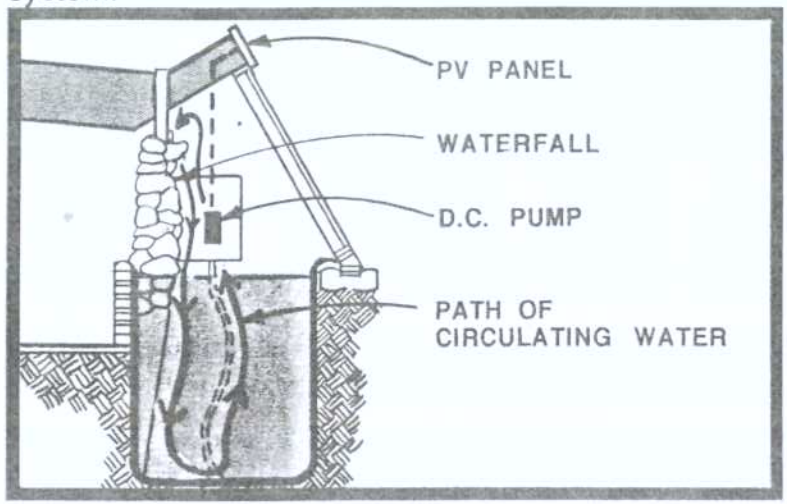
The six inch inlet from the roof drain is covered with a screen (1/8" hardware cloth) to hold in some fine gravel as a preliminary filter to keep particles from flowing into the reservoir. The inlet can then be placed directly over the waterfall so incoming water is simply *a waterfall* into the reservoir. Sometimes a particle pool is incorporated to allow particles to settle and be caught before the water tumbles down the waterfall.



We have also evolved a sand filter in the bottom of the reservoir. This makes cleaning the filters (outlined this chapter page 52-54) not necessary as often. The sand filter is detailed on the following page. The sand filter takes up 2'-0" in the bottom of the reservoir so this requires a deeper excavation in order to achieve about 3000 gallons of water .


ROCK WATERFALL
WATER CENTER
DISTANCE FROM END OF PLASTIC HOSE TO PUMP MUST BE LESS THAN 8 FEET
PUMP
3" DIAMETER PVC FEEDER PIPE
RUSCO 60 MESH FILTER AT END OF PLASTIC HOSE SUMP MUST BE ABOVE SURFACE OF SAND BED
2' PLASTIC SKIRT SEALED TO PIPE
CISTERN SIDE WALLS MUST HAVE A ROUGH FLOAT FINISH BELOW TOP OF SAND LEVEL
MINIMUM 18" OF CLEAN SAND
11/2" AGGREGATE MIN. 6" DEEP
2' - 0" "T" WITH 1/8" HARDWARE CLOTH CAPPING ENDS
ROUGH FLOAT FINISH

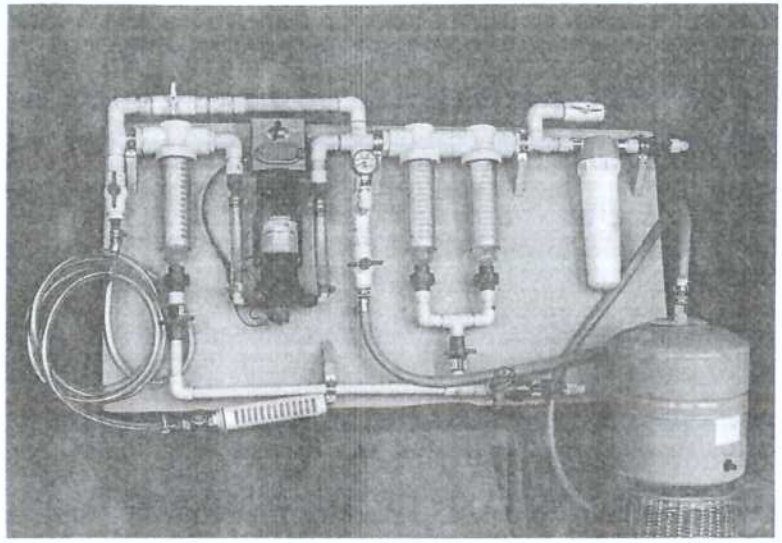
The water in an interior reservoir must be circulated most of the time to keep it fresh. We accomplish this with a small D.C. pump hooked directly to a 60 watt solar photo-voltaic panel. Thus the water is circulating automatically whenever the sun is out. This is independent of the *house power*. The D.C. pump requires a 60 mesh Rusco filter to protect it. The following diagram schematically illustrates this system.



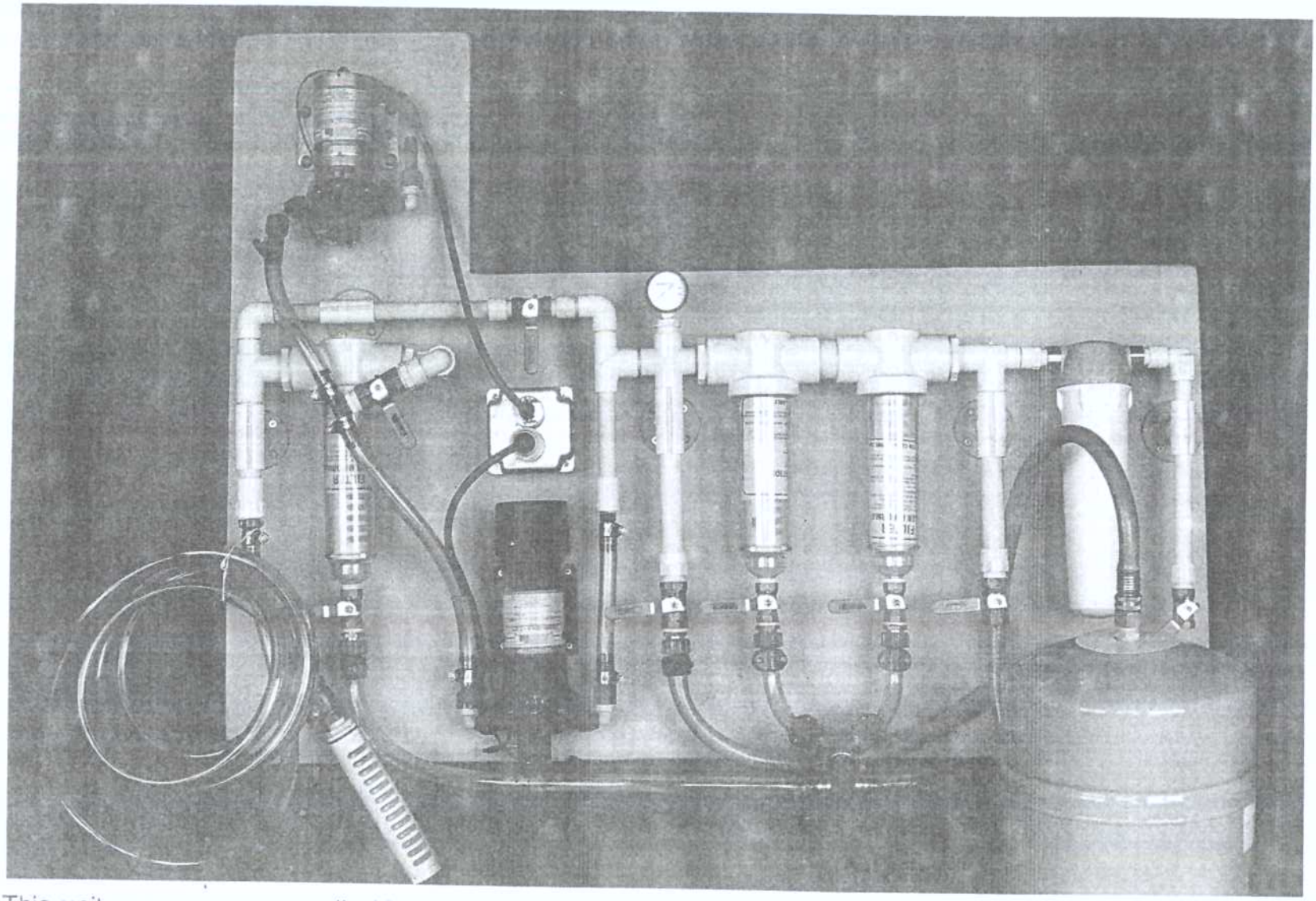
We have incorporated this pump and filter into the Water Organizer Module (WOM) described in the following pages.

WATER ORGANIZER MODULE (W.O.M.)

The indoor water catch also makes the location of the main 12 volt, D.C. pump for house water pressure more flexible. This pump has to be within 15'-0" horizontally of the reservoir and within 8'-0" vertically of the bottom of the reservoir. This pump must be installed with a bank of filters as illustrated in the diagrams on pages 43 and 44 of Earthship Volume II. We have found that finding parts for and assembling this pump and filter arrangement is not within the normal procedures provided by local plumbers. Anything *out of the ordinary* is very expensive so we are now providing the pump-filter arrangement ready to install. We present the Water Organizer Module (WOM).

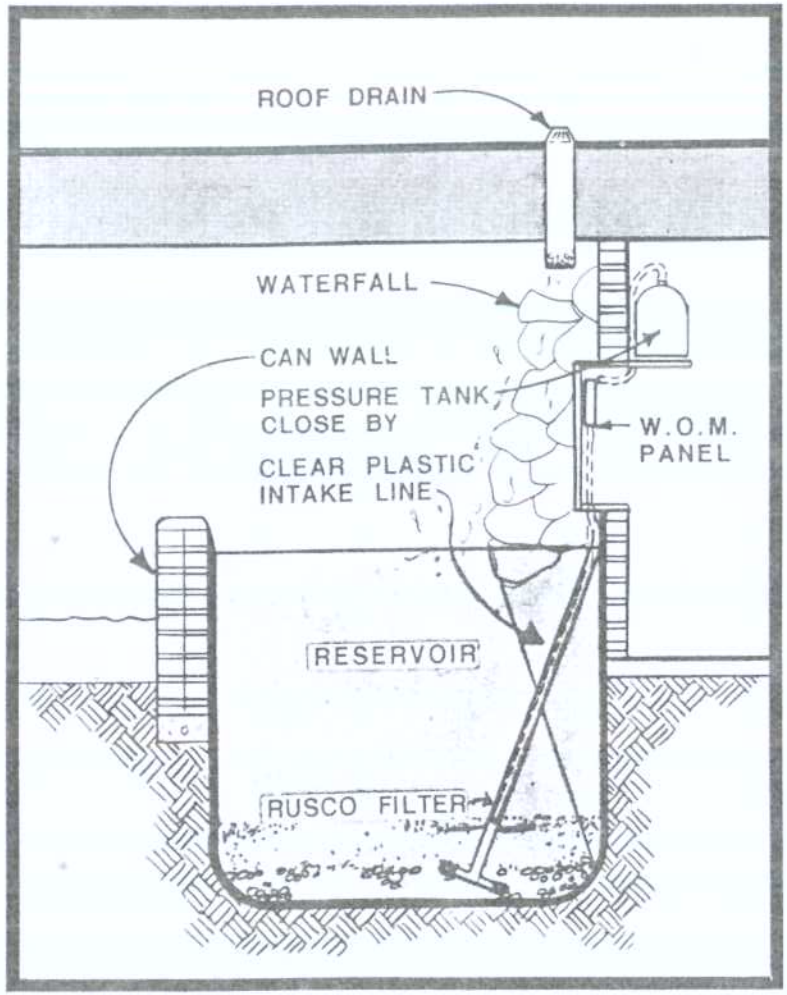


The above WOM is for an outside reservoir. When the indoor cistern is used, the waterfall pump is included as in the photo on the following page.



This unit screws on your wall. Your plumber simply hooks into familiar fitting on the right side of this panel (see photo). The panel comes with or without the water fall pump, thus there is a W.O.M.

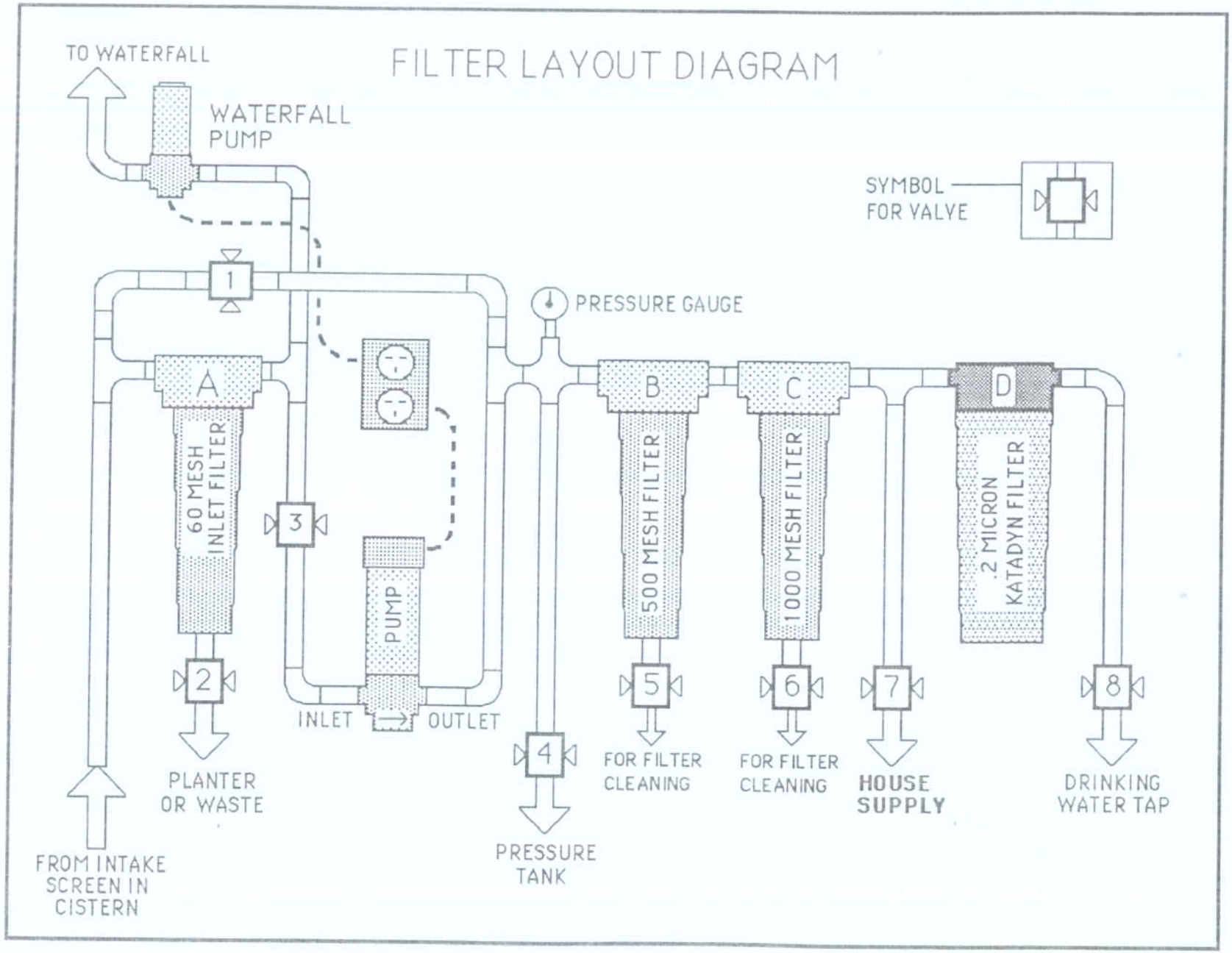
for outdoor and for indoor water catches. The following diagram is the ideal installation of this panel with an indoor reservoir and water fall.



This unit will provide on demand water pressure without a pressure tank. However, a pressure tank of any size will prolong the life of the pump. The pressure tank builds up pressurized water and stores it so the pump doesn't have to come on every time the faucet is turned on. A small pressure tank (3 gallons) comes with the WOM for this purpose. A large conventional pressure tank (60-80 gallons) provides pressure for more faucets on at once. This large tank costs about $400 and about $200 for installation. In cases of a tight budget this more expensive pressure tank can be added later. The WOM is already set up for it. The tank can be remote from the WOM but should be nearby to avoid pressure "quirks" in the system.

The clear plastic hose going from the water organizer module to the bottom of the reservoir has a 60 mesh filter on the end of it. This hose and filter comes with the water organizer module. If a sand filter is used this hose and filter are placed down the plastic feeder pipe of the sand filter (see page 49).

The following diagrams illustrate filter cleaning and operation of the water organizer module. The Rusco sediment filters do not require replacement, just cleaning. The same is true for the Katadyn drinking filter.


FILTER LAYOUT DIAGRAM
TO WATERFALL
WATERFALL PUMP
SYMBOL FOR VALVE
PRESSURE GAUGE
A
B
C
D
60 MESH INLET FILTER
500 MESH FILTER
1000 MESH FILTER
.2 MICRON KATADYN FILTER
PUMP
1
2
3
4
5
6
7
8
INLET
OUTLET
PLANTER OR WASTE
FOR FILTER CLEANING
FOR FILTER CLEANING
HOUSE SUPPLY
DRINKING WATER TAP
FROM INTAKE SCREEN IN CISTERN
PRESSURE TANK

FUNCTION *	1 VALVE	2 VALVE	3 VALVE	4 VALVE	5 VALVE	6 VALVE	7 VALVE	8 VALVE	NOTES
NORMAL OPERATION	CLOSED	CLOSED	OPEN	OPEN	CLOSED	CLOSED	OPEN	OPEN	Closing valve 3 while pump is plugged in can result in damage to pump. Pump should be unplugged for all functions other than normal operation.
BLOW DOWN FILTER A *	OPEN	OPEN	CLOSED	OPEN	CLOSED	CLOSED	OPEN	OPEN	Valve sequence 3,1,2, reverse for normal operation.
MANUAL CLEANING FILTER A	CLOSED	OPEN	OPEN	OPEN	CLOSED	CLOSED	OPEN	OPEN	After opening valve 2 open filter body just enough to admit air and drain filter. Then remove drainline and filter body and clean with soft brush.
PRESSURE PRIMING *	OPEN	CLOSED	OPEN	OPEN	CLOSED	CLOSED	OPEN	OPEN	"Crack" inlet line at pump port. Open valve 1 just enough to purge air, when air is expelled, close valve 1 and re-tighten inlet line.
BLOWDOWN FILTER B *	CLOSED	CLOSED	OPEN	OPEN	OPEN	CLOSED	OPEN	OPEN	Open valve quickly, close slowly.
MANUAL CLEANING FILTER B	CLOSED	CLOSED	OPEN	CLOSED	OPEN	CLOSED	CLOSED	CLOSED	Valve sequence 4,7,8,5. Clean same as filter A then reverse sequence.
BLOWDOWN FILTER C *	CLOSED	CLOSED	OPEN	OPEN	CLOSED	OPEN	OPEN	OPEN	Open valve quickly, close slowly.
MANUAL CLEANING FILTER C	CLOSED	CLOSED	OPEN	CLOSED	CLOSED	OPEN	CLOSED	CLOSED	Valve sequence 4,7,8,6. Clean same as filter A then reverse sequence.
CLEANING FILTER D KATADYN	CLOSED	CLOSED	OPEN	CLOSED	CLOSED	OPEN	CLOSED	CLOSED	Open filter body just enough to admit air and let excess water drain through filter C. Remove filter body and clean. Clean ceramic candle as per katadyn instructions
* BLOWING DOWN FILTERS AND PRESSURE PRIMING REQUIRES ADEQUATE WATER IN PRESSURE TANK.									

GENERAL NOTES ON WATER SYSTEM

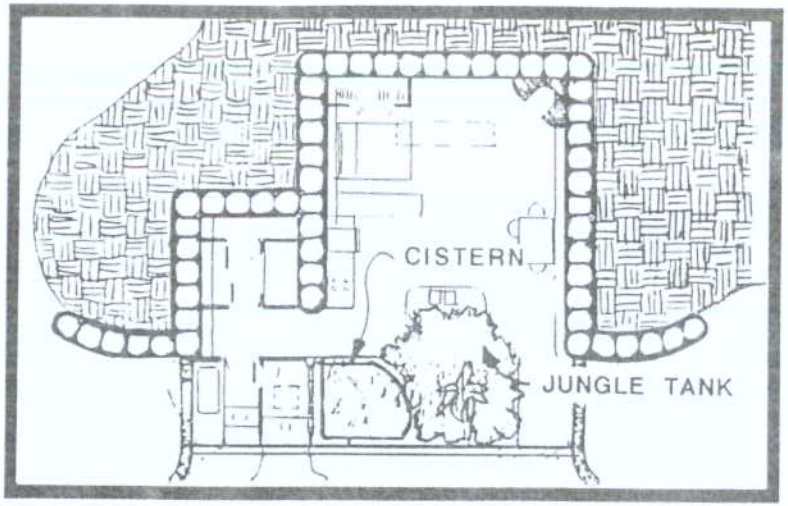
1. The pump ports are plastic. Use care when tightening connectors to the ports. Finger tight should be sufficient.
2. The Shurflo pump has an internal pressure switch set to turn on the pump at 25 PSI and shut it off at 45 PSI.
3. The pump will not be able to prime itself if:

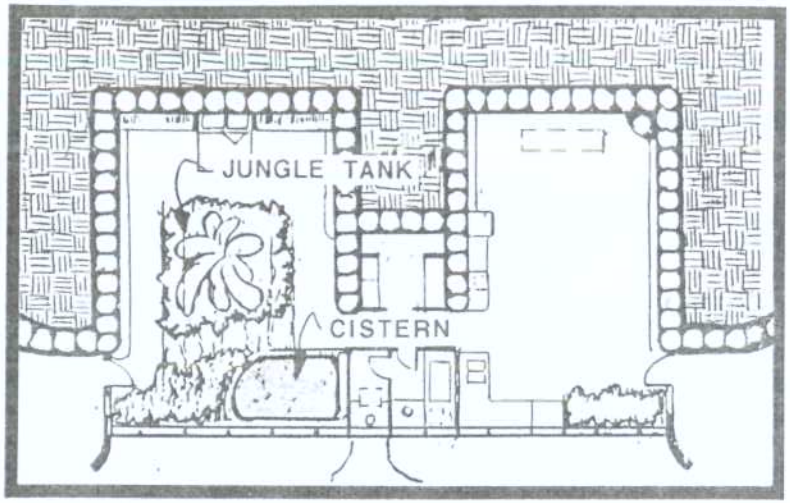
A- The water level in the cistern is more than 8 feet below the pump. B- There is no outlet open on the outlet side of the system. C- There is even a minute leak in the inlet side of the system.

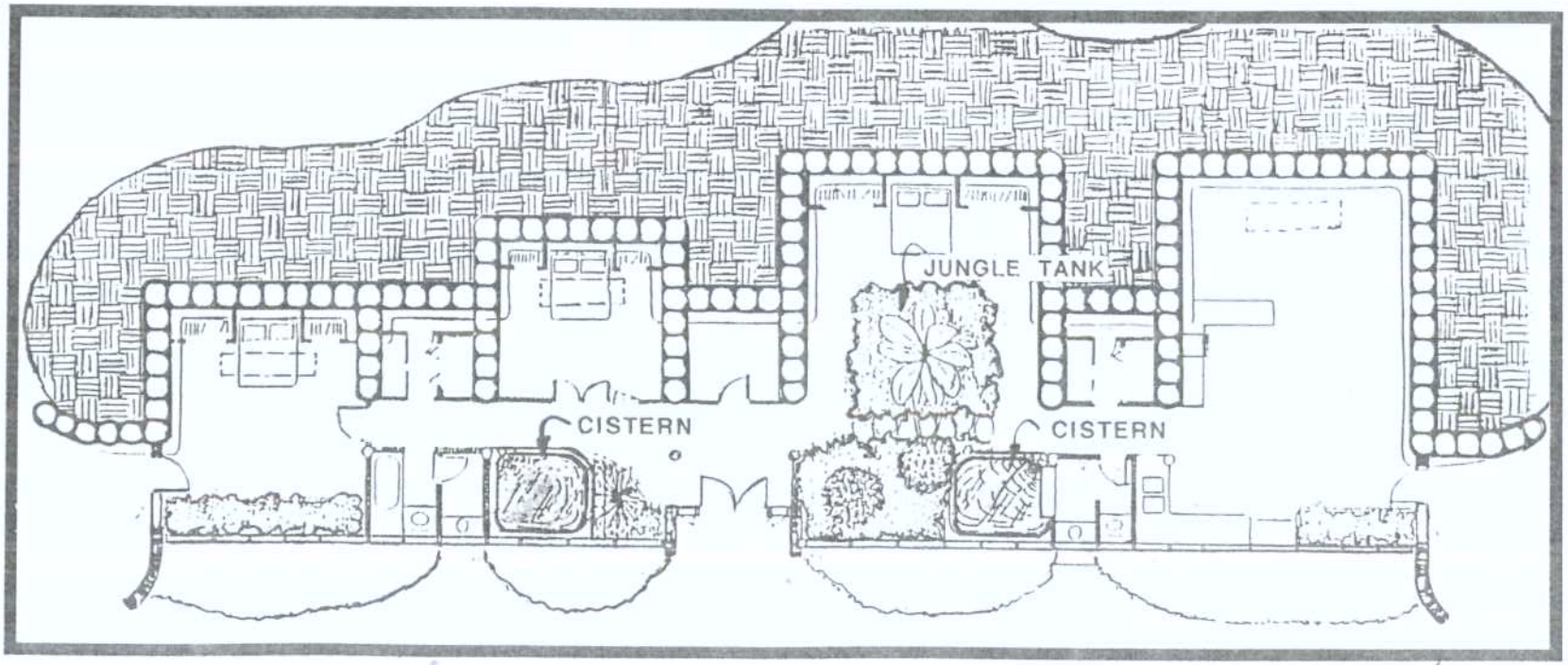
4. Clogging of the screen at the end of the cistern intake line or of filter **A** can quickly damage pump. Always watch that filter **A** is clean and always inspect and clean the intake screen when filter **A** is cleaned. Be especially vigilant if cistern water is dirty. If pump becomes noisy unplug it and inspect screen and filter immediately.
5. Do not use hose for Katadyn water line since pressure stored in the inflated hose could rupture the ceramic filter element if the pressure were suddenly reduced on the inlet side of the filter.
6. There is a 15 amp fuse in the receptacle box to protect the pump. If pump does not energize when plugged in shut off circuit breaker and inspect this fuse.
7. The air cushion of the pressure tank should be pre charged to approximately 2 p.s.i. less than the cut-in pressure of the pump which is 25 p.s.i. Therefore precharge the tank to 23 p.s.i.
8. If you have begun collecting water from your roof before it has been sealed (especially with a brai roof), you will have acummulated some foul looking and smelling construction water. This bad water can leave a permanent odor and taste in your filters. Therefore, when the water system is first put into use it is recommended that the cistern be emptied and cleaned, and then refilled with clean water. If this is not possible then temporarily remove the inside candle of the Katadyn filter for the first 3 - 4 weeks. This will prevent it from picking up any taste or odor that may have accumulated in the tank during construction.

INDOOR *CONTAINED* GREY-WATER ABSORBING TANK

Early grey water systems simply split the grey water from the black water and took it outside to various planters. We have also taken the grey water from individual plumbing fixtures and piped it to specific indoor planters as outlined in Earthship Volume II p.p. 53-55. With the increased need for food production in an Earthship we have started providing more than just *token planters*. Another consideration is that health officials as a rule are generally not going to approve of *any* grey water going outside the dwelling on the surface of the ground no matter how well kept the planter is. The point they make is that if someone has a disease like hepatitis, takes a shower and the shower water runs outside, *a neighbor child could play in it and be exposed to hepatitis*. We must deal with grey water totally inside a closed system - nothing leaves the dwelling. This, plus the fact that more space is needed for food production, has led us to create an indoor contained greywater absorbing tank that can support a virtual jungle. We are now dedicating major amounts of space to grey water absorption and food production. The floor plans following illustrate the size and integrated use of the contained "jungle" tank.

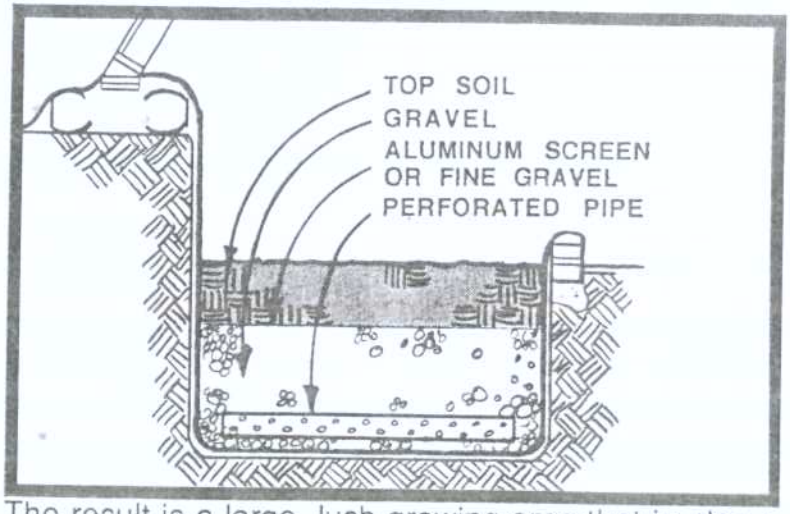

CISTERN
JUNGLE TANK


JUNGLE TANK
CISTERN


JUNGLE TANK
CISTERN
CISTERN

INTERIOR JUNGLE AT THE OFFICE OF SOLAR SURVIVAL ARCHITECTURE, TAOS, NEW MEXICO

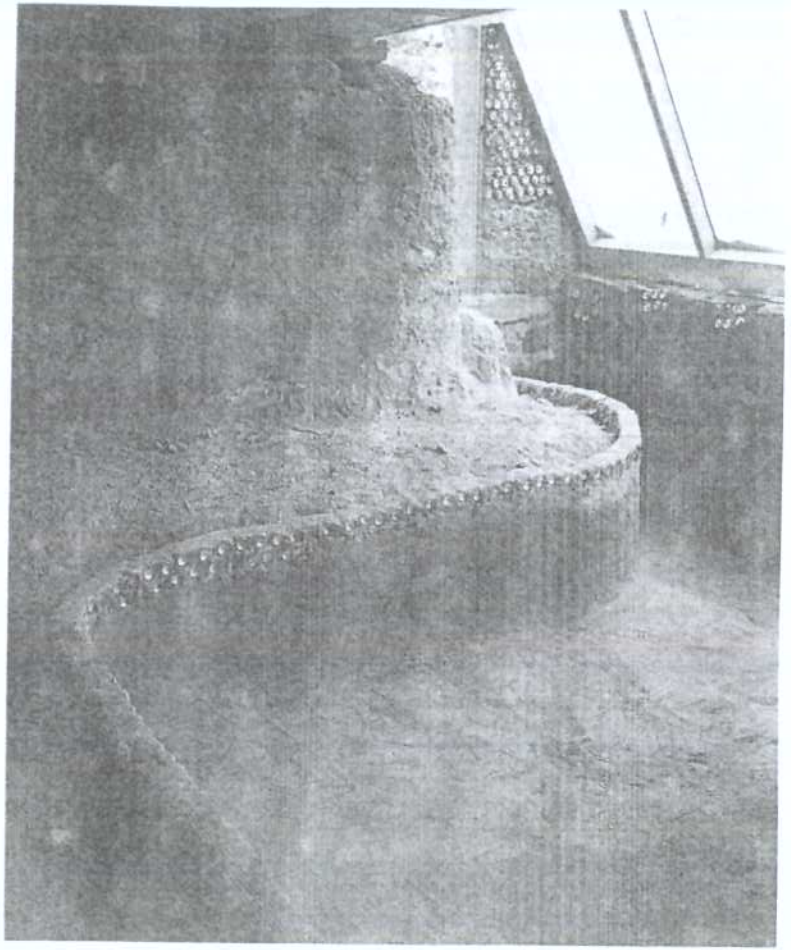
We are digging down in the jungle space and lining it with a rubber membrane. We basically *roof it* with the Brai, Firestone, or EPDM roofing. It is now actually an *indoor tank*. We then distribute the grey water from a 4" perforated pipe manifold through gravel on the bottom of this tank. Over the gravel we have a foot of top soil. Between the top soil and the gravel we have a layer of aluminum screen to prevent dirt from leaching into the gravel. Fine (1/4") gravel placed between the soil and the base gravel will accomplish the same thing as the aluminum screen.



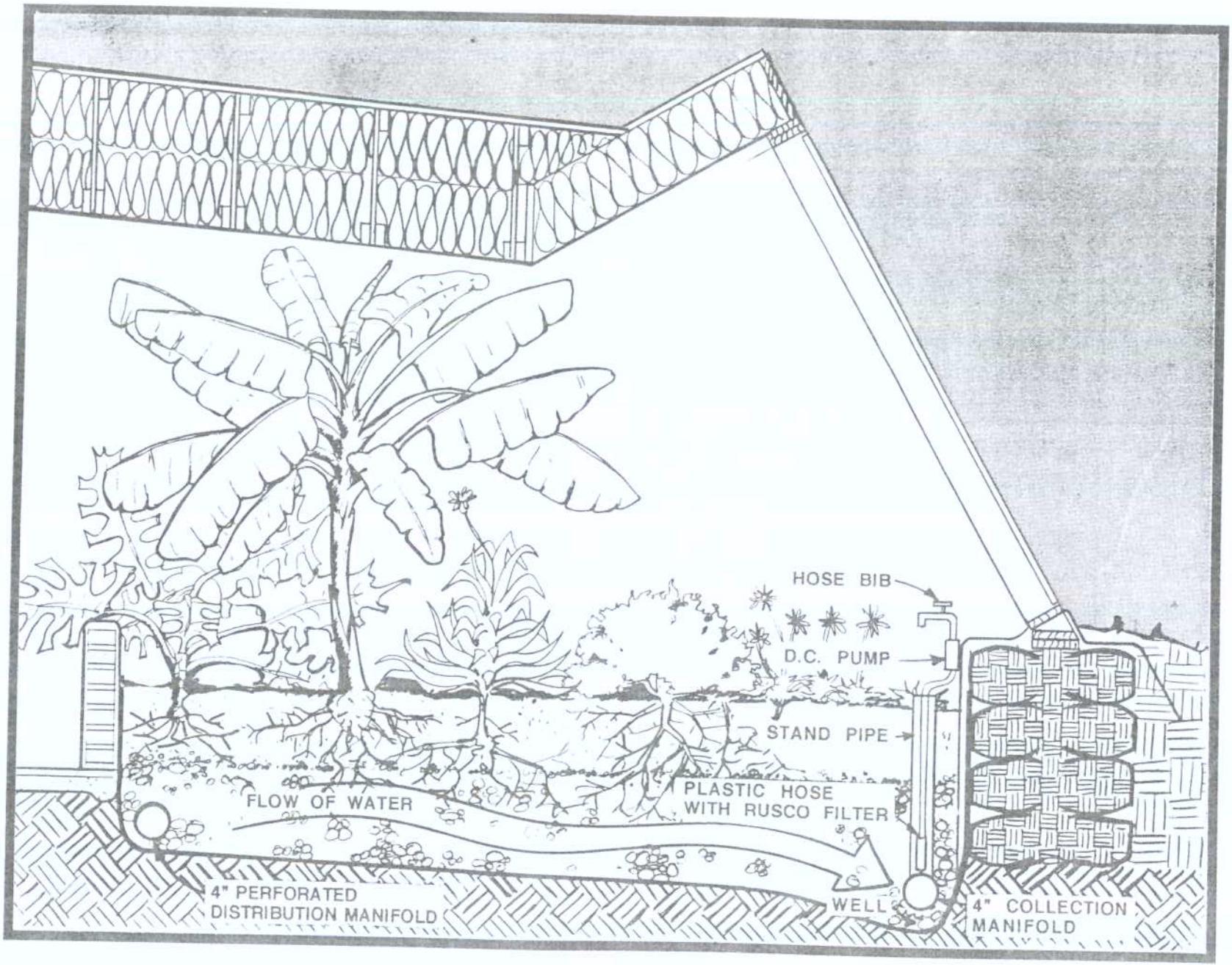
The result is a large, lush growing area that is also a grey water treatment **container**. The point is that the water is contained and used by the plants.

The water actually passes through the gravel for the entire length of the tank getting cleaned and filtered as it goes. It then collects in a well at the opposite end of the tank where a second collection 4" manifold pipe is placed (see diagram on the following page).

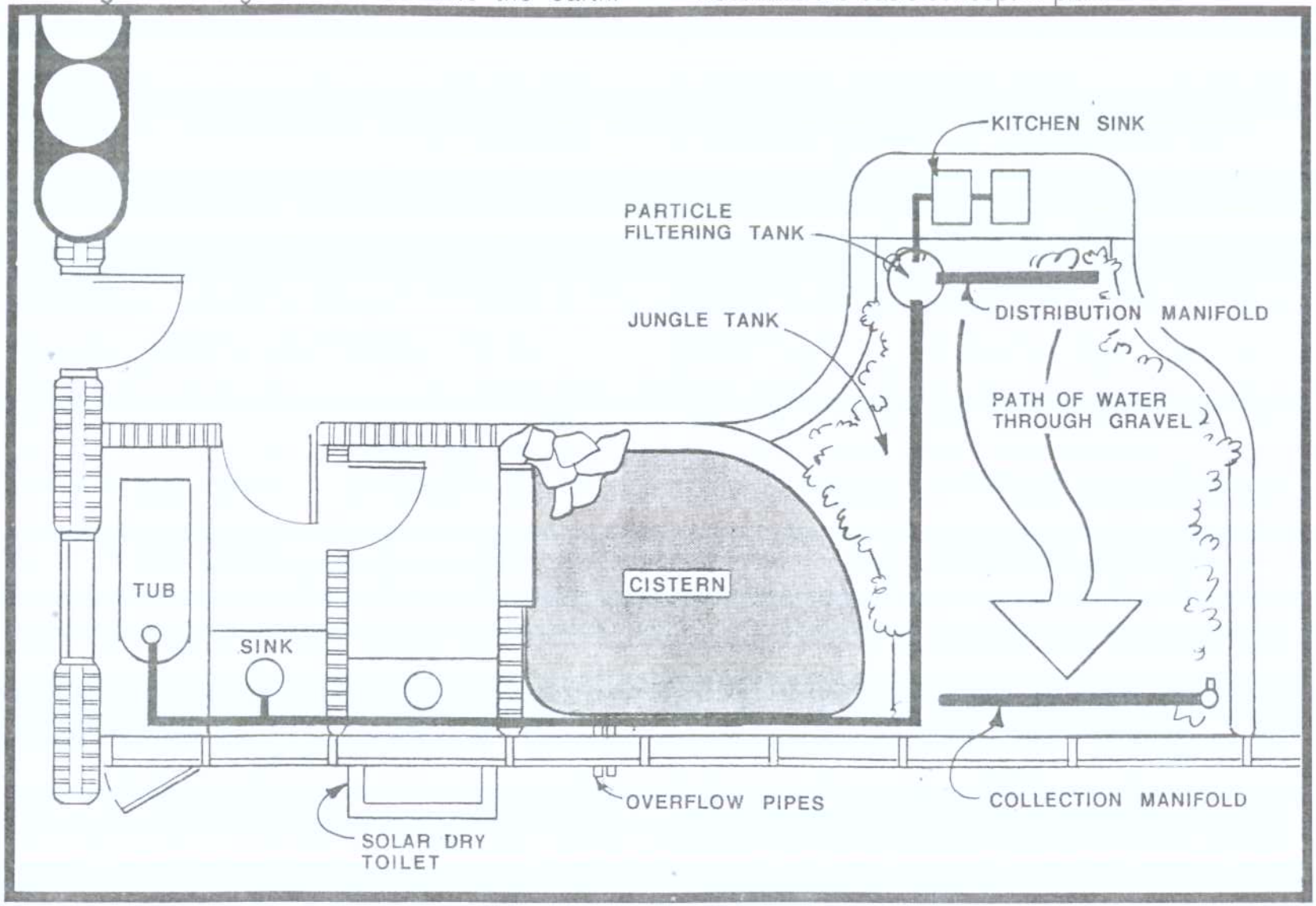
The photograph below in a grey water absorbing tank under construction



A stand pipe comes up from the collection manifold to accomodate a plastic hose going to a D.C. pump (the same pump used in the WOM). This pump facilitates reuse of the now treated water on the surface of the jungle tank or outside. The tank is sized with enough volume and planting that surface watering is a convenience not a necessity.


HOSE BIB
D.C. PUMP
STAND PIPE
PLASTIC HOSE
WITH RUSCO FILTER
FLOW OF WATER
4" PERFORATED
DISTRIBUTION MANIFOLD
WELL
4" COLLECTION
MANIFOLD

When this system is used in conjunction with a dry toilet (see Chapter 4) **no waste water leaves the building.** Nothing is absorbed into the earth. *Everything is contained and used within the building to produce food and flora.* The following diagram illustrates the basic concept in plan.

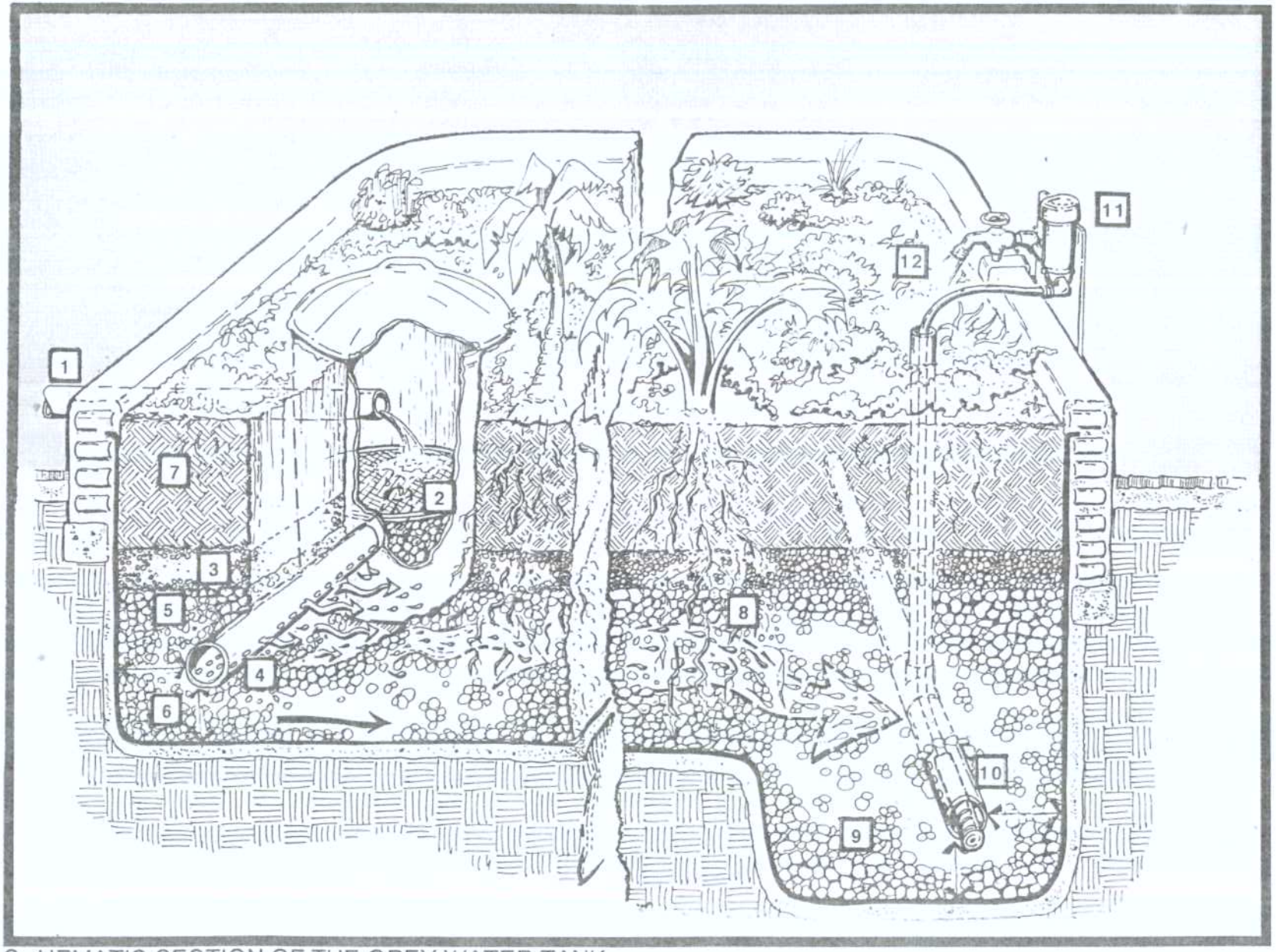


The basic objective of health officials is to contain all grey water. This contained grey-water-absorbing-jungle accomplishes that with an *already proven* method of processing - the wetlands approach. This contained grey water absorbing tank is similar to wetlands systems which have been used successfully to treat and absorb black and grey water outside. In our application *there is no black water* and **the entire system is contained inside**. The fact that we are not including toilet/black water makes it basically a much less serious contained wetlands system. Nothing is admitted to the surrounding environment. The jungle (via the tank below) takes it all. The plant roots reach down and absorb the moisture that is distributed throughout the gravel. The well and stand pipe provides access to treated water for outside or inside use. If you live in an arid climate and will need a lot of outside water, the depth of your tank can be shallow 2'-4". If you live in a wet climate and won't need much outside water, the tank can be deeper to store more water. The shallow tanks will actually function better to filter and clean the water than the deeper tanks. A plastic can with gravel on the bottom and a removable screen provides a preliminary filter (see diagram opposite) for particles and food chunks in the water. The lid of this container must be sealed with silicone to avoid odor. The lid is removed (usually every 2 months) for cleaning and must be re-siliconed when it is replaced.

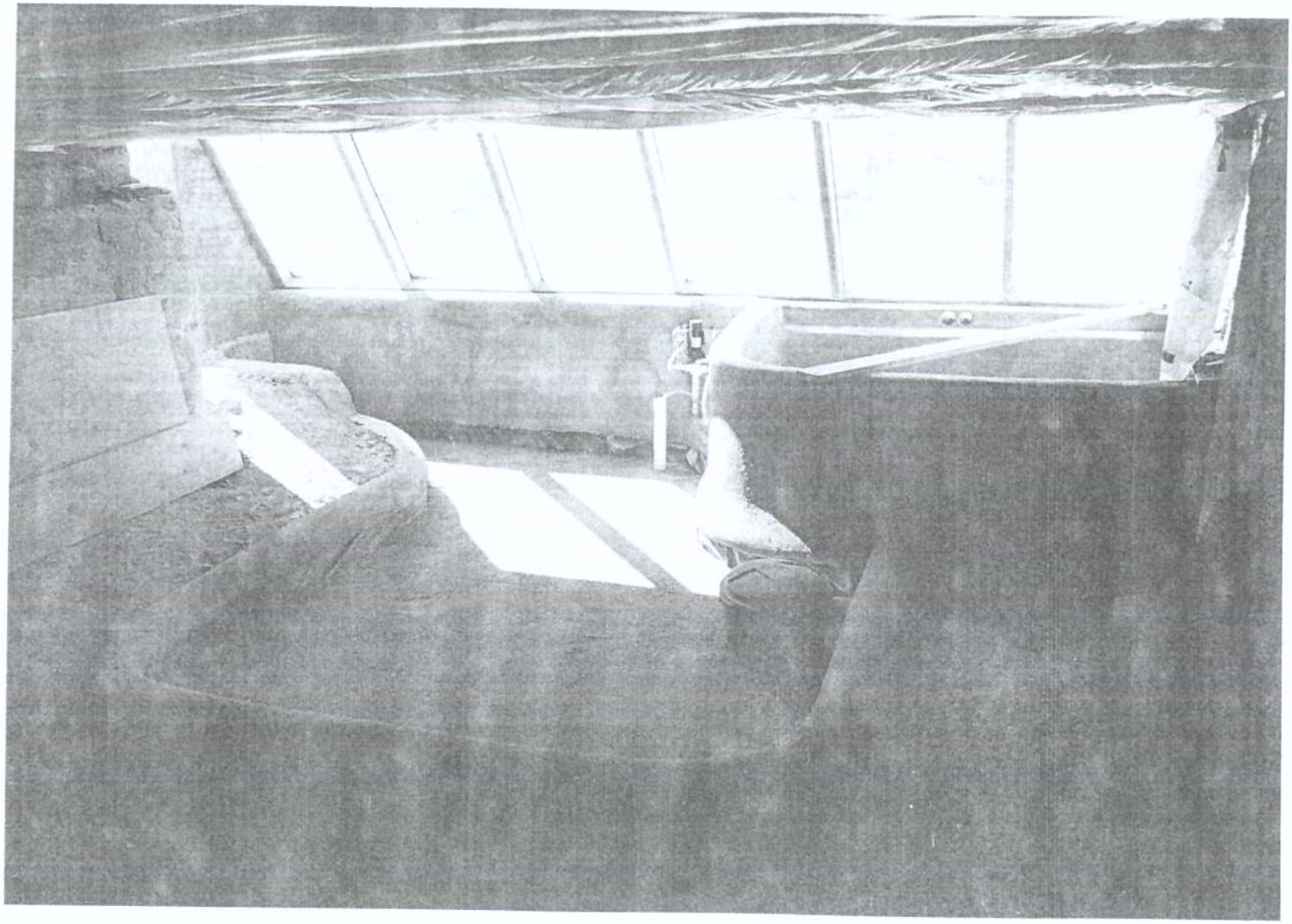
This green (jungle) space can be sized according to volume of water usage, number of people, and fixtures. Originally we planned to isolate it with doors closing it off from the rest of the dwelling. We called it a "walk in septic tank". However, people began asking if they could put a couch and T.V. in the jungle room. One thing led to another and now we present the jungle room as study, living area or even a bedroom. We are basically integrating it into the entire dwelling.. People do not want to be separate from "the jungle". *They want to live with the plants.* The average exchange is healthy for both people and plants and the containment of grey water is achieved.

Description of elements in the following diagram:

1. Grey water from sinks, tubs, shower, and washer.
2. Grease trap filters out particles.
3. 4" deep fine aggregate.
4. Distribution manifold.
5. 16" deep medium aggregate.
6. 2" - 4" large aggregate.
7. 12" topsoil.
8. Roots and gravel filter to purify water.
9. Well.
10. Intake manifold with filter.
11. D.C. pump.
12. Faucet dispenses filtered water.



SCHEMATIC SECTION OF THE GREY WATER TANK.

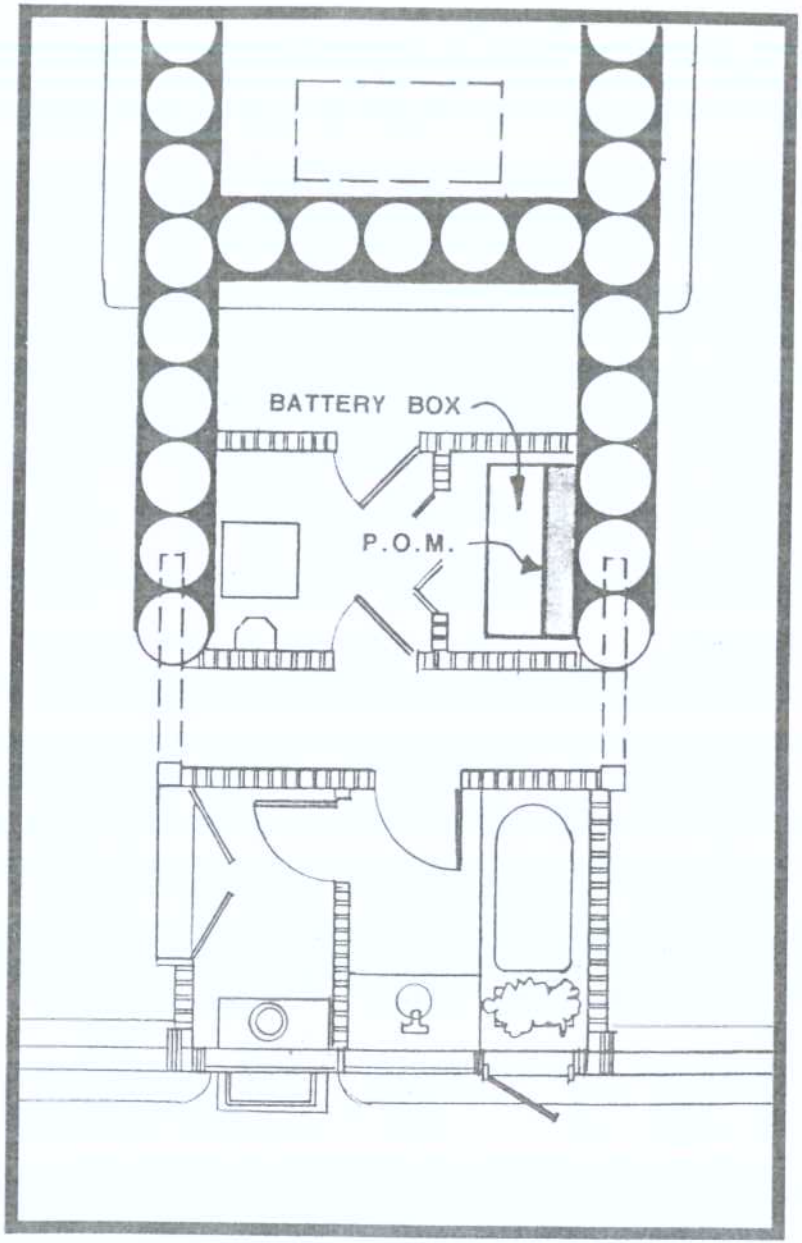


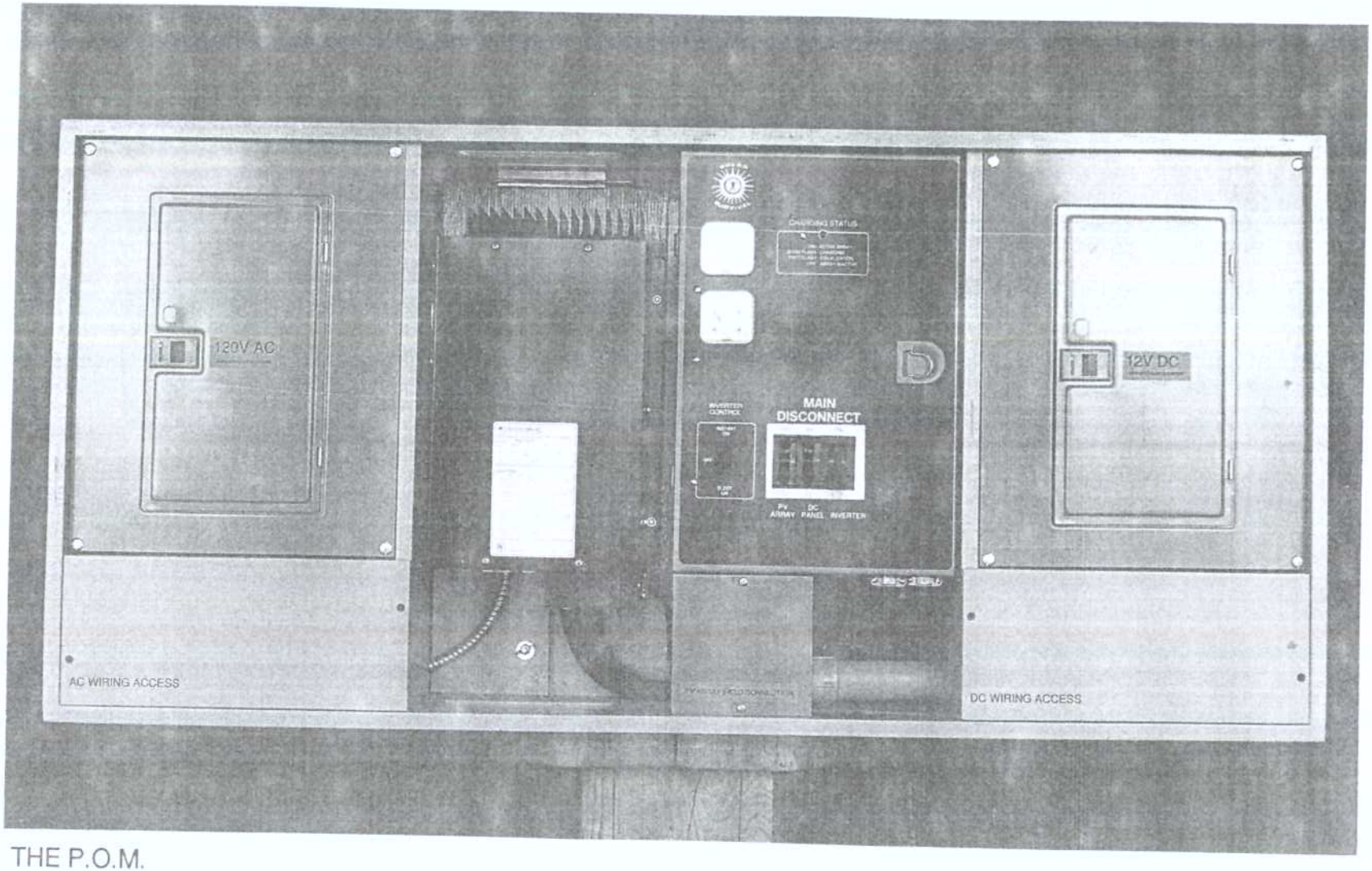
GREY WATER ABSORBING TANK AND CISTERN UNDER CONSTRUCTION

POWER ORGANIZER MODULE (P.O.M.)

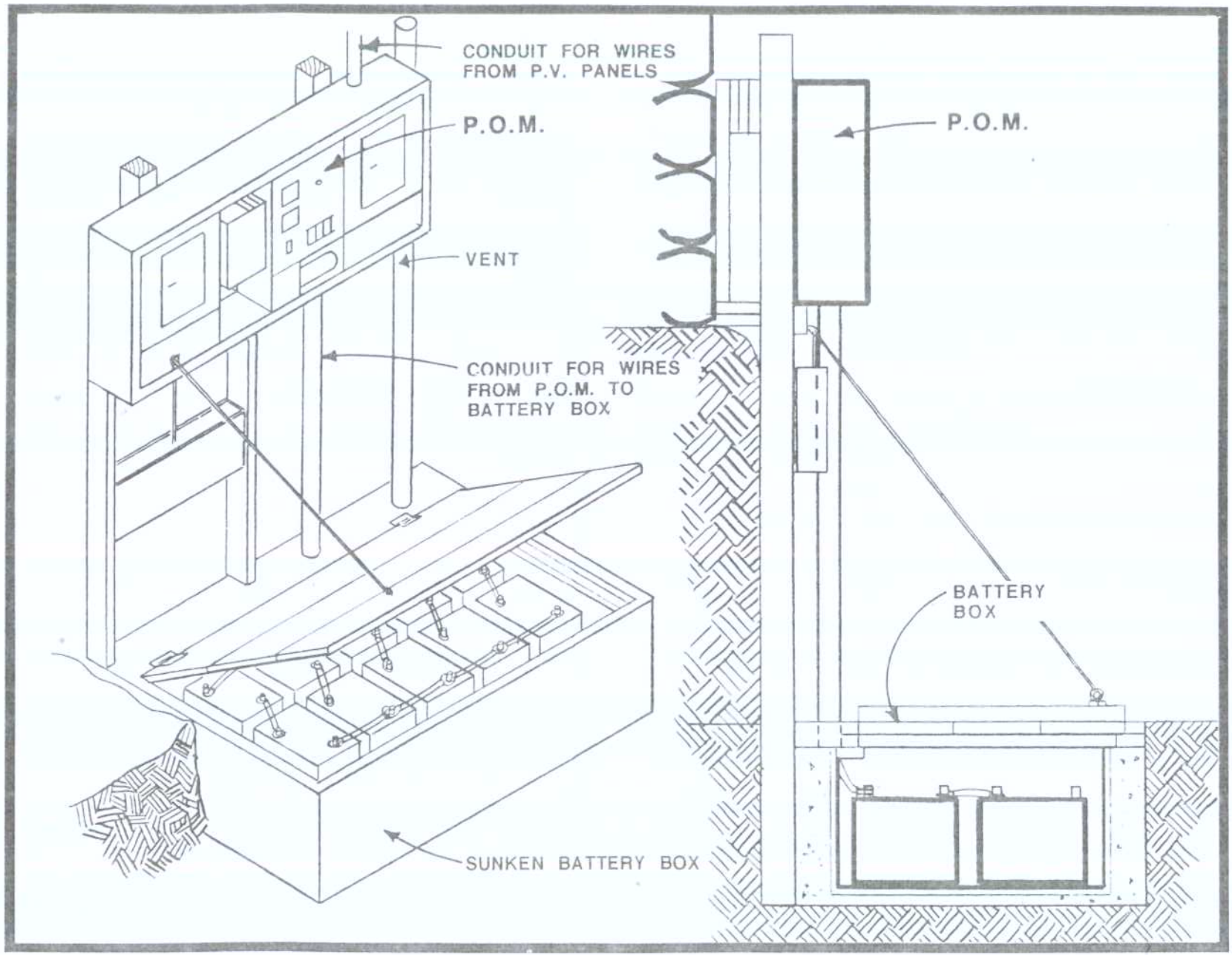
The electrical discussions in Earthship Volume II (pp 3-23) lead us to the diagrams of a power organizer on page 23 of that Volume. This module is equipped with conventional electrical circuit breaker boxes that any local electrician is accustomed to. The objective here being to allow the house to be wired absolutely conventionally so that local electricians would not have to deal with solar power. This concept (explained in depth in Volume II pp 11-12) has been successful. The Power Organizer Module itself has come a long way and is now available through Solar Survival Architecture. We have options on inverters (Trace or Photocomm) and our new module can now be expanded up to 16 panels before adding another whole module.

This unit is simply secured onto a wall with the batteries below and panels above. We now recommend that batteries be sunken into the floor for more protection and to provide flat floor space in front of the circuit panels and disconnects at the P.O.M. to conform to code. The battery box should be detailed as a "vault" with a 3 hour fire rating and should have a high and low vent to sweep battery gases out.



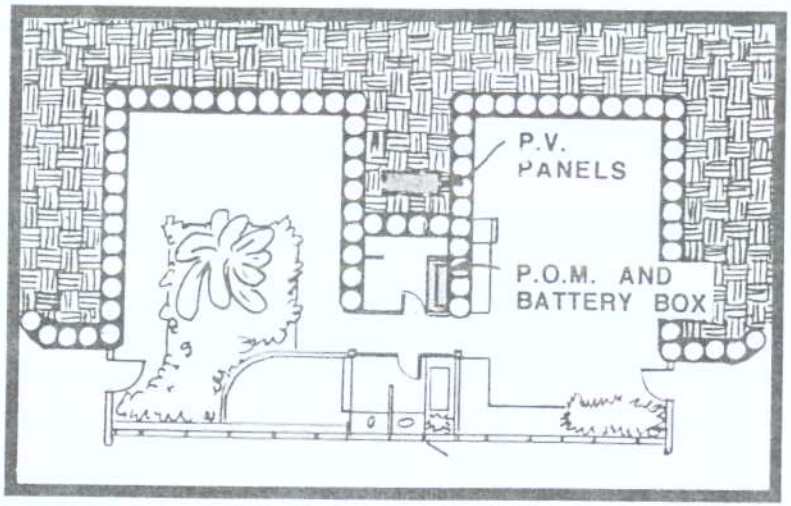

120V AC
MAIN
DISCONNECT
12V DC
AC WIRING ACCESS
DC WIRING ACCESS

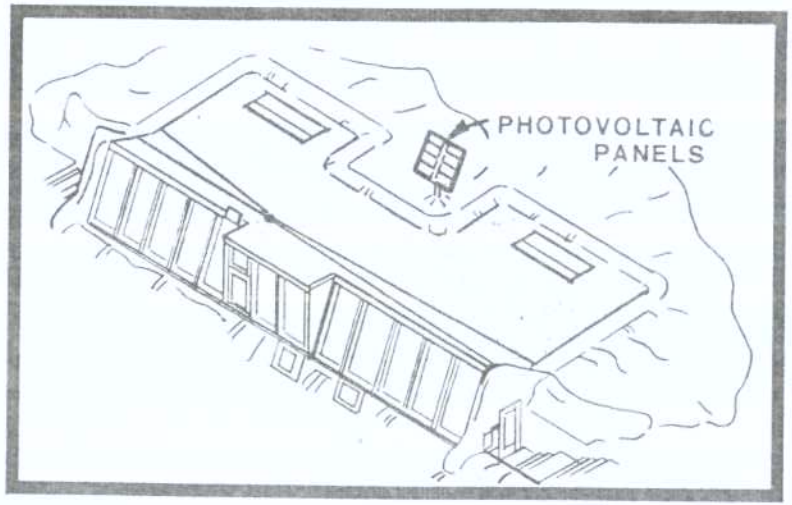
THE P.O.M.

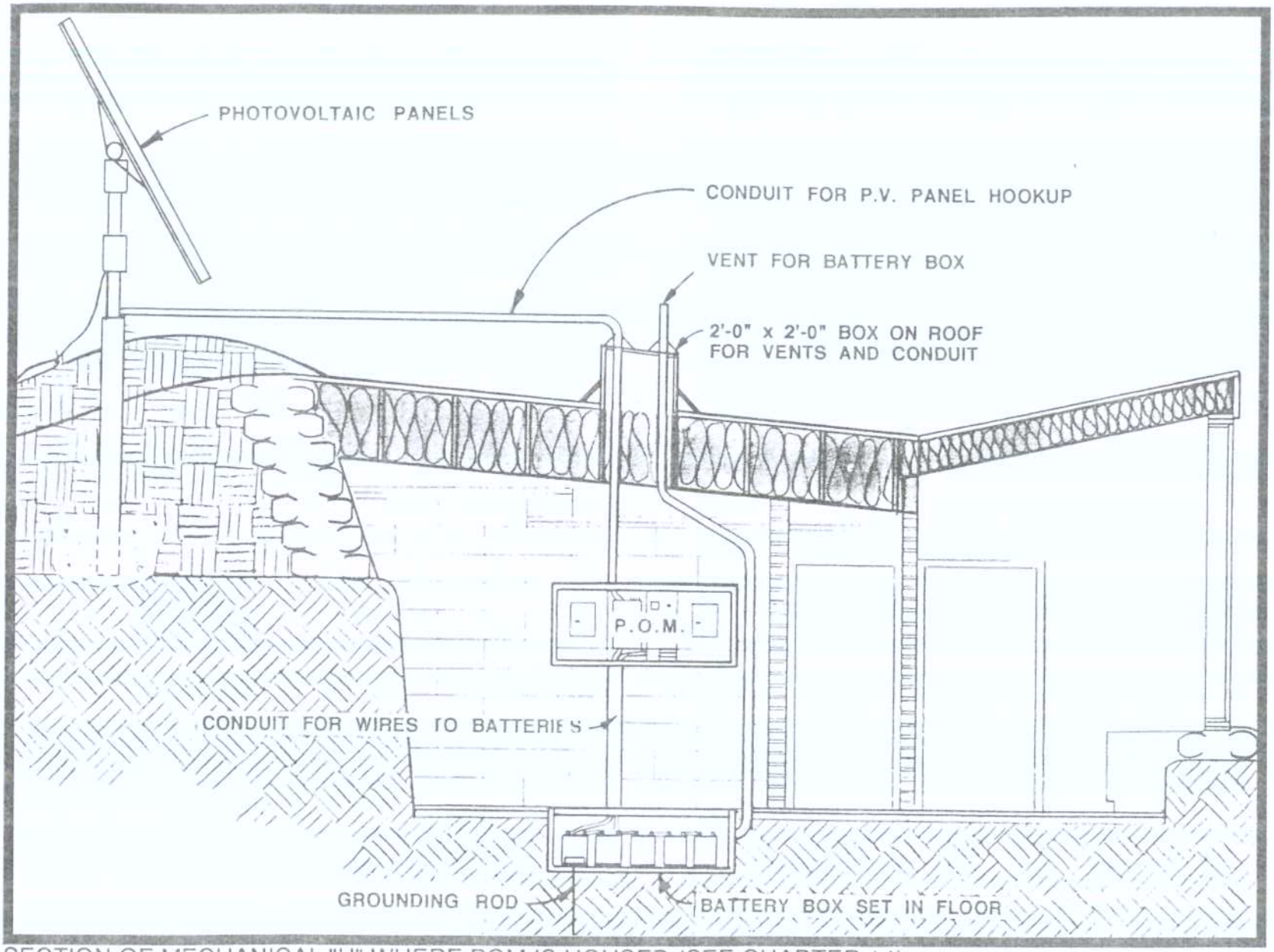

CONDUIT FOR WIRES FROM P.V. PANELS
P.O.M.
VENT
CONDUIT FOR WIRES FROM P.O.M. TO BATTERY BOX
SUNKEN BATTERY BOX
P.O.M.
BATTERY BOX

The basic P.O.M. was set up with eight 51 watt solar panels and ten 6 volt batteries. Two auxiliary panels could be added to that system for a total of ten panels. Two more panels could be added as a trickle charge independent of the P.O.M. disconnects and fuses. This basic unit has proven itself to provide ample power for a small household of 2 or 3 people. For slightly larger Earthships (2 bedroom, 4 people) we have now developed an oversized POM that will accommodate a larger load. This new unit will house a Trace 2500 inverter and have the capability to expand the system to 16 panels and 14 batteries. This new POM will allow the owner/builder to install the basic photovoltaic system (8 panels, 10 batteries) during construction. At a later date, if more power is required or if an additional "U" is added (or another family member is added) the system can be expanded *without any additional cost for modifications* other than the cost of panels and batteries. This expandable system will simplify wiring and reduce costs in larger Earthships. This is still a modular concept. The modules themselves are now capable of handling more power. A very large Earthship would still use a series of these simple power modules to avoid the costly, custom designed, hard to understand and maintain systems of the past.

The P.O.M.'s are developed and manufactured by Solar Survival Architecture and are up to the latest code and made with all UL approved components. The following page illustrates the complete hook up of this system. It is our objective to make the system easy enough for you or your builder to install the solar power and any typical electrician to wire the house absolutely conventionally. We still recommend keeping lights on D.C. power and outlets on A.C. power as described in Earthship Volume II. This wiring can be achieved within the realms of conventional code (see Earthship Volume II pp 22-23).



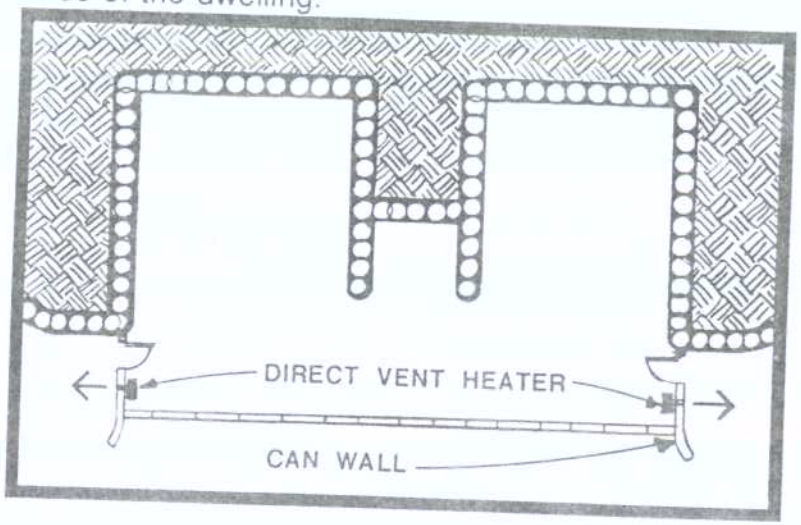




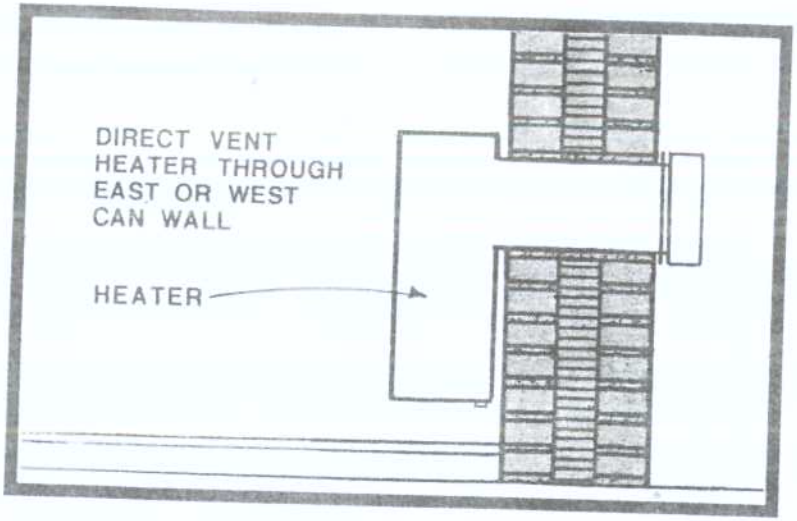
SECTION OF MECHANICAL "U" WHERE POM IS HOUSED (SEE CHAPTER 14).

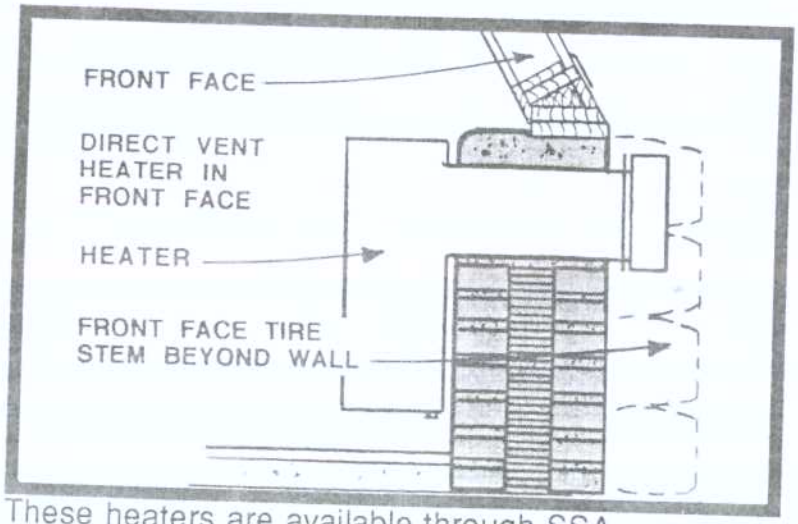
DIRECT VENT BACK UP HEATER

The ventless gas heaters discussed in Earthship Volume II, pp. 5 and 24 have proven very satisfactory in terms of a little back up heat during cloudy times in winter. Ventless heaters, however, are prohibited in some states and an alternative has become necessary. We have found a gas heater that vents through a wall up to 15" thick. Double aluminum can walls with 4" of rigid urethane in the middle are only 14" thick; they usually occur in the east and west ends of the dwelling.

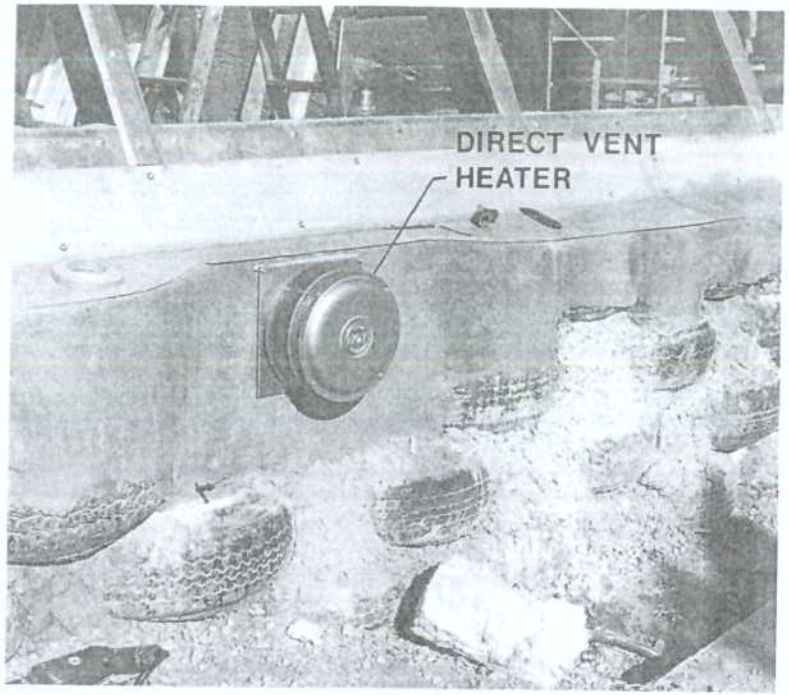


These are good places to install direct vent back up heaters. We have also used them under the front face windows.





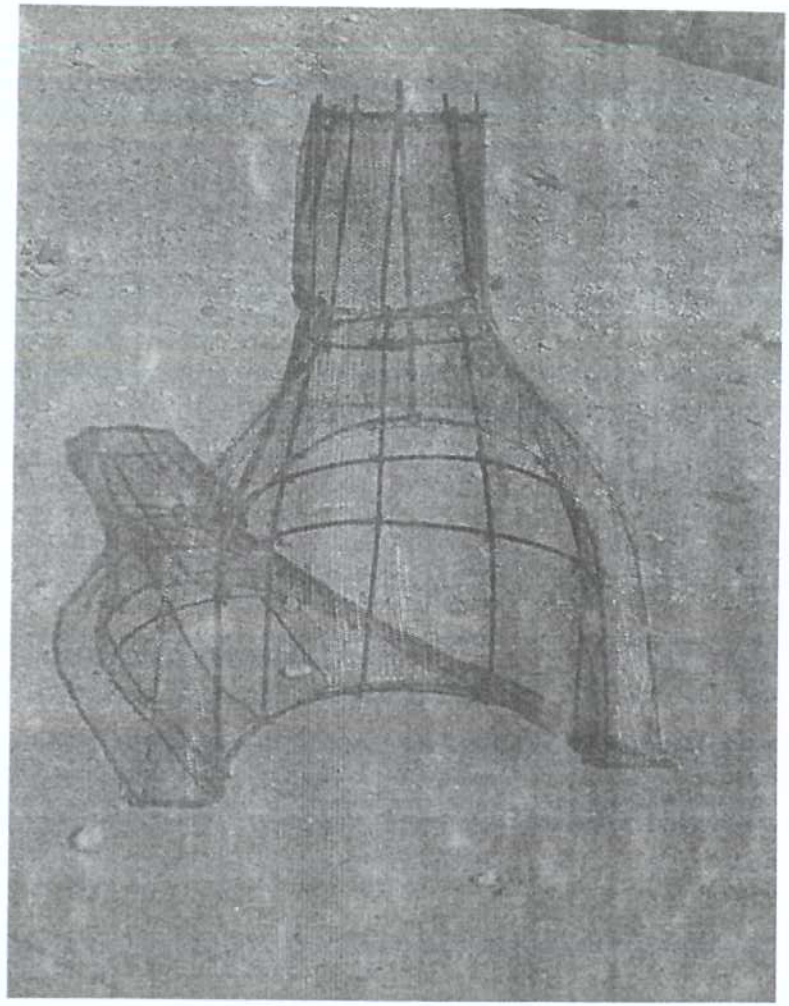
These heaters are available through SSA



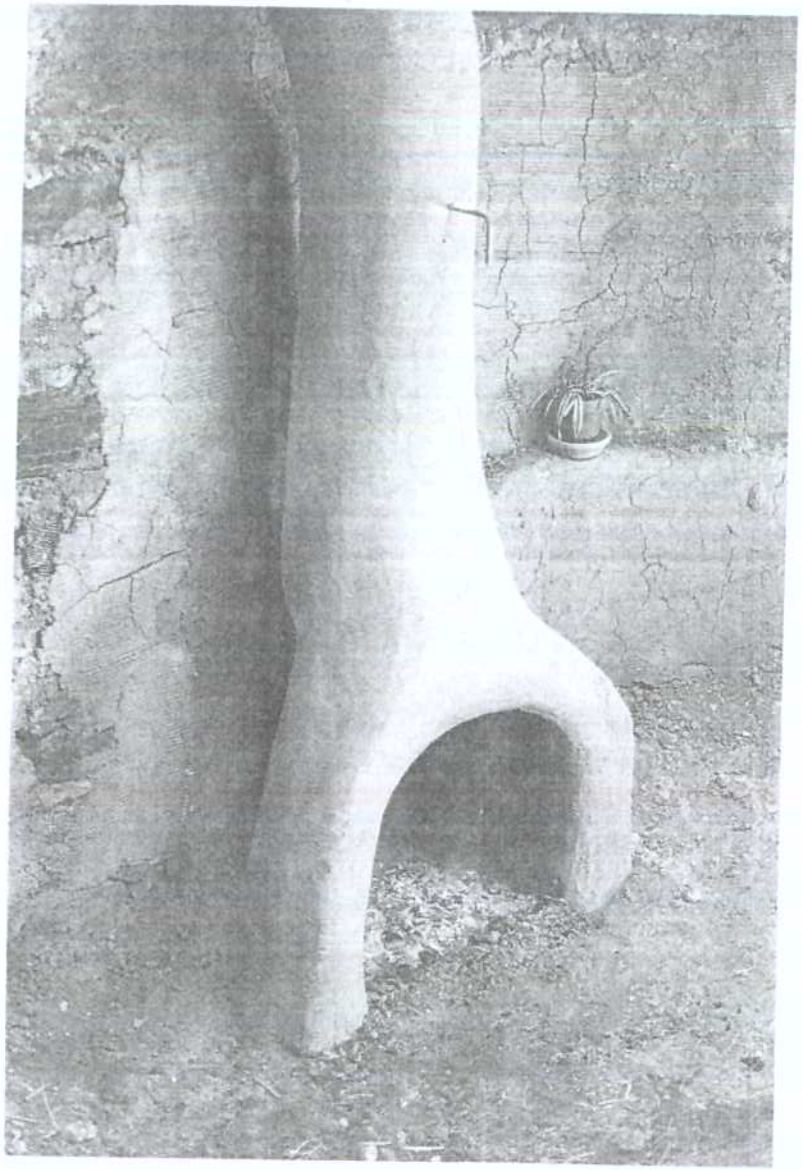
A direct vent heater through the front face tire wall shown above.

INSTANT "FIRED MUD" FIRE PLACE

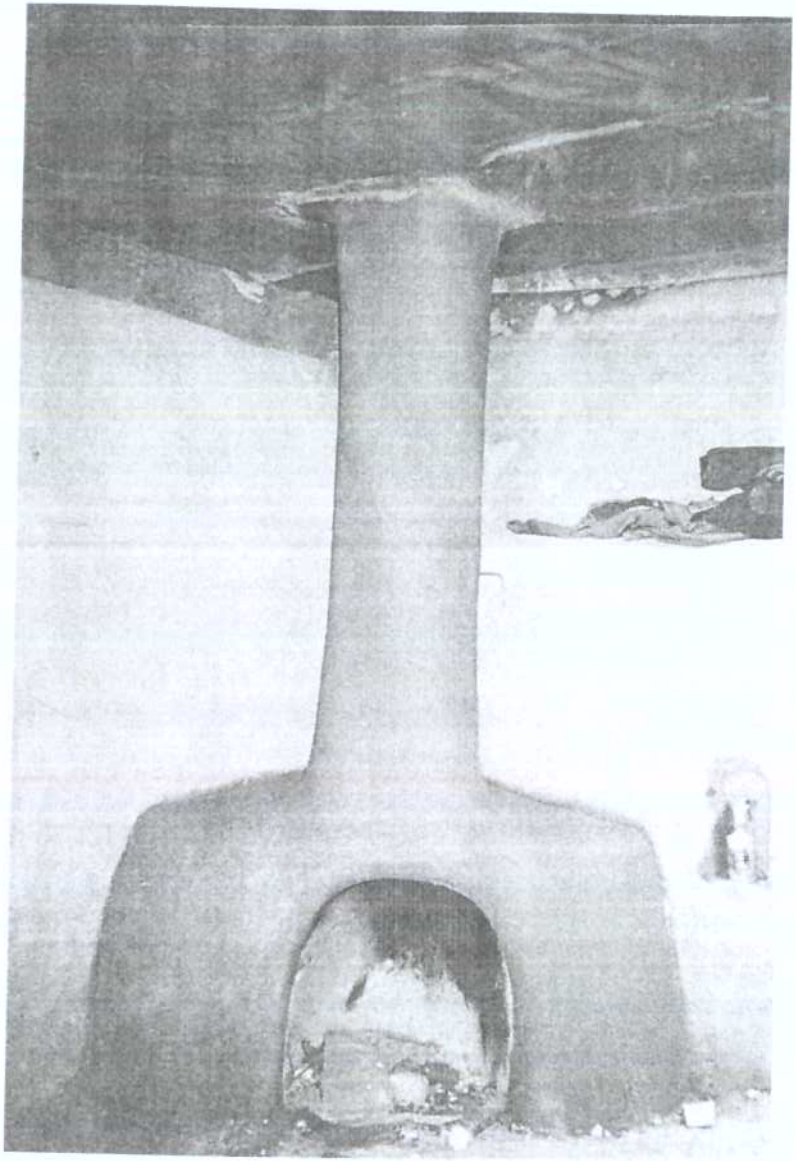
Now that Earthships are being built all over the country, the adobe fireplaces described in Earthship Volume II are proving to be difficult to build in places where adobes are not available. Shipping them is possible but expensive and time consuming because of the weight. We have therefore developed an instant *fired mud* fireplace. SSA provides a bird cage type skeleton in a kit. It is simply a bunch of 3/8" rebar bent to fit together in a code fireplace configuration.



This bird cage oven is held together with baling wire and covered with metal lath. The lath is also attached with baling wire. This cage is set where you want the fire place with a 28" x 28" skylight type box in the roof for the flue to go through. This roof box is like the one described in Earthship Volume II, p. 108.



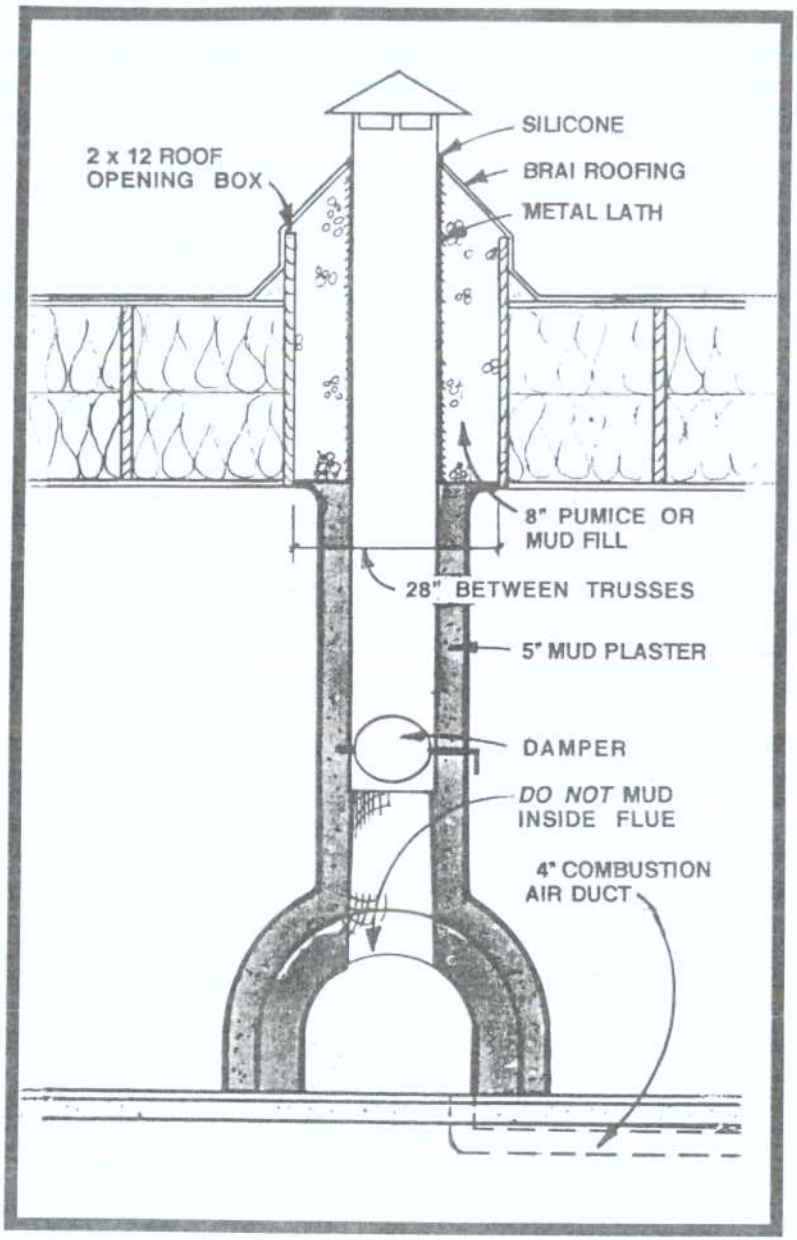
FIREPLACE WITH PRELIMINARY COATS OF MUD.

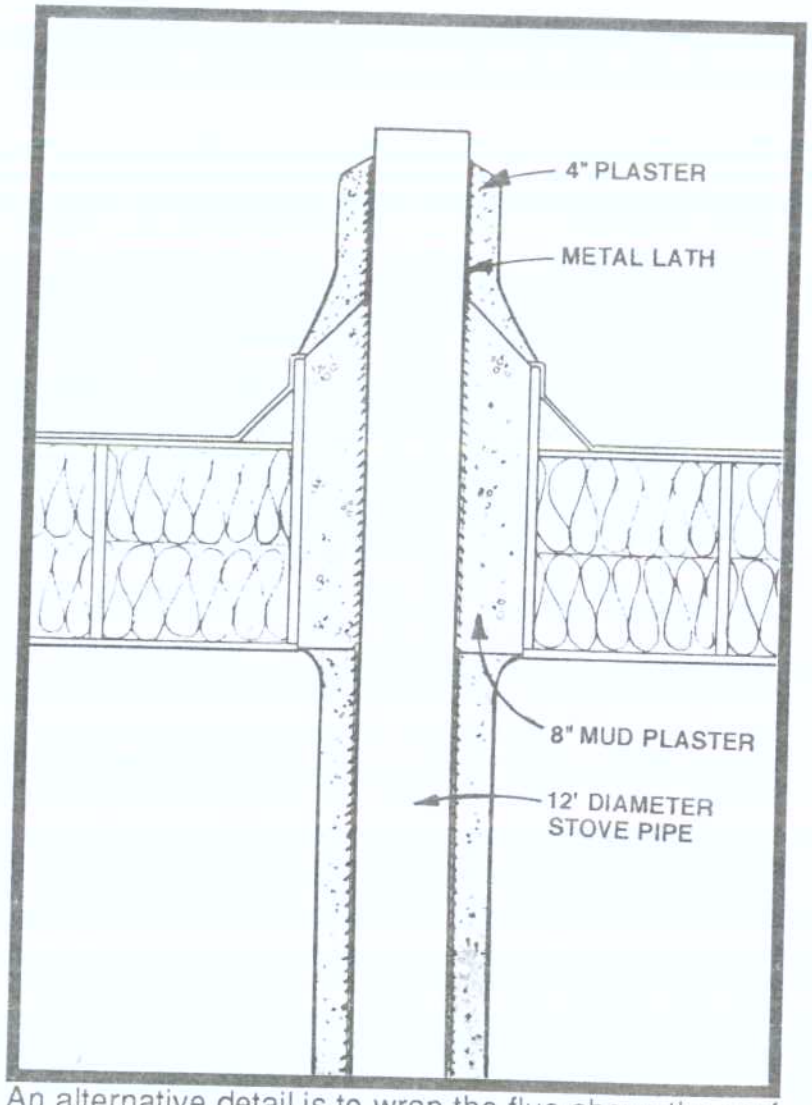


FIREPLACE WITH FINISH COAT OF MUD.

12" diameter galvanized stove or furnace pipe is then placed over the top neck of the cage. The neck is designed for this purpose. The stove pipe is run all the way through the roof and wrapped with metal lath. The lath around the furnace pipe is held on with baling wire. The damper is installed as per Earthship Volume II, pp. 115-117. Now you simply plaster this unit with the same mud from your site that you are using on the walls. You plaster both oven and stack and scratch the finish with a scratcher. Then you build a fire! The fire dries and "fires" the mud. This process is repeated over and over again until you have 5" thick of mud on the stack and 8" of mud on the oven. Then you apply a finish coat of mud as per Earthship Volume II p. 178. Do not fire this coat, let it dry like your walls. A 4" combustion air duct must be added as in Earthship Volume II, page 120.

Your plaster job goes up to the ceiling. You should temporarily fill the gap around the roof box with fiberglass insulation for protection during the firing process. After a 5" thickness of fired mud is achieved to the ceiling, remove the fiberglass insulation and fill the void with pumice-concrete mix, mud or concrete. You must have 8" of masonry around the metal flue for code acceptance. This requires a wider (28") truss placement where fireplaces occur. The pumice or mud fill goes to the top of the 2x12 roof opening box and then slopes up to the 12" metal flue. Brai roofing can now be applied up and over the box and up the slope of the pumice or mud fill. Stop the Brai about 1" from the flue and caulk the gap with silicone.





An alternative detail is to wrap the flue above the roof with lath and plaster with several coats achieving a 5" thickness. This results in an adobe type chimney.

EQUIPMENT IN THIS CHAPTER - AVAILABLE FROM SOLAR SURVIVAL SALES

Power Organizer Module (POM)		$1980. plus freight
Roof drain		$135. plus freight
Water fall pump		$165. plus freight
Water Organizer Module (WOM)		$1000. plus freight
w/ water fall pump		$1200. plus freight
Direct vent heater	small	$395. plus freight
	large	$504. plus freight

Brai or Firestone roofing
check with local roofing dealer.

Acrylic roof coating	$33./ gal plus freight
60 watt panel for water fall	$335. plus freight
Fire Place Kit	$175. plus freight
Pump, hose bib from jungle tank	$165. plus freight

EPDM tank liner - check your local roofing dealer

Prices subject to change after the printing of this book.

THE BENNSTROM EARTHSHIP AT R.E.A.C.H. TAOS, NEW MEXICO

LAW AS IT RELATES TO TIME
WHEN MURDER BECOMES LEGAL

*MURDER IS ILLEGAL - **WITHIN A CERTAIN TIME FRAME.** IF SOMEONE PUTS A GUN TO YOUR HEAD AND PULLS THE TRIGGER, YOU ARE DEAD INSTANTLY. THAT IS ILLEGAL. IF SOMEONE POISONS YOU WITH A FAST ACTING POISON AND YOU DIE INSTANTLY, THAT IS MURDER. IF SOMEONE POISONS YOU WITH A SLOW ACTING POISON AND YOU DIE WITHIN A WEEK, THAT IS STILL MURDER. IF SOMEONE POISONS YOU WITH A POISON THAT ACTS VERY SLOWLY AND YOU DIE IN ONE MONTH, THAT IS STILL MURDER. THERE HAVE BEEN CASES OF SOMEONE POISONING THEIR SPOUSE WITH LEAD OVER A PERIOD OF A YEAR OR MORE. THESE PEOPLE WERE ALSO CONVICTED OF MURDER. WHAT ABOUT POISON OVER FIVE YEARS? IS THAT MURDER? WHAT ABOUT POISON OVER TEN YEARS? IS THAT MURDER? WHAT ABOUT TWENTY YEARS? WE ARE ALL PARTICIPATING IN A TOXIC LIFE STYLE THAT IS BASICALLY KILLING OTHER (FUTURE) HUMANS OVER A PERIOD OF **TIME**. STRANGELY ENOUGH, AT SOME POINT IN OUR WORLD, **TIME ALLOWS MURDER**. IF YOU CONSCIOUSLY PARTICIPATED IN ONE OF THE ABOVE (SHORT TIME FRAME) MURDERS, YOU WOULD BE CONVICTED AS A PARTICIPANT IN MURDER. YET WE ARE ALL PARTICIPATING IN LONG TIME FRAME MURDERS EVERY DAY. WE ALL USE, BURN, PURCHASE AND DISCARD TOXIC MATERIALS, SYSTEMS AND PRODUCTS. TIME SIMPLY PROVIDES A DISTANCE SO.....*

WE DON'T HAVE TO SEE THE VICTIMS FALL.