3. WASTE WATER
S Y S T E M S

WITH THE GIVEN FACT THAT WATER IS BECOMING MORE AND MORE PRECIOUS DUE TO CARELESS CONSUMPTION, CONTAMINATION, AND SHEER NUMBERS OF HUMANS ON THE PLANET, WE MUST TOTALLY RETHINK WHAT WE DO WITH WASTE WATER. THE TRUTH IS THERE WILL BE NO SUCH THING AS *WASTE WATER*.

THIS CHAPTER WILL COVER METHODS AND CONCEPTS INVOLVED IN RECAPTURING AND REUSING ALL DOMESTIC WATER THAT IS USED IN THE DWELLING.

We are beginning to see on this planet that everything we "discard" has a value. Waste is not even a relevant issue with plants and animals. Everything is reused, transformed, or gives birth to something else as it dies. This is the frame of mind we must adopt as we decide what we do with our water after we have used it once.

Again we will start with an analysis of what we have been doing in our existing houses.

PRELIMINARY WASTE WATER ANALYSIS

BLACK WATER - TOILETS

Existing housing has two types of waste water - **black water** and **grey water**. Black water is from the toilets and needs treatment of some kind before it can be delivered back to the earth. Grey water is from everything else, sinks, tubs, showers, washing machines etc. If care is taken to use reasonably environmentally safe soaps, detergents etc, this water can (with designed control) be delivered immediately back into the earth both inside and outside the dwelling.

As discussed in the previous chapter, *using less* water makes both the effort of acquiring domestic water and dealing with "waste water" a smaller project. Thus **the first choice on how to deal with black water is to use compost toilets and therefore have no black water to deal with.**

Existing housing dumps all the black water (five gallons a flush) into the same sewage system or septic tank that the reusable grey water goes into. The result is a dozen times more black water to deal with than you had initially with just the toilet. Consequently we have massive sewage systems for even the smallest of towns. Individual homes have so much sewage that codes require they be on at least an acre of land for them to have their own septic system. This still requires soil percolation tests and EPA supervision to try to keep pollution of ground water to a minimum. In view of these facts, if you must have black water, **the first step toward dealing with it is to separate it from the grey water.** When black water is separate and low flush toilets that require a quart to a gallon of water are used, we are left with a much smaller amount of black water to deal with.

As the numbers of people continue to grow we must continue to reduce the "per capita black water volume". With black water down to a fraction of what a normal household would normally produce, the size and impact of the septic or sewage system can be greatly reduced. Septic tanks will be discussed later in the chapter.

GREY WATER

All other waste water can be reused immediately without treatment if a designed method is established. One rule of thumb is to **treat all the different sources of grey water (the tub/shower, the sink, the washing machine etc.) as separate entities so you won't have a large quantity of grey water in any one place.** A typical household gangs up all the grey water mixes it with the black water and has a big black water mess to deal with. The existing "solution" is to put it under the ground. Most of this "waste" that we put under ground is exactly what our plants (both inside and outside) would love to "eat". *We throw away nutrients for our plants in underground sewage systems. We do this in such a way that pollutes underground water tables. Then we buy manufactured "nutrients" for our plants which aren't as good as what we threw away.* This is modern day waste water technology.

The Kitchen Sink

In one of my early experimental Earthships I drained my kitchen sink in to its' own individual *inside* planter. I put a little ten inch tall $2.98 split leaf philodendron in the planter. Within a couple of years the plant became a fifteen foot tall tree with an 8" diameter trunk with seed pods and other weird things I have never seen on a philodendron before. This plant is so healthy and strong from the "food" produced by the kitchen sink that no bug or disease could touch it . It is a *being*.

The kitchen sink in a normal household probably swallows everything from Drano to Clorox to turpentine. **It is also the collector of a tremendous amount of organic matter.** The first step here is to stop putting anything down your kitchen sink that you know would be harmful to plants. Garbage disposals (in addition to increasing your electrical demand) allow the potential for all kinds of things to be ground up and washed down the drain. They should be not be used in an Earthship with a grey water system. Most dish soaps are designed to be good for your hands so, consequently, they are also ok for plants. Small amounts of dish soap mixed with water as a spray deters inside planting pests such as white flies. However, the key to dealing with pests is to have strong healthy plants fed by grey water. *No bug would even think about bothering my philodendron*

All food stuffs, drinkable liquids, and dish water are welcome food for a kitchen sink planter. Specific methods of developing a kitchen sink planter will be discussed later. The issue here is that **the kitchen sink be dealt with as a producer of strong plant food and individually drained into its own planter.** There is no need for vents and traps as the building codes demand. This is true because vents and traps are for blocking and venting sewer gases - a simple open drain sink into a planter *has no gas* . In most cases we have still had to put them in even though they are not needed because *the Code said so.* However, we are currently working on a research and development project involving several buildings which will be allowed to pursue these ideas with code variances for a limited time. The result here will be a method of dealing with kitchen sink "waste" water that is cheaper than conventional methods, that makes good food for plants, and that results in less sewage for *whatever* system to deal with.

Bathroom Sinks

Conventional use of bathroom sinks involves things like shaving for ten minutes with the water running which is simply a waste of water. Even with this careless use, the bathroom sink is still a minor water and nutrient producer with less chance for strange things to be poured down it than a kitchen sink. Much of the same information regarding kitchen sinks is also true for bathroom sinks with respect to what you should and should not put down them if you want to use them for watering a planter. They are normally trapped and vented and drained into a sewage or septic system which is a waste of some perfectly good grey water that could very easily be used for watering plants. Bathroom sinks could be an easy contributor to indoor plant watering.

Showers and Tubs
Conventional tubs and showers are major producers of large volumes of water. This large volume of water is usually mixed right in with the black water and is one of the major reasons we have so much raw sewage to deal with in conventional housing. As discussed in Chapter Two, this volume can and should be cut way down, however the potential volume of water here usually requires that the grey water be taken to an outside planter. The various soaps and shampoos are not harmful (if anything, helpful) to plants and they love the oils and grime that you wash off of your body. Whereas showers and tubs present a major burden on conventional sewage and septic systems, they could be a major contributor to the watering and nurturing of outside landscaping.

Washing Machines
Normally, washing machines are a serious source of some of the weirder water produced by a household because of bleaches, strong detergents etc. In a normal septic system, these liquids are responsible for seriously retarding if not destroying the effect of the anaerobic process that is supposed to take place in a septic tank. Some of the liquids we put down our drains actually kill the bacteria that are supposed to be working. The result is that the septic system does not produce a sludge that is welcomed back to the earth. It produces a vile sludge that is not welcomed anywhere. Washing machines are normally vented and trapped and are a major contributor to the volume of a septic system. They could, however, be open drained into a controlled exterior grey water planting area. This assumes that environmentally safe detergents and bleaches are used.

Dishwashers
Dishwashers use electricity and a large volume of water both hot and cold. The result is taxing on four systems - electrical, sewage, water, and hot water. This raises a question - is a dish washer worth it? They can be made to work on all these systems but they will make every system a bit more expensive to put into operation. *There are differing opinions on whether a dishwasher uses more water or not. If the dishwashing person is conscious of his/her water use, he/she could easily use less water than the machine. This, in addition to their electrical demand, makes this one of the items to consider dropping from your appliance list.* If a dishwasher is incorporated into an Earthship design it should be used only occasionally if you really want to sail without effort and with minimal initial investment in an Earthship. The best advice is to not use a dishwashing machine.

All of this grey water together is a significant amount even if one is being conservative with the use of water. **Why do we throw this water away?** Not only is it water, it contains free nutrients for our plants. Throwing it away creates volume problems for our various "modern" sewage systems. Then we have to use more water to water our plants both inside and outside. Also it costs more money to throw it away than to use it. How did this happen?

THE BASICS OF BLACK AND GREY WATER SYSTEMS

As with the other chapters, we will not cover ground in the following explanations that is common knowledge to conventional plumbers and various technicians or that is already available in various plumbing manuals etc. We are attempting to put forth concepts and methods that are here-to-fore little understood and little known (if known at all) for dealing with black and grey water. The actual execution of these methods involves nothing that is not already commonly practiced by conventional plumbers, builders etc.

COMPOST TOILETS

There are two types of compost toilets. The most simple and least expensive is the self-contained unit that composts right where it sets. It is vented like a stove. You add peat moss daily to help "prime the pump" for the composting process. You take a tray of peat moss material out every month. This material can be put right on the ground surface. The new models (see Appendix, Chapter 3) work very well and don't smell. However, as insurance, always put them in their own compartment with a door and an operable skylight (see Chapter 8 for gravity operated skylights). If you think of this unit as an isolated, vented, "indoor outhouse" you won't be disappointed. They cost about $1200 and almost nothing to install.

There are also flush type compost toilets that flush like an airplane toilet with a pedal. They flush into a compost unit placed below the dwelling. (This composting unit also requires the addition of peat moss daily if you are home and using it and emptying the tray of "soil" monthly.) The fact that it is not in the living space is attractive to many people. It costs about $1400 for the unit itself, plus $1000 to install and requires a composting space below the dwelling. One compost unit will handle two toilets with proper maintenance. We have combined the compost room with the battery room (discussed in Chapter 1) and this works quite well.

The appendix to Chapter Three presents information on how to acquire compost toilets and how to review their performance before you purchase one. This remains the first choice as to how to deal with black water - **don't have any in the first place.** This is the least expensive and most environmentally appropriate way to go. If (for whatever reason) you can't go this way then your best choice is to use a septic tank for black water only.

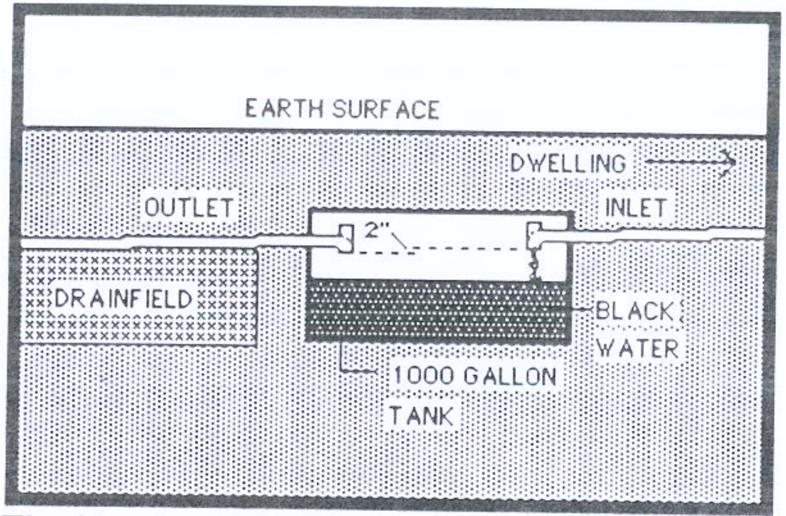
SEPTIC TANKS

If your toilet(s) is the only thing going into your septic tank, (and it should be) your septic tank and drain field can be very small even with a conventional "waste flush" toilet. With a low flush toilet, the septic tank can be even smaller. Since this concept (like most environmentally appropriate issues) is not even considered in the "real" world, there are no small septic tanks on the market and chances are the codes wouldn't let you use one anyway. Building codes determine the size of a septic tank based on the size of the house. They also require a minimum lot size - (usually) an acre for a septic system. These code requirements are based on the following:

1. Standard wasteful consumption of water by most households.
2. The common practice of mixing useful grey water with black water.
3. The very existence of black water.
4. The common practice of dumping toxic fluids "down the drain".

These are considered "givens" by the building codes.There is no way for the codes to relate to the person who has only a minimal amount of black water to deal with and who uses grey water systems. Common practice would therefore be to make you use a typical 1000 gallon septic tank with a forty foot drain field on one acre of land to the tune of $1500 to $2000 not to mention the fact that you have to have enough land to accommodate it. These code dilemmas will be discussed further in another chapter. Suffice it to say for now that we are talking here about "OUTLAW SEPTIC TANKS" that break code only because code is not evolved enough to apply.

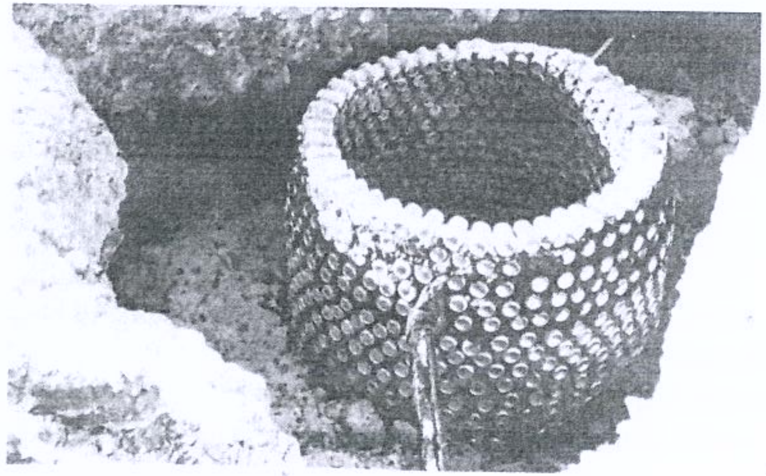
The basic idea of a septic tank is to have an underground tank (in this case a very small one) that has an inlet and an outlet. The inlet is the black water coming from your dwelling in a 3" plastic ABS pipe sloped at 1/4" per foot. The outlet is simply the same size pipe with the same slope installed on the other side of the tank. This pipe however, is 2" lower. The pipes have a sweeping "T" on the ends to direct the water down and to protect the pipes from floating debris should the water level get that high.



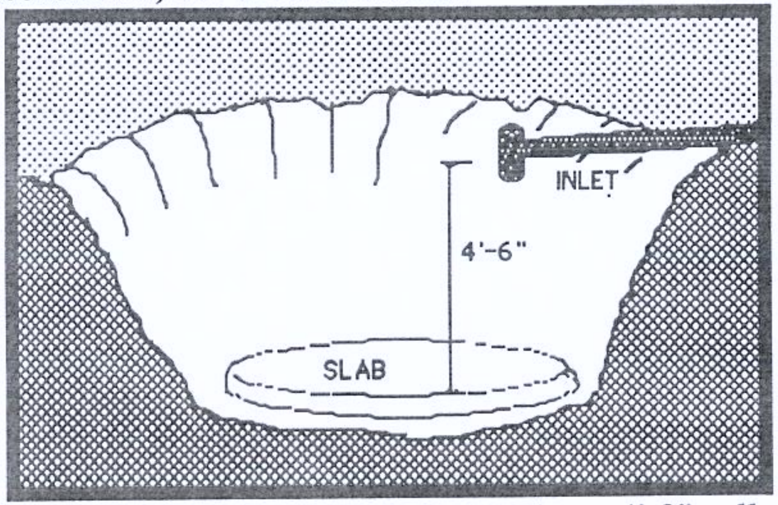
The idea here is to store the black water in the tank for a period of time (as long as it takes to fill up the tank). This allows all the solids and paper to turn into a thicker liquid sludge and begin an anaerobic process with natural bacteria. When the tank fills up with this sludge the liquid begins to move out the lower pipe and into a drainfield for distribution back to the soil. Normally the drainfield, like the tank, is sized very large (40' or more) due to the tremendous volume caused by the ridiculous practice of mixing black water with immediately reusable grey water.

Except for the ridiculous volume, this was a reasonably sound concept before Drano, Clorox, turpentine and other things began to be poured down our drains. These liquids kill the natural bacteria which turns the sludge into a natural earth product welcomed back into the soil. So what we end up with here is a really vile sludge not welcomed in the earth or anywhere else. Code is designed to make sure this bad stuff is kept under ground where the nice humans are safe from it. It is already a given in most rural areas that the first level of water is contaminated by septic systems, consequently wells all have to go much deeper (at greater expense) to second water. It is the massive **volume** and the Drano, etc. that makes septic systems such a problem. A simple little one or two toilet black water septic tank with no harmful fluids flushed down would not require a full acre of land and the fluids would be welcomed back to the land as a natural product.

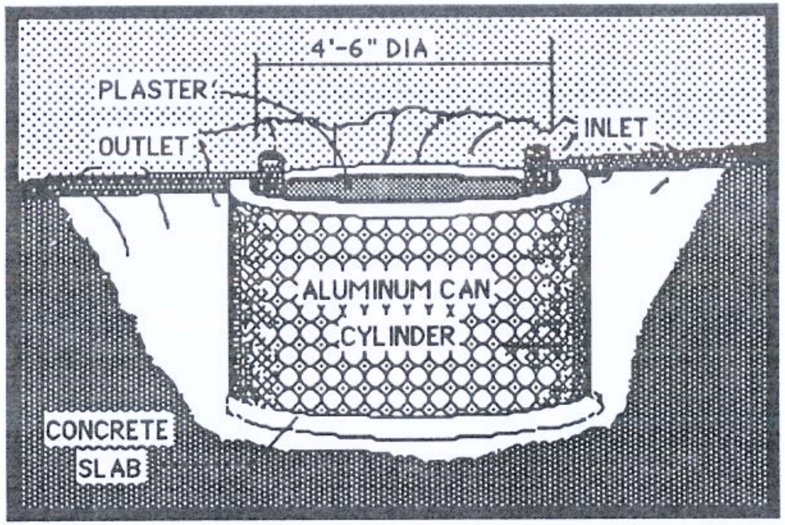
Outlaw Septic I



This is simply a small dome made of aluminum cans set on a typical concrete slab. Chapter 9 covers the process of making domes, vaults, etc. out of aluminum cans. For one low-flush toilet the tank only needs to be about 4'-6" in diameter on the inside. For two toilets make it 5'-0" in diameter. The first step is to pour a conventional concrete slab about 4'-6" below where your outlet is coming out of your dwelling. This should be about ten feet from the house. The slab should be 5'-6" (or 6'-0" for the larger size) in diameter to allow for the thickness of the aluminum cans. It should have conventional re-mesh or structural fibers (consult a local contractor) for reinforcement.



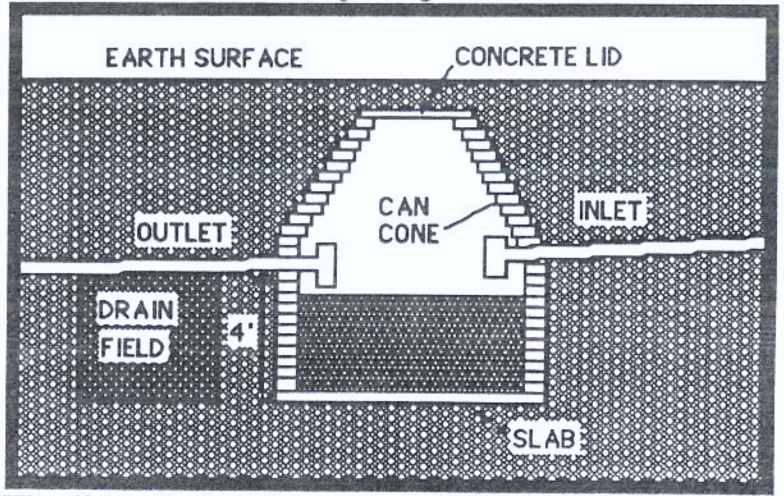
Lay up a can masonry cylinder about 4'-0" tall. (see Chapter 9).



At this point bring in your inlet and outlet. Make sure the <u>outlet is 2" below the inlet</u> and that both have 1/4" per foot slopes. Lock them in with a few more courses of cans to make sure they will not move now that you have them positioned. These cans can be slightly pulled in toward the center to begin the "cone" roof of the tank.

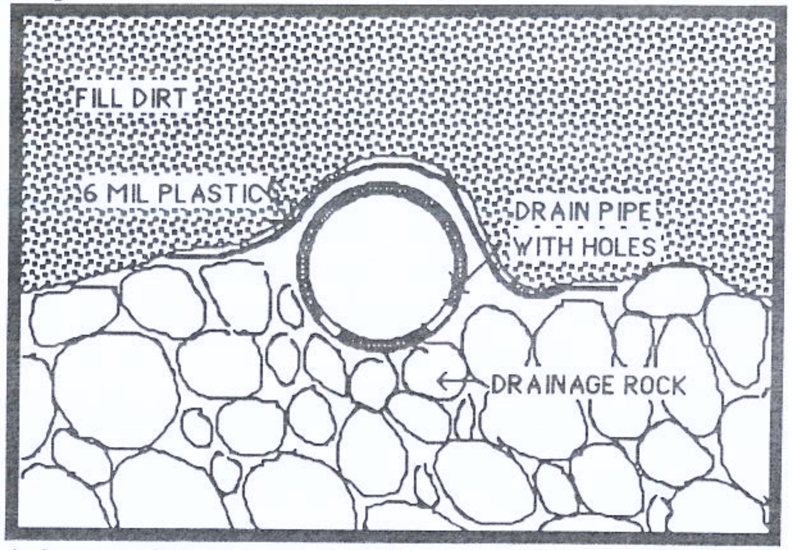
Now you are ready to plaster the inside so the tank will hold water. First a scratch coat then a smooth troweled coat of conventional hard plaster mix. The formula for this is one part cement to three parts plaster sand with water as necessary.

Next you begin laying the cone all the way up by pulling the cans in toward the center about 1/2" per course. The cone is tapered in to a 2'-0" diameter opening at the top which is then covered with a concrete lid made by pouring some concrete out of a wheel barrow over a 2'-0" circle of 6x6 reinforcing mesh and shaping it by hand or with a trowel into the desired circle. This disc should be a little larger than the opening so it can rest on the tapering can wall of the cone.



The lid will facilitate clean out which is a typical feature of all septic tanks although seldom ever needed in a "toilet only" septic tank. This lid can be buried under about 6" to 8" of soil.

This septic tank like all septic tanks has a drain field to distribute the processed fluid back into the earth. The difference here is that instead of a forty foot drain field you only need about a ten or twelve foot drain field. The drain field should be a trench about four feet deeper than the position at which the outlet leaves the septic tank and twelve to fourteen feet long. Fill the trench up with typical drainage rock which is 2" to 8" in diameter. Attach a ten or twelve foot length of 3" drainage pipe to the outlet with a plastic couple. The drainage pipe has two sets of holes that are to be placed down toward the rock.



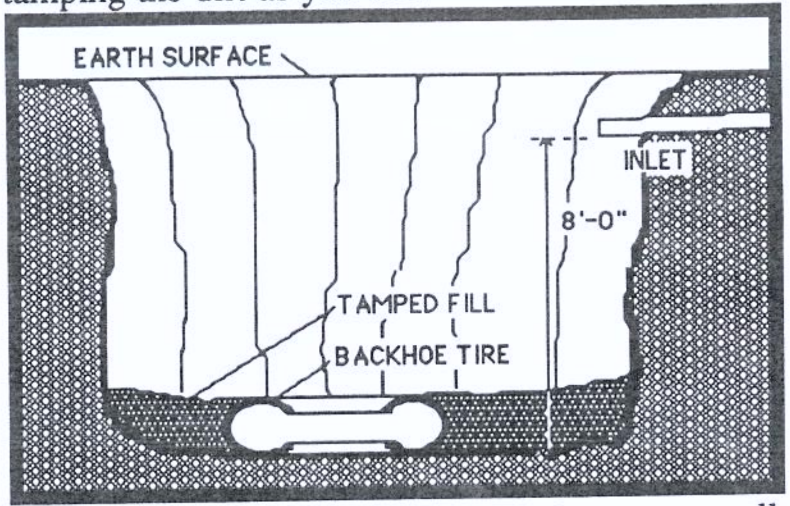
A layer of 6 mil plastic is usually placed over this to keep backfill dirt from seeping down into the gravel. This drain field is done exactly like that for a conventional septic tank if you wish to consult a local septic tank contractor. It is simply much shorter due to the fact that you are dealing with a significantly smaller volume of liquid.

The only real difference between this septic system and a conventional septic system is size and consequently cost. This method enables the home owner him/herself to install the septic system as opposed to having to pay a septic tank contractor to install his smallest system (to the tune of about $2000) which is much larger than you need for just a toilet. This system is absolutely to code. It is just on a smaller scale. A reasonable inspector should allow this system if he will allow the rest of your fixtures to be on their own grey water system.

Outlaw Septic II

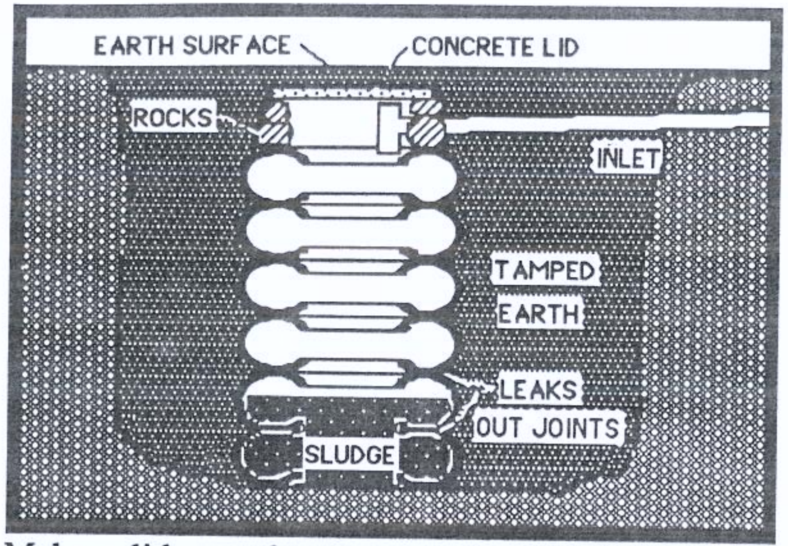
This system is one step above an outhouse. It simply allows you to have your toilet inside. The little bit of water used in a low flush toilet helps to create a sludge as opposed to just having a stack of shit like outhouses do. *Don't even ask an inspector to approve of this system.* This design is for more rural areas where inspection is not an issue. It is, however, a great way to get a flush toilet working on a minimum budget. I have used it many times. It is both easy and economical and can be installed in one afternoon. If used only for a low-flush toilet, it is perfectly harmless to the underground. A concentrated accumulation of human shit will simply turn into rich soil under ground if it is not carried all over the place with huge volumes of water, Drano and paint thinner, etc. This system is for a toilet (preferably low-flush) only. All other grey water should be dealt with separately.

The 3" inlet from the dwelling is conventional from the toilet. In this design, the tank and drainfield are the same thing. **This is possible only if the low flush toilet is the only fixture emptying into the system.** Dig a hole with a backhoe about eight to ten feet deeper than the position of the outlet coming from the dwelling. This hole should be about eight feet square. Collect about six or eight old discarded **backhoe tires.** Lay one on the leveled bottom of the hole and fill loose dirt around it lightly tamping the dirt as you fill.



Now add another tire and repeat the process all the way up to your inlet.

If you do not come out exactly where your inlet (with its appropriate slope) will lay on the last tire, make up the difference with rocks. Rocks will also have to be used to circle the top course of tires in order to incorporate the 3" plastic inlet thus leaving a level circle to receive the concrete lid.



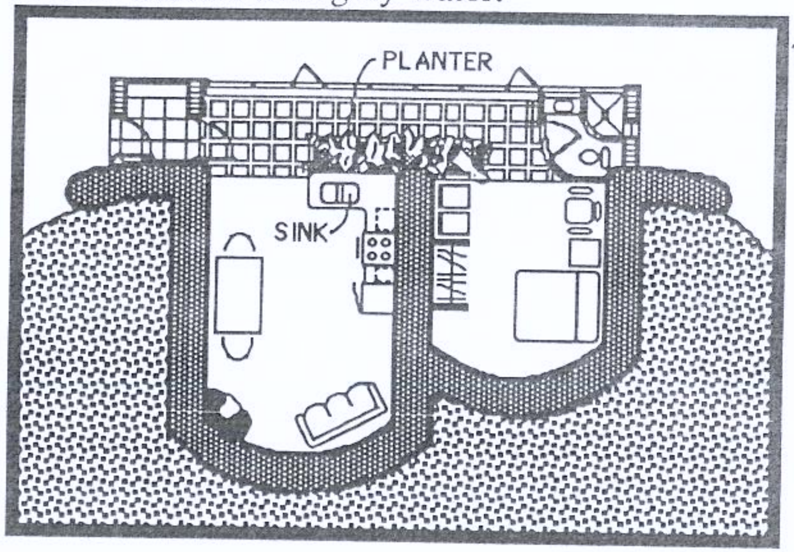
Make a lid out of a disc of concrete as described before in Outlaw Septic Tank I and install it over the circle of rocks. Bury this lid only about 6" deep and you have a septic tank/outhouse with the stool inside. In this case what little bit of sludge there is will penetrate the joints between the tires and return to the earth immediately around the unit. Due to the small amount of water content which creates a sludge, one toilet will never fill a drainfield/tank combination like this. The price is about $300 max. and you can begin flushing.

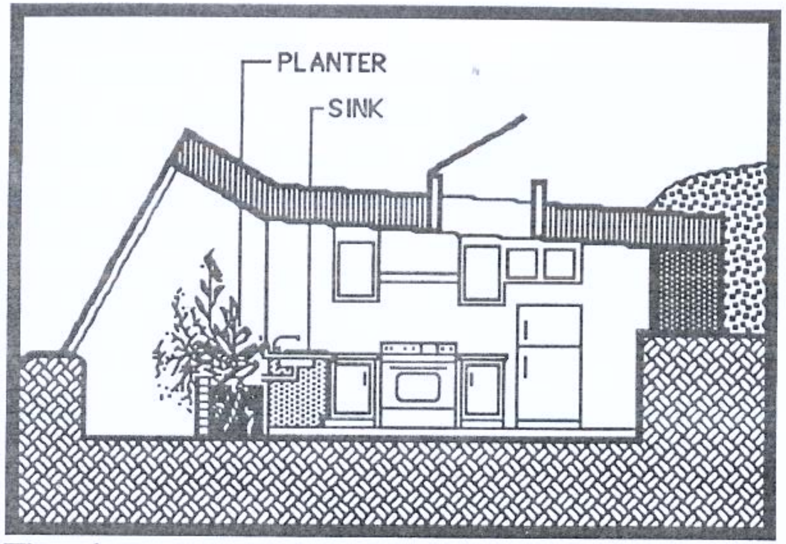
GREY WATER

Kitchen Sinks

The kitchen sink gets used every day and has the potential for producing significant amounts of highly nutritious grey water. The sink can be simply elbowed and clear drained without a trap or a vent into a nearby planter. The pipe going to the planter should be 2" ABS drain pipe with 1/4" per foot slope.

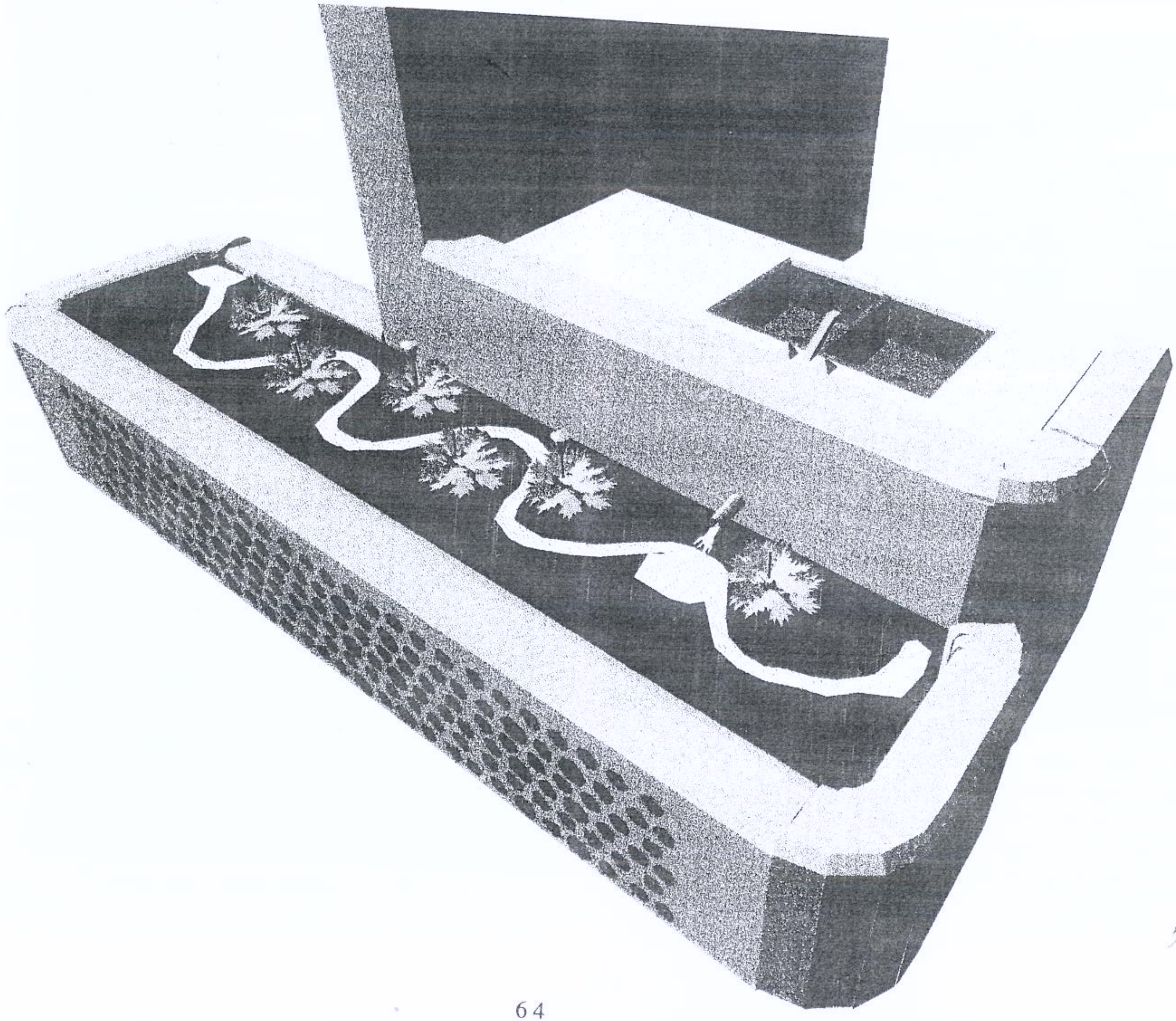
Since Earthships are so conducive to the interior growing of plants the planter can be located almost anywhere. Obviously more options are available in a multilevel Earthship than in a dwelling all on one level. Following is an example of an interior planter positioned to receive kitchen sink grey water.





The planter should not be less than 20 square feet in surface area with a foot of top soil and a foot of gravel beneath the top soil. The pipe should be open to the planter so the water *falls* a few inches into the planter and is then irrigated around in it via dirt trenches. Do not have the pipe go under the ground into the soil of the planter. This will make it so you need a trap as you will be trapping grey water gases. Sometimes the drain pipe is split so it will run part way down both directions of the planter to further distribute the water before it falls to the dirt.

Kitchen sinks are best for watering small trees and large plants. Be prepared for anything you plant in this planter to get *very large*. Small ground cover type plants should not be used alone here as they are not large enough to absorb the water whereas larger plants (trees, grapevines etc.) basically suck up the water as opposed to having it just stand or be absorbed into the planter soil. The success of this kind of high volume grey water planter (especially an inside one) is dependent on having a large hungry plant (or plants) to take all the nutrient rich water, quickly suck it up into limbs and branches and give it back to you as foliage, blooms and beauty. The planter also wants to be in direct sun as this will help create the need for the water.



Bathroom Sinks

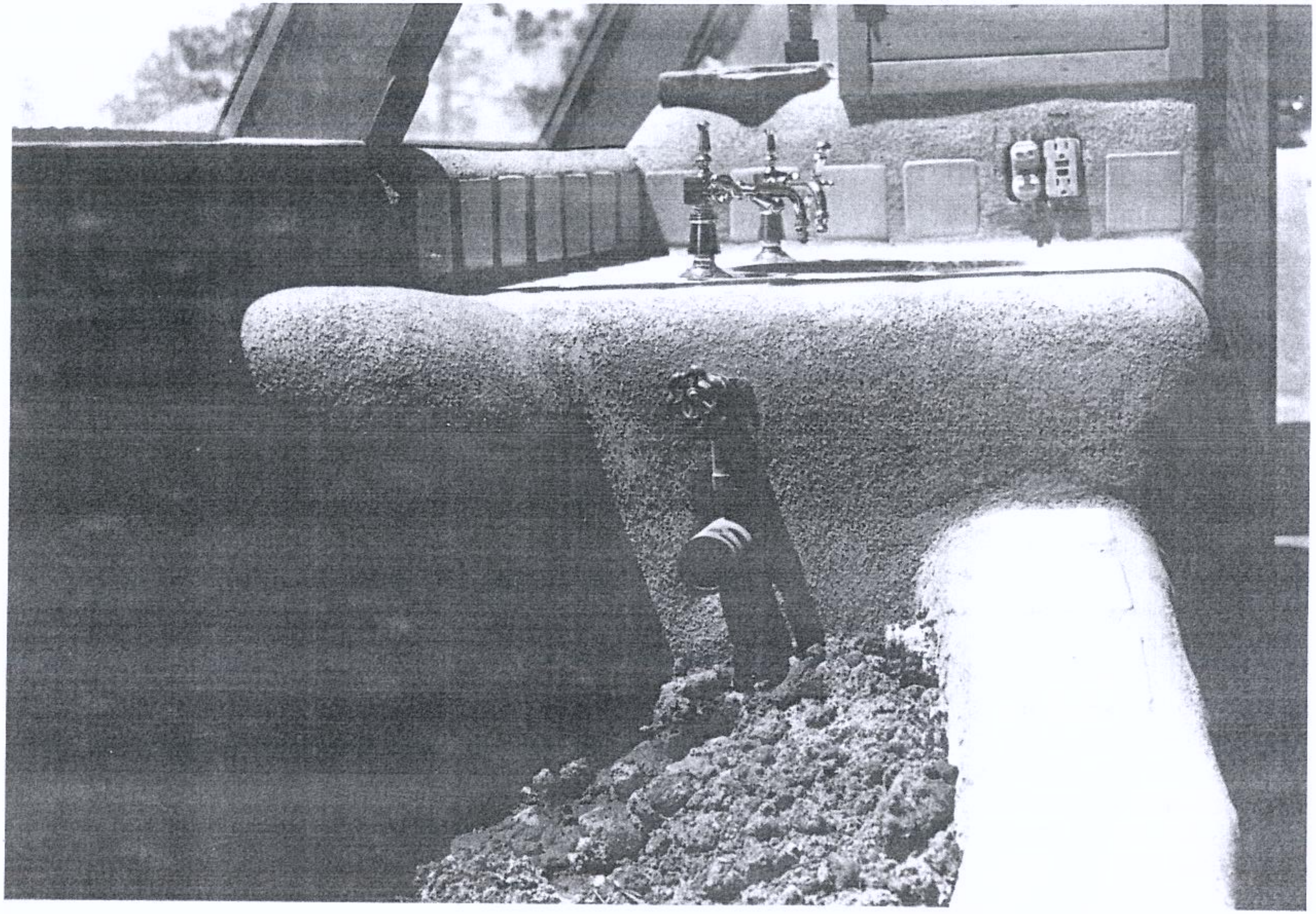
The amount of water a bathroom sink produces is much less both in volume and nutrients than a kitchen sink. You can therefore take it into almost any sized planter nearby or far away, inside or outside. You will still have to water this planter with an auxiliary water source as there is just not enough water produced by a bathroom sink to take the full load of any planter unless it is quite small- like four square feet. Once you have established a bathroom sink as a grey water supply for any planter, you can always use that sink faucet specifically for running water down the drain and watering the planter whether you are using the sink or not. This is one of the beauties of grey water systems. You are killing two birds with one stone. You don't have to put a watering hose bib in the planter because the bathroom sink (or whatever sink) is available for the sole purpose of watering the planter if need be. You are therefore saving on the installation and duplication of plumbing faucets and fixtures.

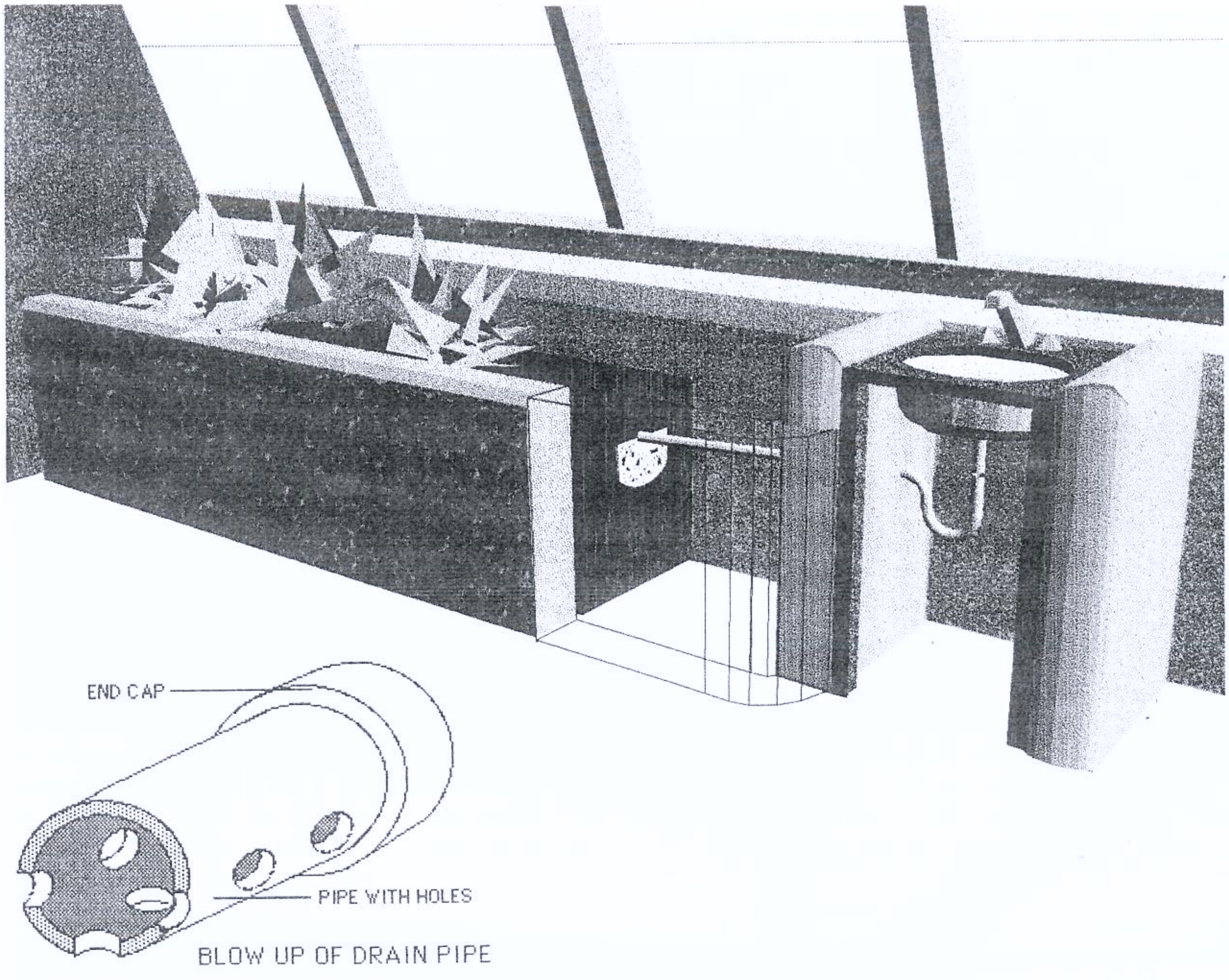
The size and slope of the pipe are the same as that described for the kitchen sink. Vents and traps are not necessary again as long as you provide an actual fall of water from an open pipe for at least four inches.

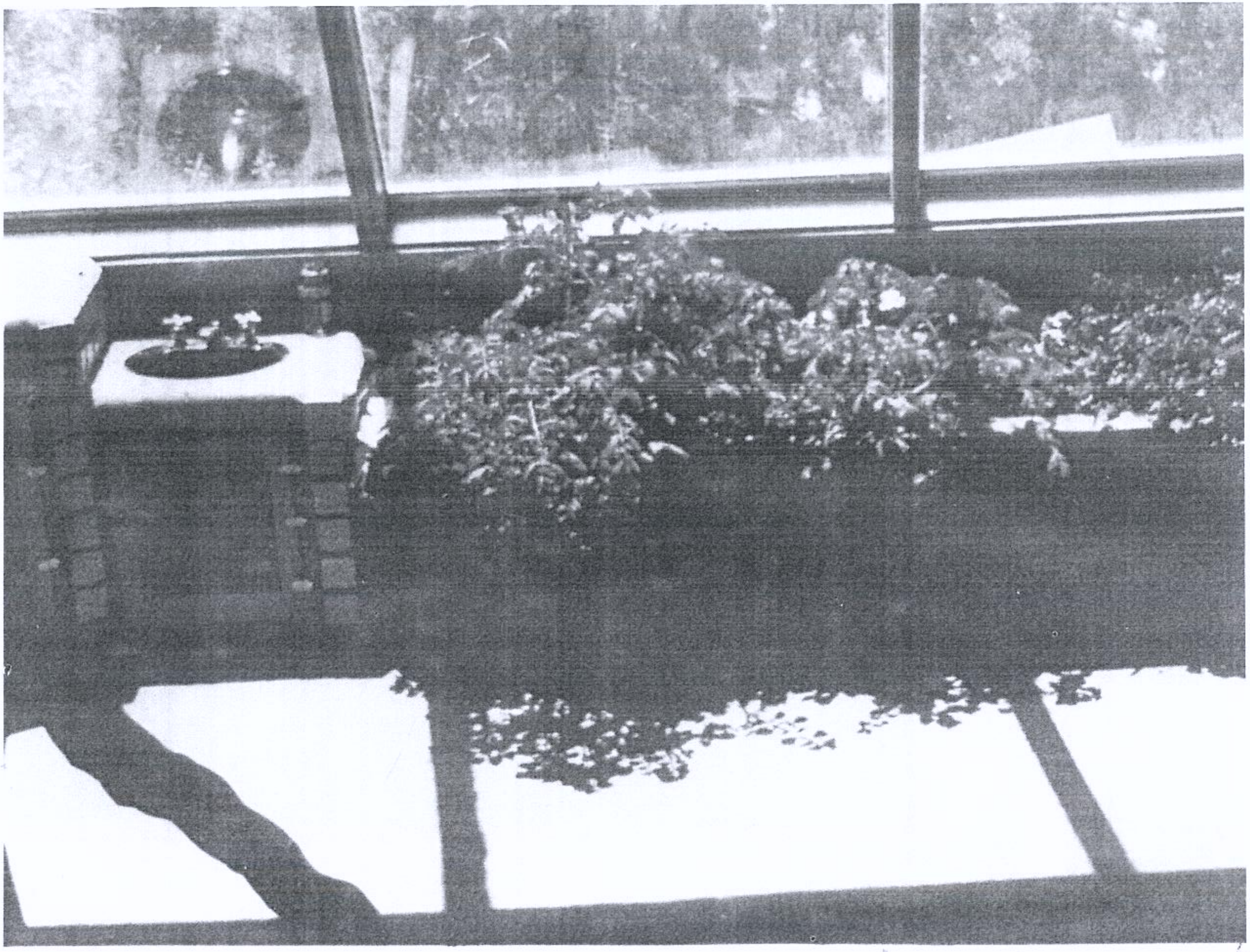
Since bathroom sinks are not usually as high as kitchen sinks, achieving a fall from the drain pipe is not always possible. In this case a mini drain field is necessary. The 2" ABS pipe comes out of the sink and lays in a bed of gravel just under the surface of the planter (4" to 6"). The pipe is drilled on both sides of the bottom with weep holes and capped on the end. This is to assure water distribution through the weep holes rather than the end.

Other than the reuse of water and the savings on plumbing fixtures another beauty of grey water systems is that you save time. You are watering you planter while you are brushing your teeth as opposed to brushing your teeth and then watering your planter. **Multiple results from one action is a way of natural phenomenon of the planet and the universe.** It is a sign of broader awareness as opposed to the single-mindedness of mice and some men.

Since the bathroom sinks usually do not handle near the volume of liquids that a kitchen sink does, nor do they have as many nutrients, they can be drained without vents and traps into almost any nearby planter. They may not even provide enough water for that planter. The point is that they will not be contributing to an under ground or municipal sewer load. Also watch what kind of mouthwash you use. Some of them may not be good for plants!




END CAP
PIPE WITH HOLES
BLOW UP OF DRAIN PIPE



Showers and Tubs

Here the volume of water is too large to keep inside unless you have an unusually large planting area. Typically tubs and showers should be detailed just like sinks with respect to pipe size and slope but they must go outside to a grey water bed of eighty square feet or more depending on the number of people using the shower or tub. A rule of thumb is that if you see standing water, your bed is not large enough. This grey water bed can be irrigated with little pathways in the dirt to carry the water to all parts of the bed. Plant things that like a lot of water such as willows, roses, or trees.

In a situation where the dwellings may be close together, the grey water bed will have to be contained in an open tank of some kind to assure that it does not run into someone else's property or terrain. This open tank can be a simple galvanized cattle watering tank or anything similar. In this situation the tank should be filled with 8" of gravel on the bottom then filled the rest of the way with soil. The quality of the soil is not too important because after you run your bath water through it for a year or so it is going to be rich. Again be sure to let the water fall clear of piping for at least 4" to avoid trapping gases or smells in your open unvented pipe.

Except for the codes, there is again no reason to vent or trap a tub or shower drain that goes outside into a grey water bed. In some cases where dwellings are close together these beds would have to be contained as described above. The issue here is that **grey water from tubs and showers be taken outside the dwelling and treated separately from everything else as their volume of water is enough for any one given spot.** Irrigation, i.e. good distribution of this water is important.

Washing Machines

Washing machines should be treated very similarly to showers and tubs. They can go into their own large grey water bed. However it is a good idea to distribute all of this free rich water to different parts of your landscaping if possible. A reason for keeping washing machines separate is that some detergents and/or bleaches you may use could be a little harsh for the plants you have planted in your bath greywater bed. It is important to remember, especially with these larger volume grey water beds, that you design, locate and plant them so they work for you and your landscaping. We are not talking about just dumping water on to the surface of the ground. We are talking about controlled and designed reuse of nutrient rich water carefully integrated in to a landscaping program.

Other Things

Floor drains, Laundry sinks, and other plumbing fixtures all fall into one of the previous categories as far as the method of drainage. The idea of separation of fixtures cannot be carried too far as this distributes the grey water to many places.

The overall effects of grey water systems are significant.

1 They reduce the cost of the building in that they ELIMINATE the need for a large commercial septic system.

2 They further reduce the cost of the building in that they ELIMINATE the need for vents traps and some plant watering SYSTEMS.

3 They provide NUTRIENTS to the landscaping both inside and out that would otherwise have to be bought and added to the soil. Commercial fertilizers often mix these nutrients with harmful chemicals.

4 They allow watering of household plants and outdoor landscaping to occur within the DAILY ROUTINE of the home owner thus saving time and/or REDUCING the need for an expensive automatic watering system.

5 They REUSE water thus greatly reducing each individual home owners personal consumption of water. *This is perhaps the most significant effect of grey water systems.*

OUR RECOMMENDATIONS

1. Use a self contained compost toilet in its own little room with a gravity operated skylight.
2. Drain your kitchen sink into a large hungry indoor planter positioned so you will get some enjoyment out of the large plants that will grow there.
3. Drain all bathroom sinks into the nearest planter to avoid piping. If your home has different levels, make the planters lower to avoid the necessity of a mini drain field.
4. Don't use a dishwasher.
5. Drain tubs and showers into well distributed exterior landscaping. Plant a tree here.
6. Drain washing machines into well distributed exterior landscaping. Plant a tree here

APPENDIX

Compost Toilets

MADE BY SUN-MAR

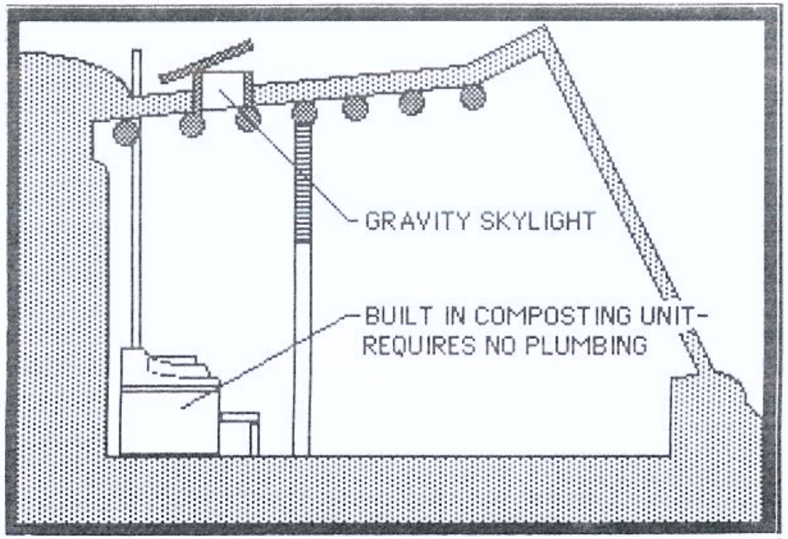
Order from SOLAR SURVIVAL ARCHITECTURE, P.O. Box 1041, Taos, New Mexico, 87571 505 758-9870

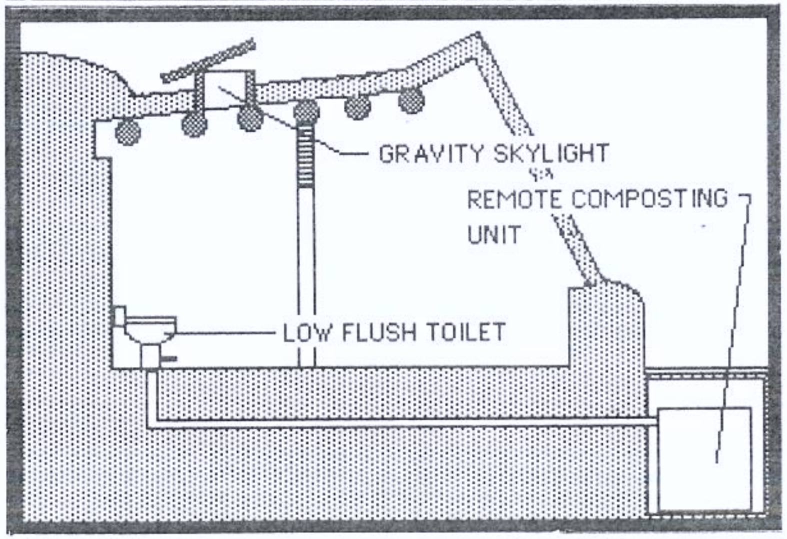
Sun-Mar makes four models of toilets. Two of these use electricity and therefore are not considered here. The other two do require the possible use of a small DC fan. This depends on the installation, location and use. The N.E. works for one to three people and is a unit that requires no plumbing. Install it in a small well vented room of its own like an enclosed toilet stall with an operable skylight above.(See Chapter 8 on Gravity Skylights). The WCM-N.E. is basically the same unit only it is remote from the bathroom and requires a SEALAND lowflush toilet. The toilet flushes like an air plane toilet and requires no vent. The remote WCM however does require a straight up 4" vent from its remote location. Three inch typical ABS plastic sewer pipe at 1/4" per foot slope connects the toilet to the composting unit. With the plumbing, the toilet and the composting unit, this is a much more expensive solution. However, because it is more like a conventional toilet, many prefer it.

Low Flush Toilets

MADE BY SEALAND

Order from SOLAR SURVIVAL ARCHITECTURE, P.O. Box 1041, Taos, New Mexico, 87571 505 758-9870





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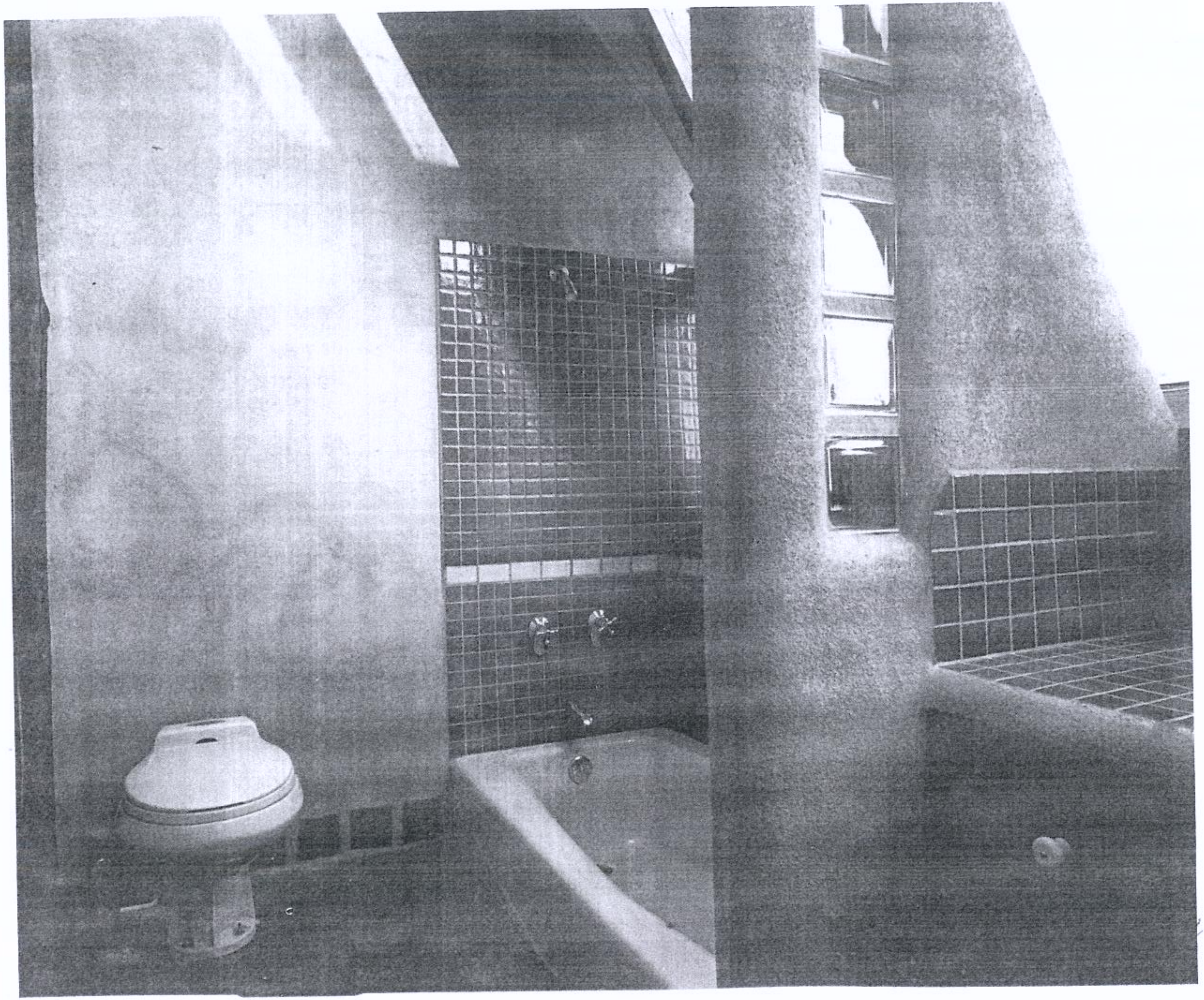


4. HOT WATER
SYSTEMS

WE HAVE GROWN ACCUSTOMED TO THE AVAILABILITY OF ALL THE HOT WATER WE CAN USE. MAYBE IT IS TIME TO LOOK AT THE REALITY OF HOW MUCH HOT WATER WE *NEED*. THE EARTHSHIP VOLUMES ARE AIMED AT SIMPLE, COMFORTABLE SURVIVAL NOT LUXURIOUS AMERICAN DECADENCE. THERE ARE MANY WAYS TO GET ENDLESS AMOUNTS OF HOT WATER FOR DOMESTIC PURPOSES. THERE ARE BUT A FEW THAT ARE BOTH ECONOMICAL AND APPROPRIATE WHEN ONE CONSIDERS THE NUMBERS OF PEOPLE AND THE CURRENT CONDITION OF THE PLANET IN TERMS OF EXTRACTED ENERGY. THEREFORE, WE WILL ONLY DISCUSS THE FEW SIMPLE METHODS OF OBTAINING HOT WATER THAT, AFTER TWENTY YEARS OF RESEARCH IN SELF-SUFFICIENT LIVING, STILL LOOK FEASIBLE BOTH ECONOMICALLY AND ECOLOGICALLY. AS WITH THE PREVIOUS CHAPTERS, WE WILL FIRST PRESENT A METHOD OF <u>FREE</u> HOT WATER PRODUCTION WHICH REQUIRES SOME PERSONAL CHANGES OF HABIT AND ATTITUDE, THEN A METHOD THAT COMES A LITTLE CLOSER TO WHAT WE ARE ACCUSTOMED TO BUT IS THE LESSER OF THE EVILS, SO TO SPEAK. AS FOR ALL THE OTHER METHODS OF OBTAINING ENDLESS AMOUNTS OF HOT WATER, THERE ARE OTHER BOOKS.

The only problem with acquiring solar hot water in the sun belt areas is *when* we need it. If we can adjust our lives to the rhythms of the natural phenomena, our problems would be few. Solar hot water is very easy to produce. It is, however, more difficult and more expensive to have *on hand* during the night or during cloudy days. It follows that solar hot water in predominantly cloudy areas is next to impossible and very expensive if it is possible at all. Therefore, we must also explore the most efficient methods of producing hot water with fossil fuels.

As with all the other household systems, our current personal requirements must be examined. The two factors involved in hot water (as well as all the other systems) are: your level of consciousness with regard to the rest of the beings on the planet and/or your level of wealth or buying power with *disregard* to the rest of the beings on the planet. For a while yet, you will be able to buy the amount of fuel you need to get as much hot water as you want, but who knows how long this will last? Will it mean the end of the last wilderness areas on the planet to get at the oil? Then again, maybe it will just mean blowing away a few Arabs and losing a few thousand American youths in the process. Having dealt with the intertwined, interrelated aspect of all systems of independent living for twenty years, I do have something to say besides the moralistic fanatical meanderings above on the subject of hot water. First lets look at how you get hot water in conventional housing.

PRELIMINARY HOT WATER ANALYSIS

Conventionally, we heat water in a tank with gas or electricity. We keep it hot and available all day and night whether we are home or not. Many homes also circulate this hot water for instant availability at the tap. Until recently the tanks that we heated up and stored our hot water in were not very well insulated. With the continuing various "alarms" relative to the unstable situation of earth energy for human consumption, we have made the *major leap* to better insulating our hot water tanks. This is not enough.

An average 75 gallon gas or electric hot water heater costs from two to five hundred dollars. This will provide hot water for a two, maybe three bedroom home. Sometimes someone may have to wait for the hot water heater to recover in order to take a shower. Operation of this hot water heater will cost from $40 to $60 a month to keep water hot depending on the current cost of gas and electricity. After a year, your hot water heater has cost you a thousand dollars and still counting - assuming gas or electricity has not doubled in price and is still available throughout the various military, economic and ecological crises we are looking at. In view of these facts lets look at a few different methods of obtaining hot water beginning with the simplest, most economical and easiest.

ALTERNATIVE OPTIONS

FOR THE FANATIC

Move to the sun belt (southwest) and use a solar batch heater. This will only give you hot water on sunny days (which is 90% of the time in the southwest) and it will be late morning before you get it. In the winter months you may only get one batch (70 gallons) a day on sunny days and in the summer you will get two batches. You will have hot water way up into the night so you are only without hot water in the early morning and on cloudy days. A batch heater can cost $1000 to $2000 depending on volume and from then on it is totally free and will last you the rest of your life. You are dependent on no fossil fuels of any kind and the only price is that you conform to the performance of the heater with your use of hot water. **All aspects of survival become very easy when we allow ourselves to follow the phenomenon rather than forcing phenomena to follow us.** There is nothing like sitting in a tub of scalding hot water knowing it was free for both you and the planet. In a large Earthship, solar batch heaters could be used over every bathroom to avoid the pumping and circulation of hot water throughout the home.

If you want to have hot water the next morning bright and early and you have a little more money to spend, drain your batch heater into a super-insulated storage tank and pump it to the tap. This obviously involves more equipment and more money and a slight bit of solar electricity, but, except for those few times (in the southwest) when there are several cloudy days in a row, you would have hot or very warm water 95% of the time.

FOR THE ENERGY CONSCIOUS

If you can't move to the sun belt and there is not enough sun where you live to make a solar batch heater practical, then a gas demand heater (these have been used in Europe for years) is the answer. These heaters heat the water in a coil as it is called for. Only a pilot burns until you turn on the tap. Then there is a burst of flame and the water is passed thru the flame in a copper coil. The flame remains on, heating the water in the coil as long as you have the tap on. You never run out of hot water and you don't waste fuel keeping a tank full of hot water when you are not at home or not using it. You only heat what you are immediately using and then the unit is off. There are many brands of these "on demand" heaters but the Paloma (see Appendix, Chapter 4) is, so far, the most trouble free (and most expensive) I have found. The others cost less but you spend more than the difference very soon in parts, replacements, adjustments etc. This is a very simple concept in hot water heating and it doesn't involve any pumps, tanks, etc. They do, however, require that the water pass through a good in-line filter *before* the hot water heater as the coils can get clogged with particles or burnt off impurities in the water. The filter type can be determined by a water test. See your local plumber for information on how and where to get your water tested. Your plumber can usually then sell you the filter you need. (See Appendix, Chapter 4).

These heaters cost in the neighborhood of $800 and will work for a one bathroom home. Two bathrooms require two heaters. Generally speaking, they cost about fifteen dollars a month to operate in a one bathroom home with 1991 gas prices. They work off of propane or natural gas. There are various sizes, a smaller one for an efficiency apartment or a single person and a larger size for more people or bathrooms. However, in a large home with two or three bathrooms, the best use of these heaters is to put a medium sized one at each bathroom as the larger units (sized for more output) use more gas. Another factor here is the inefficiency (both in terms of water and energy) and the wait when the hot water heater is not close to the fixtures it services. In very large homes the use of an "on demand " heater near each bathroom and maybe a shared one for kitchen and utility is the best way to avoid a *hot water system* with pumps, circulation, storage and the use of electricity.

THE COMBO

For the best of both worlds, a combination solar batch heater and demand heater can work very well. There are many levels of execution of this combination. The most simple being a solar batch heater independent of the demand heater with a valve to choose one or the other depending on the availability of the solar hot water. This is obviously more expensive than one or the other but it gives you the security of hot water whenever you want it and the advantage of *free hot water* when it is available. In the sun belt this can cut the hot water heating expense by 75% as you only use gas when there is no sun or in early morning.

There is also the more complicated possibility of a solar batch heater and insulated storage tank used separately or in conjunction with a demand heater. The batch heater (or warmed water in the storage tank) can be used as a preheater for the demand heater thus enabling you to use less gas to heat the water already warmed by the batch heater as opposed to heating cold water straight from a well. This situation calls for a different brand of demand heater - the Aquastar - which allows the already warmed water to use less gas to take it the rest of the way up to what you would call hot. The Paloma does not have this feature. It takes the same amount of gas no matter what the temperature of the water coming through.

OTHER OPTIONS

There is an intense solar heater that is a step up from a custom batch heater - a convection heat storage unit.* It is a plate type intense collector with a built-in insulated tank. This unit uses convection (the movement of hot water upward) to move the water from heater to tank. Neither pumps nor electricity are necessary. This unit will work where a batch heater won't because the intense collector heats a small amount of water that is constantly rising to the tank. Obviously a smaller amount of water is easier to heat with less sun. This unit is expensive but it is one of the few alternatives in areas outside the "sunbelt" if solar hot water is desired. There is also a relatively new device called the Copper Cricket* which can heat the water in your existing hot water heater. It costs over $2000 plus some installation expenses. It works without any pumps or electricity and is also a recommended alternative.

There are many intense plate and tube collectors (see Appendix, Chapter 4) on the market which heat smaller amounts of water faster and hotter. These require an insulated storage tank to store the water which is pumped with electricity to the tap from the storage tank. These are *systems* which require electricity and they are expensive both in terms of materials and installation as they have many components.

The best *tank* gas hot water heater on the market is the "Nautilus". This unit has the combustion component submerged <u>in</u> the water rather than an open flame <u>under</u> the unit as a conventional *tank* gas hot water heater does. This obviously reduces the amount of energy that is wasted, however, this unit still uses the old concept of heating a tank of water and keeping it hot. They do not supply an endless quantity of hot water as a demand unit does but they have an impressive recovery time. If you want to stay with the conventional tank hot water heater, this is the way to go.

THE BOTTOM LINE

1. Re-evaluate your use of hot water in conjunction with your budget and your environmental conscience.
2. Avoid a *system* and the use of electricity to provide or circulate hot water.
3. Be willing to spend more money now for less money and more security later.
4. If you are unable to adapt to the availability of the sun for hot water production at this point in your life and are on a limited

*1 see Appendix, Chapter 4

budget, use a Paloma "on demand" hot water heater.

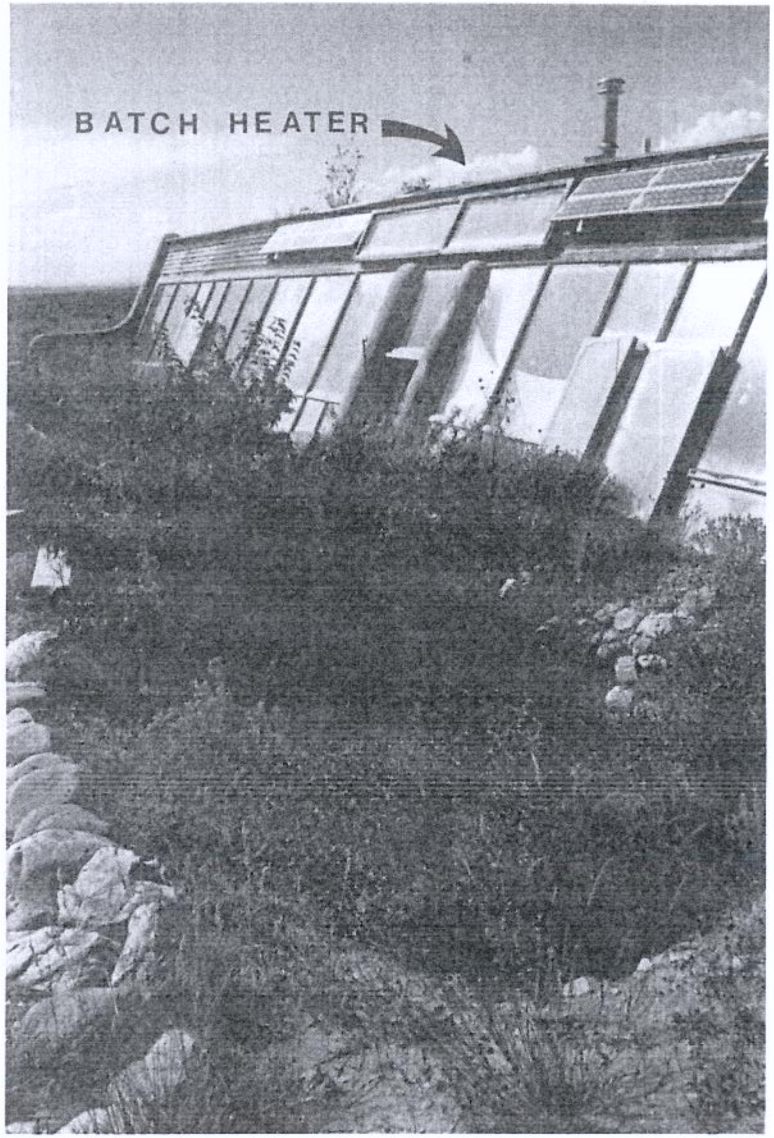
5. If you can adjust your lifestyle, are on a limited budget and want to be free, use a solar batch heater.
6. If you can adjust your life-style and are not on such a tight budget, use a solar batch heater with a storage tank or in combination with an "on demand" heater.
7. Large home and tight budget = two or more "on demand" heaters.
8. Large home and loose budget = combo of "on demand" heaters and solar batch heaters strategically placed.
9. Loose budget/fanatic/true believer in the sun belt = solar batch heater (or heaters) with super-insulated storage tank (or tanks).
10. Loose budget/fanatic/true believer outside the sun belt = convection heater storage unit.

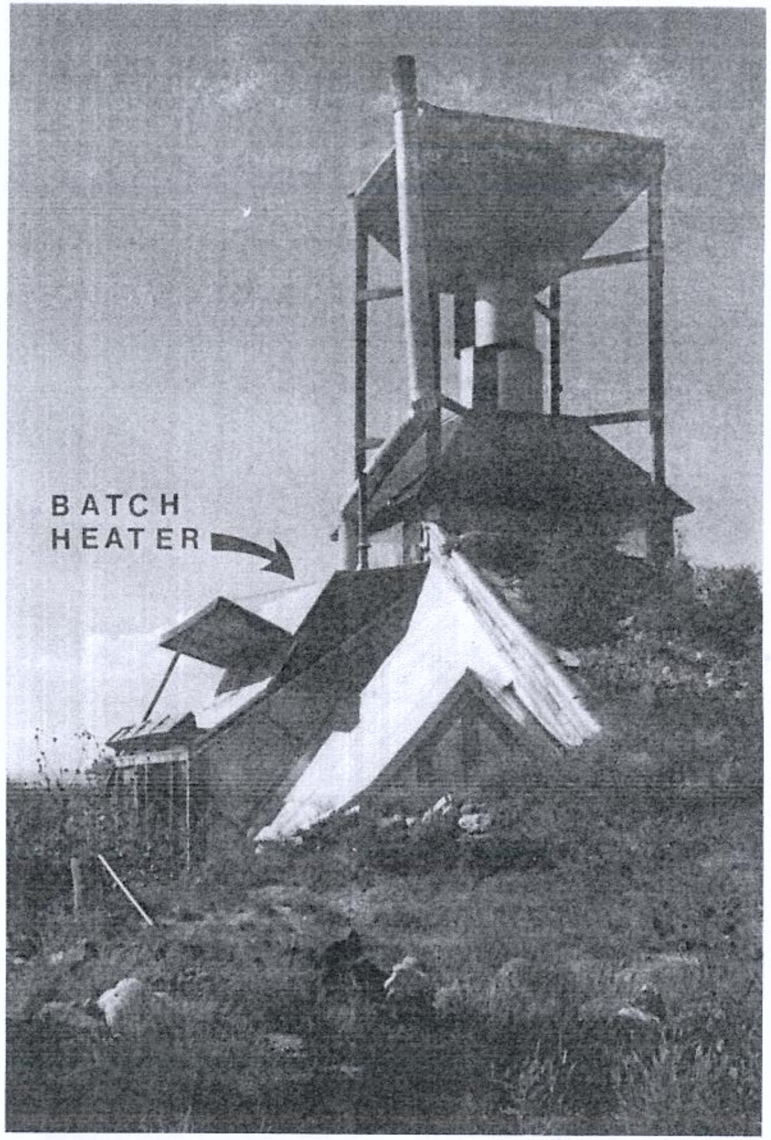
THE BASICS OF HOT WATER DEVICES

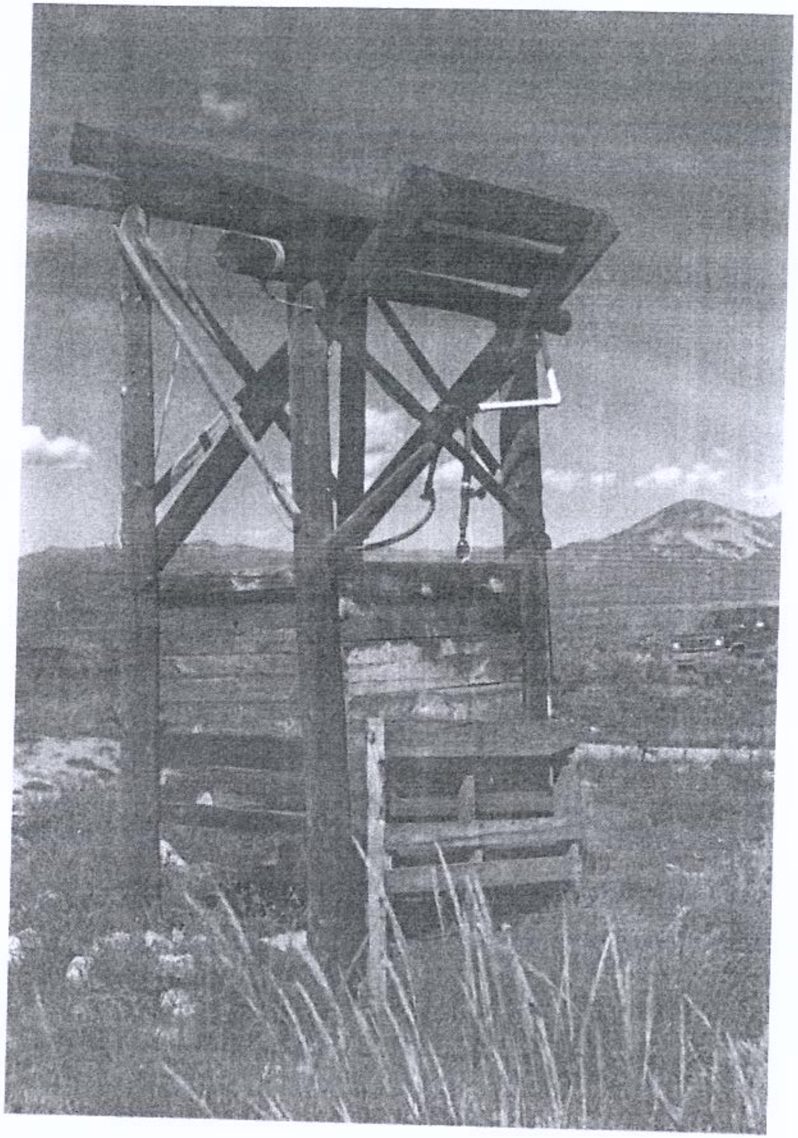
This section will explain the basic function and assembly of the methods of obtaining hot water described above.

SOLAR BATCH HEATERS

The simplest, low-tech and maintenance-free method of obtaining hot water anywhere near the sun-belt is a solar batch heater. Batch heaters are called such because they are both the heater and the storage tank for a "batch" of hot water. The tank should to be as large as possible to hold as much water as possible. The tank also has to be relatively thin so it will get the water hot enough fast enough. Other factors of size are the fact that tempered glass will have to cover the unit and since it is expensive, you don't want to have to use too large a piece (or pieces) of glass. Also, the unit is usually integrated into the profile and warmth of your Earthship in some way so it shouldn't be too tall, creating a profile of it's own. Batch heaters are seldom pressurized with your water system so they depend on gravity flow to deliver the water. A batch heater is basically a thin rectalinear tank with glass in front of it and built into your roof in some way. The following two photos illustrate two built-in batch heaters mounted high to allow gravity flow of the hot water.

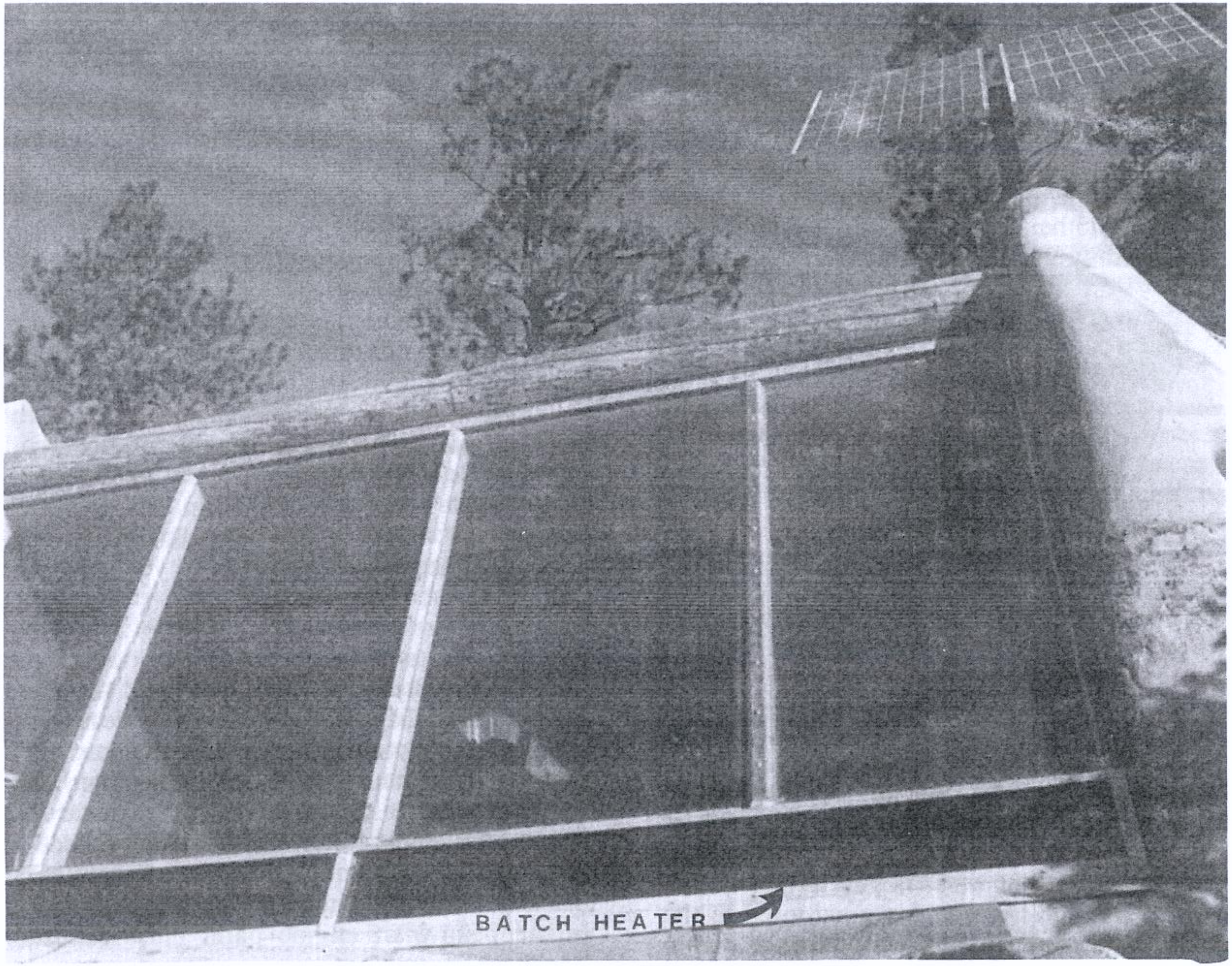

BATCH HEATER


BATCH
HEATER

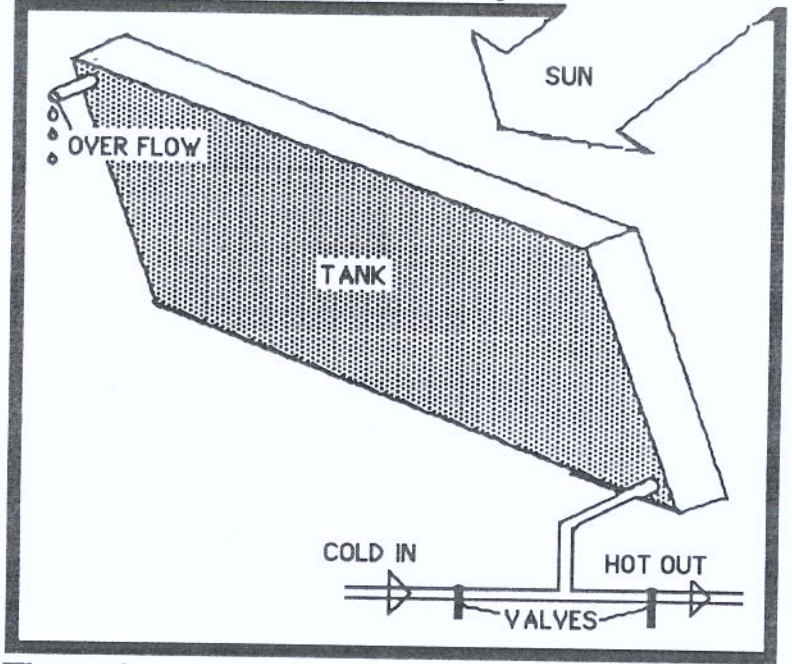


This solar shower is just a 4" thick steel tank mounted high on the outdoor shower stall itself. We fill it up untill it overflows everyday and shower in the afternoon with a view of the mountains.

The photo on the opposite page illustrates a long thin batch heater at the base of the front face windows. It is built in below the solar glass and services a space on a lower level.


BATCH HEATER

Water is pumped into the tank from below until the tank overflows (outside or into a planter). The water is then heated by the sun and allowed to flow back down the same pipe that filled it and into the hot water lines. This involves some simple valving to close off the supply of cold water to fill the tank and open the hot water (gravity fed) to the hot water taps.

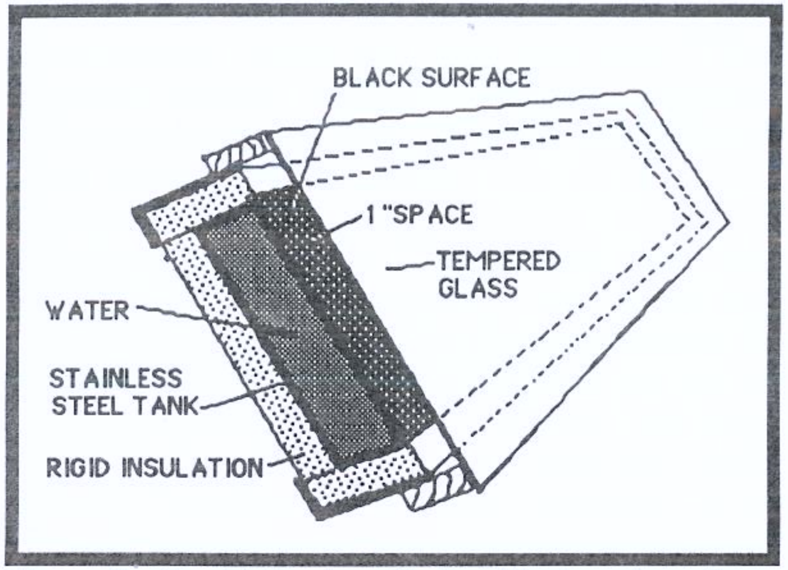


The valve arrangement shown can be located anywhere down in the dwelling. This tank is filled every morning and a few hours later (2 in the summer-4 in the winter) you have free hot water. Since the hot water is gravity fed to the taps the pressure is not very strong. This requires some custom easy flow fixtures or a mini booster pump.

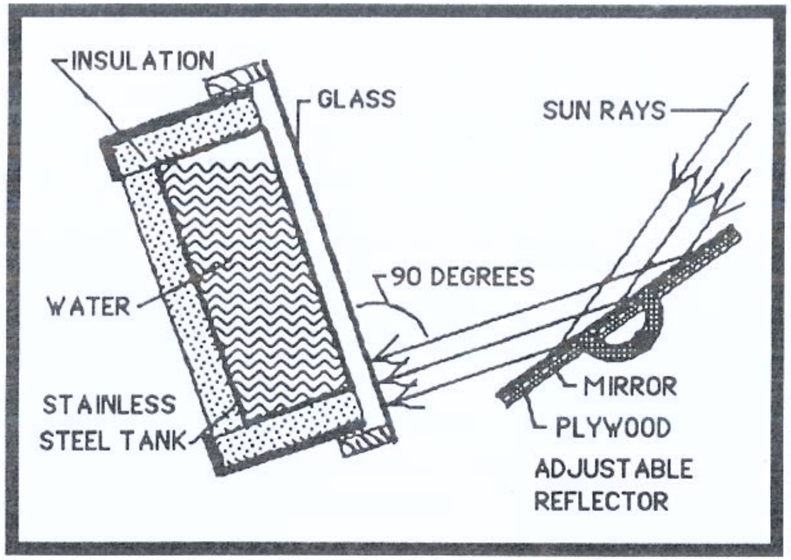
The tank itself must be made of stainless steel. Regular steel tanks eventually rust out even when they are coated on the inside. If you want it to be permanent, use stainless steel. Any welder who can weld stainless steel can make the tank to your custom size with threaded fittings to receive pipes as shown in the diagram. After considering the factors of size discussed above the tank can be any size you want. The thickness should be 4" in the sunbelt areas. A thicker tank will hold more water but it will not get hot enough fast enough. A thinner tank will not hold enough water, will cool off faster and will get actually too hot. For areas with less sun outside the sun belt, go with a thinner tank (3") so it will heat up with less sun. This will make it hold less water so you may want to increase the surface area.

The tank must be insulated on three sides and glazed on the sun side with 1/4" thick tempered glass 1" from the surface of the tank. If the glass is not tempered, it will break from the heat. If it is closer to the tank than 1", it will break anyway. The sun side of the tank must be painted flat black. The stainless steel can be lightly sanded to give it a flat (not shiny) surface to hold the flat black paint. The temperatures are extreme so furnace, stove or engine paint must be used. Regular paint will peel.

This is the basic unit and how it works.

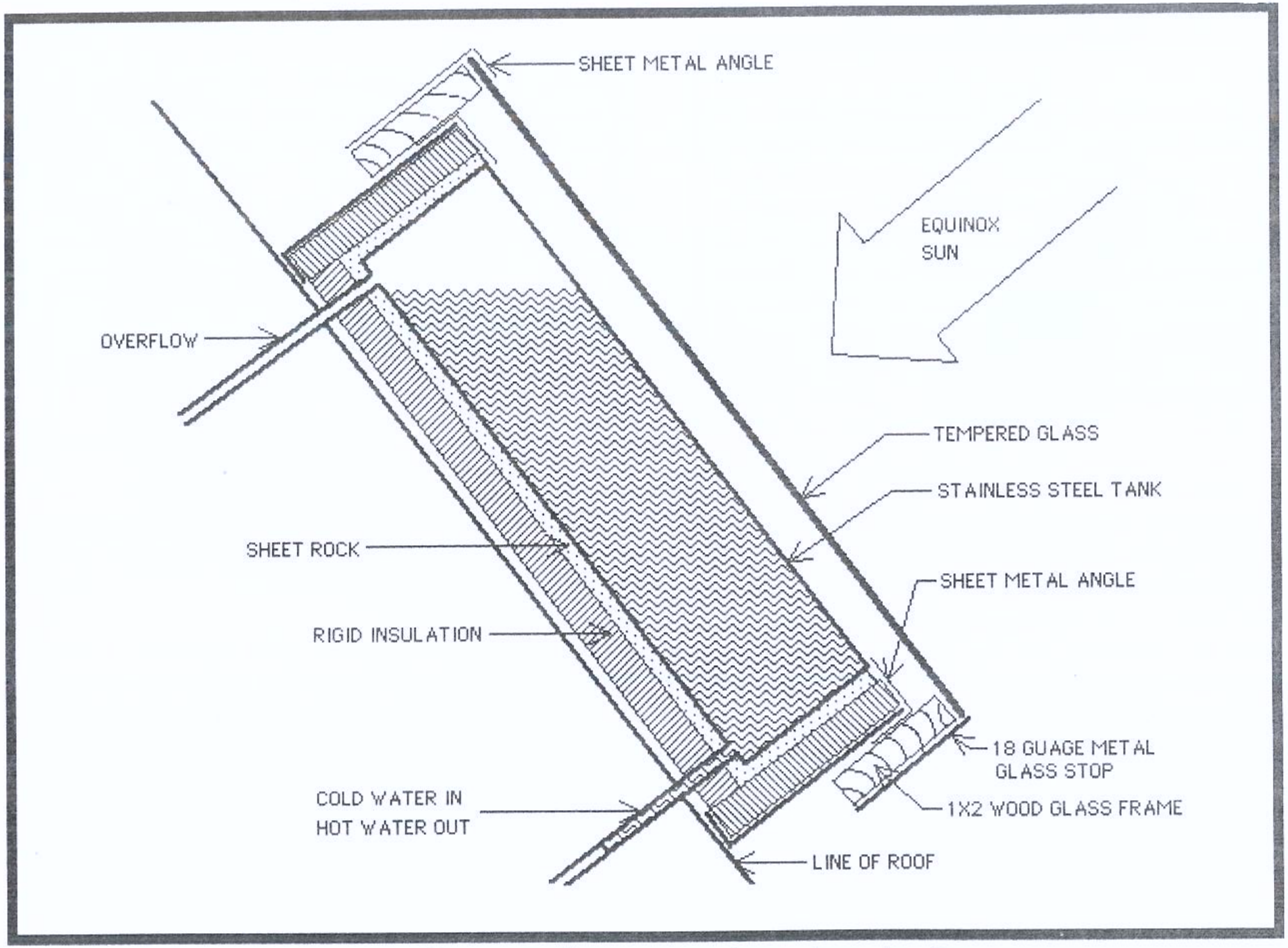


The unit should be installed with the glass face perpendicular to equinox (spring or autumn) sun. (see <u>Earthship Vol. I</u>, page 30) This will give you the best performance for the majority of the time. Ideally, for optimum performance the unit should be adjustable but the expense of doing this outweighs the added performance you get. Another option is to set the tank perpendicular to the winter solstice sun. This will give you the best winter performance. Summer performance will not be as good because the high sun will reflect off the glass. However, in the summer the water does not have to be as hot to be comfortable. In this case, reflectors as shown in the following diagram can increase summer performance.



You want the reflectors (shiny metal or mirror on plywood) to be adjustable to reflect the sun so it hits the glass at a 90 degree or perpendicular angle. The sun reflects off of a surface at the same angle it comes in.

There are many different ways to detail a batch heater and there are even some (ugly) ready-made ones on the market. The best way to go is to have your own custom tailored solar batch heater built into your house.



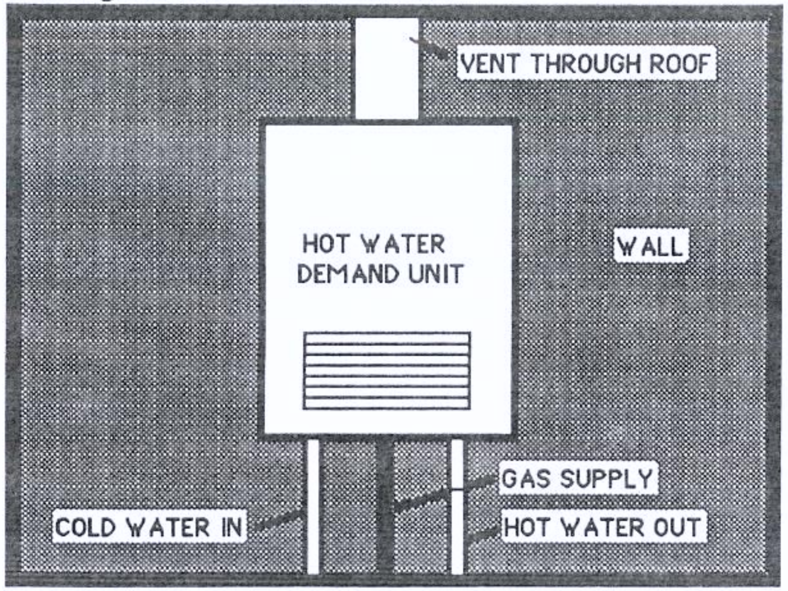
The above diagram shows actual construction detailing with a few more specifics than the previous schematics above.

Notice the layer of sheet rock between the tank and the insulation. This protects the insulation from melting when the tank gets hot. The sheetrock buffers the heat of the tank from all rigid insulation and from all wood. I have seen wood scorched by these tanks. Line the outside of the tank carefully and thoroughly with 1/2" sheetrock, making sure the stainless steel tank touches nothing but sheetrock. Also notice that the overflow is at the highest possible location on the tank. This is because it allows air to be displaced as water comes in. Without this your water pressure would blow the tank up like a balloon. Locate this overflow someplace very visible (preferably over a planter) so you can see when your tank is filled.

Ideal locations for batch heaters are high on the roof immediately above places where the hot water will be used. If the budget allows, it is ideal to have one over each bathroom. It is best to locate them in such a way (built into the roof) that the supply (water in and out) pipe never has to go outside. This will avoid any freezing problems in the pipe lines and keep detailing simple.

GAS *DEMAND* HOT WATER HEATERS

These heaters are wall mounted and take up very little space. They are roughly 18" wide, 13" deep, and 36" high. They must be located where they can be easily vented through the roof with a 6" double walled vent which takes a hole about 8" in diameter. They are usually mounted about three to four feet off of the floor. Cold water and the gas supply come in at the bottom and hot water goes out at the bottom.

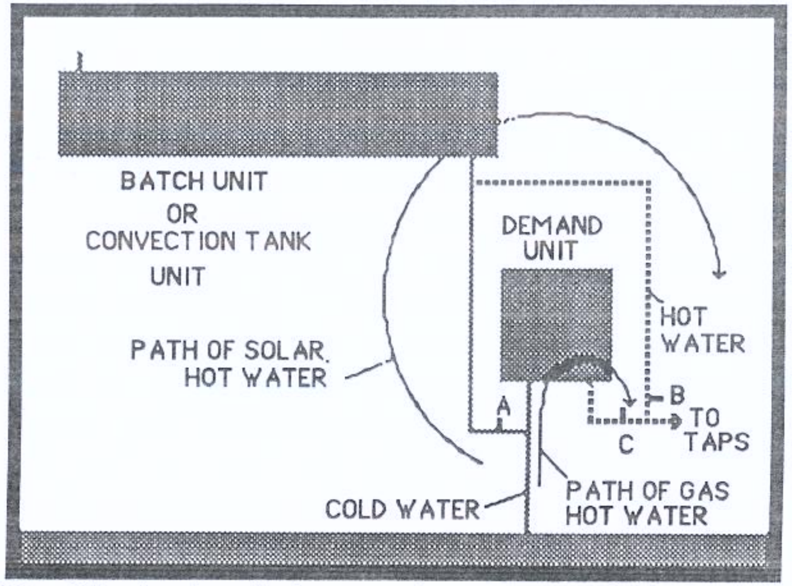


These units should be placed as near to the fixtures they will be servicing as possible. This will keep the time it takes to get hot water at the tap to a minimum. Remember, **the average sized demand unit allows you to use only one faucet at a time**, i.e. you can't take a shower while someone is washing dishes.

Due to their small size, demand units are easy to locate in the dwelling, however they must be allowed to get adequate combustion air. This means they can't be shut up in a tight closet. If they are in a small room or closet, the door must have louvers to let in air. Sometimes a dampered air vent (from the roof or through the wall) near the heater is necessary as some dwellings are so tight they don't allow enough combustion air for the flames. Most Earthships are vented so well in the summer *and* the winter that this is not necessary.

THE COMBO

The best of both worlds is the "combo" which is an ideal hot water system. It gives you free hot water from your batch heater when the sun allows. If you need hot water when there is no sun, you have your gas demand unit to provide it. The only drawback here is that you are essentially paying for two units. The total price here would be around $2500. The simplest way to set up this system is as two individual sources of hot water valved into the same line to the taps.



To fill the batch heater (every morning), open valve A and close B&C. When the tank is full close valve A. It remains closed during the use of both units, i.e. valve A is only opened to fill the batch tank. To use the batch heater, open valve B and close C. To use the demand heater, open valve C and close B. This gives you solar hot water whenever it is available and an unlimited supply of gas heated hot water when solar is not available. When no hot water is called for, a small pilot light burns. In homes with many bathrooms, you would want one of these systems for every two bathrooms or, if you can afford it, one for every bathroom. You can share one of these systems between kitchen and utility or kitchen and one seldom used bath.

This combo could also be used the same way with the convector tank unit instead of the batch heater for areas out of the sun-belt where a batch heater won't work. Hot water is very fun to use when you know it is free.

RECOMMENDATION

All things considered, our recommendation is to install a Paloma "on demand" gas hot water heater and to plumb for the addition of a batch heater or a convection heat storage unit. Install the batch heater or convection heat storage unit when you can afford it. This method will give you the most efficient, immediate and reliable fossil fueled hot water and provide you with the option of having free hot water when you can afford the luxury of the second system.

APPENDIX

Gas Demand Hot Water Heaters Made by Paloma

Order from SSA
Box 1041, Taos, NM 87571
(505) 758-9870
These units come in many sizes. The most common size is PH-16M-DP. This will work very well for one bath and a kitchen. There is a smaller size for an efficiency or studio structure and a larger size that will service two bathrooms. Be advised that the larger size uses more gas and should not be used unless absolutely necessary. We recommend a smaller unit at each bathroom.

Gas Tank Hot Water Heaters Made by Nautilus

Order from SSA
Box 1041, Taos, NM 87571
(505) 758-9870
These units range in size from 40 to 114 gallons.

Convection Heat Storage Unit

These are not easy to obtain. A limited supply is available from SSA. These are units at a good price from a company that went out of business. Other companies are making them (more expensive) and we are in the process of obtaining a dealership. Order from SSA.
Box 1041, Taos, NM 87571
(505) 758-9870

Big Fin Made by ZomeWorks

Order from Zomeworks
1810 2nd Street, Santa Fe, NM
(505) 983-6929
This device requires a storage tank and pumps but can be mounted inside the solar face of the Earthship in the greenhouse, hallway heating duct. This allows it to work year round without freezing.

Copper Cricket Made by Sage Advance Corporation
Order from SSA
Box 1041, Taos, NM 87571
(505) 758-9870
This unit uses an existing gas hot water heater tank as a storage unit. It needs no pumps or electricity but installation in a new Earthship requires the use and and installation of a used hot water heater tank. Installed and working, it will cost you over $3000.

Filters Made by Mountain Filtration System
Order from SSA
Box 1041, Taos, NM 87571
(505) 758-9870
Send water sample to determine what type of filter you need to protect your gas demand hot water heater. This filter goes in right before the Paloma unit and may be in addition to your catch water filter described in Chapter 2.

5. LIGHTING
SYSTEMS

"AND GOD SAID LET THERE BE LIGHT AND THERE WAS LIGHT." MAN SAID, LET THERE BE LIGHT AND THERE WERE NUCLEAR POWER PLANTS, UGLY POWER LINES, AND RADIOACTIVE WASTE.

LIGHTING HAS BECOME AN EXPENSIVE, *(ECOLOGICALLY AND ECONOMICALLY)* ENERGY CONSUMING ENDEAVOR IN CONVENTIONAL HOUSING. THE OBJECTIVES OF EARTHSHIP LIGHTING ARE TO SERIOUSLY REDUCE BOTH EXPENSE AND ENERGY REQUIREMENTS FOR PROVIDING DOMESTIC LIGHT. IN MANY CASES THE REDUCTION OF ENERGY USE HAS RESULTED IN AN INCREASE IN EXPENSE. THIS IS BECAUSE MANY OF THE NEW SOLAR ELECTRIC PRODUCTS DO NOT HAVE A LARGE ENOUGH MARKET TO BRING DOWN THE PRICES TO A COMPETITIVE AND REASONABLE LEVEL. ANOTHER FACTOR IS THAT THERE ARE SO MANY DIRECTIONS TO GO IN TERMS OF LIGHTING (AC VERSUS DC, INCANDESCENT VERSUS FLUORESCENT, ETC) AND EACH DIRECTION HAS ITS OWN CATALOG OF PRODUCTS THAT WORK FOR SPECIFIC SITUATIONS. THE BOTTOM LINE IS THAT, AT THIS POINT, NO STANDARD, SIMPLE, INEXPENSIVE DIRECTION FOR LIGHTING HAS BEEN ESTABLISHED FOR SOLAR DWELLERS. THE PURPOSE OF THIS CHAPTER, THEREFORE, WILL BE TO ESTABLISH THIS DIRECTION AND TO PRESENT THE CONCEPTS AND EQUIPMENT FOR SIMPLE, INEXPENSIVE "OFF THE POWER GRID" LIGHTING.

Fruit generally grows on trees. Animals and humans come along and pick it off and gather it or eat it on the spot. It is usually sized so that most creatures that harvest it can hold it in their hand or paw. Fruit is therefore accessible to all who want it through nature's standardized method of production and delivery.

Lighting (as well as construction detailing and all systems for conventional housing) has become standardized. It is through this standardization that various products have become both available and affordable to the general public. **This standardization is the one phenomenon of *existing* housing that we must align with in order to make new directions accessible to the masses.**

Having been involved in solar electric living for twenty years, both in terms of building for others and using it myself, I have observed some basic problems. These are not performance problems of the various products. They are problems related to the availability and standardization of the products as well as the initial design concepts themselves. Currently, solar housing presents the average homeowner with many directions and a multitude of varieties and types of bulbs and lights - few of which will work in existing fixtures without adaptations; all of which are more expensive than conventional fixtures and none of which are available at a local hardware store. Most of this equipment requires a technician for installation and sometimes a technician is even required for bulb replacement. This makes many new jobs for people who are hip to this equipment but it alienates the average homeowner who wants to be able to change a light bulb him/herself. The result here is that solar living is kept in a place where it is more difficult and expensive to use. Therefore, line grid electricity and the environmental price that goes along with it remains the immediately easiest and most accessible form of power to use for lighting for anyone other than environmental fanatics. This must change.

Conventional housing is loaded with inefficient fixtures that are readily available at the local Walmart or variety store. The replacement bulbs and repair parts for these fixtures are common and easy to understand for the typical handyman/homeowner and are also easy to find at your local variety store. **This availability and economic accessibility is a must for solar electricity to even begin to replace conventional electricity.**

The concepts and methods presented in this chapter may not be the ultimate in solar technology and do not come from the high tech specialized expertise of an electronics wizard.

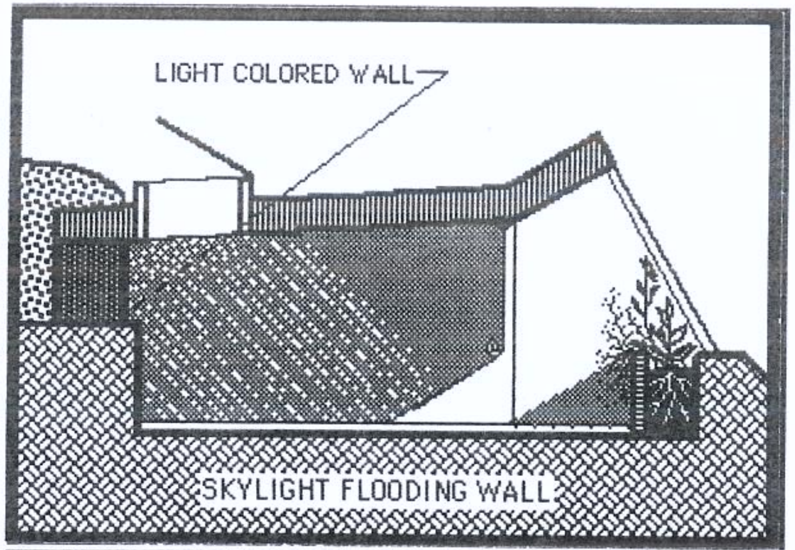
They are aimed at making solar electricity available to the average person without requiring hours of study, thousands of dollars and/or a dependence on an expensive solar technician for maintenance of your lighting system.

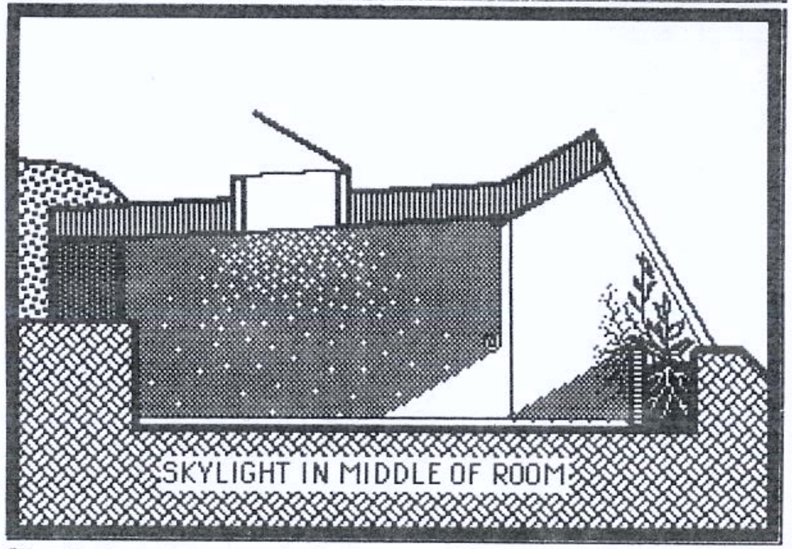
CONCEPT

DAY TIME LIGHTING

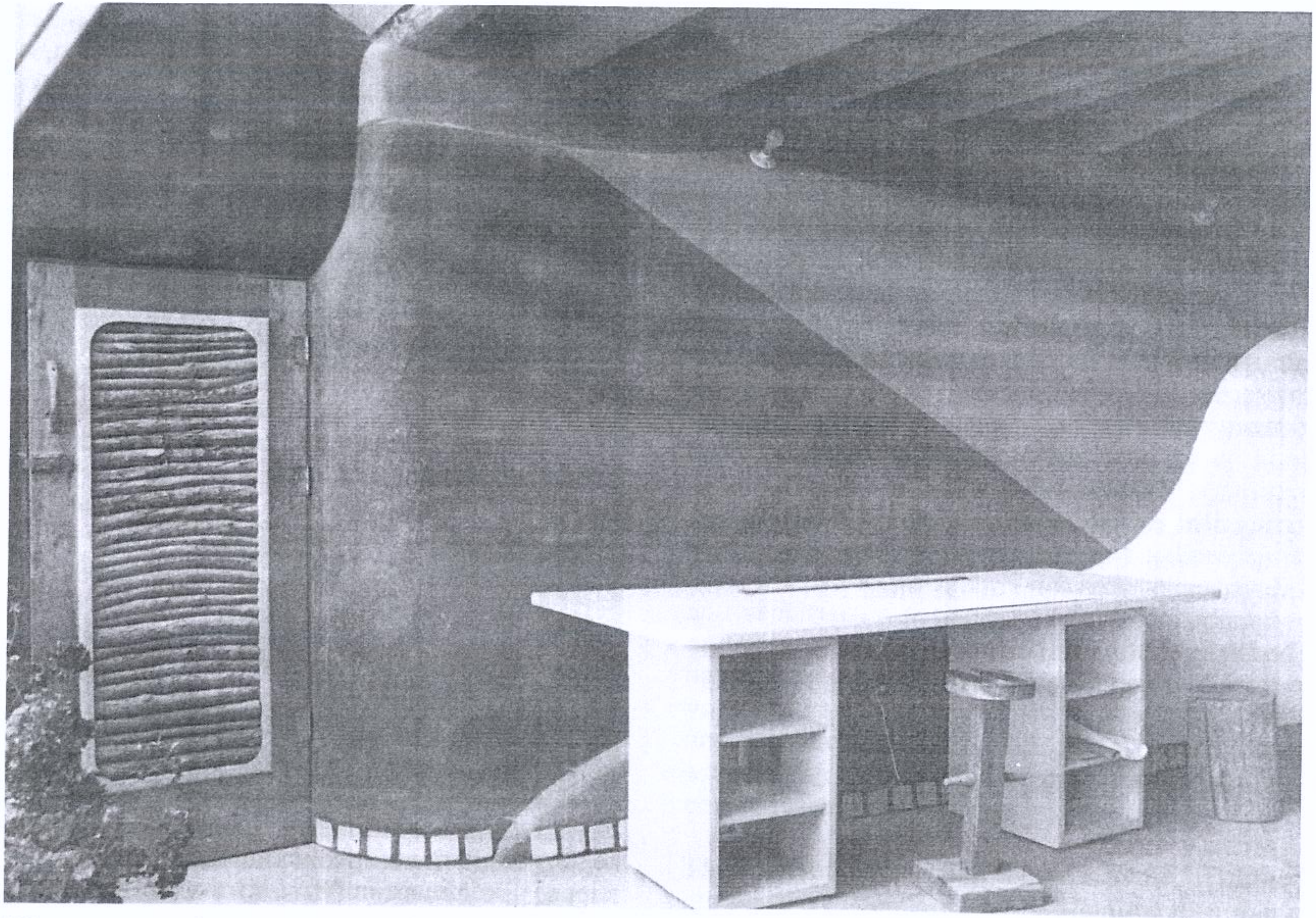
The foremost aim of Earthship lighting is to get as much natural light from the sun as possible during daylight hours. This is an inherent feature of the Earthship design resulting from the admission of sun for heat and the use of skylights for ventilation. When locating skylights and solar glass, an awareness of domestic lighting needs in addition to heat and ventilation needs will be necessary. For example, a skylight that floods a light colored wall with reflected light is more effective than a skylight in the middle of a room. This is a good idea for work areas.

The skylight box itself can be painted a light color to maximize reflection of the in-coming rays.



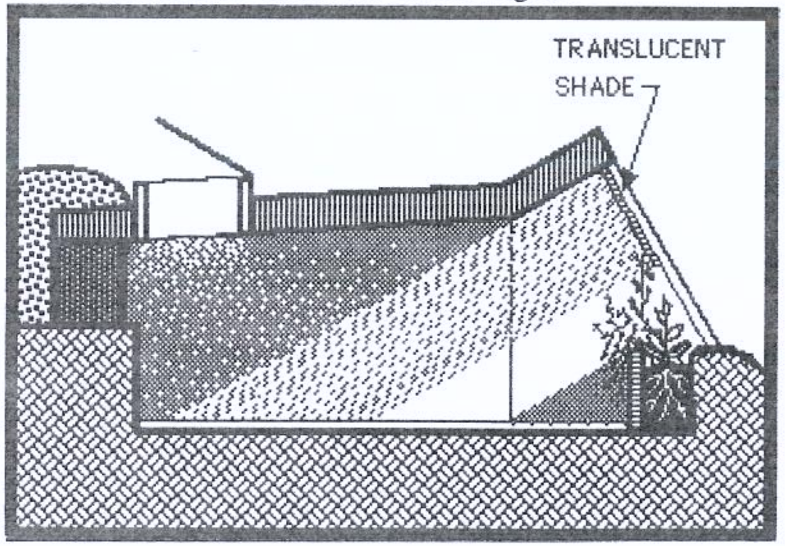


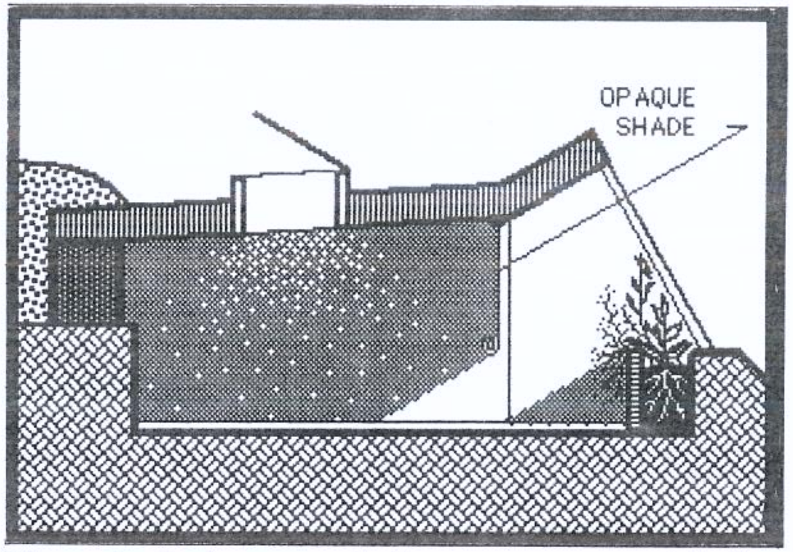
Skylights are needed for ventilation but should be kept to a minimum in cold climates. In temperate climates skylights can be used for almost all of the daytime lighting needs. See Chapter 8 for details of how to build operable skylights.



We recommend that you paint the back of each "U" a light color to reflect light but keep the walls dark out near the greenhouse where they can absorb the direct rays of the sun.

Lighting needs should be considered with regard to the front face glass when choosing shades for controlling the admission of heat. For example, shades that reduce sunlight coming through the front face can be translucent rather than opaque. This will reduce heat but allow light.





These techniques and the very nature of the Earthship design itself can almost eliminate the need for daytime lighting.

NIGHT LIGHTING

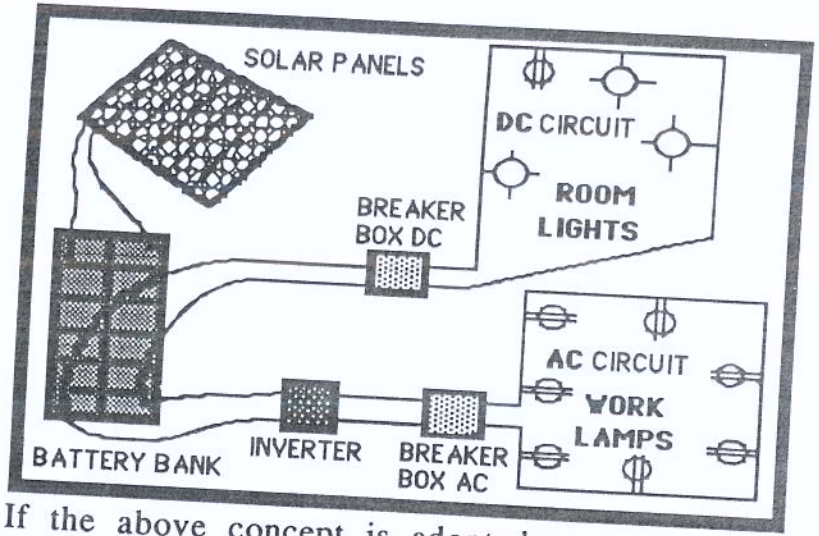
Night lighting can be broken into two categories, work lighting and atmosphere or general room lighting. This is a good method of delineating the AC and DC branches of the power system discussed on page 13 of Chapter 1. Work light is on AC power and room lighting is DC powered.

Work lighting

AC work lights are readily available in regular stores as are the replacement bulbs. They are plugged in to regular sockets, i.e. this is conventional equipment to start with. This is why all plug outlets are suggested to be on the AC branch of your system. The majority of work lights are conventional lamps bought in conventional stores that are part of the furnishings of a room as opposed to being built in. Therefore, other than the bulbs themselves which will be discussed later, work lighting is conventional AC equipment.

Room lighting

Room lighting is usually a broader usage of electricity involving more fixtures (sometimes indirect) and is generally used to light up the dwelling space overall. Room lighting does not necessarily involve moveable lamps as much as it does built-in fixtures to reflect and/or bounce light around the room creating an atmosphere or ambiance. Since this lighting usually involves more use of electricity than a particular spot light for working, it is suggested that the DC branch of your solar system be used directly for room lighting. It is not dependent on the inverter and will provide light without the 10% energy sacrifice of the inverted power and will provide light even if the inverter is down.



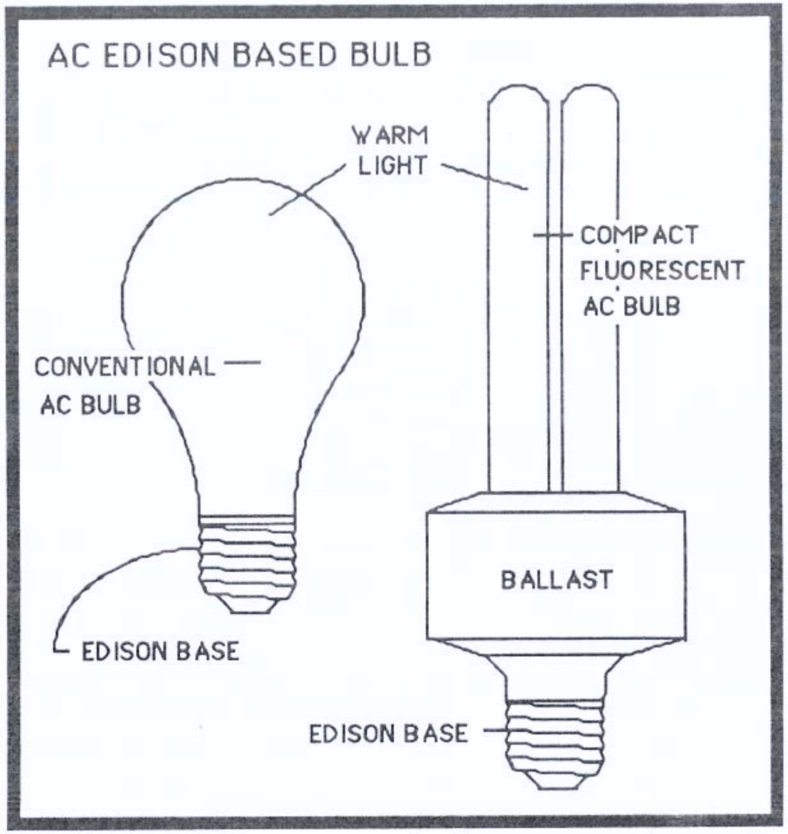
If the above concept is adopted, an occasional DC plug could still be added to the ROOM LIGHTING circuit to allow an occasional DC lamp. The "code required" AC plugs would still exist without interruption. The occasional DC plug on the room lighting circuit would simply be in addition to the DC room lighting.

EQUIPMENT

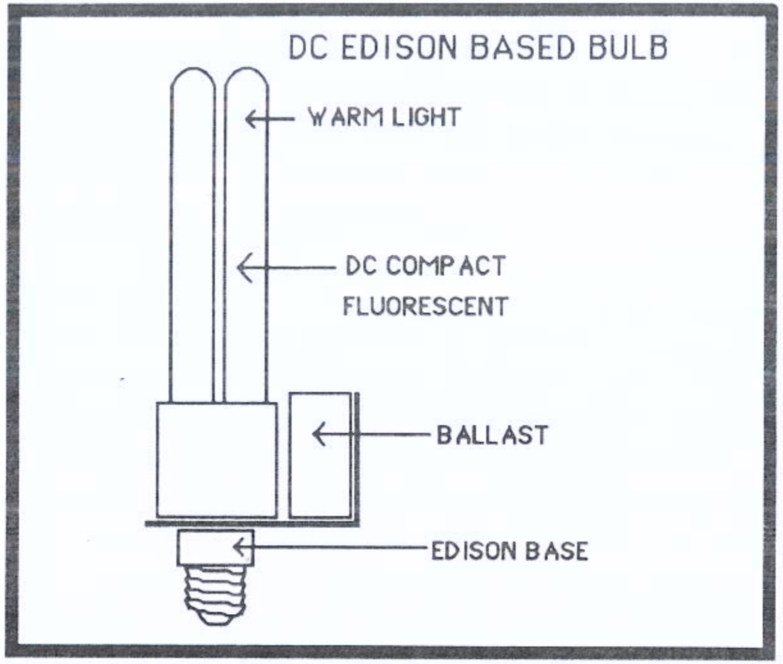
Both types of lighting discussed above obviously require bulbs. The conventional light bulbs bought in conventional stores are **incandescent** bulbs and are very inefficient. Most hardware stores either handle or can order both DC and AC incandescent light bulbs. Thus you can equip both your DC and your AC lighting with bulbs immediately or temporarily. **Fluorescent** bulbs use a fraction of the electricity that incandescent bulbs use. However, they have a reputation for

providing white, unhealthy light and usually require special fixtures to accommodate the fluorescent tubes. They are usually known to be ugly and unhealthy but efficient. In recent years, **compact fluorescent** bulbs *that provide warm light and screw into regular lamp sockets* have become available in both DC and AC forms.
These bulbs (see appendix this chapter) make any conventional lamp or lighting fixture capable of being used in a solar system with no modifications. All you do is install an AC or a DC compact fluorescent bulb to almost any fixture and reduce your lighting electrical load by 60% to 80%.

The compact fluorescent bulbs require what is called a ballast to regulate the electricity to the bulb. This ballast is heavy and bulky and requires the shape and weight of the bulb to vary from that of a conventional light bulb. Both bulbs have what is called an Edison base (see following diagram). The Edison base is what allows them both to be screwed into a conventional lamp.



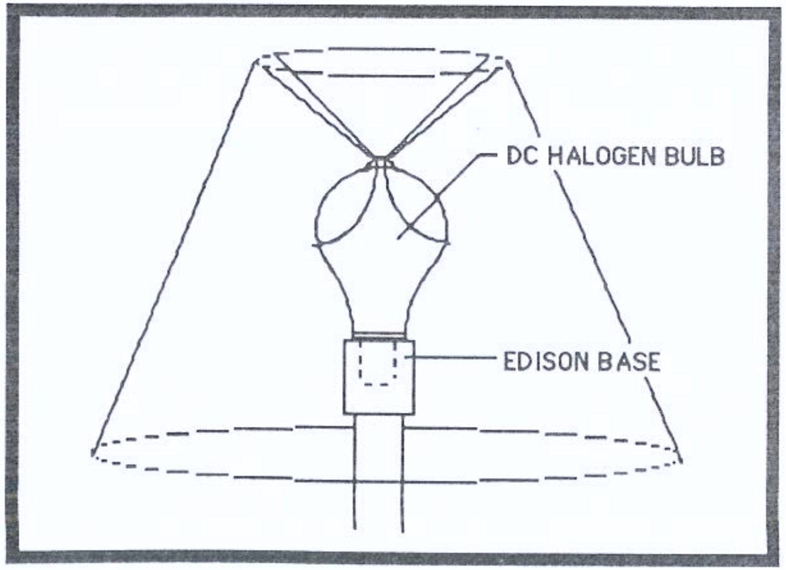
DC compact fluorescent bulbs are not in much demand. Consequently, they are not as refined in their design as the AC compact fluorescent bulb. They still can be obtained with Edison base which allows them to be used in a regular lamp.



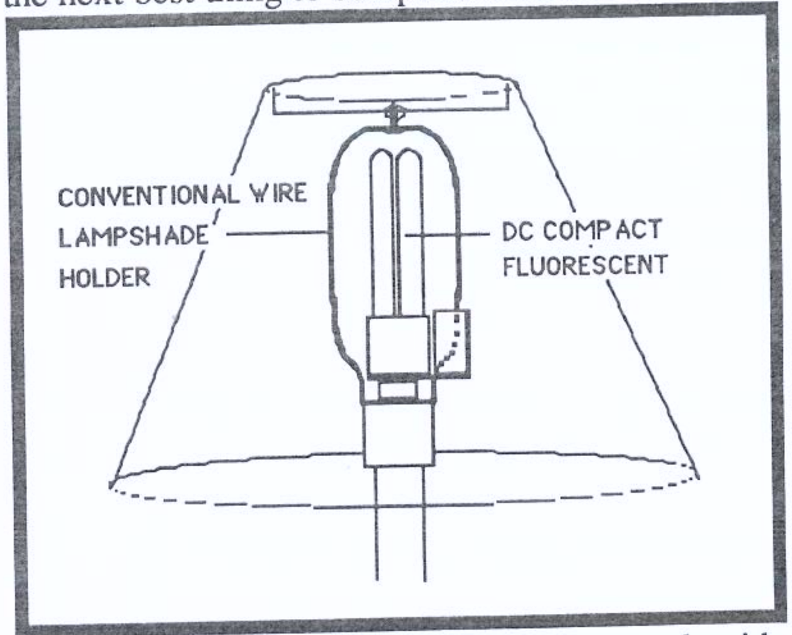
There are various shapes, sizes, styles and brands of AC and DC compact fluorescents both for diffused and spot lighting much the same as conventional incandescent bulbs. The only ones worth considering are those with the ballast built in and an Edison base (screw into a regular socket as shown above). All others end up requiring more technical labor to install and maintain than they are worth.

One negative feature of the above DC compact fluorescent is that if your power system is not "hot" (strong voltage), the light takes a long time to come on. Sometimes, touching the bulb (thus grounding it) helps it light up faster. For this reason you should stay away from DC compact fluorescent fixtures with enclosed bulbs as they can't be touched.

The cost of compact fluorescent bulbs is considerably more than conventional incandescent bulbs but the life expectancy of the bulb is also considerably (up to 10 times) higher. The real issue is that they use a fraction of the electricity that common incandescent bulbs use thus allowing you to exist on a less expensive power system. (See appendix this chapter for obtaining compact fluorescent bulbs). Another objection to compact fluorescent bulbs is that some standardized lamp shades designed to clamp on the bulb itself will not work on the linear shape of the compact fluorescent.

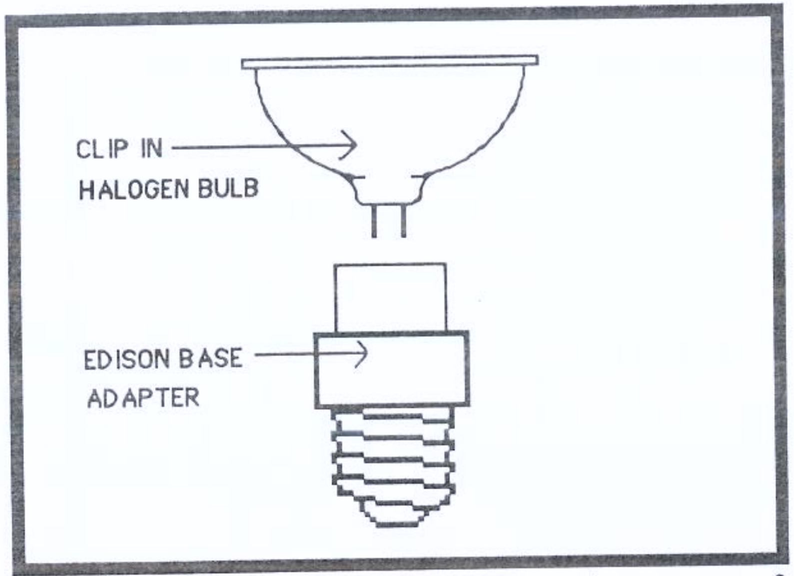


For these cases there is a DC halogen bulb that looks just like a regular light bulb. It is more efficient than DC incandescent bulbs but not as efficient as compact fluorescents. It is more expensive than DC incandescent bulbs but not as expensive as compact fluorescent. It is therefore the next best thing to compact fluorescent bulbs.



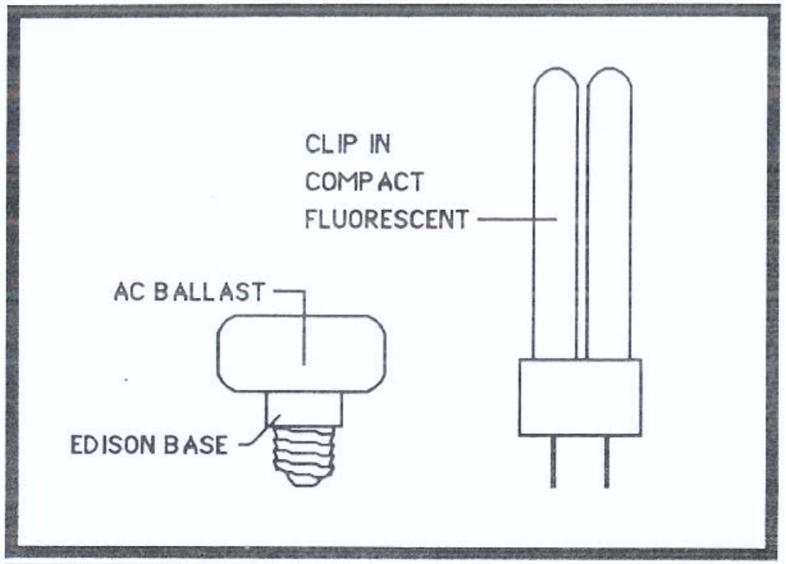
Both AC and DC compact flourescents work with conventional wire lamp shade holders.

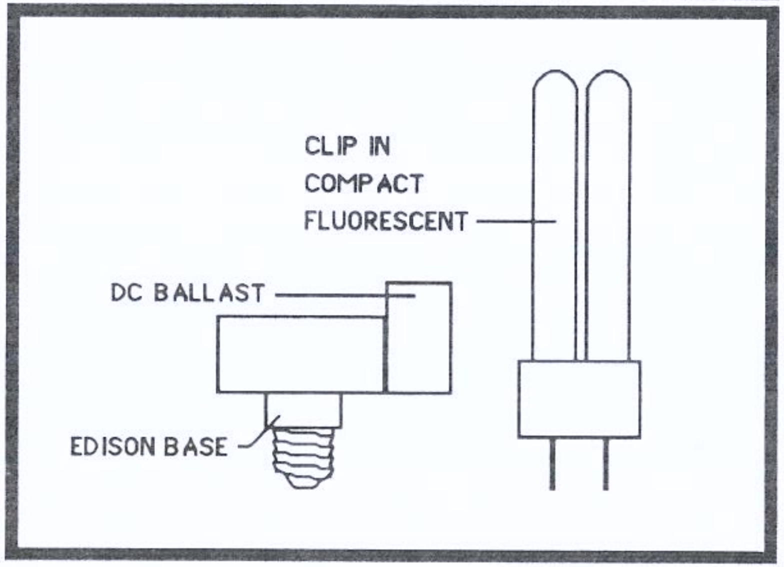
There is also an Edison adaptor available for many types of clip-in halogen bulbs.



These adapt spot lights and many other types of lights to halogen use. Halogen lights however, are not as efficient as compact fluorescents. They are clearly a second choice on efficiency. Their selling point is that they provide more light with less wattage.

This is, however, often debatable. Soon there will be available an Edison based adaptor for a clip-in DC compact fluorescent bulb. This will increase the usage of these bulbs as the bulb often wears out before the ballast. This system is available now for AC compact fluorescent bulbs.





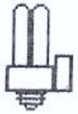
The information presented here is only a fraction of what is available. However, other types of efficient lighting are prohibitively expensive and difficult (at best) to service and maintain for the typical homeowner. People are accustomed to buying lamps and lighting fixtures wherever they want for a reasonable price and simply replacing the bulbs occasionally. The method of solar lighting discussed above allows this. Other methods do exist but they require so much money and frustration that they will not even be discussed in this chapter.

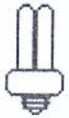
REVIEW OF BULBS


AC Incandescent - don't use except in emergency - available at local stores.

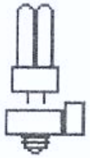

DC Incandescent - don't use except in emergency - available at local stores.

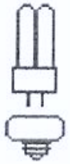

DC Halogen - can be used as a second choice - cheaper than compact fluorescent - available through SSA


DC Compact Fluorescent - best DC choice - less power than any other - most expensive - available through SSA


AC Compact Fluorescent - best AC choice - less power than any other - most expensive - available SSA


Halogen Clip-in, Edison based adapter - good for special situations - available through SSA

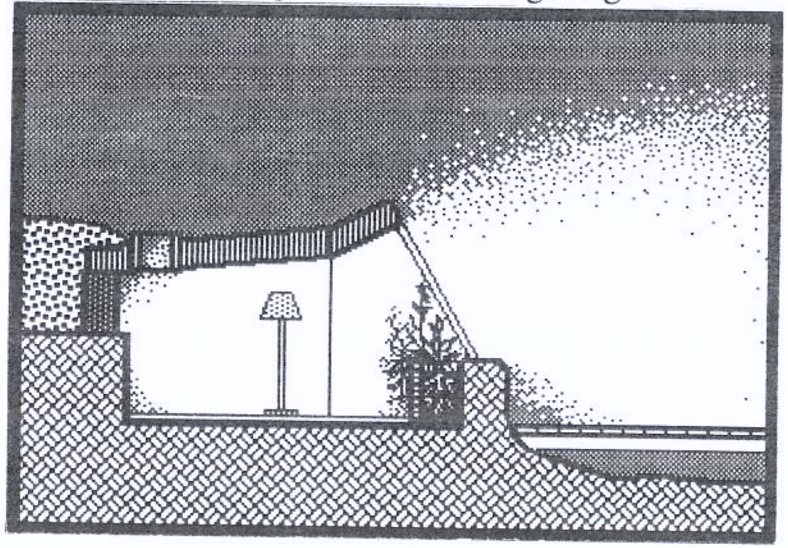

DC Compact Fluorescent, clip-in Edison base - good choice when available - available through SSA


AC Compact Fluorescent, clip-in Edison base - good choice when available - available through SSA

EXTERIOR LIGHTING

There are many exterior, self contained solar lights on the market. Few (if any) work for very long. It is better to use the same information presented in the first part of this chapter for exterior lighting. Simply use exterior lighting fixtures for the bulbs discussed previously.

There is one important fact to consider in Earthship exterior lighting. The exterior to the south can be lit up with interior lighting!



REVIEW AND RECOMMENDATIONS

We recommend AC compact fluorescent, edison based bulbs for all AC lamps. They are reliable, provide warm light, last a long time, use a fraction of the power that anything else does and are easily available. AC clip-ins with Edison based adapters are a second choice as they are not as easy to obtain.

For DC lighting we suggest the DC compact fluorescent, edison based bulb with (awkward) built in ballast. Do not use it where you can't touch it. Again the DC clip-ins with Edison based adapters are a second choice as they are not as easy to obtain.

For places where the DC compact flourescent is inconvenient, use the edison based halogen DC bulb. It works just like a regular AC bulb and allows you to use any conventional fixture you want. Also the halogen adapter is a possibility there.

These recommendations cover the simple basic lighting needs for getting solar light in to the average home. More elaborate lighting will require a lighting consultant and greater expense, however, the basics presented in this chapter should still prevail whenever possible.

APPENDIX (DC in shaded area)

AC Compact Fluorescent Bulbs-with Edison base, 120 volts.

available wattages	= equivalent AC incandescent
7w	40w
11w	60w
15w	75w
20w	100w
27w	120w

Last 10 times longer than incandescent bulbs, (Can not be used with a dimmer switch)

AC Clip-in Bulbs

AC Compact Fluorescent Adapters - available in wattages similar to AC compact fluorescent bulbs

DC Compact Flourescent Bulbs-with Edison base, 12 volt

available in wattages equivalent to:

= 25w AC incandescent
= 40w " "
= 50w " "
= 60w " " (Can not be used with a dimmer switch)

DC Clip-in Bulbs

DC Compact Fluorescent Adapters - available in wattages, similar to DC compact fluorescent bulbs

Halogen Edison Based Bulbs - 12 volt

available wattages	= equivalent AC incandescent watts
21w	50w
35w	75w
50w	100w

Halogen Adapters - 12volt, with clip-in bulbs available in 50 watt.

Order from: Solar Survival Architecture, P.O. Box 1041, Taos, New Mexico, 87571 505 758- 9870

A PARABLE ABOUT LIGHT

ONCE THERE WERE MANY PEOPLE TRAPPED IN A DARK CAVERN. THEY STUMBLED AROUND IN THE DARKNESS AFRAID AND SUFFERING. GOD LOOKED DOWN UPON THESE PEOPLE AND DECIDED TO HELP THEM. A BEAUTIFUL BEAM OF LIGHT WAS SENT DOWN TO SHINE UPON A **DOOR** THAT OPENED INTO A PASSAGEWAY WHICH WOULD TAKE THEM OUT OF THE DARKNESS FOREVER.

THE PEOPLE SAW THIS BEAM OF LIGHT.

THEY BECAME VERY JOYOUS AND BEGAN TO WORSHIP THE LIGHT.

THEY PERFORMED RITUALS AND MEDITATED ON THE LIGHT.

THEY DANCED AND SANG IN THE LIGHT.

THEY TRIED TO PULL OTHERS INTO THE LIGHT.

THEY ERECTED MONUMENTS TO THE LIGHT.

THEY DRESSED IN WHITE CLOTHING TO LOOK LIKE THE LIGHT.

THEY MADE PICTURES AND SYMBOLS OF THE LIGHT.

THEY GAZED AT AND PRAYED TO THE LIGHT.

THEY WROTE SONGS AND STORIES ABOUT THE LIGHT.

THIS WAS VERY BEAUTIFUL, BUT THEY NEVER SAW THE **DOOR**.