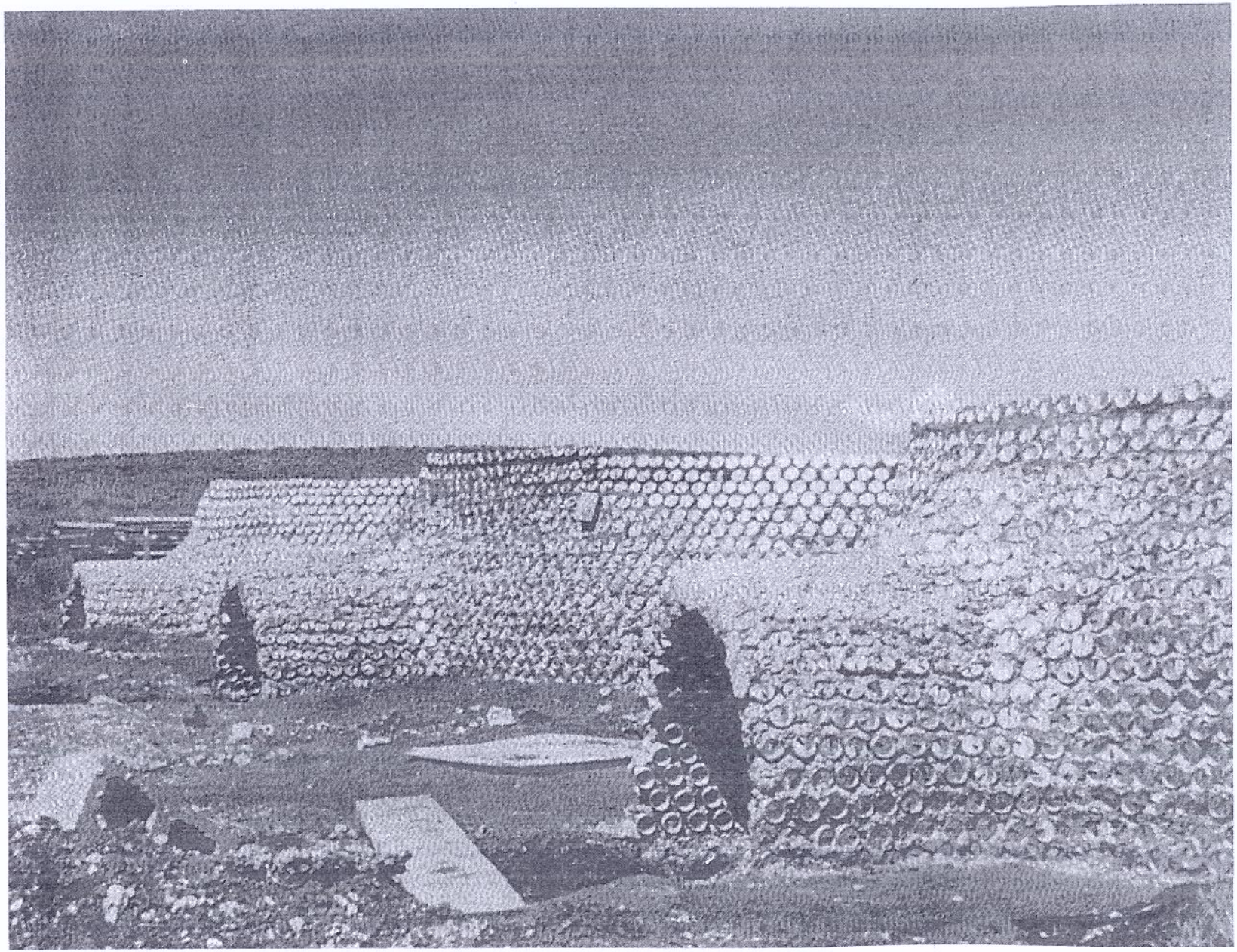


11. CAN DOMES AND VAULTS

C O M P O N E N T S

THE IDEA OF BUILDING WITH RECYCLED MATERIALS STARTED IN 1970 WITH BUILDINGS MADE OF STEEL CANS. THIS WAS BEFORE ALUMINUM CANS WERE MADE. MANY CAN BUILDINGS WERE BUILT USING VARIOUS TECHNIQUES. AT FIRST THE CANS WERE USED AS INFILL PANEL WALLS IN A POST AND BEAM STRUCTURE. SOON WE REALIZED THAT THE CAN WALLS THEMSELVES COULD BE USED AS BEARING WALLS AND THIS LED TO THE CONTRUCTION OF DOMES, VAULTS, ARCHES ETC. ALL THE CAN BUILDINGS BUILT WERE SUCCESSFUL STRUCTURES, HOWEVER, IN THE MID SEVENTIES WE BEGAN LOOKING FOR WAYS TO BUILD THERMAL MASS INTO BUILDINGS FOR THE PURPOSE OF STABILIZING TEMPERATURES. BECAUSE WE WERE ALREADY BUILDING WITH CANS, WE FOUND OURSELVES IN THE FRAME OF MIND TO SEE THE POSSIBILITY OF USING TIRES FOR BUILDING. ONCE WE TRIED TIRES RAMMED WITH EARTH FOR STRUCTURE AND THERMAL MASS WE SAW THAT WE HAD A METHOD THAT COULD NOT BE MATCHED BY CANS OR ANY CONVENTIONAL MATERIAL IN TERMS OF THE AMOUNT OF THERMAL MASS THAT COULD BE OBTAINED BY THE STRUCTURE ITSELF. THIS PUT AN END TO BUILDINGS MADE TOTALLY OF CANS. HOWEVER, FOR MINOR WALLS LIKE CLOSETS, BATHROOMS, OR ANY INFILL AREAS, THE CAN TECHNIQUES WE HAD EVOLVED OVER THE YEARS PROVED TO BE IDEAL. WE ARE, THEREFORE, PRESENTING THE METHODS USED FOR CAN CONSTRUCTION IN THIS CHAPTER IN MORE DEPTH THAN THE CAN LAYING DISCUSSED IN EARTHSHIP VOLUME I. AS CANS CONTINUE TO BE AN IMPORTANT FACTOR IN EARTHSHIP CONSTRUCTION. THE DOMES, VAULTS AND ARCHES CAN BE USED AS SPECIAL SPACES IN MORE ELABORATE EARTHSHIP DESIGNS. THEY CAN ALSO BE USED TO CREATE A LABYRINTH OF SPACES ABOVE GROUND IN A TEMPERATE CLIMATE AND BELOW GROUND LEVEL IN AN EXTREMELY HOT OR COLD CLIMATE. CANS ARE VERY VERSATILE AND ARE AN EASY WAY TO DO ALMOST ANYTHING IN AN EARTHSHIP THAT ISN'T ALREADY DONE WITH TIRES. THE INFORMATION PRESENTED IN THIS CHAPTER WILL OFFER YOU A *PALLET* OF TECHNIQUES TO SUPPLEMENT THE BASIC TIRE STRUCTURE OF YOUR EARTHSHIP.

CAN PANEL WALLS

This building technique is structured with a typical post and beam network of concrete, steel or wood as shown in the diagram opposite. Post and beam is a standard structural system and can be designed for any size or height of building. In this case it is simply infilled with insulated panels made of aluminum cans. Almost any type of container (steel or aluminum cans and/or bottles) can be used for the infill panel. The cement to sand ratio is 1to4 as the can wall panels are not structural.. Regular portland cement should be used, not masonry cement and concrete sand should be used, not plaster sand. Refer to page 158 of Earthship Volume I for can laying techniques.

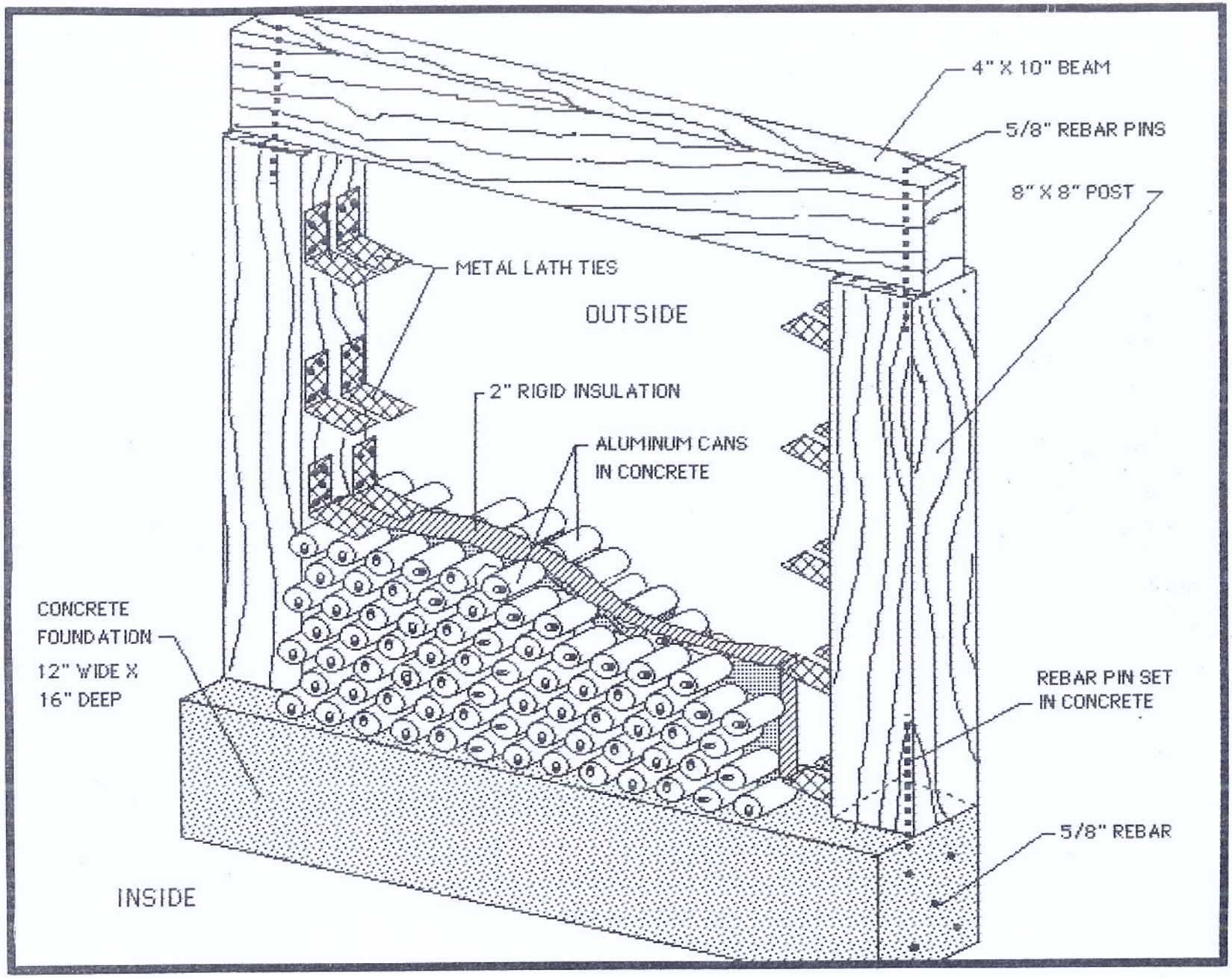
Four inch thick rigid foam panels* provide the necessary insulative qualities for the wall (R-30). The air spaces in the containers either side of the foam panel make the insulative qualities of the overall wall a little better. The foam panel is installed between the columns first. It should be tacked or propped up in a vertical plumb position. The masonry work on either side is laid up against it. The inside and outside masonry should be tied together with small strips of metal lath going through the foam. The masonry work must be allowed to set up briefly after about 2-3 feet in height.

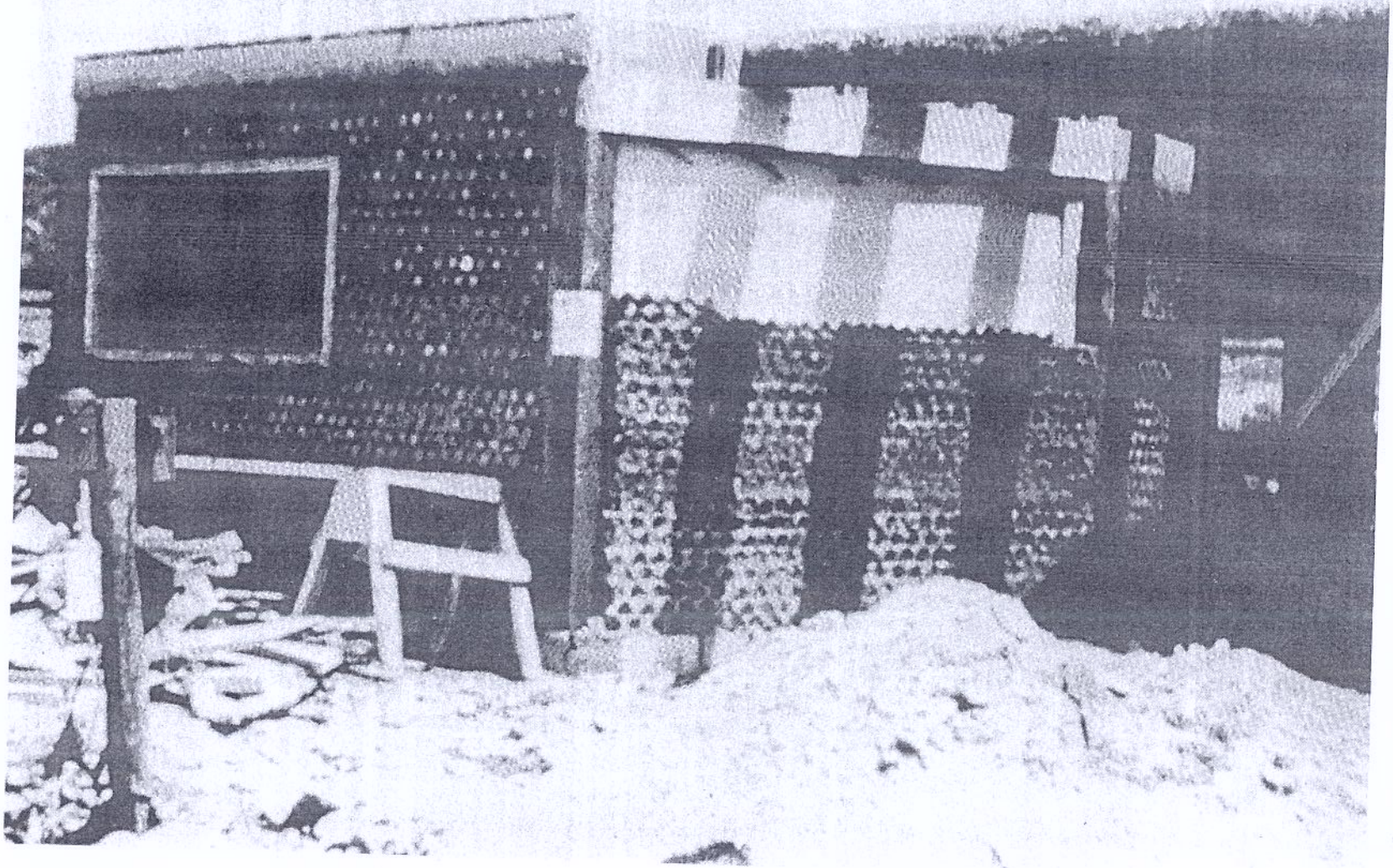
*1 see Appendix, Chapter 11

This will avoid bulging of the panels. Recommended maximum panel size is 10'-0" high by 14'-0" long. Any larger size could get expansion cracks.

The outside course of the panels can be designed to bypass the columns or to butt them squarely leaving the column exposed.

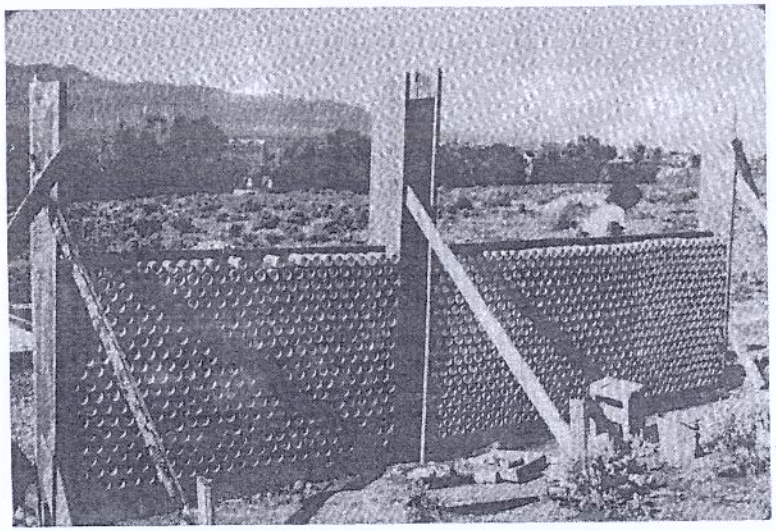
If the building is to be plastered, the panel should be made of cans with the mouth holes out to receive the plaster. No stucco netting or other preparation is necessary to plaster over cans, however, any exposed wood or other materials should be treated properly (wrapped in plastic and covered with metal lath) before plastering. The panels do not have to be plastered. We have developed a technique we call "grooming". We rub cement into the joints between the cans after the initial masonry work is laid and set up. We then rub the cement off of the cans or bottles and polish them with a cloth. The cement can also be sprayed off the cans or bottles with a fine mist from a hose this leaves exposed cans in a matrix of cement and can look very interesting if executed well. This technique also opens up the possibilities of bottle mosaic work with the can work, etc.

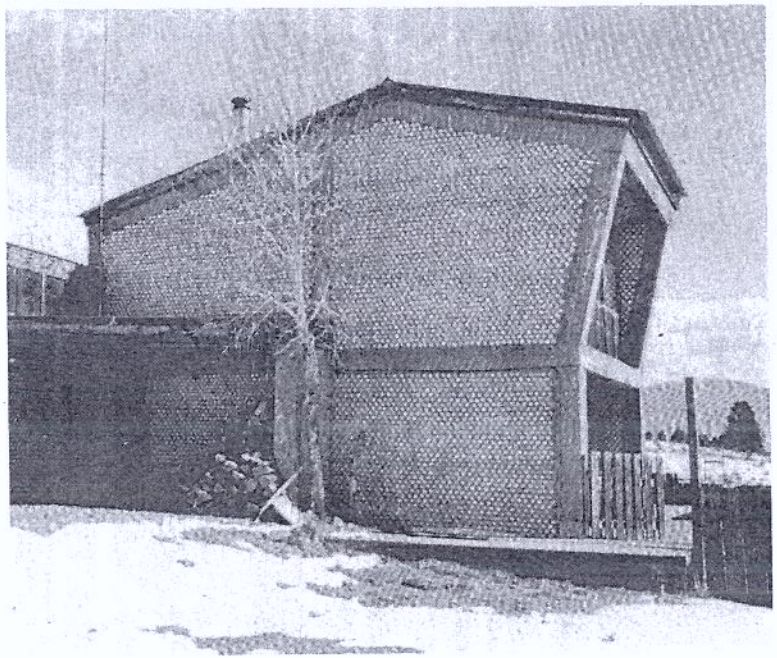

4" X 10" BEAM
5/8" REBAR PINS
8" X 8" POST
METAL LATH TIES
OUTSIDE
2" RIGID INSULATION
ALUMINUM CANS
IN CONCRETE
CONCRETE
FOUNDATION
12" WIDE X
16" DEEP
REBAR PIN SET
IN CONCRETE
5/8" REBAR
INSIDE

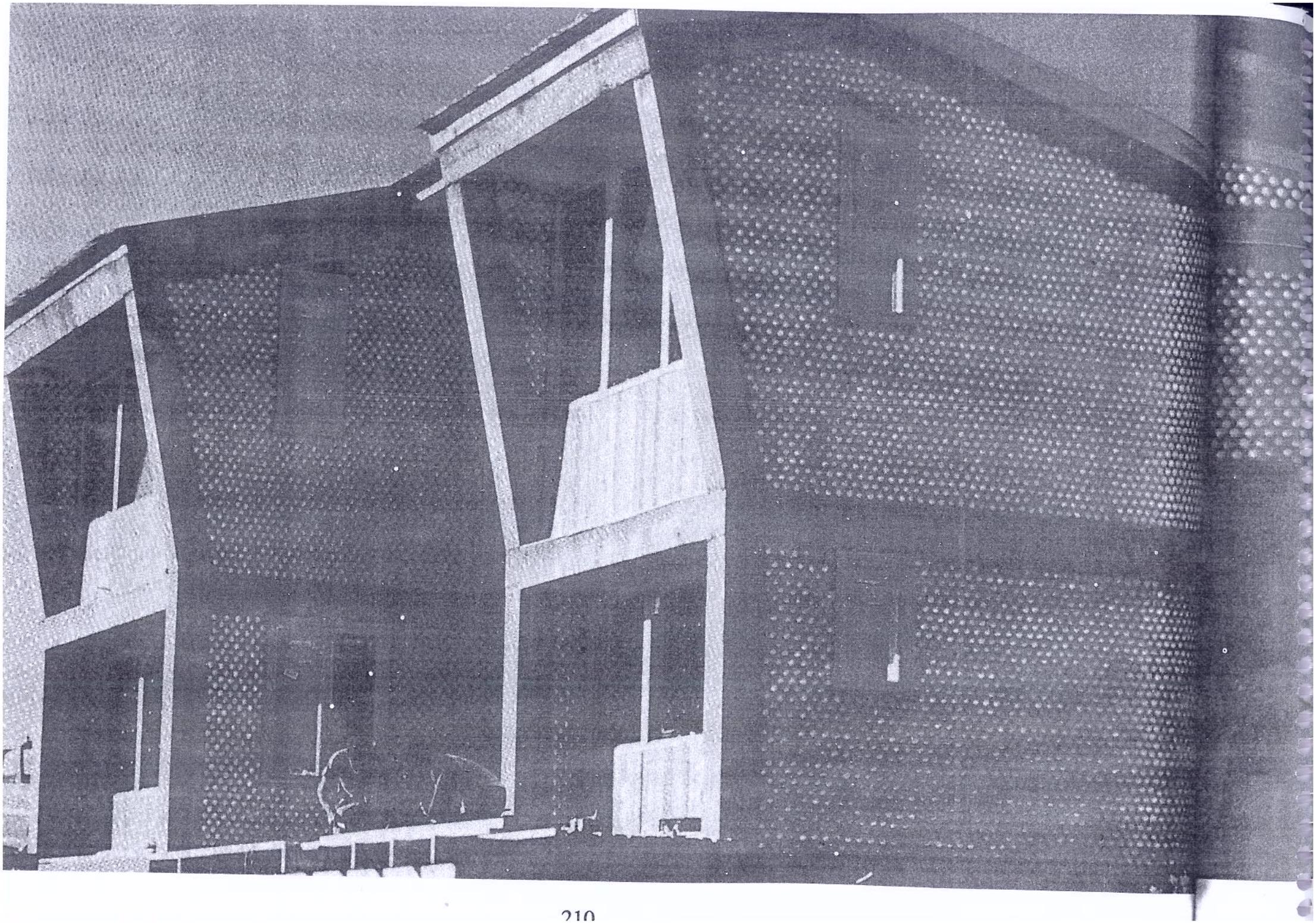


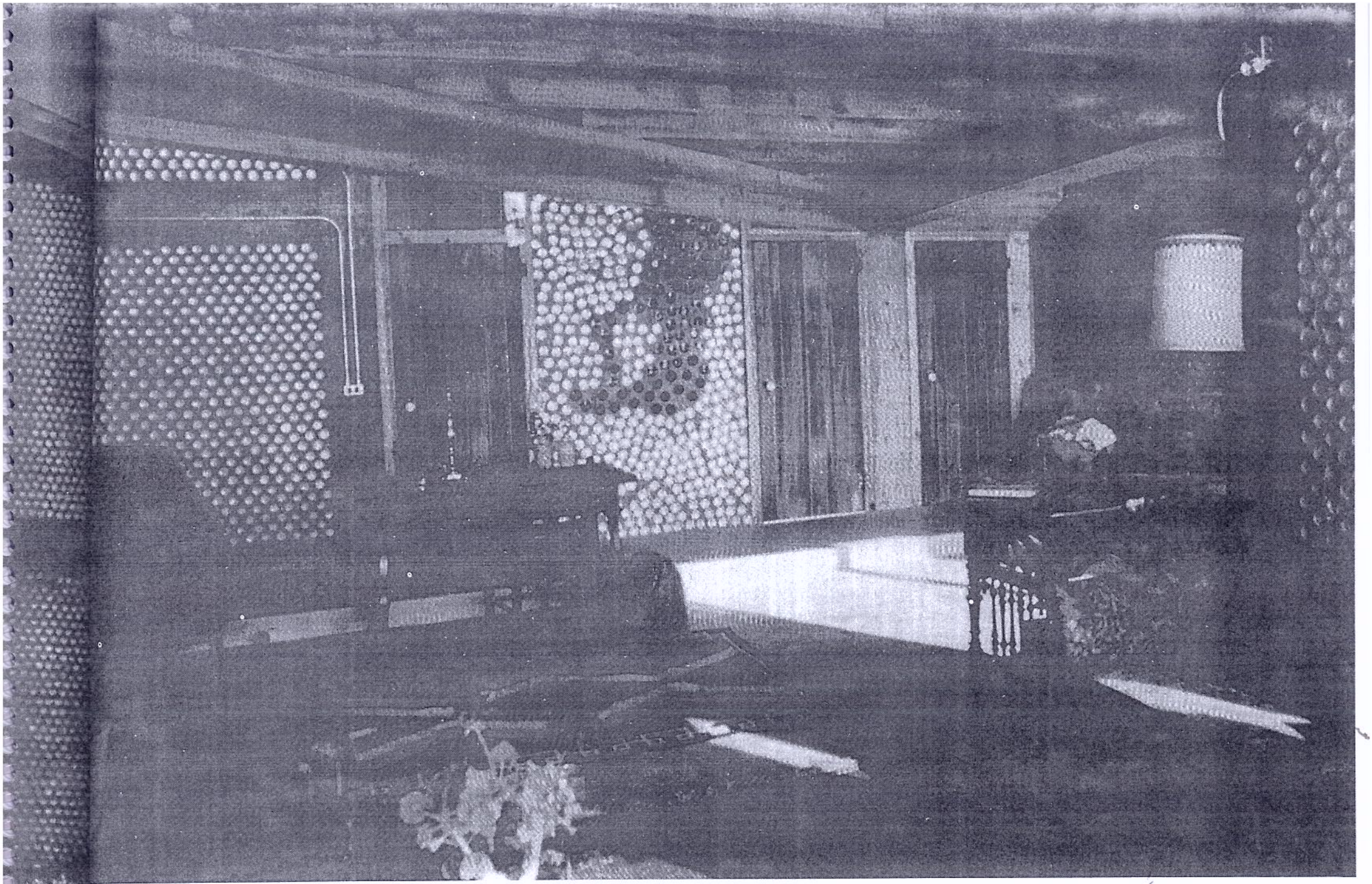
If the panels are not to be plastered, the joints between the columns and the panels as well as between the beams and panels should be made weather proof. An architect or builder should be consulted here as this initial detail can be handled in many ways. It depends on the material being used for the post and beam network.

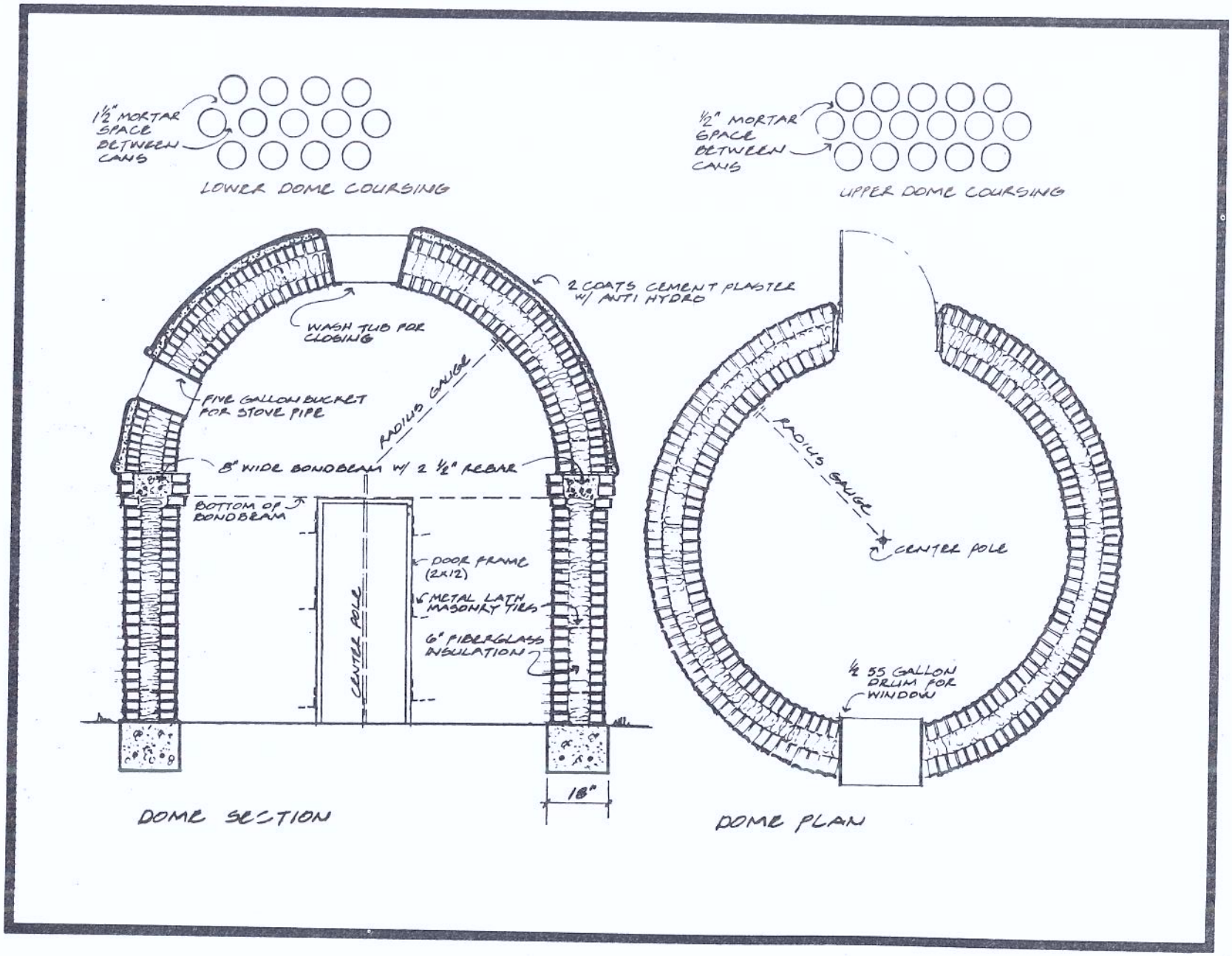
Mortar techniques vary with the panel material used. In any case, the mortar should be firm not loose. When pressing a can into the mortar the cylindrical can should be crimped to create a sharp edge. This allows the can to be layed with less pressure. Mortar should remain recessed from the outside face of the cans. If it oozes out you are probably using too much or else the mortar is too wet. The cans or bottles should never touch each other. The panels can be groomed, plastered, painted, or left rough. Cans should be laid a minimum of 3/4" apart. This system has passed building codes and been approved for bank financing everywhere it has been used.










1½" MORTAR SPACE BETWEEN CANS
LOWER DOME COURSING
½" MORTAR SPACE BETWEEN CANS
UPPER DOME COURSING
2 COATS CEMENT PLASTER W/ ANTI HYDRO
WASH TUB FOR CLOSING
FIVE GALLON BUCKET FOR STOVE PIPE
RADIUS GAUGE
8" WIDE BONDBEAM W/ 2 ½" REBAR
BOTTOM OF BONDBEAM
DOOR FRAME (2x12)
METAL LATH MASONRY TIES
6" FIBERGLASS INSULATION
CENTER POLE
18"
DOME SECTION
RADIUS GAUGE
CENTER POLE
½ 55 GALLON DRUM FOR WINDOW
DOME PLAN

ALUMINUM CAN DOMES

Aluminum can domes have been built using a similar can laying technique to that used in the panel wall system. The drawing opposite illustrates the most popular dome which is actually a hemisphere on top of a cylinder. Can masonry is not limited to the hemisphere. Ellipse domes, vaults, and structural arches of all types have been successfully built. An entire home can be built using a series of domes connected by vaulted hallways.

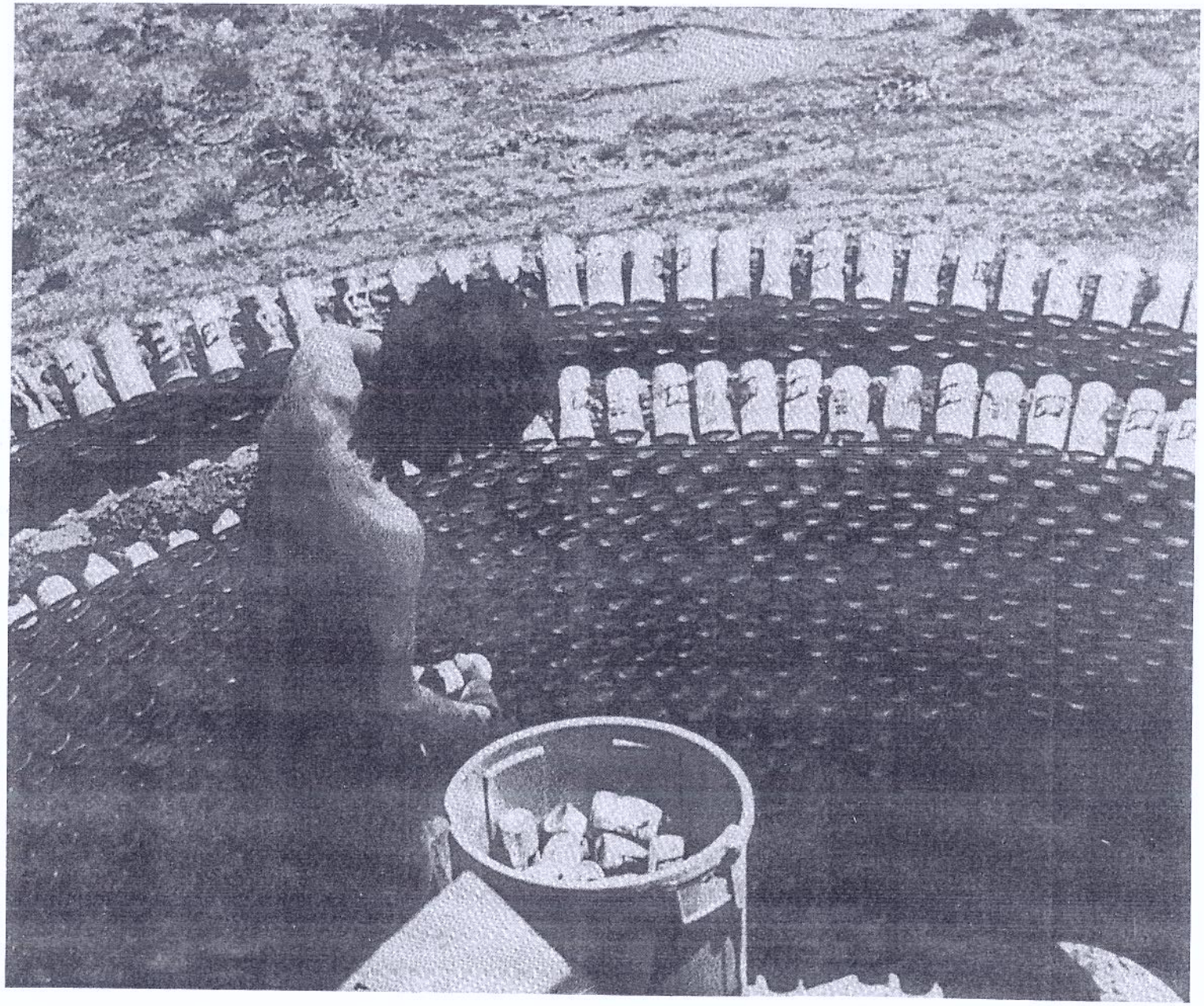
THE DOUBLE DOME

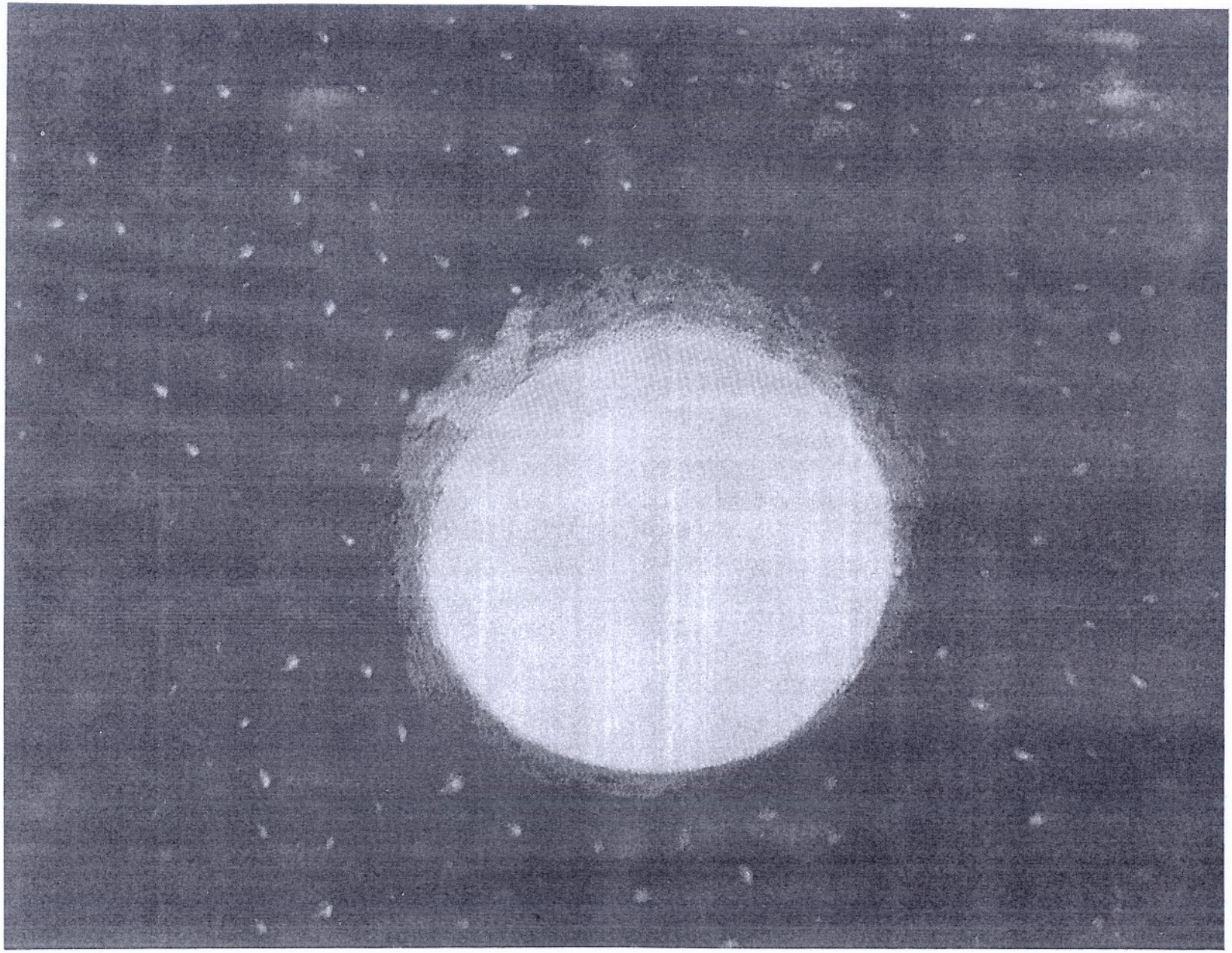
The foundation depends on location. It should go down to the frost line as in conventional construction. However, If the dome is buried for insulative reasons the foundations would already be well below the surface and need only be 12" deep with two half inch rebars continuous. The can work is then laid on top of the foundation. This can work is structural so use a mortar mix of 1 cement to 3 sand with engineering fibers*. The amount of water added is very important. Too much water and the mortar is loose. The wall will fall apart as it is being built. Too little water and the mortar is too dry. The cans will have to be forced into it. Find the right consistency to hold the wall together yet still allow the cans to push easily into the cement. (Refer to page 158 of Earthship Volume I).

*2 see Appendix, Chapter 11

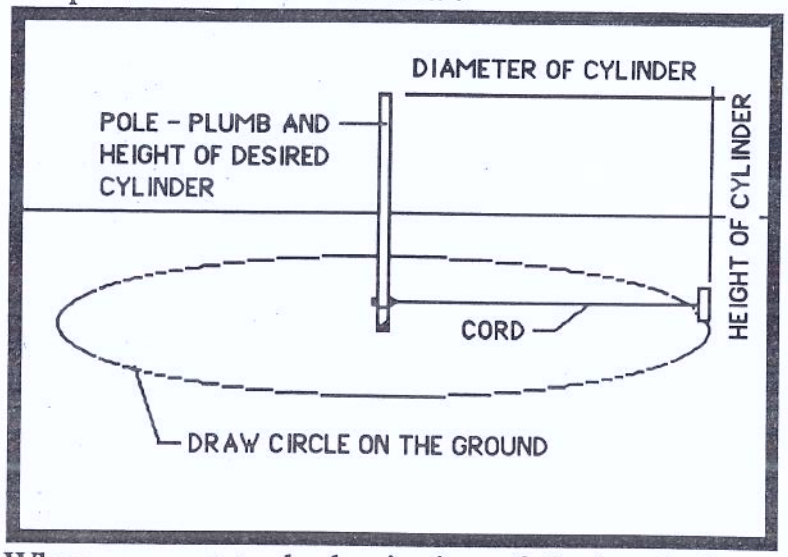
The spaces between cans in a dome vary. The lower courses of the dome want to have more cement for more strength and mass while the upper courses should have less cement for lighter weight. Therefore, the spaces between the cans on the lower courses should be a minimum of 1-1/2" while in the upper courses a minimum of 1/2" should be used.

The coursing can only be laid up 2 or 3 feet in height at a time. The mortar must be allowed to set up before going any further. As the dome begins to curve in and the joints get smaller (1-1/2" decrease to 1/2") the slope of the cans will only allow 2 or 3 courses at a time. Near the end, the cans are almost vertical and only one course can be applied at a time. Finally at the very end only a few cans at a time can be laid. No forms are needed because the aluminum cans are so light that the stickiness of the mortar will hold them up even in a vertical position. Near the end you may want to add a shovel full of masonry cement to the regular mixture to make it even stickier and which will help hold the cans in the vertical position.

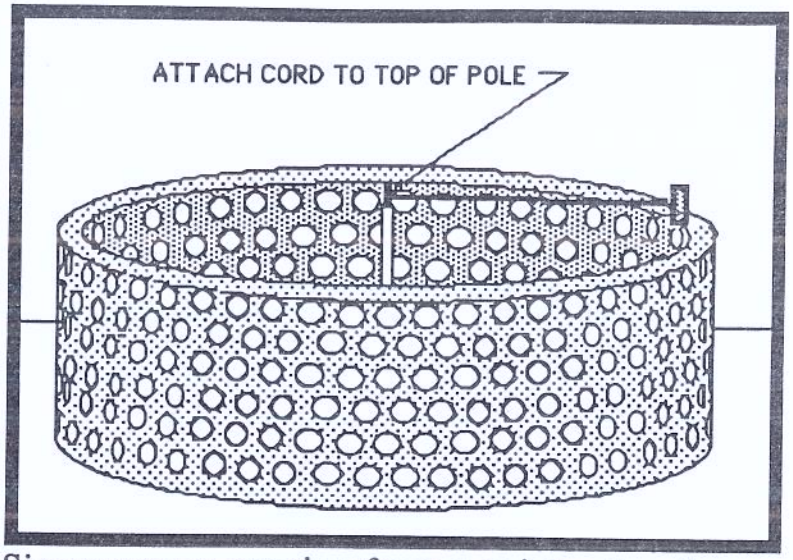




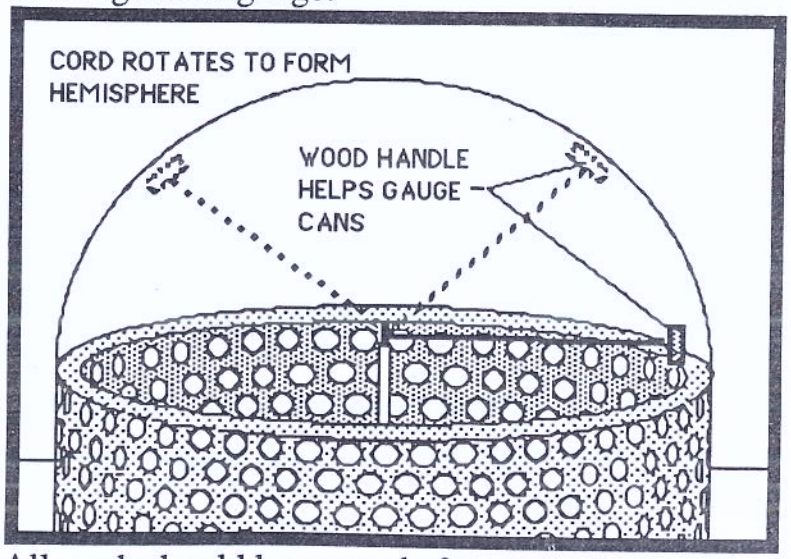
Since the dome is just a circle on the ground, it can be laid out simply by driving a stake in the ground with a nail in the top of it and striking a radius with a string or heavy cord for the desired diameter. We suggest you try a small diameter of 8-10 feet first. We do not recommend domes of over 20'-0" in diameter. The dome illustrated is a simple hemisphere and the layout radius for the cylinder part can be used as a gauge for the dome itself. The radius cord should be attached to a perfectly plumb pole or pipe which is the desired height of the cylinder. The cylinder is gauged by rotating the cord around the pole, raising it as you go up. Keep it level to the horizontal.



When you get to the beginning of the hemisphere you attach the cord to the top of the pole and keep using it in the same way.



Since you are rotating from a point rather than a pole now your string will form a hemisphere. A little wood handle on the end of the cord is helpful in using it as a gauge.



All work should be gauged after every course.

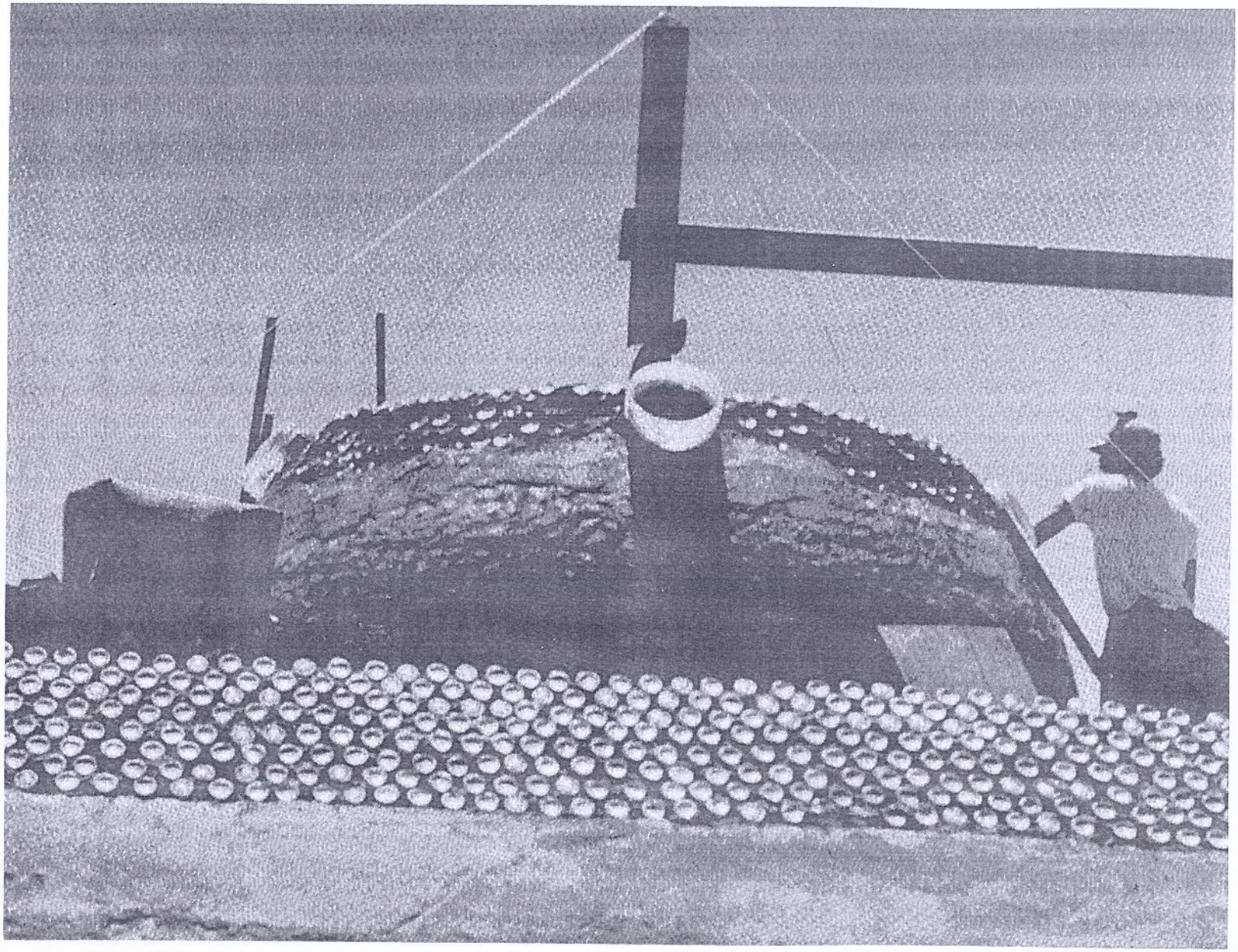
Entrances for this structure can be made with standard wood frames (see Earthship Volume I, pages 157 &166) and formed into the wall as it goes up using metal lath masonry ties to anchor the wood frame to the can work. This is similar to the masonry ties tying the columns and beams to can work on the panel wall diagram.

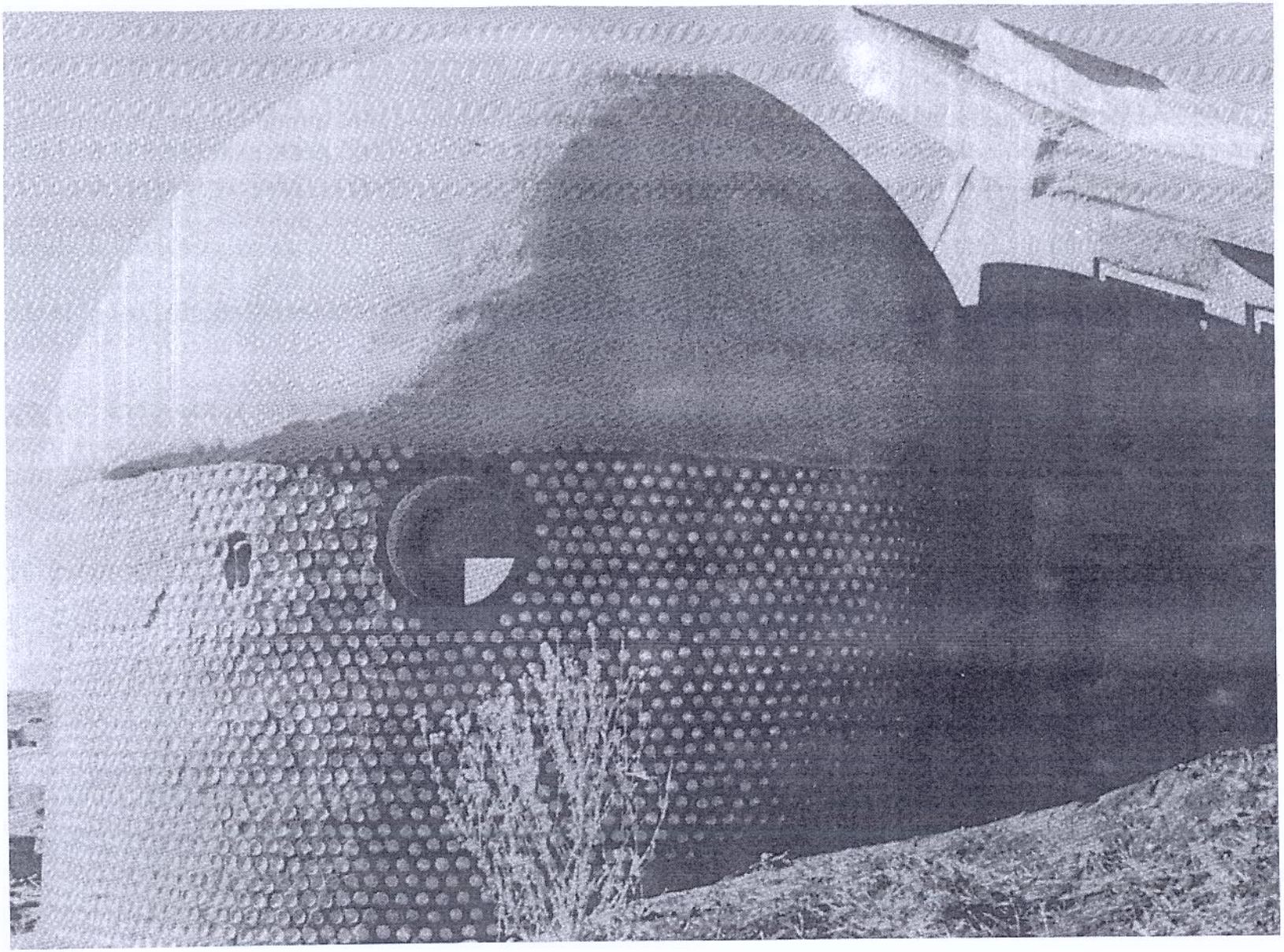
Notice that the cylinder in the section is a double can wall with 6" batt insulation stuffed in the middle. This double wall accommodates the necessary insulation and tension bond beam at the transition point between the cylinder and the hemisphere. It is formed by widening the wall at the top, placing two 1/2" rebar continuous, overlapping 18" at ends and then filling with a concrete mix of 3 parts cement, 4 parts sand, and 5 parts gravel. After construction of the bond beam, the double hemisphere is laid up using the radius gauge as a guide. On double domes, both walls go up simultaneously.

Fifty gallon barrels cut in half or five gallon buckets are laid into the walls just like large cans and used for porthole windows. Do not put them close together. All openings should be kept at least 3'-0" apart. Handmade wooden porthole windows can be attached to the inside of the barrel or bucket. The double dome is closed using a washtub with the bottom cut out or custom made facsimile. This makes a skylight by simply caulking in a triple pane piece of insulated safety glass before plastering the roof.

The entire dome is plastered with two coats of conventional masonry plaster mix which is usually 1 cement to 3 plaster sand. The plaster mix is applied directly over the can work and should have a waterproof additive such as Anti-hydro put into the mix.

Masonry can domes are serious structures. They require only one skill for walls and roof, but that skill must be **competently** executed. No two cans should ever touch each other in a can dome. The cement between the cans is the real compressive strength of the structure. Consequently, it must be mixed accurately and thoroughly. The aluminum cans simply allow one to lay up a lightweight cement dome without forms. If properly executed, an aluminum can dome can be buried with 2-3 feet of earth. Again, we urge you to experiment with something under 10 feet in diameter before attempting a larger dome.





THE SINGLE BURIED DOME

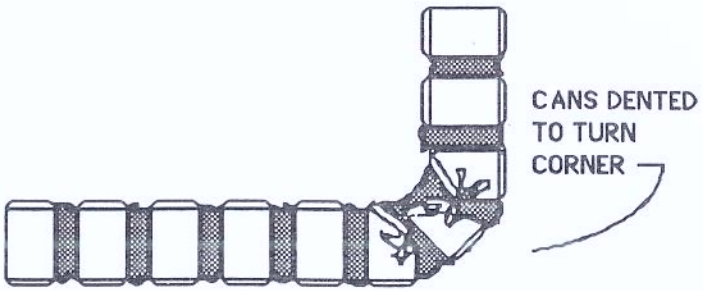
This dome requires less can work but the excavation expense brings it back up to nearly the same effort as the double dome. It is, however, a unique and simple thermal mass structure. The buried dome is laid by driving a stake in the ground at the desired center of the dome. Put a nail in the top of the stake and tie a cord to it. Make the cord the length of the radius of the plan circle. Tie a little wood handle on the end of the cord and this will make a radius gauge for the entire dome.

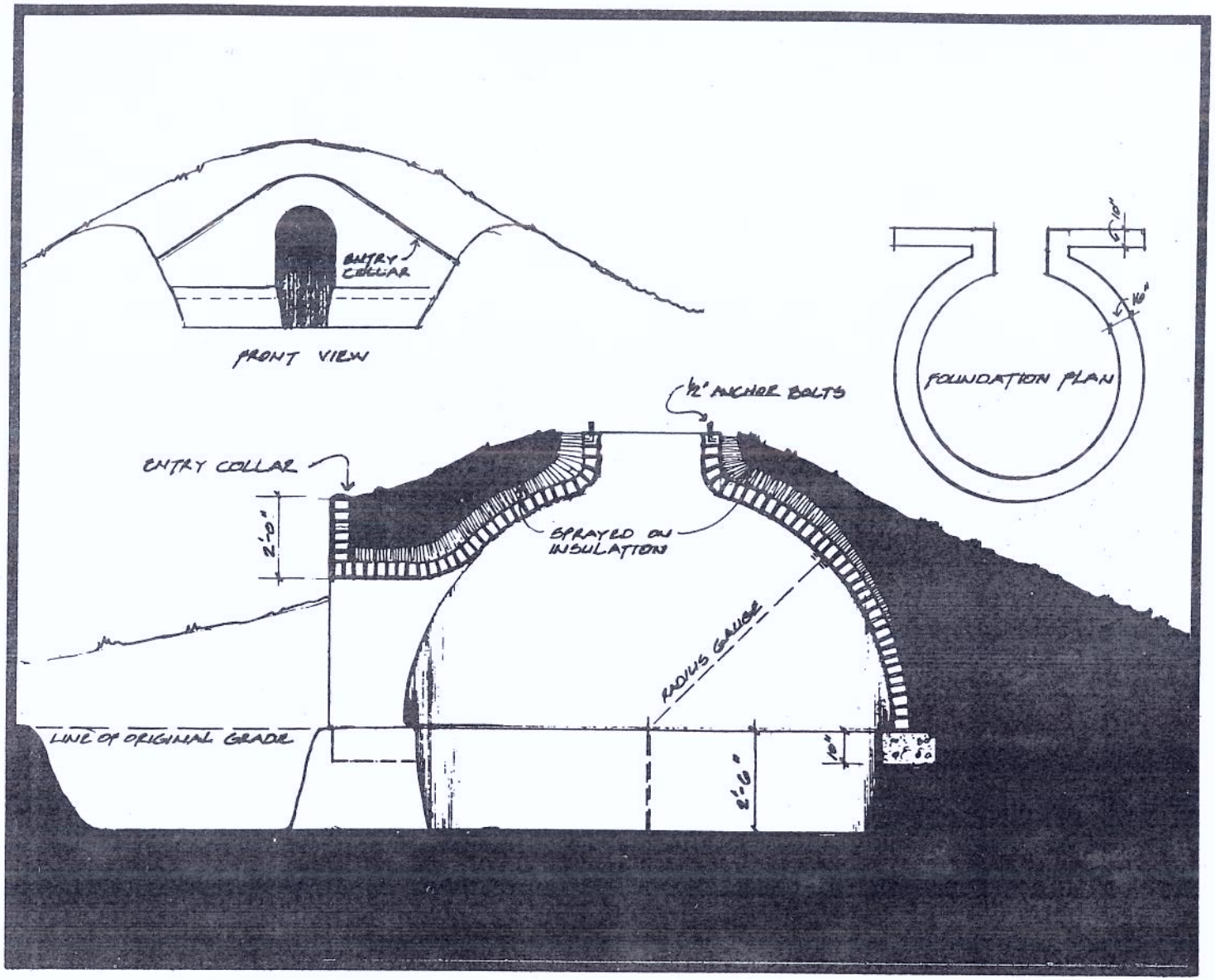
The foundations need only be 10" deep and 16" wide because they will be well below the frost line. Two pieces of 1/2" rebar should run continuously in the foundations. The foundations are broken to allow for an arch igloo entrance.

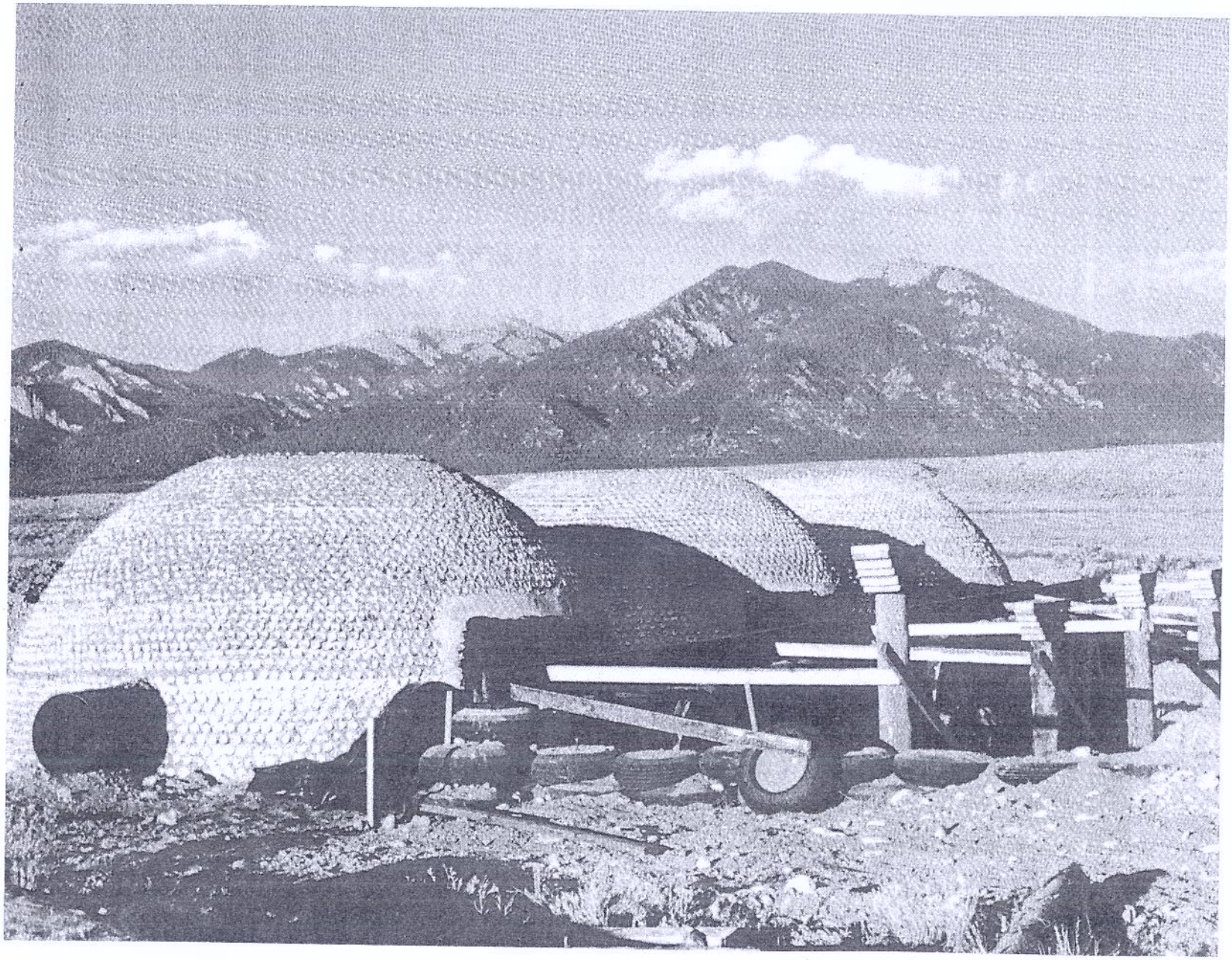
The excavation of the floor (2'-0" to 3'-0") should take place before can laying begins. The excavation can initially be cut with a backhoe but final trim should be done by hand to be sure the footings are not undermined. Plaster this resulting 2 -3 foot dirt cliff with two coats of mud formula. (See Earthship Volume I, Chapter 9). Apply one coat with your hands and let dry for two days then apply the second coat.

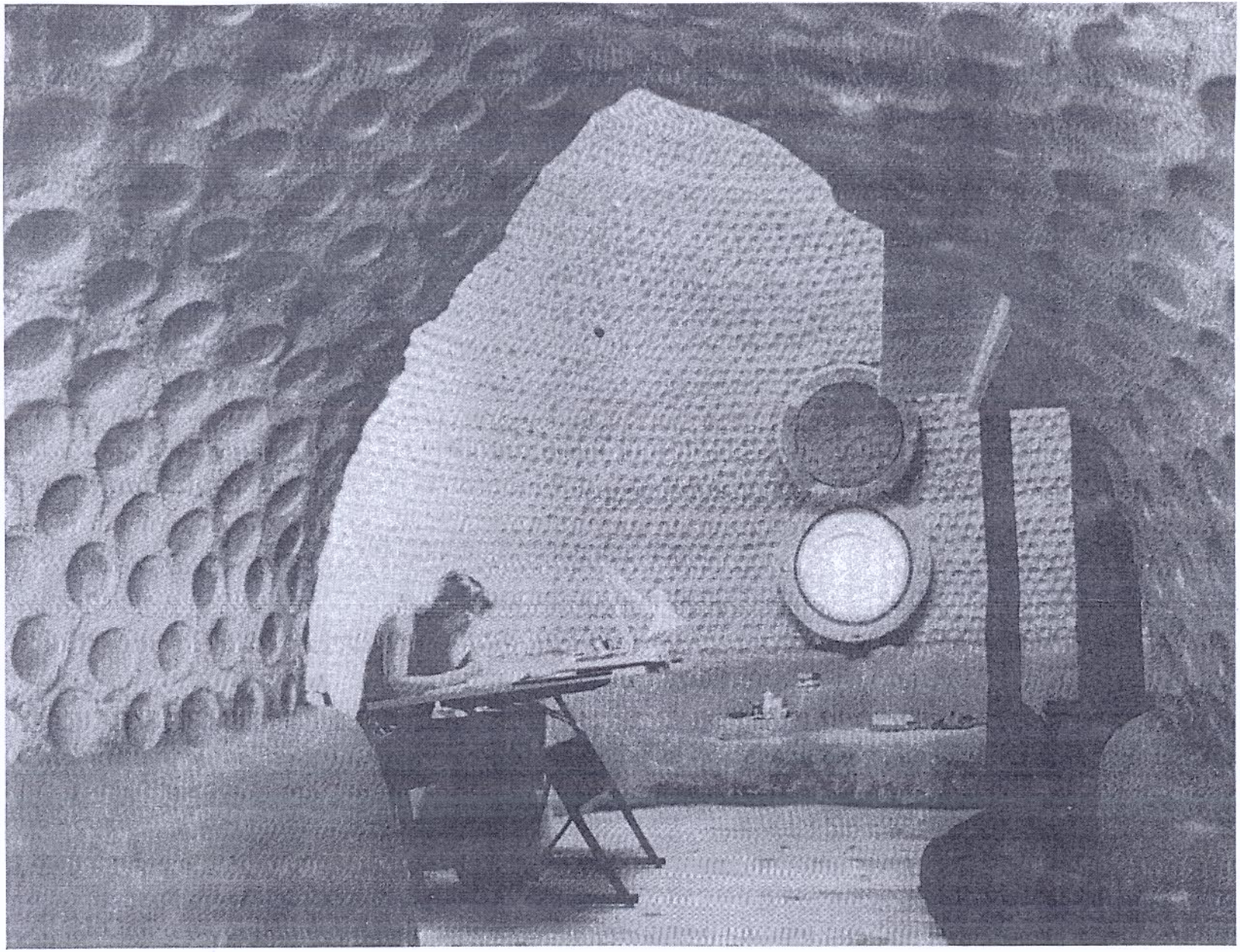
Cans are laid in a 1 part cement to 3 parts sand mortar mix with 1-1/2" spaces between cans in the lower courses and 1/2" spaces in the upper courses. The radius gauge will guide the arc of the dome in every direction. These single domes are turned up at the top like a turtle neck to receive a skylight. Leave a few cans out at the very top and set 1/2" anchor bolts in a cement pocket. This will provide anchorage for a wood plate to receive a skylight. This wood plate should have metal flashing that extends out to cover the exposed insulation at the top of the dome.

The igloo entrance and the turtle neck for the skylight are both fairly tricky. They require more patience than skill. One course at a time just turn the cans where you want them to go, never allowing them to touch each other. Cans can be tapped into a wedge shape with a hammer to accommodate sharp turns.




ENTRY COLLAR
FRONT VIEW
½" ANCHOR BOLTS
FOUNDATION PLAN
ENTRY COLLAR
2'-0"
SPRAYED ON INSULATION
RADIUS GAUGE
LINE OF ORIGINAL GRADE
2'-6"





A masonite form could be helpful as a guide on the entrance. A door frame can be anchored to the walls of the entrance by punching out cans and setting anchor bolts and cement in the void. The collar around the igloo entry retains the earth around it.

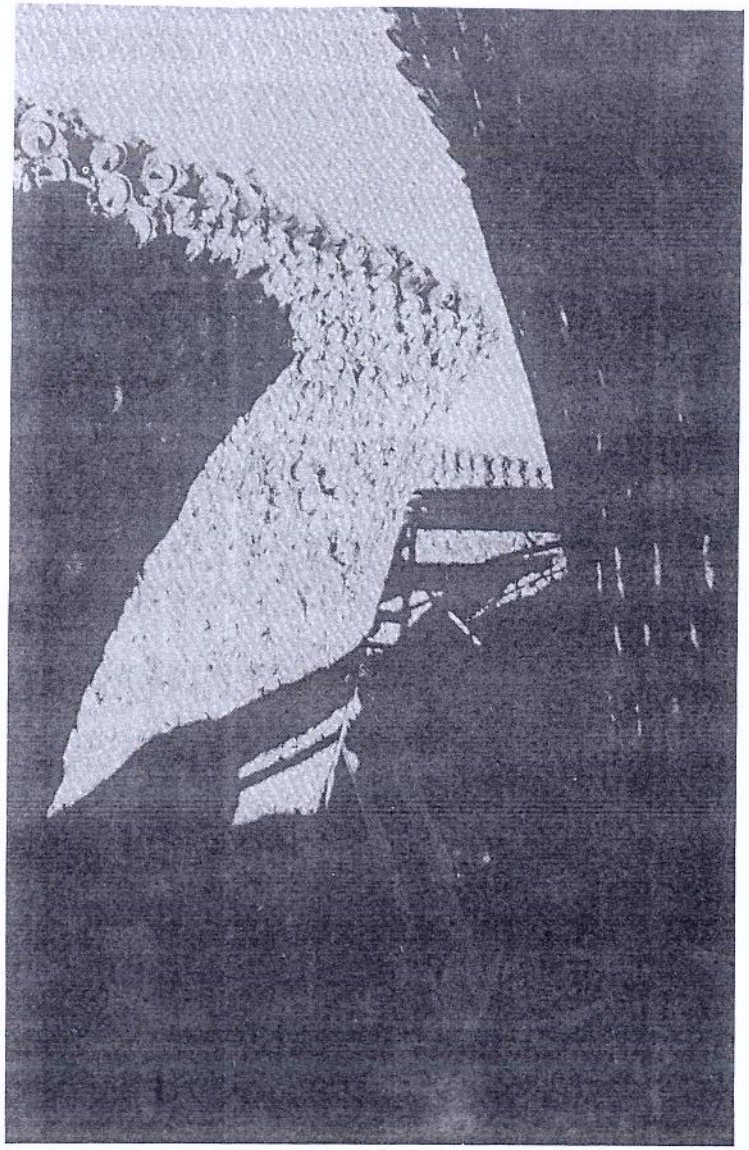
Before burial, the dome should be sprayed with some type of insulation. Cellulose or urethane are both good for this purpose. Rigid, one inch thick foam insulation has also been "cut and fit" in this situation. Apply a thick layer near the top and taper it to nothing about half way down. At this point the dome is deep enough that no insulation is needed. It should be pointed out that the buried dome would be satisfactory without any insulation in temperate climates. Two coats of plaster with engineering fibers* should be applied before burial. The plaster mix should be 1 part cement to 3 parts plaster sand. It can be applied directly onto the can work and should have a waterproof additive such as Anti-hydro* put into the mix.

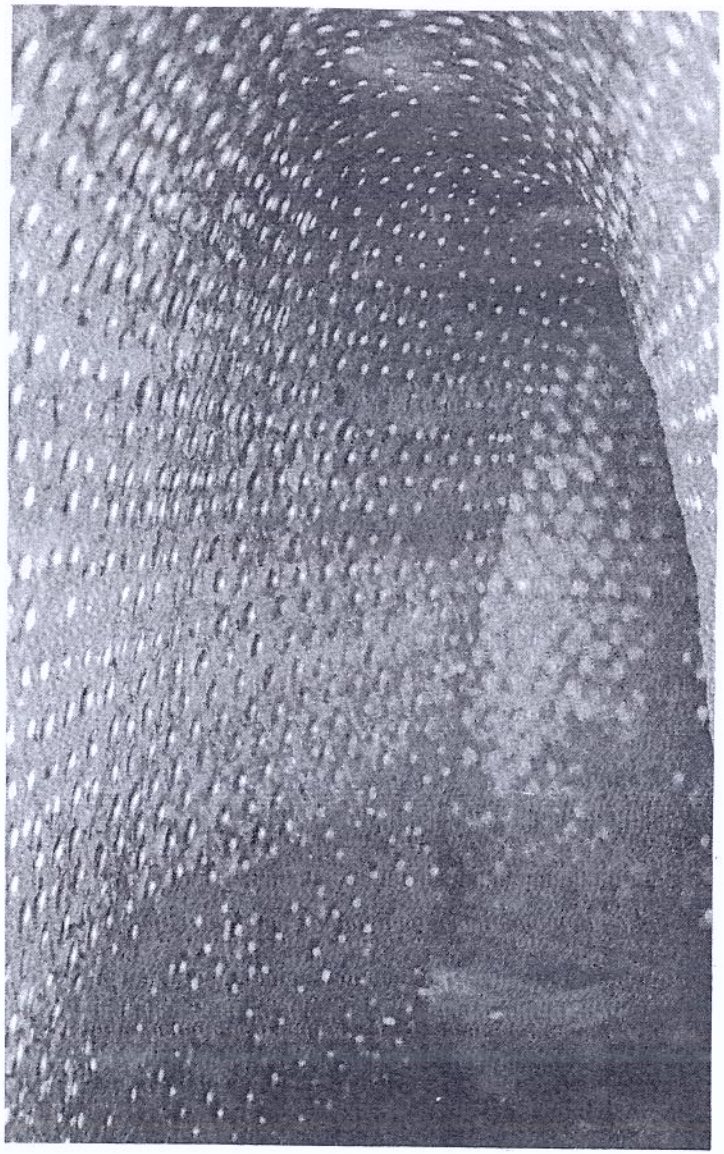
*3 and 4 see Appendix, Chapter 11

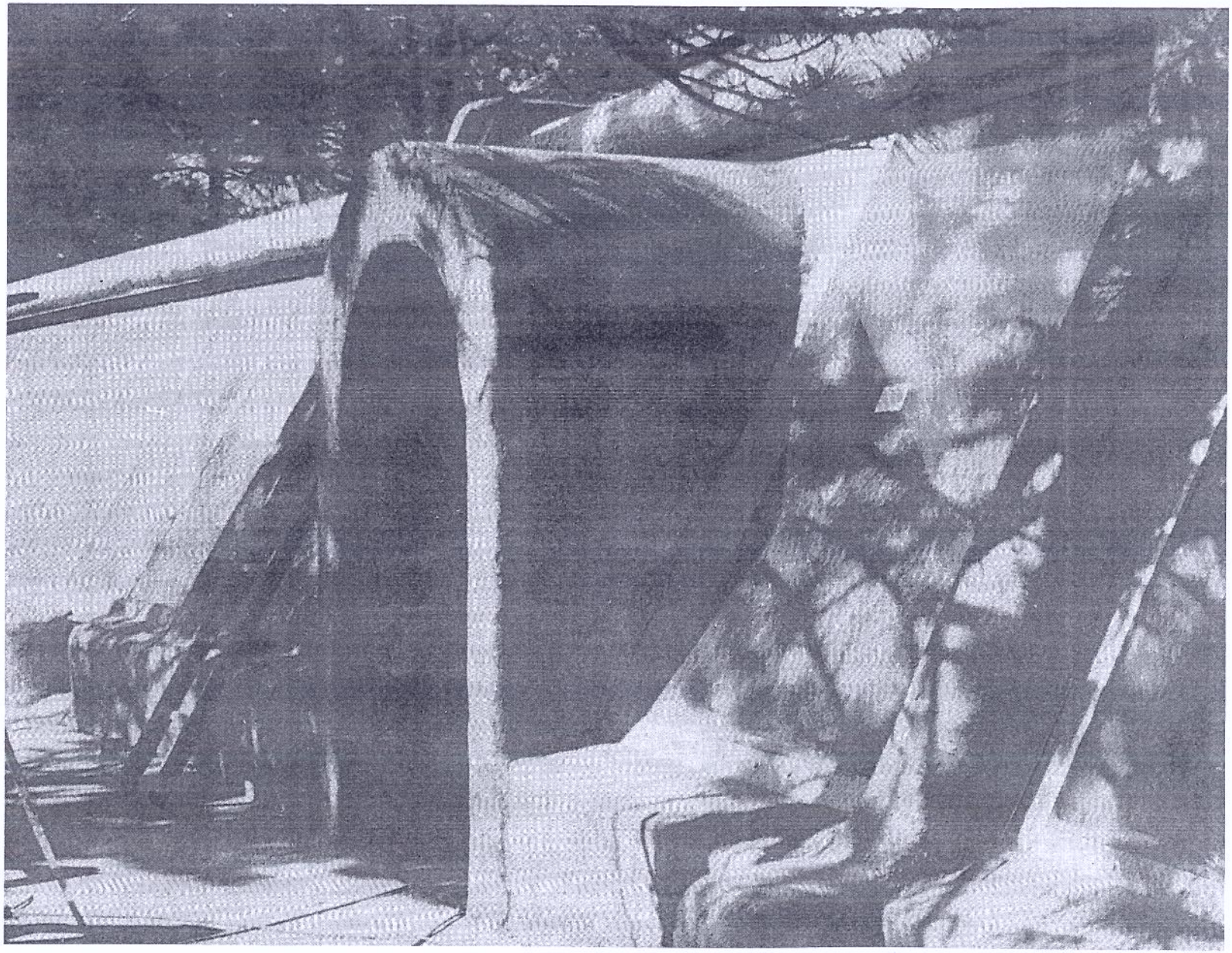
VAULTS

Vaults, arches and vaulted hallways follow much the same procedures and mortar mixes. Remember to use engineering fibers in all dome or vault mortar mixes. This will definitely make your structure stronger and last longer. Forms are necessary only as a guide or to make it possible to work faster, i.e. more courses in a single day. String or chain gauges without forms will guide you through almost any labirynth of spaces you can imagine. It is important to note that geometric and/or true natural shapes are stronger than organic funky shapes in these applications. For example, vaults should always be made using a cantenary curve. This is the curve a chain would make if you held it upside down. It is a natural shape (egg like) found in nature. Hemispheres and half circles have a thrust that must be contained, hence the necessity for the bond beam described on page 217.

If you want to seriously use the methods described in this chapter for dwelling spaces, we advise that you consult an engineer or Solar Survival Architecture for design of the shapes. The same structural masonry principals of design that have prevailed in arches. domes and vaults through the ages apply here. The only difference is that we are using cans to form the concrete as opposed to bricks between mortar.







APPENDIX

Geometric Shapes, Arcs and Curves
Architectural Graphic Standards
by Ramsey and Sleeper
The American Institute of Architects
Publisher - John Wiley and Sons, Inc.

Engineering Fibers
Fibermesh Company
4019 Industry Drive
Chattanooga, TN 37416

Stucco
El Rey
4100 Broadway SE
Albuquerque, NM 87105
(505) 873-1180

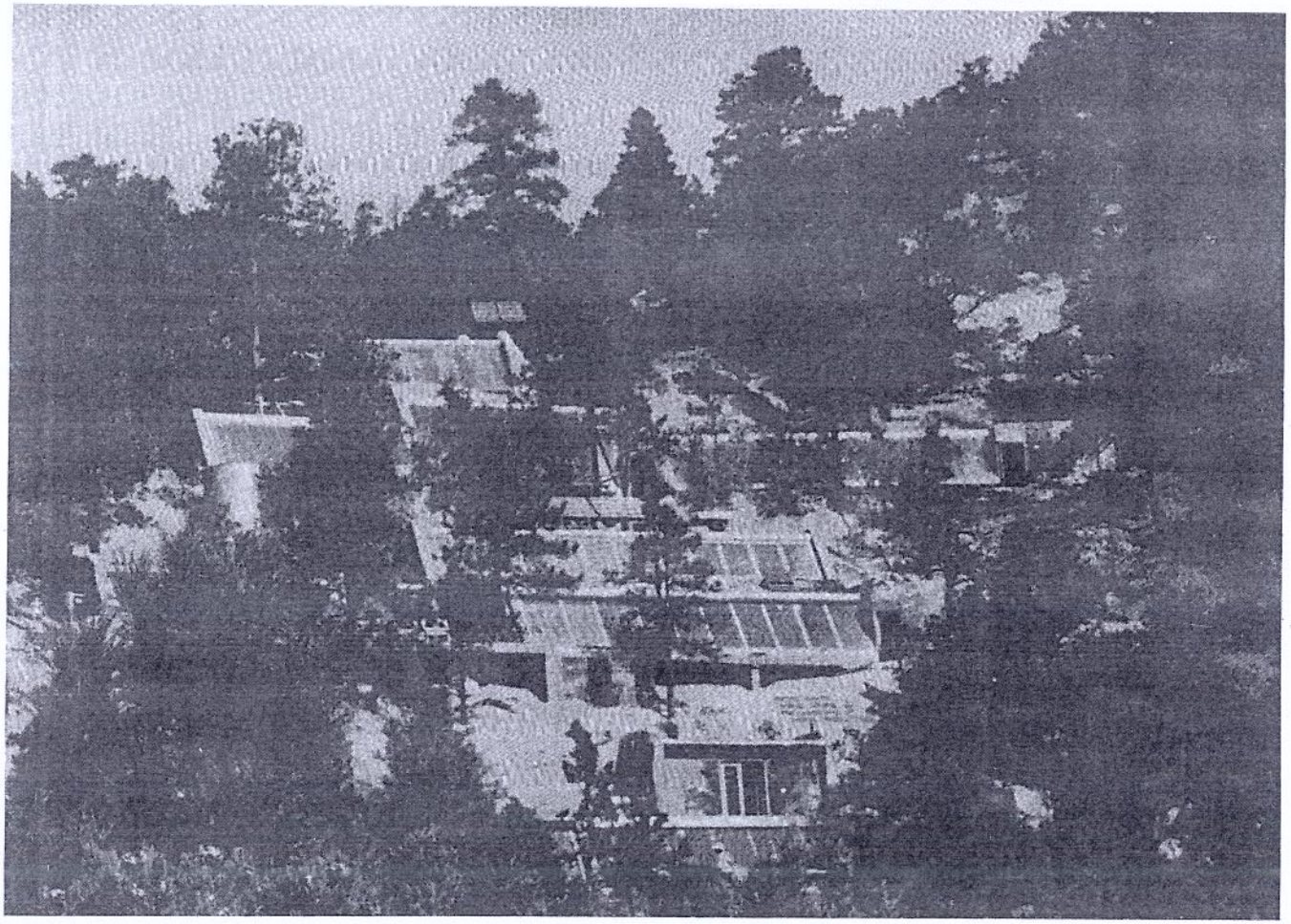
Acrylic (Tinted Polymer Based Finish)
El Rey
4100 Broadway SE
Albuquerque, NM 87105
(505) 873-1180

MODERN ECONOMICS

AN OLD MAN AND A SPIDER ONCE MADE A DEAL. THE OLD MAN WANTED A CLOAK AND THE SPIDER WANTED TO TRAVEL. THE OLD MAN WAS TO CARRY THE SPIDER ON A JOURNEY WITH HIM IF THE SPIDER WOULD SPIN THE OLD MAN A CLOAK WHILE HE RODE. NEITHER ONE TRUSTED THE OTHER THAT MUCH. "IF YOU STOP SPINNING, NO MORE RIDING" SAID THE OLD MAN. "IF YOU STOP TRAVELING, NO MORE SPINNING " SAID THE SPIDER. THE OLD MAN BEGAN HIS JOURNEY AND THE SPIDER BEGAN SPINNING. DOWN MANY TRAILS AND ACROSS STREAMS AND THROUGH CITIES THE OLD MAN CARRIED THE SPIDER. ALL THIS TIME THE SPIDER WAS BUSY SPINNING THE CLOAK. THE SPIDER LOVED THE TRAVELING SO HE SPUN MADLY OUT OF FEAR THAT THE OLD MAN WOULD KICK HIM OFF. THE OLD MAN WANTED THE CLOAK MORE AND MORE AS IT BEGAN TO TAKE SHAPE SO HE TRAVELED AND TRAVELED OUT OF FEAR THAT THE SPIDER WOULD STOP SPINNING.. AFTER MANY MILES OF TRAVEL, THE OLD MAN BEGAN TO MOVE SLOWER AND SLOWER AS THE CLOAK WAS GETTING HEAVIER AND HEAVIER. STILL HE TRAVELED NOT REALIZING THE CLOAK WAS BEGINNING TO RESTRICT HIS MOVEMENT. THE SPIDER HAD GROWN TO LOVE THE TRAVELING AND CONVINCED THE OLD MAN THAT MUCH MORE SPINNING HAD TO BE DONE TO PROPERLY FINISH THE CLOAK. AFTER MANY MORE MILES THE OLD MAN COULD HARDLY MOVE BUT HE KEPT TRAVELING AS THE SPIDER, WHO BY NOW WAS ADDICTED TO TRAVEL, KEPT CONVINCING HIM HE NEEDED A BETTER CLOAK. AFTER MANY MORE DAYS OF TRAVEL THE OLD MAN WAS BARELY ABLE TO INCH ALONG, BEING RESTRICTED BY THE THICK HEAVY CLOAK THAT KEPT GETTING THICKER AND MORE CONFINING. THE SPIDER WAS, AT THIS POINT, ABSOLUTELY AFRAID OF ANY OTHER KIND OF LIFE AND, THINKING THAT IF HE STOPPED SPINNING THE OLD MAN WOULD NOT LET HIM RIDE ANY MORE, KEPT SPINNING AND SPINNING. THICKER AND HEAVIER THE CLOAK GOT UNTIL FINALLY IT WAS IMPOSSIBLE FOR THE OLD MAN TO MOVE. HE COULD NO LONGER CONTINUE HIS JOURNEY. HE STOPPED AND ROLLED DOWN ON THE GROUND SMOTHERED BY HIS OWN CLOAK. THE SPIDER WAS STRANDED.

PART THREE

FACTORS OF THE EARTHSHIP



12. LANDSCAPING

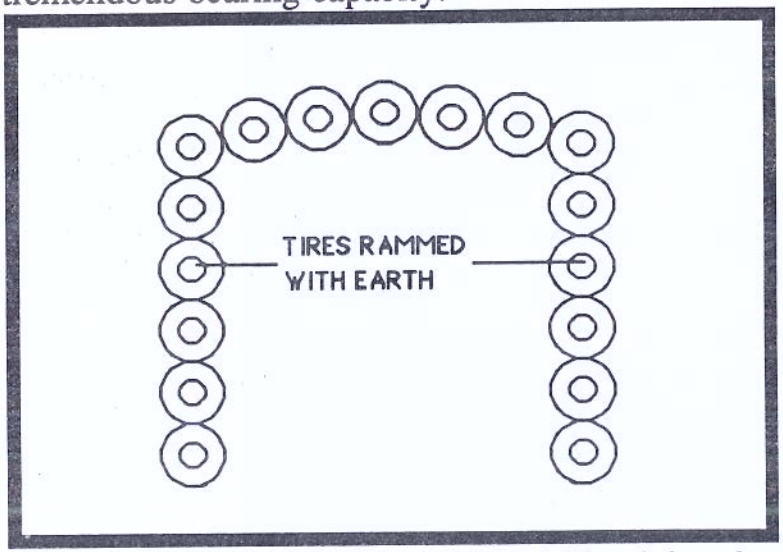
F A C T O R S

THE EARTHSHIP IS AS MUCH A PART OF THE **EARTH** AS IT IS A **BUILDING**. FOR THIS REASON EARTHSHIP LANDSCAPING IS AS MUCH A PART OF THE **BUILDING** AS IT IS A PART OF THE **EARTH**. LANDSCAPING FOR EARTHSHIPS IS PART OF THE ROOFING AND DRAINAGE SYSTEM, PART OF THE CATCHWATER SYSTEM, PART OF THE GREY WATER SYSTEM, ETC. THIS, TOGETHER WITH SOME NECESSARY REGIONAL AND GLOBAL AWARENESS, MAKES LANDSCAPING AN EARTHSHIP SOMETHING MORE THAN JUST A DECORATIVE PROJECT. IT IS A PROJECT THAT CAN ENHANCE AND IN SOME CASES *MAKE POSSIBLE* THE PERFORMANCE OF AN EARTHSHIP. IMPROPER LANDSCAPING CAN, ON THE OTHER HAND, RENDER AN EARTHSHIP *DEAD IN THE WATER* SO TO SPEAK. IT IS, THEREFORE, NECESSARY TO TAKE THE INFORMATION IN THIS CHAPTER AS SERIOUSLY AS THE EARTHSHIP STRUCTURE ITSELF.

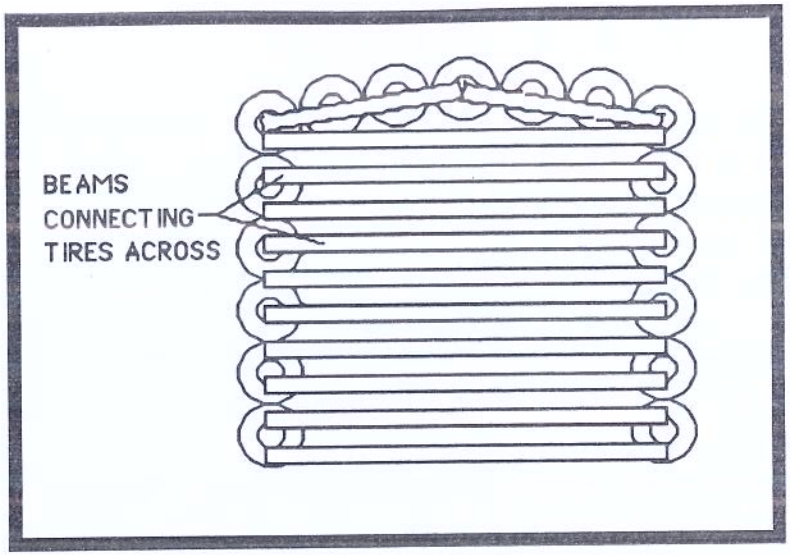
Landscaping affects many aspects of Earthship design and performance. We will take these aspects one at a time and discuss their interface with landscaping.

EARTHSHIP STRUCTURE

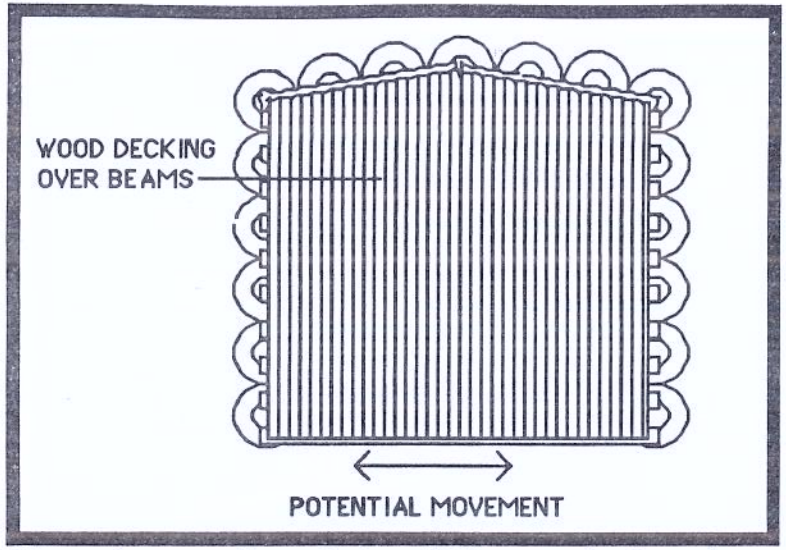
The structure of the Earthship "U" module as presented in Earthsip Volume I is basically created by a "U" shape made of tires rammed with earth thus creating two parallel walls tied together because of the "U" shape. This "U" has tremendous bearing capacity.



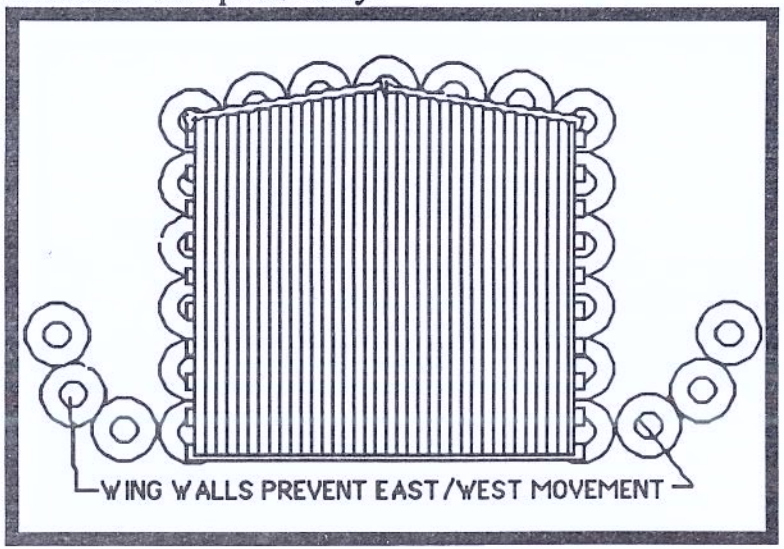
The open end of the "U" is stabilized by the beams connecting the two legs together



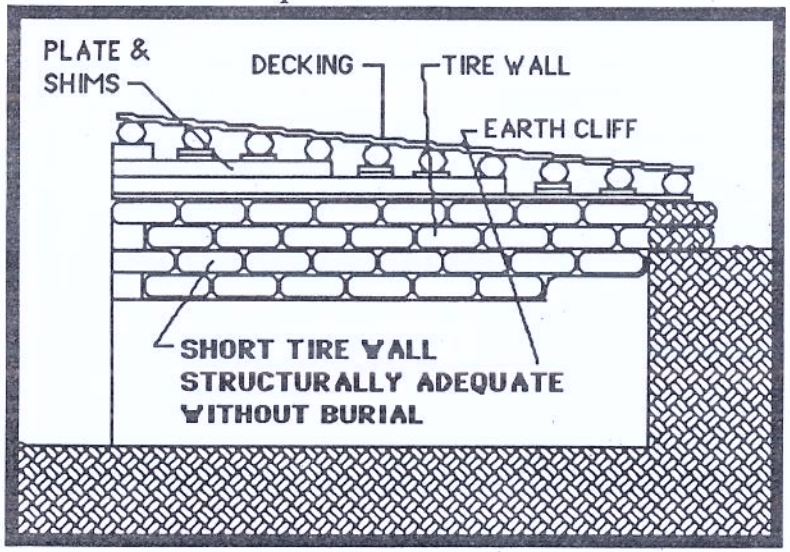
The "U" itself and the addition of the beams and decking (which in effect make a diaphragm connecting the two legs of the "U") result in a very rigid, structurally self-contained shape. The only possible movement of this structure would be in the east west direction.



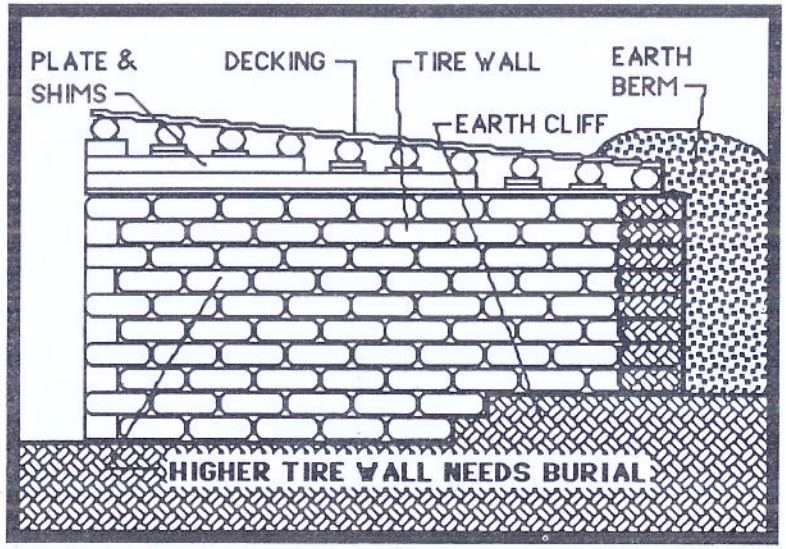
The wing walls of the "U" are designed to eliminate this possibility.



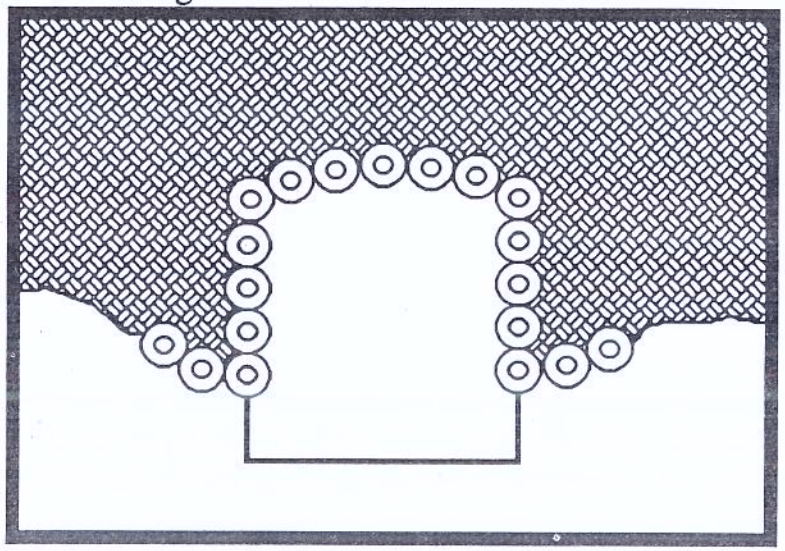
Since many Earthships are submerged sometimes as much as five feet, the tire work is not very high and the structure above without burial would be more than adequate.



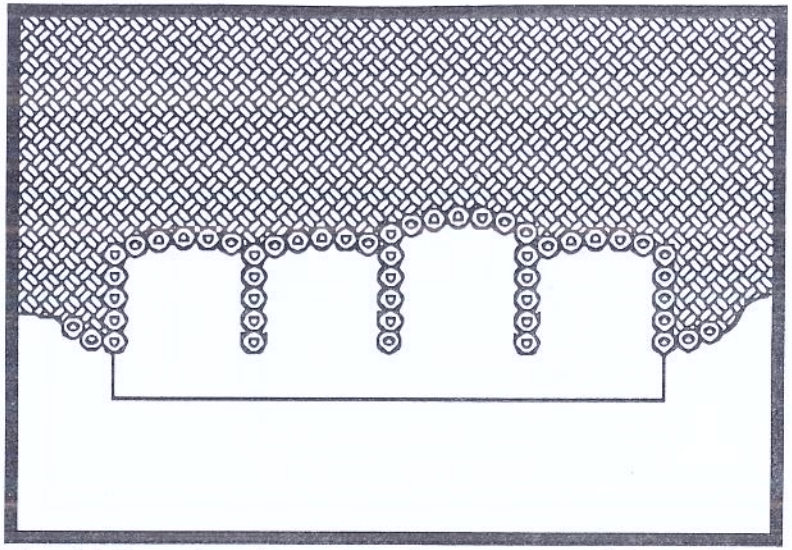
When the building is not submerged much and the tire walls get higher, the added strength and stability of berming earth up against the structure creates a situation where the earth is *against and into* the voids between tires thus rendering the building literally a part of the earth itself.



In this case the building is *locked into* the surrounding earth.



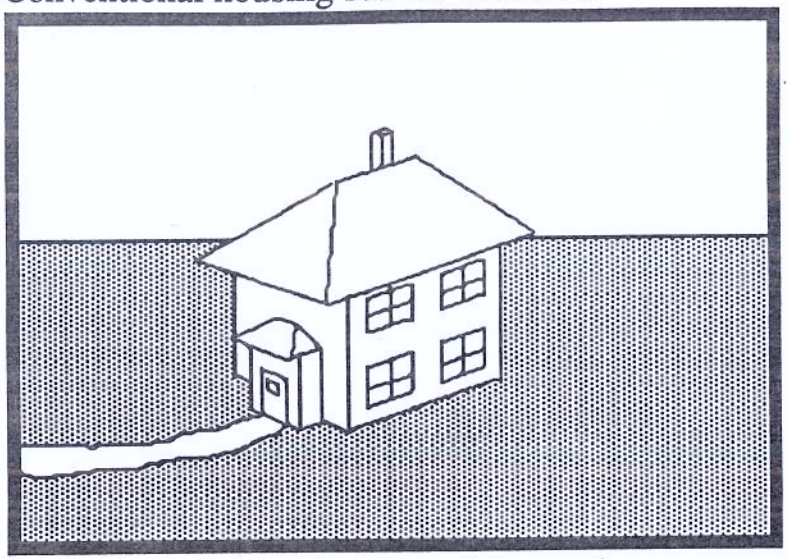
This concept works for one or many "U"s



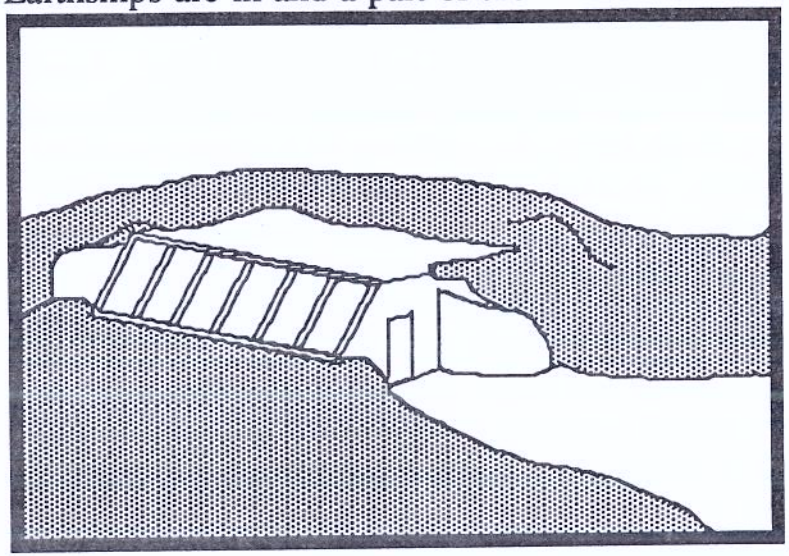
The higher the tire work the more positive effect the burial or "berming" can have as it stabilizes the higher walls by almost becoming a part of them. It should be noted that Earthships can be built with no berming at all but this requires more overall structural analysis not to mention insulation and plaster i.e. more money. When an Earthship is "snuggled" into the earth, it is actually being structurally reinforced by the earth against any structural movement. The walls are no longer free standing walls, they are (because of the voids between the tires) knitted into the surrounding earth. **Thus, berming up earth against an Earthship is a factor of landscaping that has a positive effect on the structure of the building and is advisable if at all possible.**

ROOFING

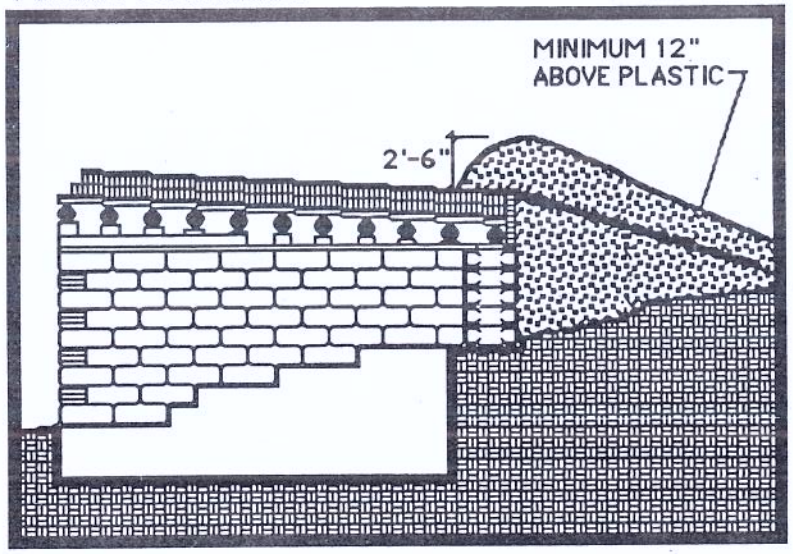
Conventional housing sets on the earth.



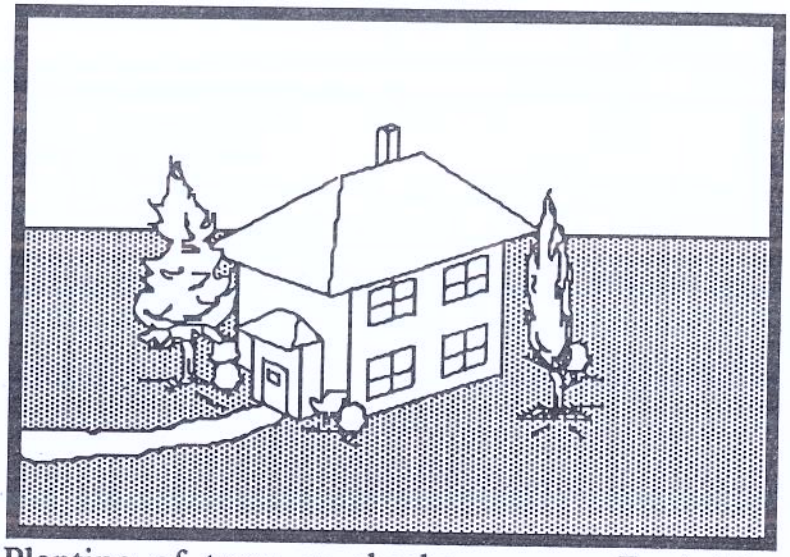
Earthships are in and a part of the earth.



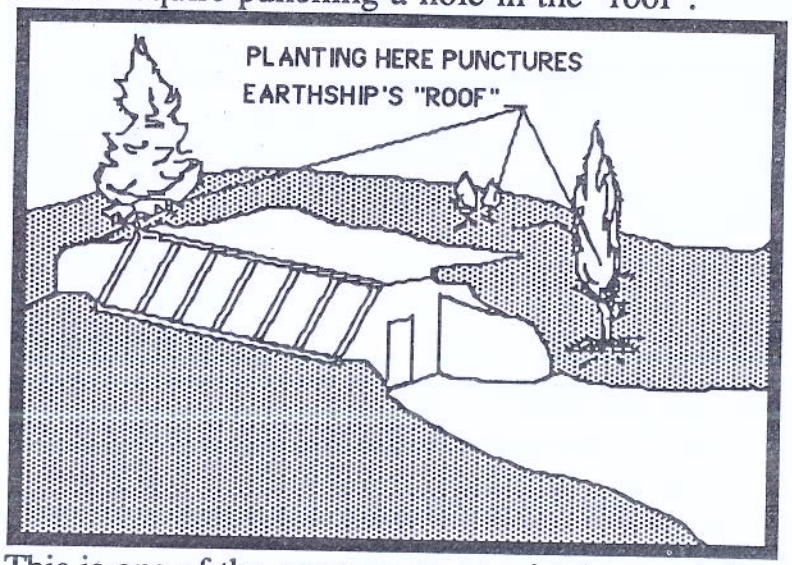
Consequently, when roofing an Earthship one is also roofing the earth as the details in Earthship Volume I illustrate.



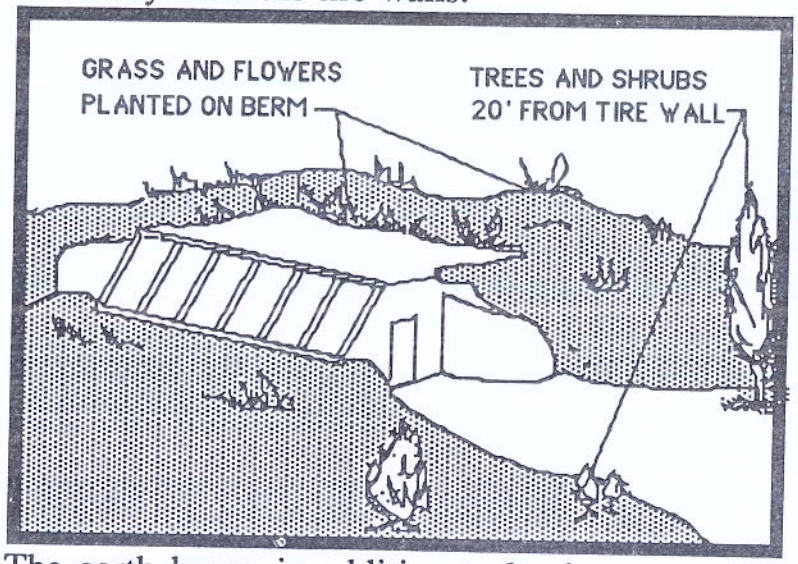
This fact has serious effects on planting near the building. Conventional planting and landscaping techniques are not valid for Earthship landscaping. Conventional housing allows planting of trees or shrubs right against the building.



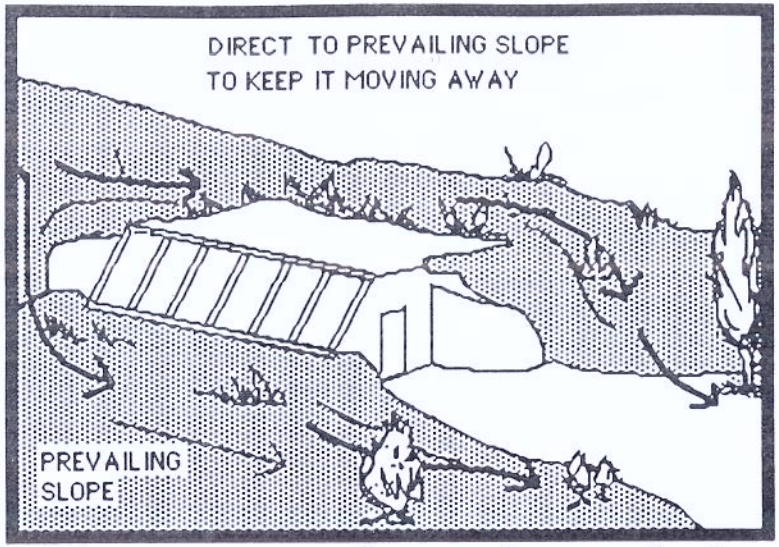
Planting of trees or shrubs near an Earthship would require punching a hole in the "roof".

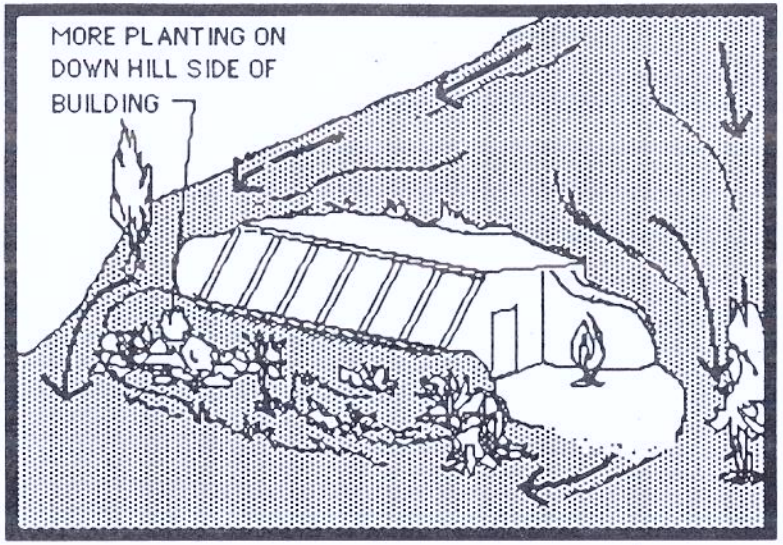


This is one of the most common mistakes made by owners of Earthships. Remember, **your berm around your Earthship is also an integral part of your roof.** Only ground covers such as wild flowers ands grass can be planted here. Trees and plants with deep roots and wells for catching water around them should be kept 20 feet away from the tire walls.



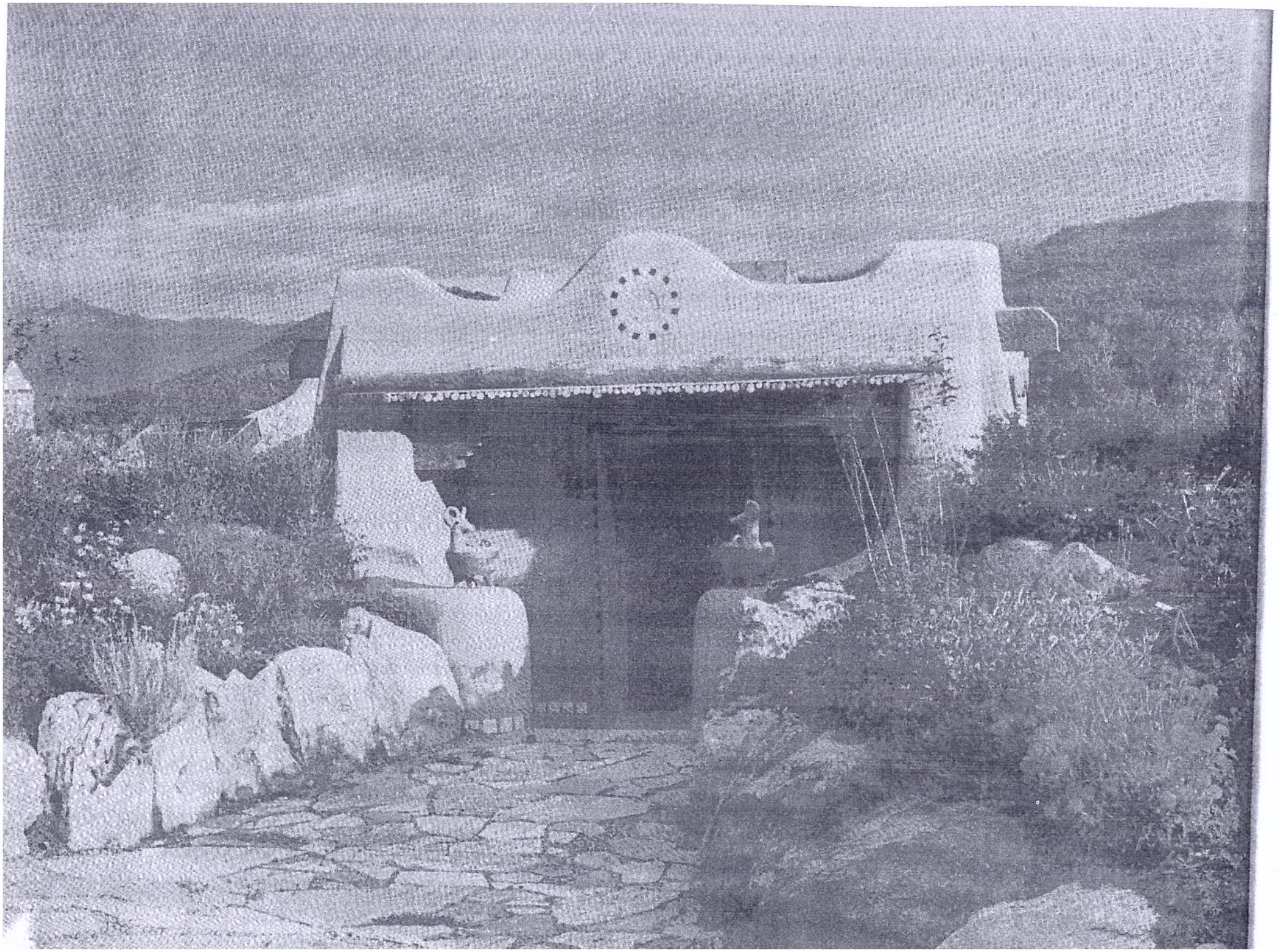
The earth berm, in addition to having structural effects, is also part of the roof. It actually contains roofing material 12" down and creates the slope to carry water (quickly) away from the inner building. The surface water is manipulated up to fifty feet from the building. It is carried away from the walls and off in the direction the site would naturally have it go. Almost every site has a slight slope in one direction. You simply find this slope with a builders level. Shoot a few elevations and run your water from the berm around the Earthship toward the prevailing slope of the site no matter how subtle it is.





Do not create any dips, swales or planting conditions that hold water anywhere near the tire walls. Move surface water away from the building fast by sculpting the land. Water can be directed toward landscaping areas (trees and shrubs) a safe distance from the walls of the building. This safe distance varies with the nature of the site. A site with a good slope would allow major tree planting closer to the building on the downhill side of the building.

Flatter sites would require at least twenty feet between the Earthship and trees or anything requiring a deep hole filled with water. Following is a photo of a north entrance into an Earthship with wildflower and ground cover landscaping which does not impede the flow of water away from the buried walls of the building.

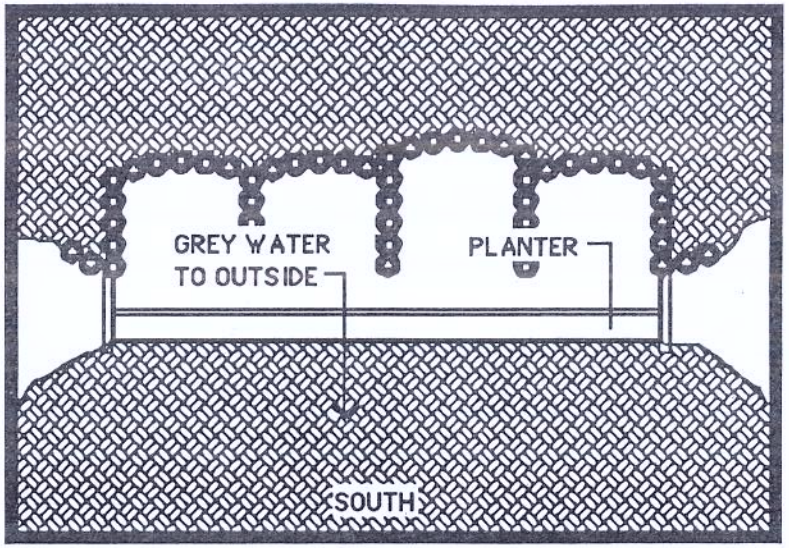


Another consideration with respect to planting near an Earthship is to plant indigenous plants that will be happy with local rainfall as their only water supply. If you are using a catch water system this is usually a must. The idea here is that **you do not want to be the one adding water to the area around your Earthship and you want to carefully manipulate the water that comes from the sky.** There are exceptions to this with respect to the grey water discussion that follows.

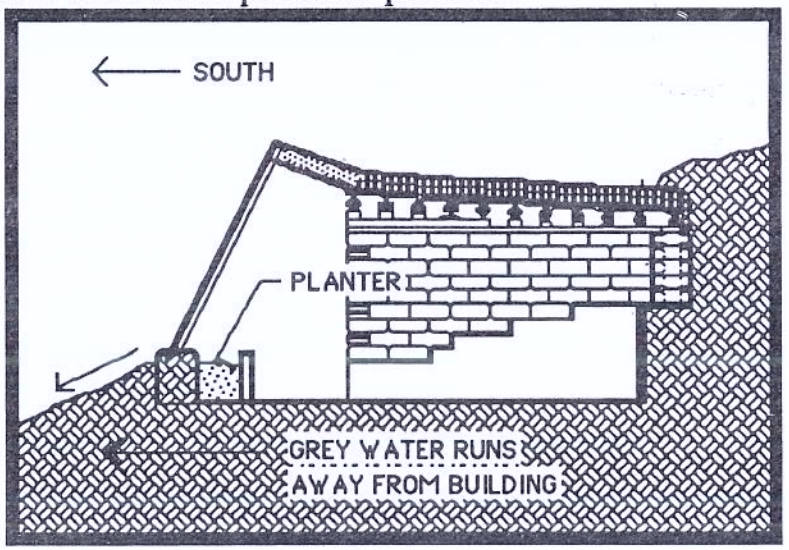
GREY WATER

Some grey water must go to exterior planters. This is the only water recommended to be purposefully placed near an Earthship. The locations for grey water planters are carefully thought out with respect to prevailing slope and proximity to the tire walls. The deeper the building is in the ground the more critical this situation is. Grey water locations should generally follow the same rules presented in the discussion above.

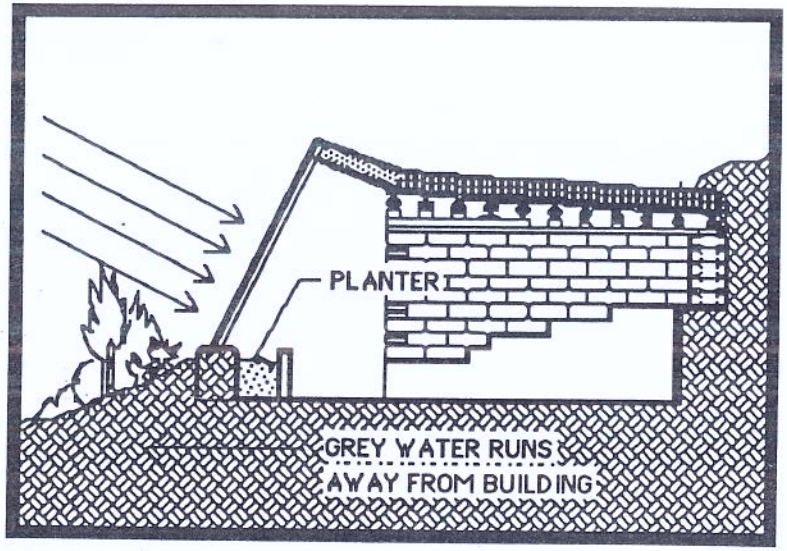
Grey water usually comes out the south (front face) side of the Earthship and this is the least vulnerable area because there is no plastered tire wall here. In most cases there is a planter along this wall that would welcome any dampness that occurred.



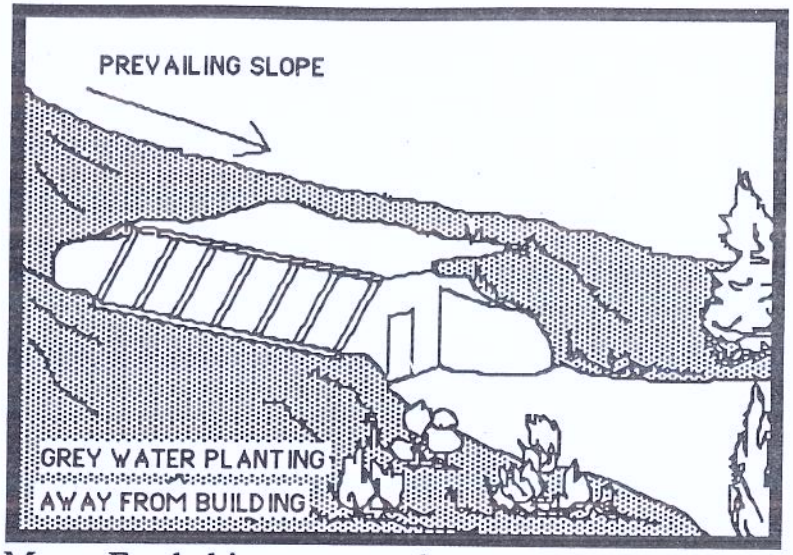
Since most Earthship owners choose a south sloping site, the grey water coming out the south side is running away from the building naturally and there is no potential problem.



Planting beds can occur as close as desired in this situation. The only factor here would be the effect that tall plants would have on the solar gain of the front face.



If the site is not sloped to the south, orient the grey water planting toward the prevailing slope and keep it at at least twenty feet from the building.

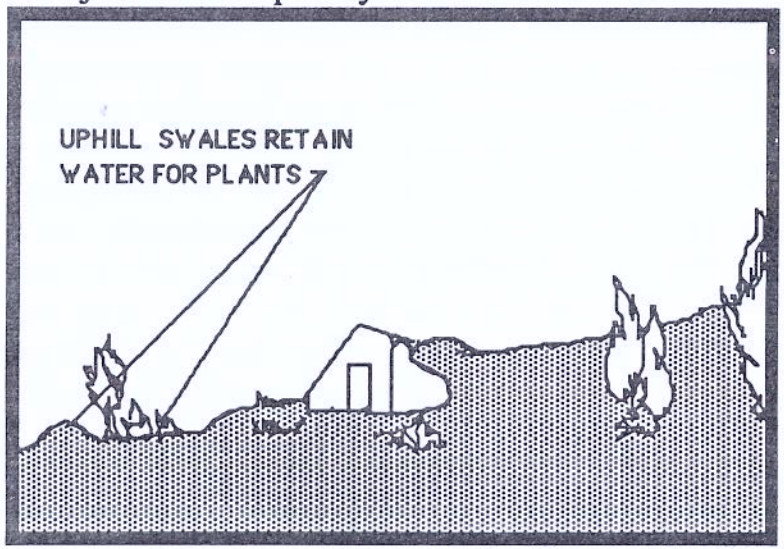


Many Earthships use catchwater systems which don't allow much landscape watering. This makes a grey water planting area the only area with the potential of being watered regularly. Grey water can be irrigated to many little beds or trees or gardens. Grey water is a major factor in Earthship landscaping. Use this wisely and keep it away from the tire walls. Except for the south side, get it away from the building fast and develop your own little jungle.

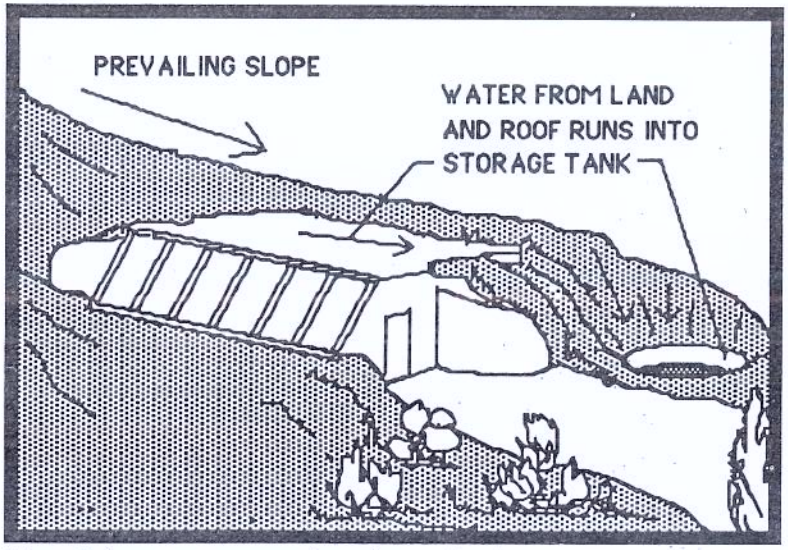
CATCHWATER

Catchwater life usually does not allow the wasteful decadent use of water that most of us are accustomed to. Catchwater life requires indigenous landscaping capable of survival on local rainfall with grey watered planned planting areas. This is one good reason to save every

existing tree possible - so you don't have to start so many new ones as this takes water. Landscaping an Earthship involves sculpting and shaping the terrain to manipulate the water where you want it - usually away from the building. Now, since you are already sculpting and manipulating water, you may as well take this one step further in your landscaping efforts. You can create uphill swales away from and on the downhill side of your Earthship to catch and retain water so it will soak into the ground rather than just run off quickly.



This is just the opposite of what you want to do immediately around your building. These swales trap water and allow it to soak in slowly to provide moisture for plants below. If your Earthship is below, it will provide moisture there too. This, you don't want. We are moving water quickly away near the building and trapping it in areas safely away from the building. In some cases where roof water is not enough to provide adequate water supply, the land is further sculpted toward a lined tank and stored with the roof water.

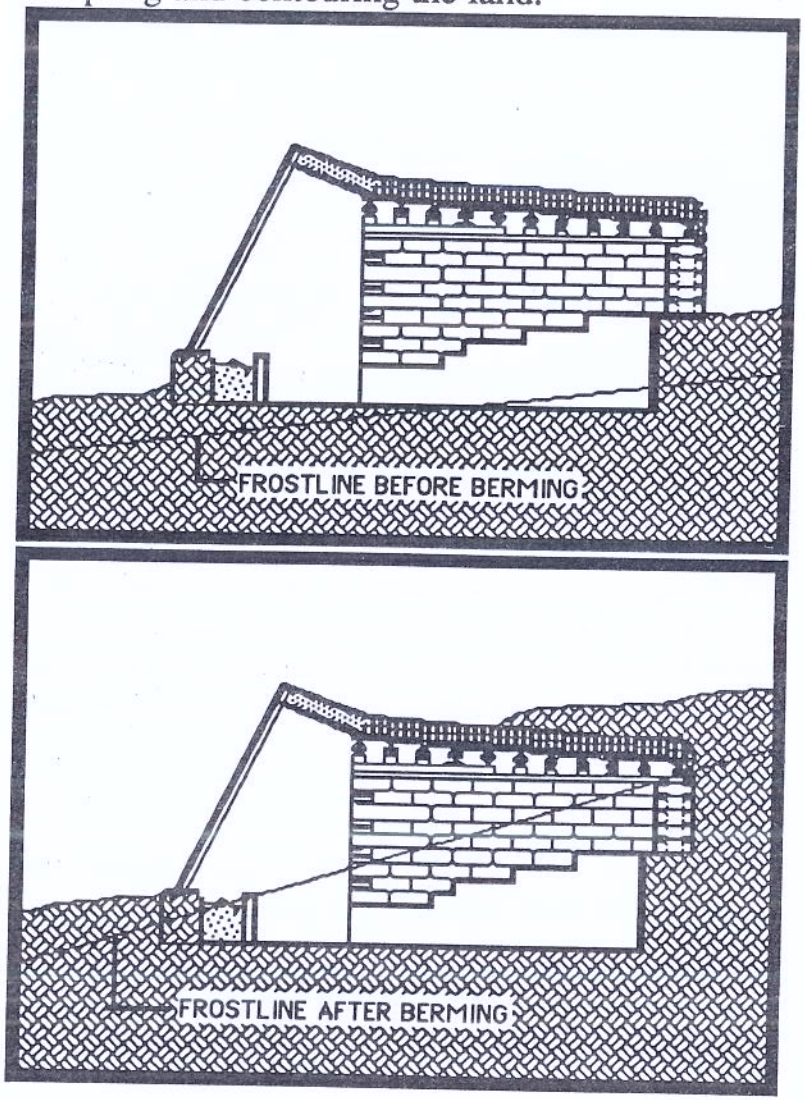


The thing to remember here is that you can move water away fast by surface contours and you can trap it by surface contours. You are the designer and all you have to know is where you want and don't want water, then do it.

INSULATION

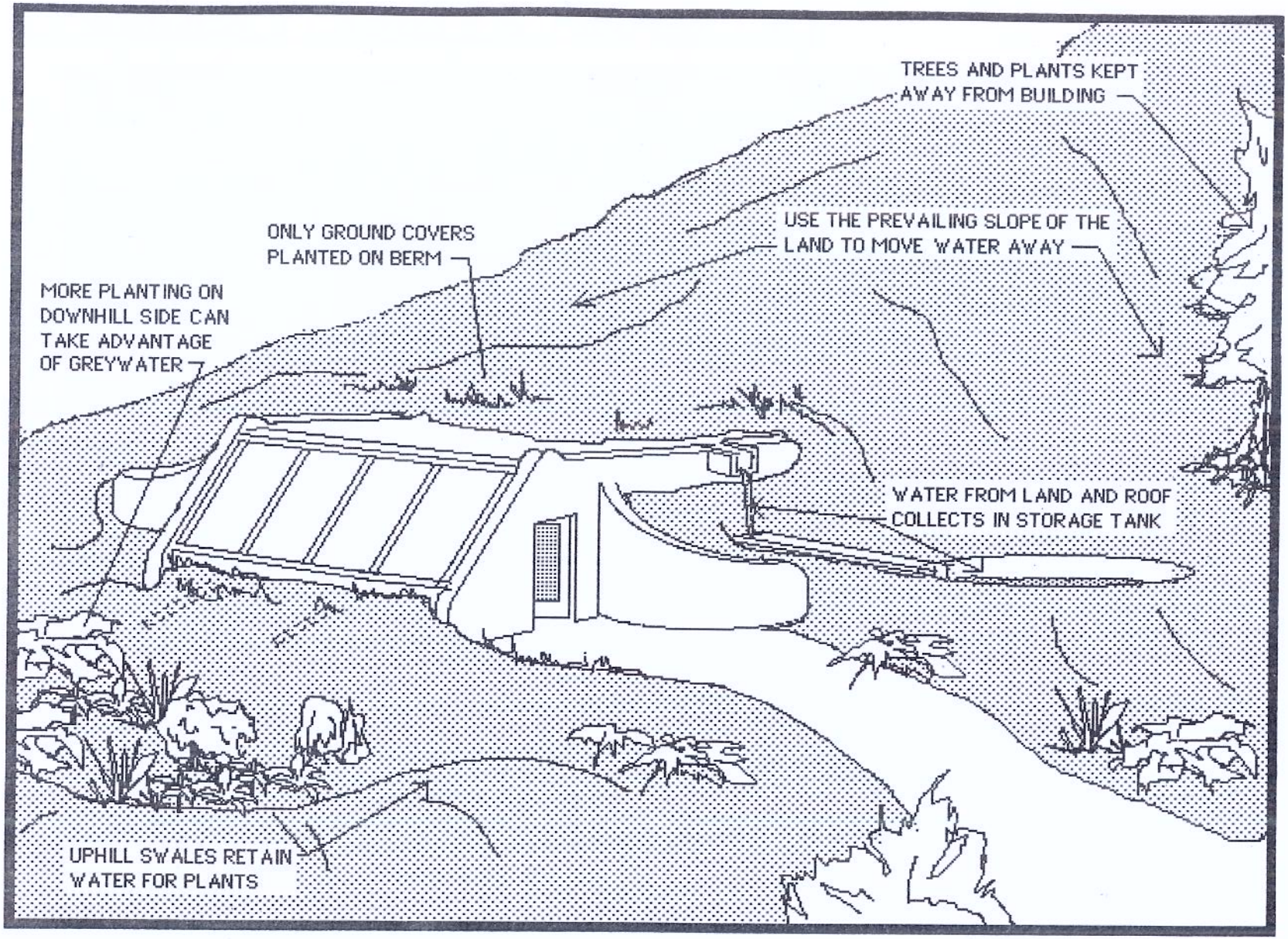
Earth is not a very good insulator. However, enough earth does prevent the penetration of cold or heat. For example in areas where the winters reach 30 degrees below zero, the ground does not freeze below 4 feet. Therefore, four feet of earth

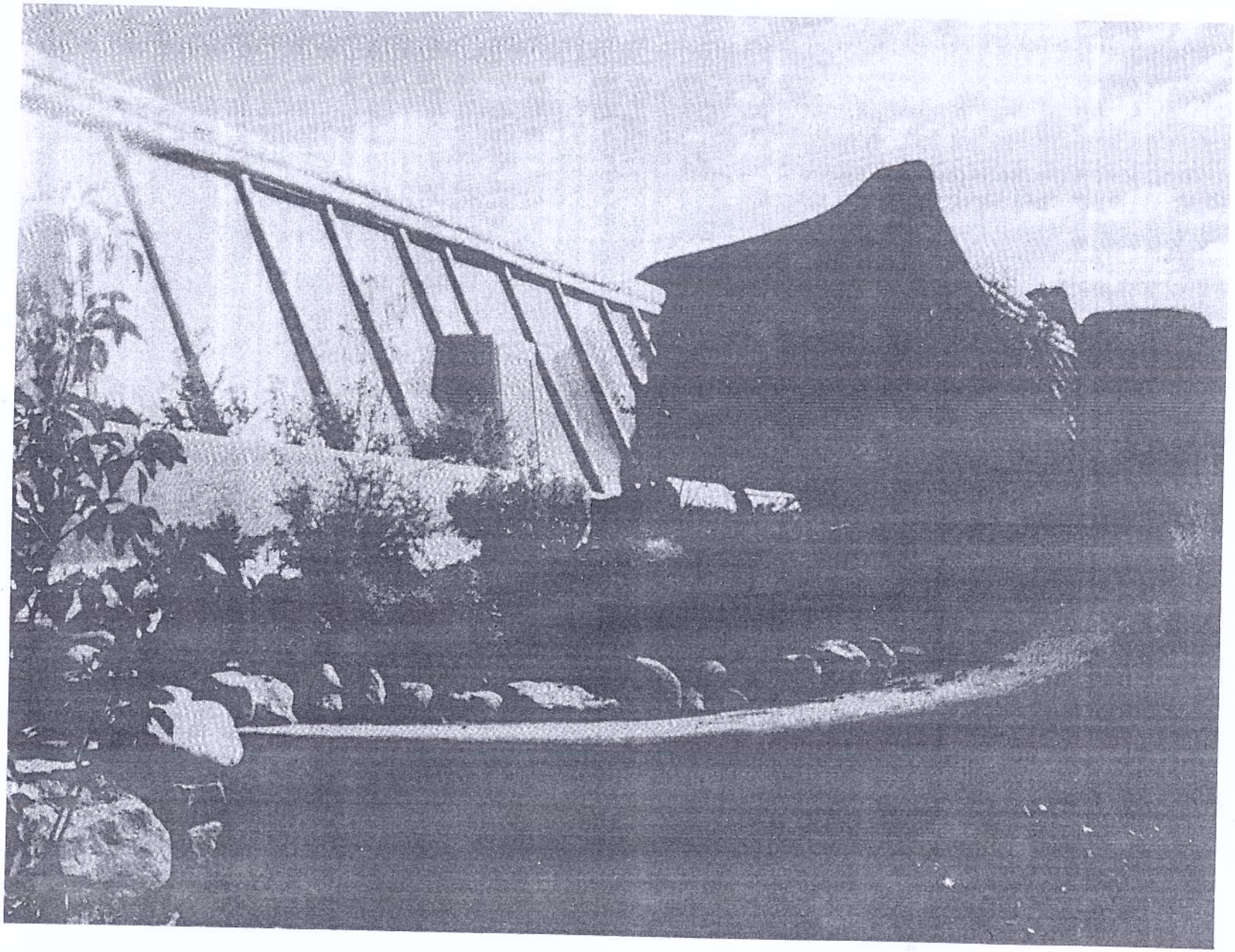
is enough insulation to maintain temperatures above freezing in this area. This area would have a 4 foot frost line. Earthship landscaping tries to recreate the frost line and make it higher by sculpting and contouring the land.



Berming and burying the parapet of the Earthship actually recreates the frostline as it recreates the surface of the earth. This is another reason to bury and berm against an Earthship. Every wall of an Earthship except the south glass wall should be buried with an earth berm parapet if possible. Many people want to expose various walls of their Earthship to get windows, views and entrances. This adversly effects structure, water-proofing and insulation (and price$$) all at once.

The discussions above illustrate how seriously landscaping is related to the overall performance of an Earthship. The most often repeated mistake is to turn the landscaping over to someone unfamiliar with the principals of Earthship design. They can cause one catastrophe after another. Landscaping is as important to the Earthship owner as manipulating sails is to the sailor. Not many sailors turn this job over to anyone.


TREES AND PLANTS KEPT
AWAY FROM BUILDING
ONLY GROUND COVERS
PLANTED ON BERM
USE THE PREVAILING SLOPE OF THE
LAND TO MOVE WATER AWAY
MORE PLANTING ON
DOWNHILL SIDE CAN
TAKE ADVANTAGE
OF GREYWATER
WATER FROM LAND AND ROOF
COLLECTS IN STORAGE TANK
UPHILL SWALES RETAIN
WATER FOR PLANTS

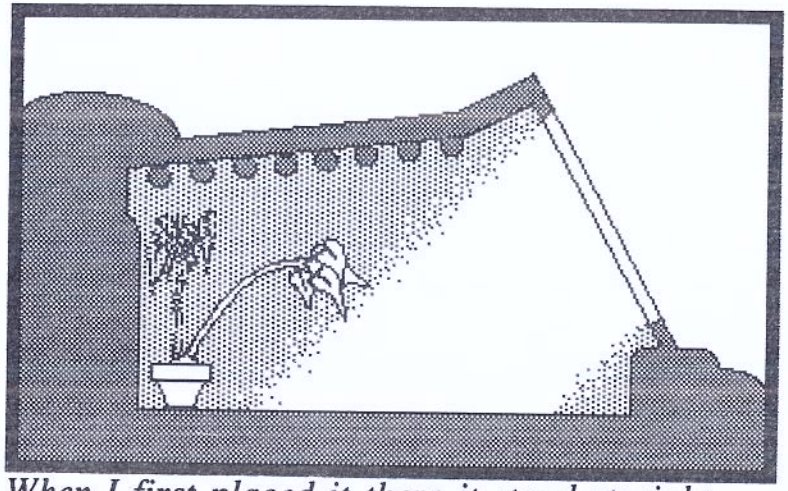


13 CODES, PERMITS & FINANCING
F A C T O R S

BUILDING CODES AND LENDING INSTITUTIONS BASICALLY CONTROL THE TYPE OF HOUSING THAT IS AVAILABLE OR POSSIBLE. THIS IS BECAUSE BUILDING PERMITS AND FINANCING MUST BE OBTAINED PRIOR TO BUILDING. MOST NEW OR DIFFERENT CONCEPTS HAVE TO BE RIGOROUSLY PROVEN TO THE BUILDING CODE OFFICIALS AS OFFICIALS ARE NOT BEING PAID TO TAKE RISKS ON NEW IDEAS. THEY ARE BEING PAID TO ENFORCE EXISTING DOGMA. CONSEQUENTLY, THEY TEND TO GO BY THE EXISTING BOOKS REGARDLESS OF ENVIRONMENTAL OR HUMAN ISSUES TO MAKE SURE THEY DON'T LOSE THEIR JOBS. TO FURTHER COMPLICATE THE MATTER, THE LENDING INSTITUTIONS DO NOT NECESSARILY ACCEPT ANY APPROVALS OF NEW IDEAS BY THE BUILDING CODE OFFICIALS ANYWAY. THEIR OBJECTIVE IS TO SECURE THE RESALE VALUE OF THE DWELLING TO COVER THEMSELVES IN CASE OF DEFAULT BY THE BORROWER. CONSEQUENTLY THEY STICK TO THINGS THAT HAVE PROVEN TO RE-SELL OVER THE YEARS REGARDLESS OF WHETHER THEY ARE APPROPRIATE FOR THE PLANET OR FOR PEOPLE. WHAT WE HAVE FACING US IS A FORMIDABLE MOUNTAIN RANGE OF OBSOLETE DOGMA INHABITED BY BUILDING CODE OFFICIALS AND LOAN OFFICERS WHO ARE FROM A DIFFERENT WORLD THAN THOSE OF US WANTING TO BUILD AND SAIL IN EARTHSHIPS. THIS CHAPTER DISCUSSES THE ART OF DEALING WITH THOSE INDIVIDUALS AND ULTIMATELY CROSSING THE MOUNTAIN RANGE TO THE "PROMISED LAND".

I WISH TO POINT OUT THAT I HAVE WORKED WITH THE NEW MEXICO CONSTRUCTION INDUSTRIES DIVISION FOR TWENTY YEARS IN DEVELOPING THE EARTHSHIP CONCEPT. THEY ARE AN EXCEPTION TO THE GENERAL NATURE OF BUILDING CODE OFFICIALS. THEY HAVE BOTH ALLOWED AND SEEN THE VALUE IN THE EVOLUTION OF THE EARTHSHIP. THEY HAVE CHALLENGED THE WEAK POINTS AND ENCOURAGED THE STRONG POINTS OF THE EARTHSHIP CONCEPT. THE NEW MEXICO C.I.D. IS AN EXAMPLE FOR OTHER STATES TO FOLLOW.

I once had a banana plant in my office. It was on the back north wall of a solar space - a prototype of an Earthship.



When I first placed it there it stood straight up. SLOWLY OVER TIME, I NOTICED IT LEANING TOWARD THE LIGHT COMING FROM THE SOUTH SOLAR FACE. AFTER A FEW MONTHS IT WAS LEANING SO MUCH IT WAS ABOUT TO FALL OVER. THE STALK OF THE PLANT IS QUITE RIGID. IF I TRIED TO BEND IT IN AN INSTANT FROM ITS STRAIGHT UP POSITION TO ITS NOW LEANING POSITION IT WOULD HAVE BROKEN. HOWEVER, THE SLOW INCH BY INCH LEANING THAT IT DID ON ITS OWN EVERY DAY ALLOWED IT TO MAKE A RADICAL CHANGE IN ITS POSITION OVER TIME. THE POINT HERE IS THAT RADICAL CHANGE OR ***FLEXIBILITY IS A FUNCTION OF TIME.*** *IMMEDIATE RADICAL CHANGE WOULD HAVE BROKEN THE PLANT. THE SAME IS TRUE OF BUILDING CODES AND LENDING INSTITUTIONS. WE MUST BE AWARE OF THE FACT THAT THEY ARE NOT CAPABLE OF RADICAL OVERNIGHT CHANGE. THEY WILL BREAK OR BREAK US. WE MUST ALLOW THEM TO LEAN A LITTLE MORE EVERY DAY TOWARD THE CONCEPT OF EARTHSHIPS. THE LEAN HAPPENED TO THE BANANA PLANT IN SMALL DOSES - THE EARTHSHIP MUST BE PRESENTED TO THE POWERS THAT BE IN SMALL DOSES. **

THE EASY WAY OUT

Since the Earthship does not need electricity, well water or sewers for construction or operation, remote land (which is far less expensive) is always an option. Remote land always has fewer restrictions than land right in a subdivision. Building officials always tend to be more adamant about the letter of the code in highly visible areas such as existing subdivisions, "developed estates", etc. The bottom line here is that if you choose remote land (which the Earthship concept allows) you will have an easier time with building officials. In some cases, you won't encounter them at all.

*For more on "The Art of Leaning" see A COMING OF WIZARDS, Chapter 6, by Michael Reynolds.

Since the Earthship is designed for the owner/ builder, slow "out of pocket" construction of the dwelling is possible even for the novice builder. This has already happened in many cases. Of course, you don't start with a ten thousand square foot home. To assure your own success in getting sheltered in a reasonable amount of time with "out of pocket" funding you must start with one or two "U"s, get them livable, then add on as you can.

So it stands that our first choice on how to deal with codes and bank loans is to not encounter them at all.

CHOOSE REMOTE LAND
BUILD YOUR OWN EARTHSHIP

BUILDING CODES

WHERE

If you must deal with building code officials on any level there are some pathways to follow. Remember, they will be easier to deal with in less visible locations. Avoid planned subdivisions whenever possible.

Every state follows the same Uniform Building Code. This code has a clause that allows for alternative methods "not covered in this document". It states that alternative methods must meet requirements and standards of those presented in the UBC. Your objective would, therefore, be to illustrate that Earthship construction meets and exceeds the standards put forth in the UBC. In New Mexico, this has already been done. If you plan to build in New Mexico you are home free as far as the codes and permits go.

Every state has a different policy on how approvals are handled. For example, New Mexico has a statewide policy. If something is approved by the state office it holds true all over the state. Colorado (where many Earthships have been built) has a county by county policy which means that each county has the power to interpret alternative methods as they see fit. This means that if one county approves, it does not necessarily mean that the next one will. Several counties in Colorado have approved of this concept. No one has rejected it as of this date. Some, however, have been more difficult than others to deal with. Thus the first step is to find how your state operates and then you will know where to go to present the concept.

HOW

Step One - Presenting the Concept

If your particular state or county has not already approved an Earthship, you must first present the concept. Solar Survival Press has documents and videos that will help with this. The following items will help in initially presenting the concept

to an official:

ENGINEERING REPORT - a twenty page document analyzing the structural integrity of tire walls as used in the Dennis Weaver Home in Ridgway Colorado. This document shows experiments, graphs, calculations, photographs, and conclusions which support the structural concept entirely. It was put together by a licensed engineer in Colorado.

DENNIS WEAVER VIDEO - a 30 minute color video going from the ground up on Dennis Weavers home in Colorado. It contains interviews with building inspectors, congressmen, engineers and the architect. This is a very professional video financed and executed by Dennis Weaver himself. It contains explicit graphics and structural footage.

HOW-TO VIDEO - a 30 minute color video explicitly focusing on the tire and can techniques - how to execute them and why they work.

EARTHSHIP VOLUME I - The "how - to" that presents the Earthship concept. This book is packed with evey kind of information about the concept. You can't expect a building official to read it cover to cover but skimming through it will help give the concept credibility.

Presenting the above items will introduce your building officials to the concept. This information is well presented and to the point. 95% of the time you will get a favorable reception to the concept from this information. This is all you are looking for at this point.

Step Two - Presenting Your Project

Now you must evaluate the reception that you got to your initial presentation of the concept. You determine the scope of your initial project based on this reception. If it was overwhelmingly good, you could present a reasonable sized simple "by the book Earthship" as your project that you are requesting a permit for. If the reception was somewhat skeptical then you reduce the scope of what you are asking for. The point is to not ask for too much at first. Under the worst circumstances, you may only want to ask for a demonstration permit for one "U". A demonstration permit is simply for demonstration. You do not present it as your home. You say you will use it only if they approve of it after physical observation. You may think this is risky. However, when a building inspector walks in a finished "U" in early February, feels how warm it is with no heating system and experiences the structure himself, you will have no problem in getting him to allow you to occupy it. What you are doing here is allowing an official the chance to see the concept before he

is asked to risk his job on it. You are asking small inch by inch steps (like the banana tree) of him. Rarely would a building official refuse a demonstration. This puts the risk on your shoulders not his. Officials, engineers and even skeptics have always been impressed upon actual on site observation of an Earthship "U".

The point here is to determine just how small of a"bite" to ask the inspector to swallow in this phase. It is better to have it too small that too large both for you and the inspector. One or two "U"s is a good demonstration size and can easily be evolved into phase one of your total home.

You present this demonstration as a rammed earth thermal mass dwelling - not a rubber tire house. Rammed earth is a term that many are familiar with. Earthships are in fact rammed earth. The earth is rammed in steel belted casings. This makes a rammed earth brick more durable than conventional rammed earth or adobe. Another factor of your presentation is not to mention all the other systems at first. Get approval on the structural concept of the Earthship first, then go for the systems. If you go to a building inspector and say I want build a rubber tire house with grey water, catch water, compost toilets and solar electric systems, he will definitely freak. That is just too much new stuff to lay on him all at once. You go and present the concept - get a feeling for his reception to that and then ask to build a small demonstration unit or prototype to illustrate the concept - that is all. You design this demonstration to be *phase one* of your total project. After you have structural approval, you begin with the systems.

As with the Earthship itself, your various systems will meet with less and less resistance the more remote you are.

SOLAR ELECTRICAL SYSTEM

As presented in chapter one, your Earthship will be absolutely conventionally wired. You will therefore need no special approval for solar electricity. The systems presented in chapter one are already approved by electric codes. You should have no trouble with solar electric approval if you even have to mention it.

CATCH WATER SYSTEM

The catch water system requires nothing out of the ordinary from the conventional pressure tank on. The source of your water (whether well or stream or spring or city) is not a thing that has to be approved. In terms of running water your "in-house system" is conventional and needs no approval. The catch water systems presented in chapter two use totally conventional in-house plumbing. As above, I would not even mention catch water because it doesn't effect your house

plumbing.

GREY WATER SYSTEMS

There are counties in California that have approved and advocate the use of grey water systems. This is due to existing water shortages. In view of this and the potential future water shortages in many parts of the USA, grey water systems are being allowed in many areas. Here, the best thing to do, after you have received approval to build the Earthship itself, is to present the information in chapter three to your official. They may allow it but will still make you install vents and traps. This is a small price to pay. Some areas will make you put all grey water in a tank and pump it out for later use. Some areas will not allow it at the present time. In these instances you can fight (and we will help you if possible) or you can do it the way they want but including certain fittings in certain places to allow you to valve the water where you want to yourself after the final inspection.

COMPOST TOILETS

There are places that do not allow compost toilets. This is mainly because some of the early ones were pretty bad. Presenting the new technology and possibly a demonstration to your official is the best way here. Again, do not attempt this until you have approval for your Earthship itself. The new SUNMAR compost toilets presented in chapter three actually flush and should meet approval almost everywhere. If you have trouble, contact SSA OR SUNMAR for assistance.

Remember, all these systems are minor battles compared to the approval of your Earthship itself. Do not cloud the issue (or scare your inspector) by attempting to get these approved at the same time. The plumbing is the only possible disapproval you may have on these systems and plumbing is not dealt with in an Earthship until the structure is up. After your inspector has seen that the Earthship is a very positive approach to building, you can explore the possibilities of the slightly unconventional plumbing necessary for grey water and compost toilets.

FINANCING

This is a difficult area for me because I view the savings and loan associations of the USA as neck and neck with nuclear power plants in terms of harm to the country. There is no right way to use a nuclear power plant. Likewise, there is no right way to use a savings and loan mortgage. They are a rip off. They have been managed and developed by dishonest people and everyone today (early 1990's) is aware of the condition of the S&Ls relative to mismanagement and greed. They sell the use of money at a very high price and they hold all the cards. They even control the type of house you build. My best advice is to

avoid them if at all possible.

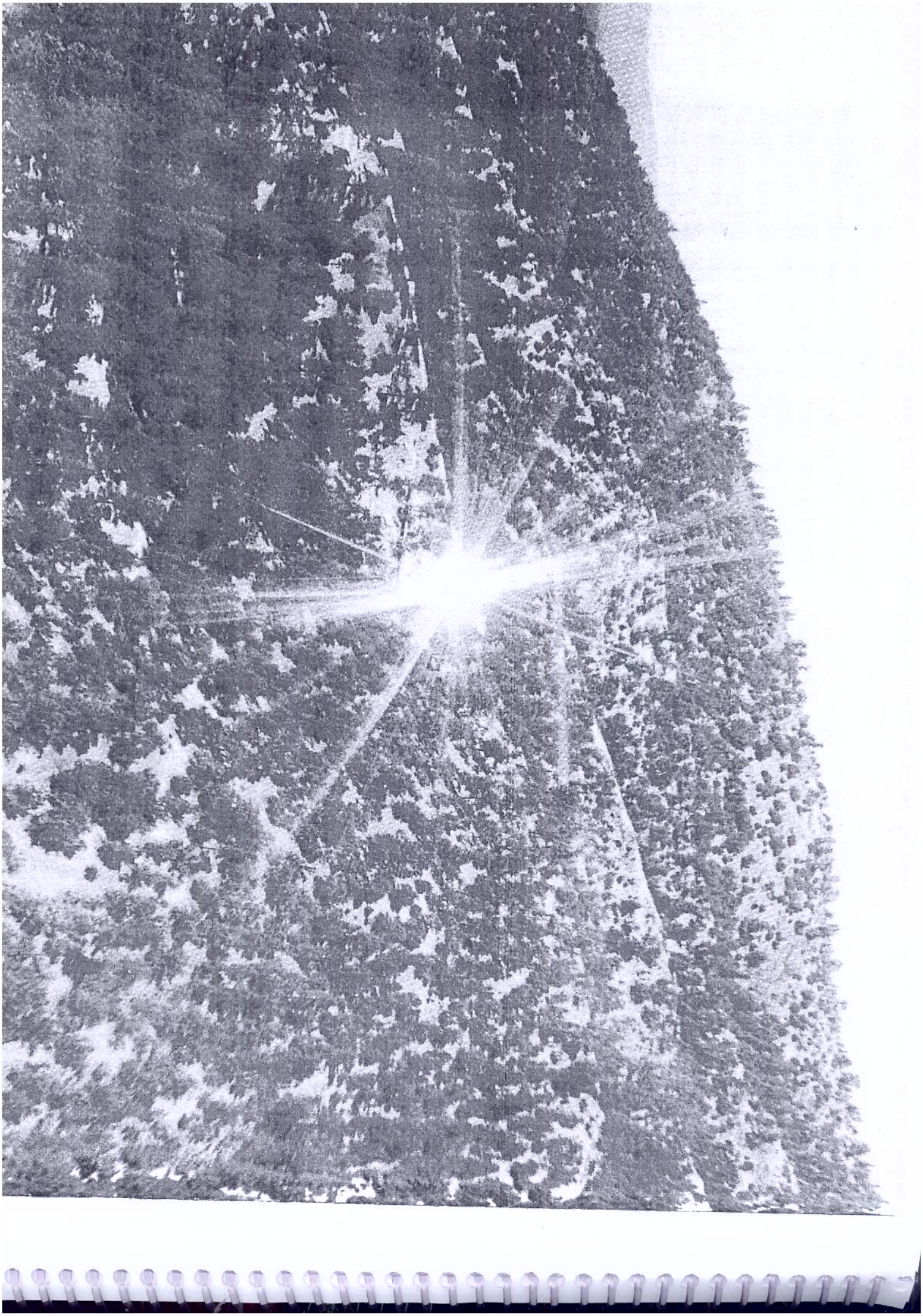
One method of avoiding them is to build slowly out of pocket. The Earthship concept does allow this and I have seen it work for many people. Obviously, there are those for whom this will not work. The next best thing is to get small business type bank loan that doesn't involve the project at hand. Another possibility is to get a second mortgage or home equity loan on your existing home. The bottom line is to try to get money any other way than an S&L loan. If these avenues don't work then you can try an S&L loan. Begin this process about one year before you want the money and use the same approach as you used on the building code officials. Be prepared to make some compromises (or deceptions) and be prepared to pay. S&Ls have loaned money on Earthships. We have had to install phony back up electric baseboard heaters to satisfy them as well as a few other ridiculous things that make them happy. Remember, present it as rammed earth and do not mention the rest of the systems at first.

There is a lending institution that has loaned and says they will continue to loan on Earthships. They have affiliates all over the country. The company name is Stanchart Mortgage Company, 3200 N Central, Albuquerque, NM. The contact name and phone number is Ray Mendoza, (505) 883-6213.

They will have certain requirements that will slightly affect your design or systems and will require a complete set of construction drawings (see last page of book). They will also require the stamp of an architect and an engineer on your construction drawings. All of this is possible, it simply involves more time and money just to get started.

It will be much easier to acquire your loan if you have a large down payment relative to the proposed cost of your Earthship. Normally, lending institutions only loan 60% to 80% of the proposed price of the project. If you have more than 20% as a down payment, it will look much better for you.

Another requirement you can expect is the use of a licensed contractor to build the project. This will obviously add 15% to 20% to the cost of the project for his fee, unless you can make a deal with him to just be the "figure head" and let you build it. You might even need him for some conventional construction advice. Using a licensed contractor for a "figure head" and consultant involves a much smaller fee and is often the best way to go. If you do have a contractor build your Earthship, you should have him attend a Solar Survival Seminar on how to build Earthships (see last page of this book).



EPILOGUE

The information presented in Earthship Vol I and Earthship Vol II is not the final word. It is the beginning of a journey. In a world where a healthy economy has become more important than a healthy planet and healthy people, we have found that it is time to leave the place where we are. When you are in a burning building and you see a way out, you don't sit down and decide where you are going. You take the way out and survive, then you are in a position to think about where to go. This is the purpose of the EARTHSHIP concept. It is a way out of the "fire" of modern civilization. There are definite improvements and evolutions of various aspects of the concept that are and will be developing, however **the "boat" floats now.**

We have developed a small prototype community called **REACH - Rural Earthship Alternative Community Habitat.** This is a community of EARTHSHIPS that is **being built** with the same solar power systems that are going to provide electricity for living.. It is also **being built** with the same catch water systems that are going to provide water for living. There is no sewage system that dumps into nearby streams as all the buildings deal with their own waste individually via grey water and compost toilet systems. There is no actual "sale for profit" of land. This community is emerging free of all centralized systems that support conventional housing and feed the economic dinosaur that carries us as it consumes us.

The process of construction uses much more power and water than simply living. If we can *build* with these systems, we can certainly *live* with them. Most housing developments spend hundreds of thousands of dollars on infrastructure (sewage, water, gas and power systems to the houses) before the housing can even begin. Land has to be sold at a tremendous profit to finance this (as well as to make the developers a fortune). The **REACH** project broke ground on the first EARTHSHIP the very day we closed the deal on the land. We needed no infrastructure, no power lines, no wells, no sewers as the EARTHSHIP itself *is* its own infrastructure. The last few months of working on this project have shown us that the "boat" really does float and it will take us anywhere on Earth without leaving a trail of devastation behind. We/you can build EARTHSHIPS and/or communities anywhere you can drive a four wheel drive truck. This opens up some of the most beautiful places on the planet where land is not "valuable" because there is no

power or water. We don't need power and water because we get them free from the sky. The journey has begun.

Currently, it is the dependency on centralized conventional utility systems that keeps us from journeying further with our housing. This same kind of "systems dependency" also keeps us from journeying further with our thinking. We have become stationary creatures with regard to our concept of living. This is very dangerous because the unarguable world around us is constantly evolving. We must be mobile enough both mentally and physically to evolve with it. The EARTHSHIP concept provides this mobility physically. That is the beginning of the journey. Mental, emotional and spiritual evolution follows once we are in a physical position to allow it. Our current "stressed out" method of living based on a **hollow economic Wizard of Oz** keeps us running for the dollar. The dollar is just a piece of paper.

The EARTHSHIP concept is meant to place shelter and a less stressful method of living within the immediate grasp of people. If land is made available for no profit; if shelter can be obtained with little or no mortgage payment; if utilities come free from the sky; if much of our food can be grown in our homes; people will become more mobile with their thinking. They will begin to have time to think of each other and the planet. Peace on Earth will no longer be a dream, it will simply be a result of the way we live.

Michael E. Reynolds

Other books by MICHAEL REYNOLDS

Earthship Volume I, Solar Survival Press
A Coming of Wizards, High Mesa Press

Both available from Solar Survival Architecture

The objective of the Earthship books is to make the concepts we have developed over the years available to people who want an alternative to what we call "living" today on this planet. These concepts have been presented in a very simplified manner. In some cases, more information and/or consultation will be needed by the readers. SSA has many services available to fulfill this need. These services range from full architectural service to architectural consultation and guidance to hands-on seminars throughout the spring, summer and fall of 1992. Due to the numbers of people wanting further Earthship information, all consultation and guidance must be by phone appointment and seminar applicants must make reservations as far in advance as possible. Generic construction drawings are also available for acquiring building permits. These drawings work with any generic floor plans from one to four bedrooms. Owner customized floor plans will also work with these generic plans if generic Earthship concepts are followed.

The information presented in Earthship Volumes I and II has been recently developed and will obviously evolve over the coming months and years. Let us know if you are interested in a newsletter to keep you updated on Earthship evolutions.

SSA is also developing whole communities of Earthships which will offer finished and partly finished Earthships for sale, rent, or lease, as well as guidance programs for building your own Earthship and land parcels for building on. Land in these communities is not sold. Building sites are made available on a membership basis. Write to us for a packet of information on one of the Earthship communities. These information packets will include site surveys, explanations on the structure of the communities, membership fees, objectives, photographs, legal documents for membership association, etc. They will cost $10.

As with any other "build your own" concepts, the execution of the ideas in this book is subject to your own level of competence. These methods have been successful for SSA and show promise of evolving even further. We wish you luck in using them and thank you for your interest in them, however, we cannot be responsible for any applications of any methods put forth in this book unless they are executed under the direct supervision of Solar Survival Architecture.