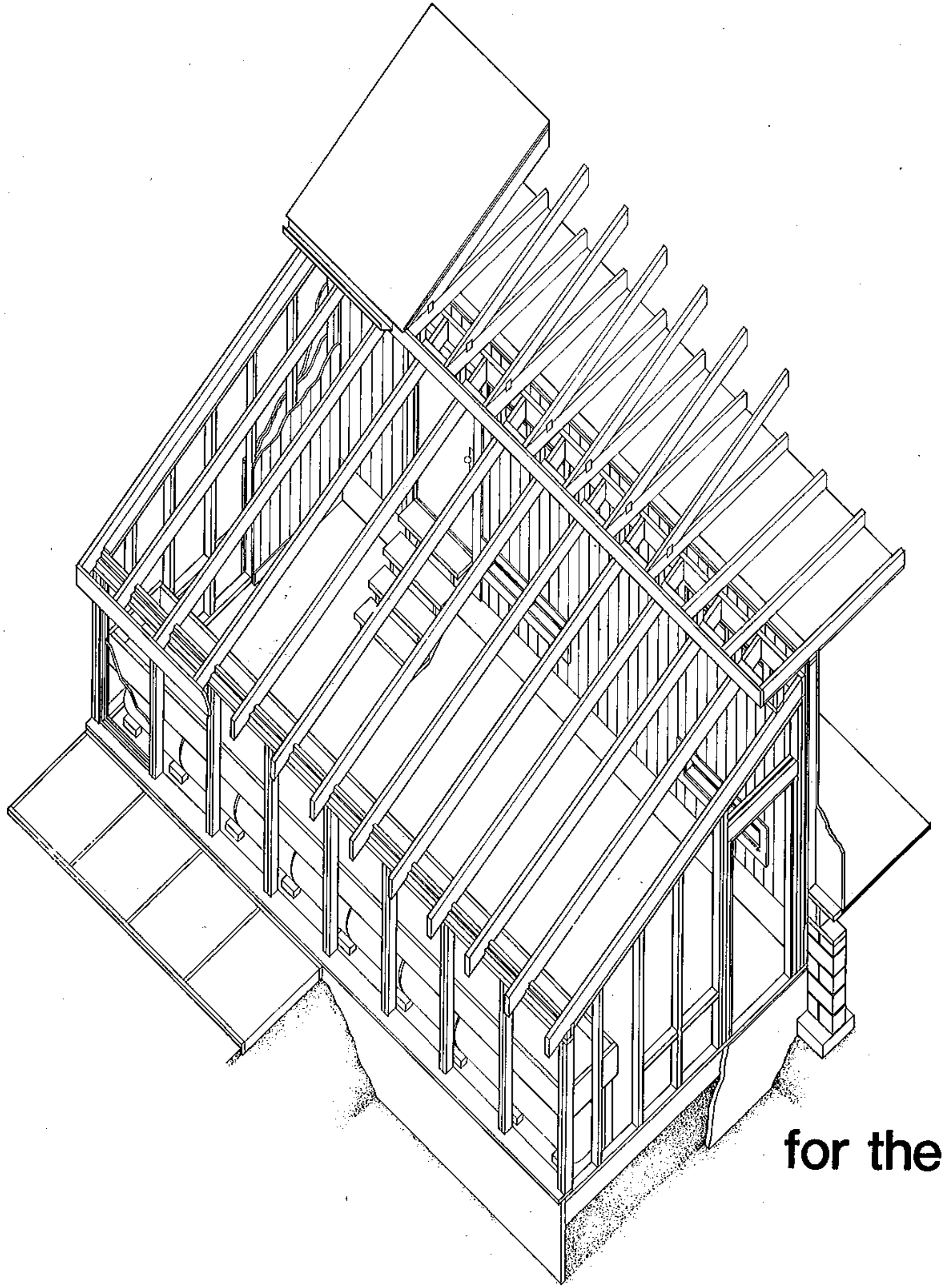

u. s. department of energy
region – IV atlanta, georgia
office of appropriate technology

sunspaces
for the southeastern united states

principles and construction of a passive solar greenhouse

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2nd edition

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APPROPRIATE ENERGY TECHNOLOGY SMALL GRANTS PROGRAM

Appropriate technology is defined in this book as those technologies for which the level of sophistication involved in producing energy is suited to the task being done. Appropriate technology generally utilizes local skills, tools, and conditions to supply energy for local needs.

The U.S. Department of Energy has offered a small grants program in support of small scale, appropriate technologies. The goal is to encourage development, demonstration, and dissimination of information about local, small scale energy technologies.

This book presents principles and methods of passive solar construction which are appropriate in the eight southeastern states included in Region IV. Those states are Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee.

DOE REGION IV SUNSPACES WORKSHOP PROJECT

The appropriate technology small grants program requires that information about systems and technologies be published. The purpose is to educate the public about new small scale technologies which have developed as a result of the program. Grant applications for 1979/1980 revealed great interest in and potential for sunspaces. However, when funded by grant alone and without additional technical input, construction tended to be expensive and slow.

In response, DOE Region IV set aside some funds to produce these books and co-sponsor over fifty workshops. Preliminary data collection indicates that an average of two sunspaces were built for each subsequent workshop. This multiplier effect has brought down the cost of a sunspace and sped up construction.

A variety of persons has been involved in the sunspace workshop project. Appropriate Technology groups, rural groups, individuals, local government agencies, churches and educational institutions have conducted workshops.

The workshops have been held throughout the southeast. Some of the lesser known places where they have occurred are Epes, Gallant, Fairhope, and Flat Rock, AL; Joy Lake Community, GA; Berea, KY; China Grove, Pittsboro, and Westfield, NC; Jenkinsville, Fairfield City, and Winsboro, SC.

Another way the DOE cost per sunspace has been brought down even further is through the distribution of workbooks. Many recipients have returned questionnaires indicating that they have built or they will build a passive solar greenhouse. This kind of response validates the workshop/workbook project as a means of accomplishing the Program goal.

Sunspaces For The Southeastern United States – Principles And Construction Of A Passive Solar Greenhouse

United States Department Of Energy – Region IV

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contents

1.
SOLAR ENERGY AND THE SOUTHEASTERN UNITED STATES

passive solar and active solar

The use of solar energy for space heating and providing domestic hot water has received a great deal of attention recently. In the southeastern United States, because of our mild climate and abundant sunshine, solar energy can be harnessed to provide a substantial portion of a building's energy needs.

WHAT IS PASSIVE SOLAR?

Passive solar applications use the sun's energy to do work without the aid of mechanical systems. They operate as a function of the design of a building rather than as a function of separate heating and cooling systems. Quite simply, sunlight is allowed to enter a building through windows. The sunlight hits solid objects in the building and warms them. The solid objects hold the heat and release it slowly to the air, thus heating the building, even after the sun has set.

There are several requirements which a building must meet to be effective as a passive solar building.

- The building must have a southerly facing wall (within 15° east or west of south is preferable).
- The building's south wall must receive unobstructed direct sunlight during the cold months of the year.
- The building must have adequate vents for summertime use to avoid overheating.
- The building must be "tight" with no air leaks.
- The building must be well insulated.

If a building meets the above requirements or has the potential for meeting them, then it is an ideal candidate for passive solar applications.

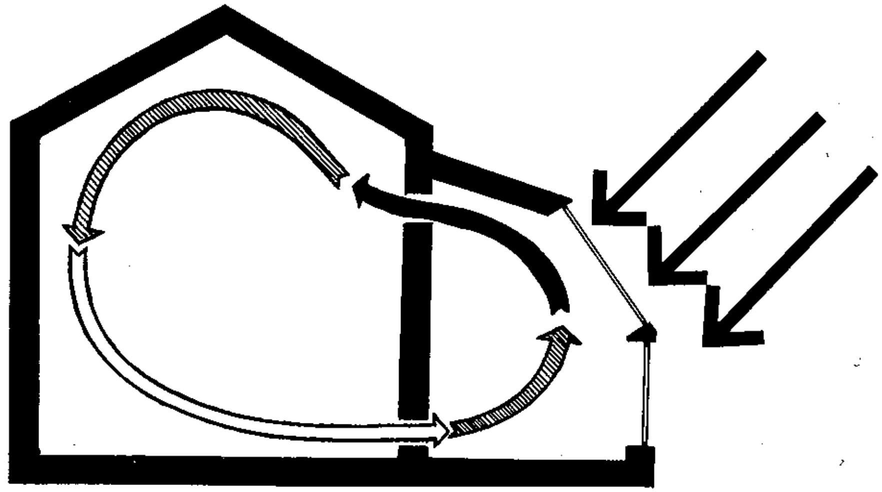


Fig. 1 A Passive Solar System

Another means of harnessing the sun is through an active solar system. Active systems are those which many people think of when solar energy is mentioned. They usually consist of a series of flat plate collectors mounted on the roof of a building. A small pump or blower circulates a liquid or air through the collector when the sun is shining as shown in Fig. 2. In passing through the collector the fluid picks up heat and transports it to an insulated storage tank for later use. As the house becomes cool, stored heat is released by pumping the hot fluid through radiators of a heat exchanger in the house's forced air heating system. Active solar systems, while quite effective at heating a house, have high initial costs. The mechanical systems of pumps, valves, piping and ductwork require periodic mainte-

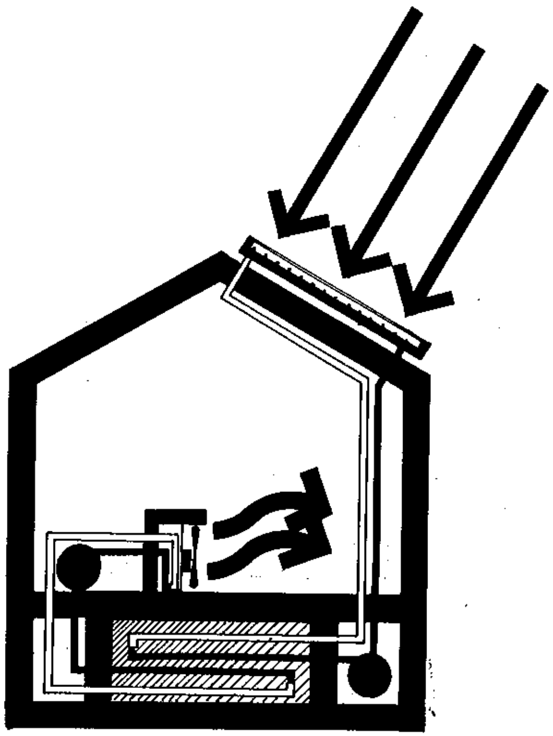


Fig. 2 An Active Solar System

nance, and cost something to operate. Consequently, the additional costs incurred in building and operating active solar heating systems may take years of operation to recover in energy savings what they cost initially.

Passive solar heating systems, on the other hand, require no pumps, valves, or elaborate plumbing. They do require some special building practices to be effective and they must be maintained and operated by the occupant for maximum efficiency. In fact the occupant of the passive solar building could be said to be the active part of the system. Integral to the design of a sunspace is a series of operable vents to move air, shades for summer use, and movable insulation units to hold heat in at night. Although some sunspaces avoid shades and movable insulation, all must have vents to control and encourage the movement of air. Daily attention to operating systems is therefore important to the proper operation of the passive solar building. This daily attention consists mainly of adjusting vents and shades for daytime and nighttime operation and is no problem for most systems. Daily operation quickly becomes routine and ranks along with putting the cat out for effort.

There are additional costs associated with retrofitting an existing house for passive solar energy. However since the heat collecting apparatus in a sunspace is a room in and of itself, the economics may be justified by the addition of productive space to the building. Construction of a sunspace need be no more expensive than construction of a conventional sized room in the same area. In fact any one who has average handyman and carpentry skills and who is willing to look around for used materials should be able to construct a passive solar addition to his or her house for next to nothing.

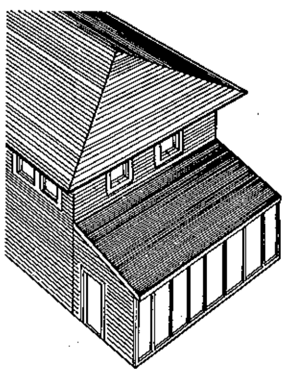


Fig. 3. A Living Room Sunspace

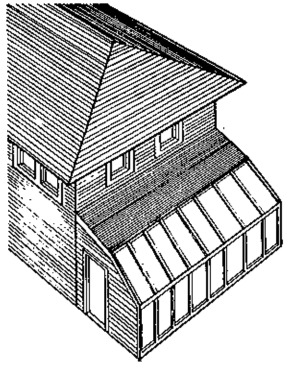


Fig. 4. A Passive Solar Greenhouse

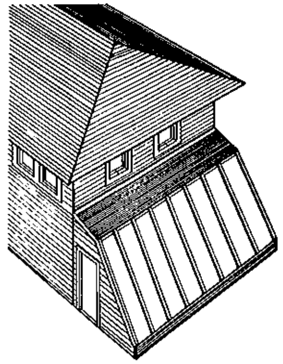


Fig. 5. A Heat Producing Sunspace

3 functional sunspaces

This manual discusses some of the theory and design considerations for constructing a sunspace suited for the southeastern United States. Also included are detailed designs for three types of sunspaces. These designs are intended to serve as guides, not as the only means, of constructing a sunspace. The three designs serve three different purposes. The first design serves primarily as a solar heated living space. The second design will function as a solar heated greenhouse for raising food. The primary function of the third design is to provide additional heat for the house. All three designs overlap in function: they all produce heat and they all can be used for plants. However, each has details which make it more suitable for its specific function than the other two.

The designs and plans illustrated in this book are meant to provide the average homeowner with an economic way to add heat to his or her home while also providing a functional and self-sufficient addition to the house. All plans use standard construction techniques and materials. It should be noted that the techniques and materials presented here are by no means minimum standards. The designs used in this book are designs which will work in most instances and which will meet most building codes (check on these before you build anything). At no time should the builder feel restricted to use materials listed in these plans if he or she feels that a more economic material or design would work just as well. The principles given here for the location of insulation, glazing, ventilation and the like, however should be considered vital to the successful functioning of the sunspace.

2. WHERE TO START

principles for planning

Before rushing out and picking up a hammer, it is a good idea to think about the design of the structure. How do you plan to use the space?

If you want to use the sunspace primarily as a greenhouse, consider what types of plants you would like to grow, how much light they require and what temperature ranges the plants prefer. You will need to compare the winter temperature requirements of your plants with winter performance characteristics of the sunspace designs in Chapter 4. If you plan to use the sunspace more as a means of heating your house, other considerations, such as ideal placement of thermal mass and transfer of heat between the sunspace and house should be addressed.

Size is another important consideration. How large you build the sunspace depends not only on how much money and space are available but also how large an area you require.

Next, information regarding your local climate should be gathered. The southeastern United States has very diverse climate zones ranging from the cool mountain areas of the Smokies and the temperate forest regions of north Georgia to the swamps of south Mississippi and the semitropical Florida Keys. Therefore, this manual will not attempt to offer a single design suitable for all parts of the Southeast. While the basic concepts and designs outlined here apply in general to the Southeast , they should be modified to suit your particular climate and geographical area. For example, if you live in a region with mild sunny winters and moderate summer temperatures you may want to reduce the amount of glazed area and consider using single pane windows. You will also need to pay particular attention to summer shading and ventilation. If, on the other hand, you experience frequent periods of extended cloudy weather during the winter, you might opt for a larger south facing glass area and more thermal mass to capture available sunlight. In every case try to adapt plans to use locally available materials. Common local materials will be cheaper and are proven to work in your area.

SOURCES OF INFORMATION

While planning you should gather enough information on passive solar energy and sunspace design to enable you to build with complete confidence in what you are doing. Information can be gathered from a variety of sources. The bibliography in the back of this book lists organizations which can give you more information or put you in touch with local groups and individuals who are involved in passive solar projects. Hands on experience is invaluable, so consider volunteering some time to help with local projects. The bibliography also lists some good books on the subject, has definitions of terms, and gives specific information on availability of materials and specialty manufacturers.

For information in your locality try the County Extension Service. Chances are good that someone at a nearby Community College will know about passive solar energy and will be happy to talk to you about it or sign you up for a class on it. Many architects are familiar with passive solar energy and would be happy to assist you in planning and building your sunspace. If you do decide to hire an architect or consultant be sure to hire someone with a proven track record in design for climate. Ask for references and talk to the occupants of your consultant's existing buildings. Not only will you be able to get an idea of how the buildings work but also you should get a feeling for the overall functioning of the place.

One excellent source of information on passive solar energy is the passive solar greenhouse or sunspace workshop. These workshops are often supported by a government agency and sponsored by local solar energy clubs. Similar to an old fashion barn raising, workshops rely on volunteer work in exchange for experience in passive solar technology and general building practices. A slight fee is normal at many workshops to pay for meals and a qualified solar consultant to supervise the whole thing. For more information on workshops in the Southeast contact the Office of Appropriate Technology, U.S. Department of Energy—Region IV, 1655 Peachtree Road, N.E., Atlanta, GA 30367, or call 404/881-2386.

questions

Next you must ask some questions.

1. "Is the south wall blocked by anything that would cut off winter sunlight?" Remember that in December the sun gets no more than 1/3 of the way up the sky for much of the day. Trees that shed all their leaves do not count as shade in winter. In fact they can be very helpful as they reduce overheating in summer.
2. "Do you have enough room on the south end of your house to build?" A simple question but be sure not to build over subdivision setback lines. Information on setback lines can be found at your county planning or zoning office.
3. "Do I want a sunspace next to the south facing rooms on my house?" You will have to build your sunspace off of one or more of these rooms, so decide whether or not you can live with it. If your kitchen, living room, dining room, den, or basement have a south wall, go ahead and build. If you are limited to south facing bedrooms, think seriously about whether or not you really want a sunspace located here.
4. "Is your lot sloped properly for building a sunspace on the south end of your house?" If you have a level lot or if your lot slopes down to the south it is probably suited for a sunspace. If the lot slopes down toward the house on the south side you may have to move a lot of earth and lose some of your glass space.

If you answered no to the first question and yes to the last three, your house and lot should be well suited for passive solar applications. If you answered differently you should give the situation more thought before proceeding.

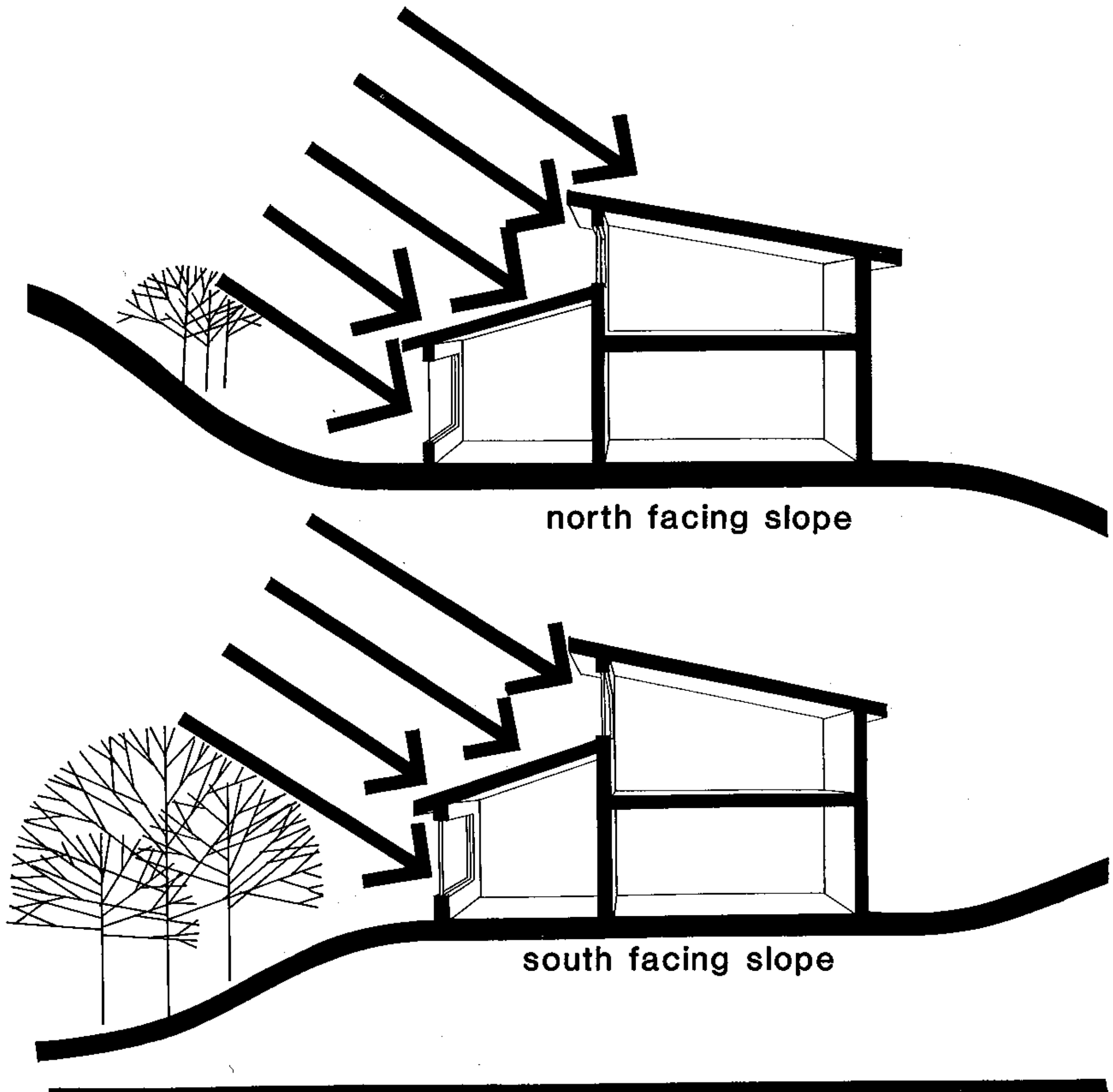
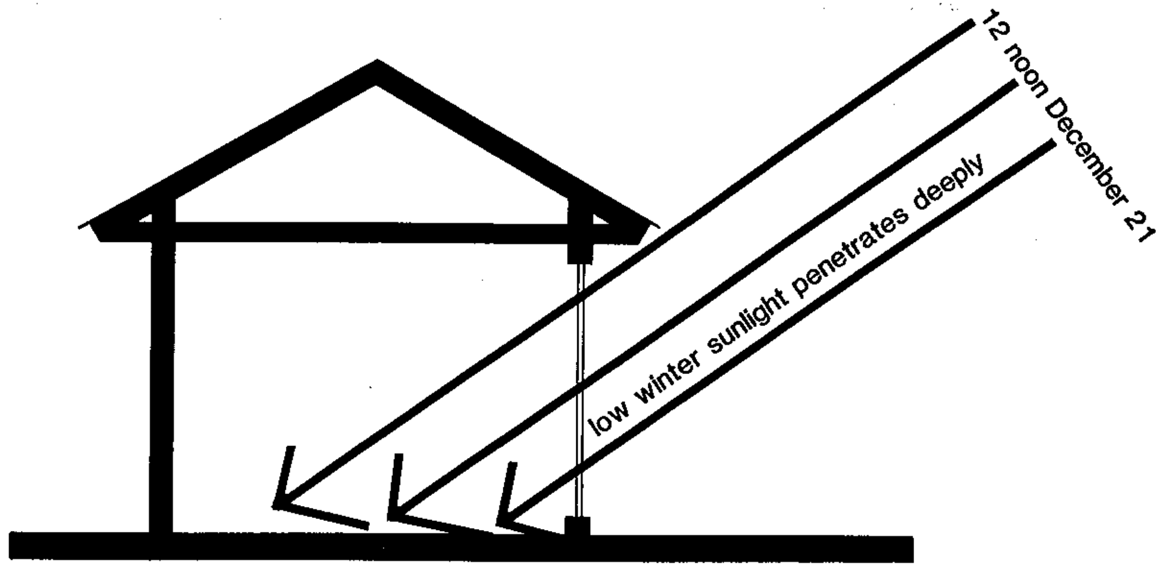


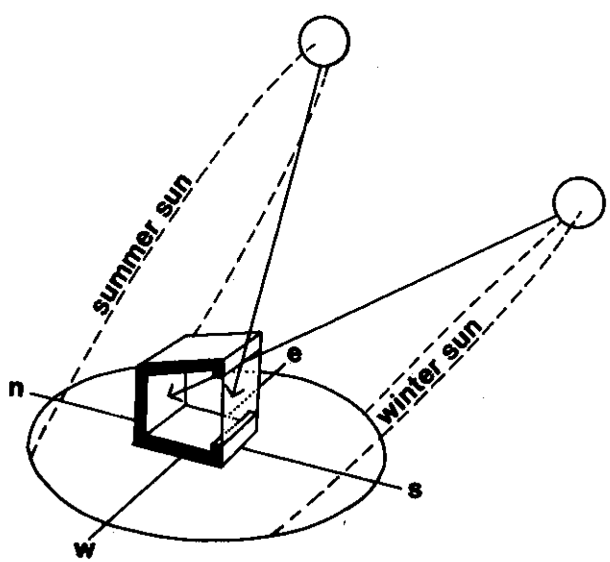
Fig. 6 Sloping Lots

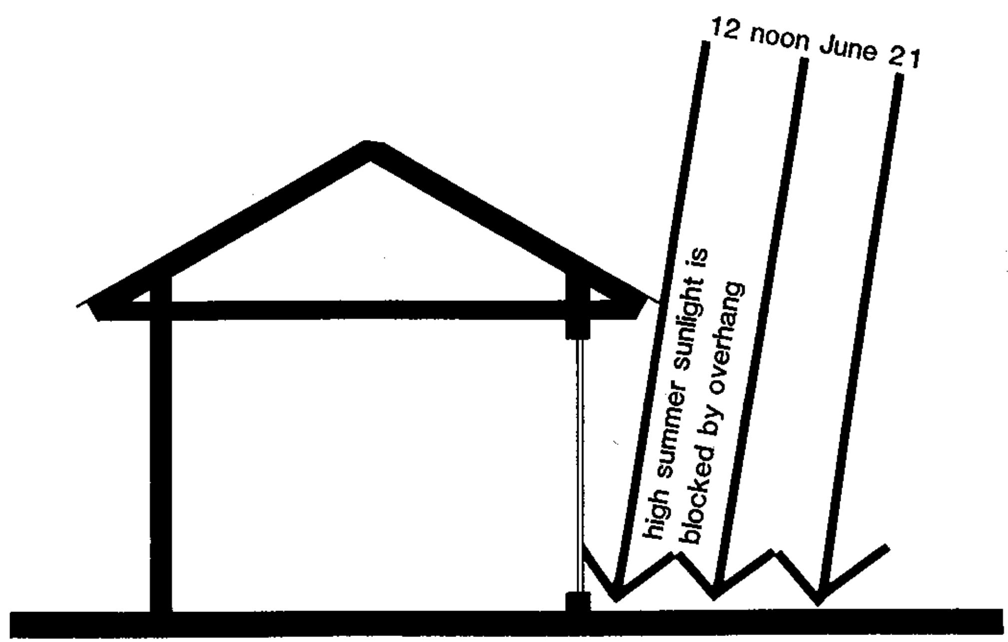
Lots which are flat or which slope down to the south are generally better suited for passive solar applications than lots which slope in other directions. With care in selecting and preparing your site, however, you can have a successful sunspace on many types of terrain.

Fig. 7
seasonal sun angles

Best performance of sunspaces is achieved when they are built on south facing walls because the winter sun is low in the southern sky. However, the sun comes from a much higher angle in the summer and may be blocked with overhangs and other shading devices.







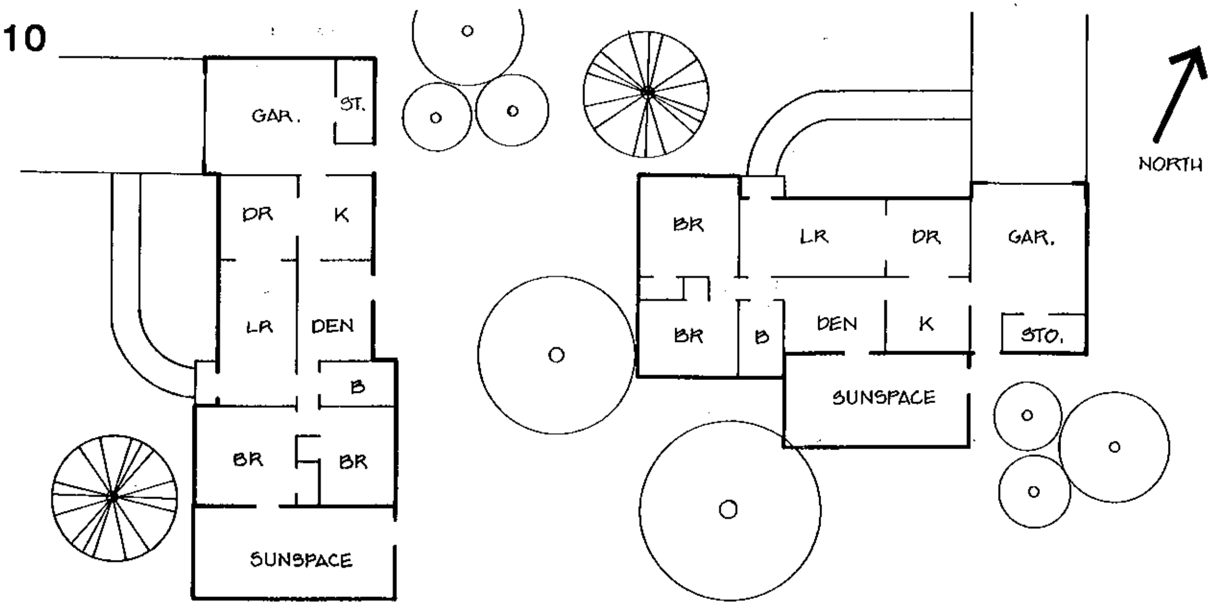


Fig. 8
location of sunspace on house

Because the sunspace is a part of the house, access to it through the house should be determined. If the sunspace adjoins the kitchen, den, or living areas of the house, access can usually be handled by making the sunspace a part of the house's traffic flow without altering the room's normal useage. Exterior doors to the sunspace are helpful particularly if the sunspace is used for growing plants.

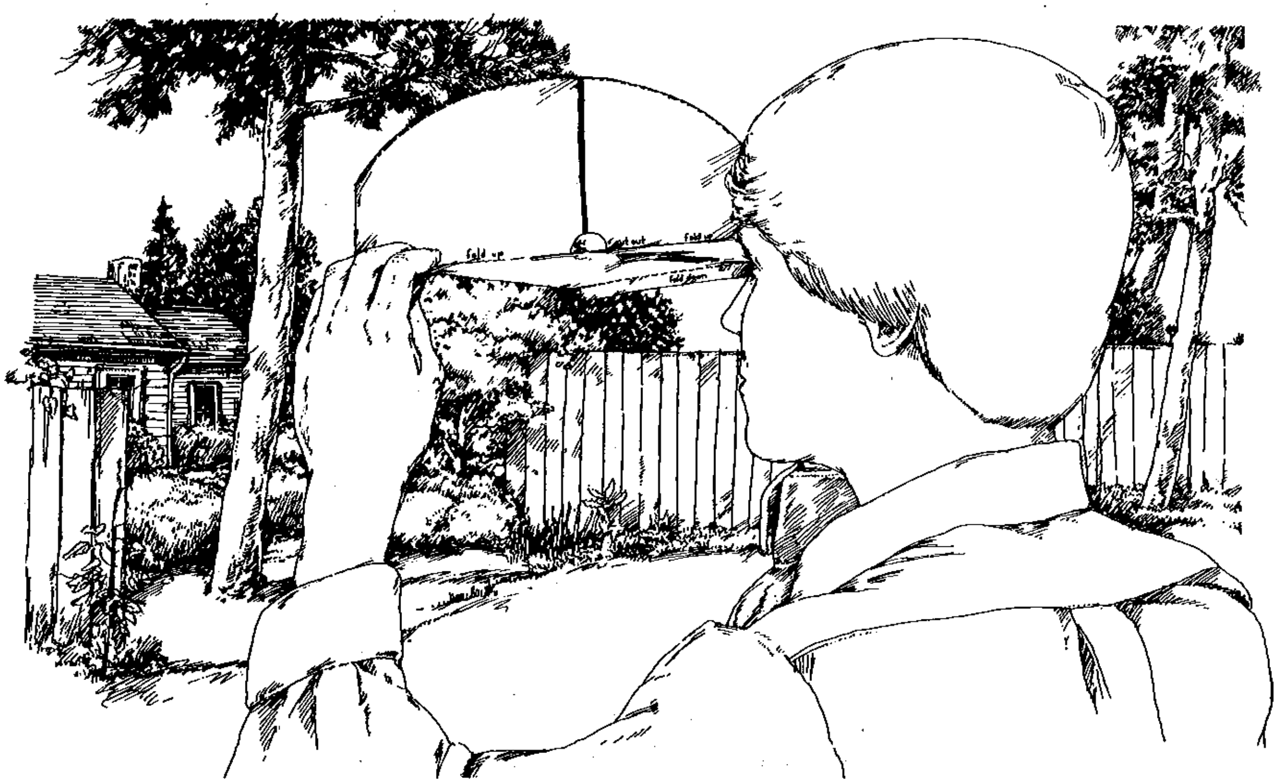


Fig. 9
finding the sun

SUN PATH CALCULATOR

The sun path calculator and instructions for its use are on the back cover of this book. Use it to determine whether or not your site gets enough winter sunlight for a sunspace.

Following the instructions on the sun path calculator, determine whether there is anything that will block off winter sunlight. Deciduous trees that lose their leaves in the fall will allow most of the sunlight to reach your sunspace in the winter while providing much desired shading in the summer. If more than half the southern sky is obstructed by pine trees and buildings, you will probably not get enough sunlight for a sunspace to heat itself.

Next, consider your specific site. Here it will be helpful to draw a floor plan of your house. Using a tape measure, find the length of each exterior wall to the nearest foot and draw it on the attached grid letting each square represent one foot. Now, using a compass, determine which wall faces most nearly south. Mark this wall on the grid with a double line. Label the rooms which are adjacent to south facing walls. Locate trees, shrubs and adjacent structures wherever they occur on the grid.

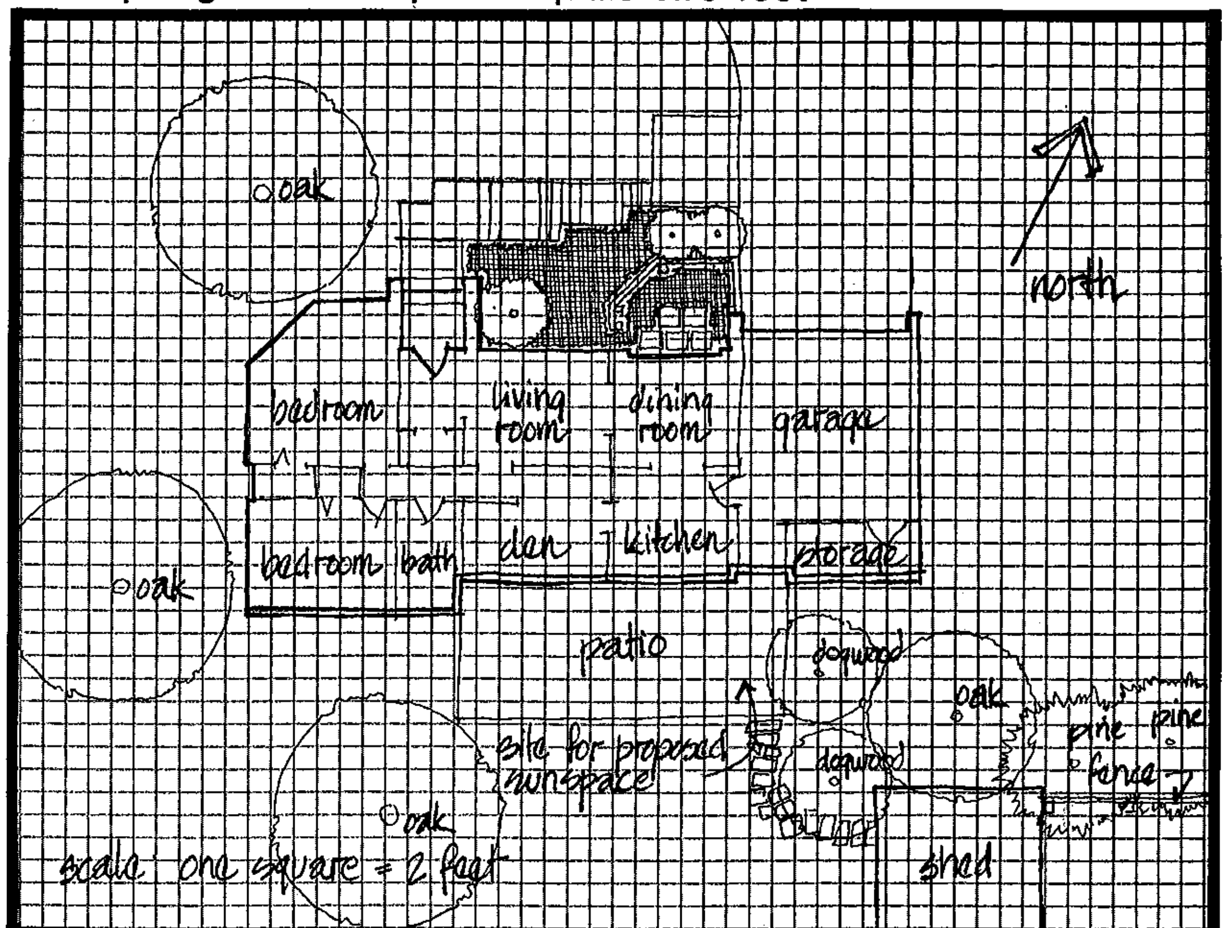
The south facing wall is the one on which you will have to build your sunspace because winter sunlight comes in low from the south.

Indicate on the grid which trees are visible above the sun path calculator (See Fig. 8). If you have serious questions about whether your house or site is adaptable to make use of passive solar energy wait until winter—November, December, January, February—and make direct observations of the amount of sunlight which hits your selected site.

Do not fail to consider future construction adjacent to your property which might block your winter sunlight . Solar access rights are not valid in most courts of law.

Fig. 10

example grid: one square equals two feet



grid: one square equals four feet

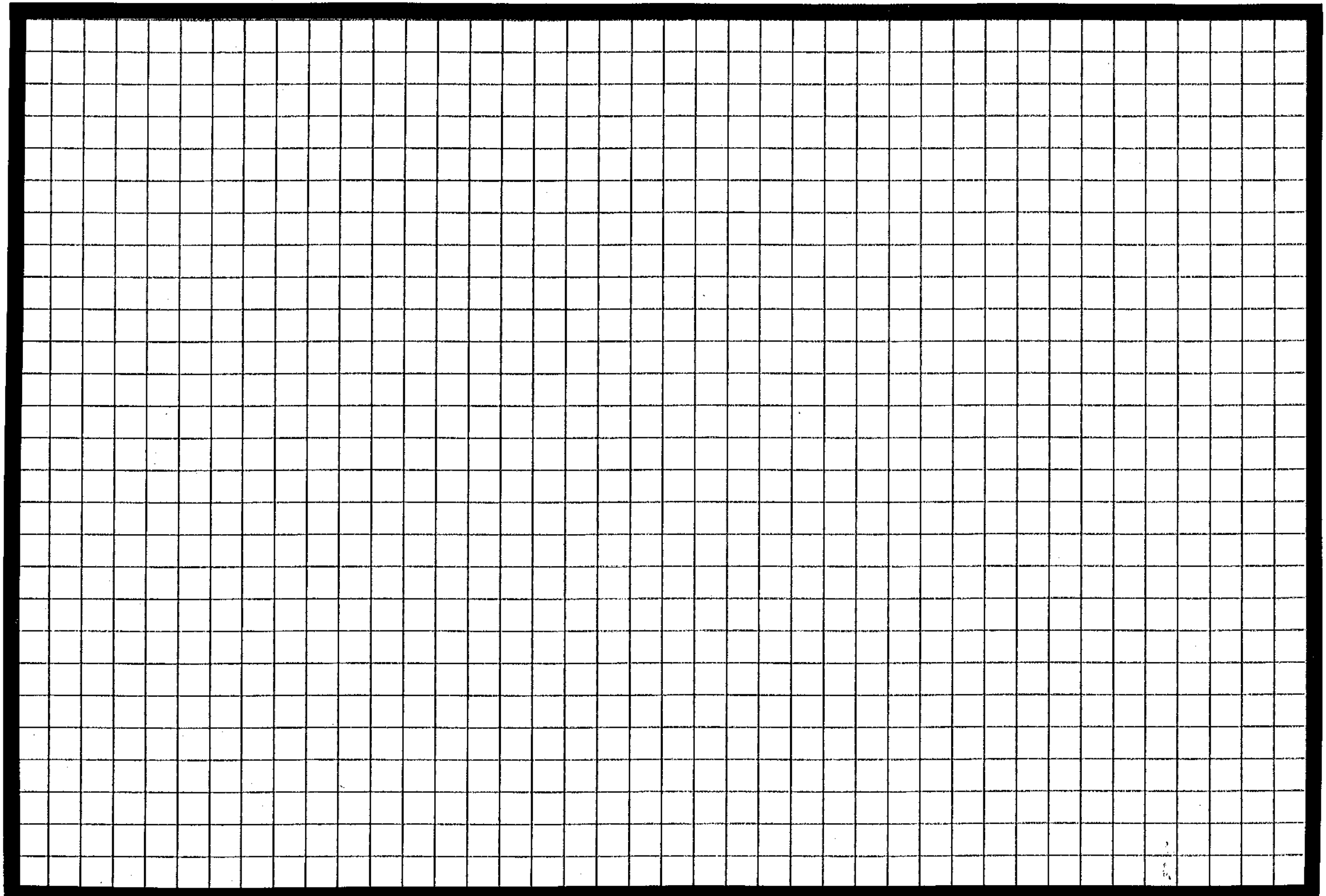


Fig. 11
Draw the outline of your house and locate trees, walks, etc. here. Add an arrow pointing north; make the most southerly wall extra dark. It is the south wall along which you will build your sunspace.

attaching the sunspace

Now you must determine the type of sunspace that will best suit your needs. There are four factors that determine how well your sunspace works as a structure and solar heating device. They are as follows:

1. How and where the sunspace is attached to your house.
2. How heat is collected and stored in the sunspace.
3. How heat is moved to other parts of the house.
4. How you plan to use the space.

This section will review some of the basic requirements of a successful sunspace.

ACCESS

You will probably want a door leading from the house directly into the sunspace. One or two windows opening into the sunspace are also helpful. If you do not have a door that will go directly into the sunspace from the house, be prepared to put one in. Locate the best spot along the south wall for a door. Place the door so as to avoid disturbing other people in the room as you move through into the sunspace. Generally, the more space that you can open up between the house and the sunspace the better off you are in terms of circulation and ventilation.

VENTILATION

If you have no windows which will open into your sunspace, you need to provide for ventilation. Typical vent locations are shown in Fig. 12. The idea is to provide for convection air currents (the natural tendency of warm air to rise) by installing a high vent and a low vent in the wall between house and sunspace. In winter, warm air from the sunspace will enter the house through the high vent and cool air will flow back into the sunspace to be warmed by way of the low vent. This flow of air is called a convection loop and is illustrated in Fig. 12.

A simple control may be devised to cut off ventilation when the sunspace becomes too hot or too cold. A hinged wooden door on the inside of the house can be hung inside a weatherproofed frame. Wherever possible, control doors should hang down while open. A magnetic or friction closing device will keep doors tight while in the closed position.

COLLECTING AND STORING HEAT

As mentioned earlier, sunlight comes in low from the south during winter. This low winter sunlight will heat dark objects and they will in turn stay warm longer if they (and the sunspace) are insulated from outside weather. To maximize the amount of sunlight entering the sunspace the whole south wall should be transparent or translucent and pass as much light as possible. Fiberglass, or sun resistant plastic works just as well as clear glass and will protect plants and fabrics from direct sun. If your budget does not allow for glass, then by all means use sun resistant* plastic or fiberglass.**

*The plastic or fiberglass should have been tested and proved capable of standing up to prolonged exposure to sunlight without damage.

**Polyethelene is not a suitable material unless used in conjunction with glass or another material. Sunlight passes readily through glass, fiberglass, polyethelene and other glazing materials. Most glazing materials will also block radiant heat, created when sunlight warms objects inside the sunspace, from passing back out. Polyethelene does not block radiant heat and therefore must be used together with other glazing materials in order to avoid losing valuable heat.

As for glass on the roof of your sunspace, in order to maximize heat collection, you may want to make the lower half of the roof transparent. The upper half should remain solid in all parts of the South to allow for summer shade on the south wall of your house. If you do put glass or fiberglass in your sunspace roof you will need to devise some insulated panels to fit under the glass in summer to keep out the hot sun. These panels may snap in place, slide in place from under the covered portion of the roof or swing up into place from hinges.

EAST AND WEST WALLS

Windows on the east and west walls will probably loose more heat than they gain in winter as east and west walls are necessarily in shade for half of the day. In designing your sunspace plan to make your east and west walls solid and well insulated.

INSULATED GLASS, DOUBLE GLAZING

Many sources suggest that in the Southeast, you do not need insulated glass or that insulated glass will not pay for itself in energy savings. You are making a considerable investment in building your sunspace and it seems a waste not to get its full benefits. Therefore, we recommend some type of double insulation on your sunspace, even if it is plastic sheeting taped in place only for the winter. For best results the two sheets of transparent material used for double glazing should be placed about one one-half inch to one inch apart. If the two sheets are placed more than an inch apart air currents will move between them and allow more heat to escape than is necessary.

If you are using fiberglass or plastic for your windows and decide to double insulate try to assemble the windows on a cool, dry day and use only rot proof wood or other materials as spacers between the clear sheets. Also, build the windows so that you can take them apart and clean between the sheets within one or two years. Unless perfectly sealed, as with manufactured glass units, you will have a moisture buildup between clear sheets that will require some maintenance at a later date.

DO IT YOURSELF INSULATED GLASS

Glass is quite expensive. A broad wall of manufactured insulated glass will cost more than most people will want to pay. You can, however, build your own insulated glass window units for less money than you might think.

Some of the materials needed for insulated glass may be available only in quantity—such as special sealants and moisture adsorbants. If you find that your local glass supplier can provide some materials only in bulk ask him to put you in touch with other interested people who might be willing to split an order with you. You might also contact your state energy office and ask them for information on solar organizations in your area. Many of these organizations exist so that members can help each other with passive solar projects and you might well find someone interested in building insulated glass there too. For further information on insulated glass check with sources listed in the bibliography.

COLLECTING LIGHT AND HEAT—
CONCLUSIONS

First, all of your glazing should be on the south wall and in the lower one half of your roof. Transparent materials in east and west walls will lose more heat than they take on in winter. Remember that frosted or diffuse materials work just as well as clear glass, or better, and that frosted glazing materials are actually better for your plants than clear glass. Finally, double glazing will make your sunspace a more effective heating device.

Frosted sheets spread light more evenly over the interior allowing for more even absorption of heat by mass inside the sunspace. Since frosted sheets spread light more evenly than clear glass, all plants receive more even light for better growth.

STORING HEAT

Now that you have a good, tight, well insulated sunspace you must devise a way to store excess heat. Your sunspace standing empty, will become quite hot on a sunny day. The idea behind storing heat is to put objects in the sunspace that will absorb heat from the air and sunlight. These objects are always heavy, usually dark in color, and they conduct heat rapidly. In technical jargon these objects are said to have "thermal mass."

Take special note that thermal mass is not something that is simply added to your sunspace. A certain amount of mass is built in. If the back wall—the original outside wall of your house—is brick, you have mass there. If your foundation and floor are concrete or masonry you also have mass there. The structure of the solar space, especially concrete and masonry, works to absorb and hold heat.

However, most solar spaces will need additional mass. This heat absorbing material can be placed after the sunspace is complete. Water is considered by most experts to be a good form of thermal mass. It is cheap, abundant, and will conform to any shape for which you can find a container. Water also conducts heat rapidly and absorbs heat completely throughout its mass. Masonry and concrete will develop "hot spots," where the sun hits directly, and overheat in these spots while the surrounding mass remains relatively cool. But since water flows within its container it spreads the heat more evenly throughout its mass.

Several manufacturers supply black water containers specifically for solar spaces. They come in all shapes and sizes. The easiest to move and maintain are the ones made of reinforced fiberglass. Just as effective, and far cheaper, are black painted oil drums, honey tins, and other recycled containers. The steel in many recycled containers has its own mass and conducts heat more rapidly than fiberglass so that you have a double advantage in using steel drums or other metal containers. New oil drums may be quite expensive so shop around for used or reconditioned oil drums.

NOTE: Rust may become a problem in used or untreated oil drums, especially when filled with water for a period of time. To avoid a problem with rusty barrels, inspect them inside and out before you buy. Rust preventatives may be added to the water in your barrels as per manufacturer's instructions or you can buy reconditioned drums in which the inside steel surfaces have been chemically treated to prevent rust. Be careful not to drop or dent treated drums as resulting damage might break the interior rust seal.

The arrangement of the interior of your solar space should take into account the proper arrangement of thermal mass, plants, and your ability to move around inside.

COLOR

White is the best color to use on the non-massive interior surfaces of the sunspace such as frame walls, ceiling and gravel floors (where white gravel is economically available). Massive — or heat absorbing — surfaces should be dark. Dark red, brown, blue and green are good colors but black is best for maximum heat absorption. If you incorporate mass in the floor in the form of brick or tile you will get good results from terracotta, red, and brown materials. A light colored gravel or a concrete walk directly in front of the solar space will reflect additional low winter sunlight into the space.

SUMMER USE

Most commercial greenhouses are far from comfortable in the summer. The level of comfort in your sunspace will depend on how you plan to use it in the summer. If you intend to grow vegetables or other sun-loving plants in the summer, then your sunspace will probably be too hot and humid to use for living space. However, if you are willing to grow most of your summer plants in an outside garden, you can turn your sunspace into a comfortable living space during warm weather. The secret is to keep the sun out during the day and to draw cool air through air through at night. It should be mentioned here that some people prefer to take advantage of a hot summer sunspace for drying herbs, fruits and even bamboo poles so consider these uses in planning your sunspace also.

SHADING

Summertime shading can be placed inside the sunspace or outside. Outside shading is best accomplished with trees, shrubs, and vines. Trees which loose their leaves in winter are the best way to provide effortless summer shade. If your sunspace is situated so that you cannot take advantage of large shade trees, smaller fruit and ornamental trees planted close to the sunspace will do nicely. A local nursery should be able to help you select good plant materials for your area.

Another way to shade outside the sunspace is to build a trellis about one or two feet in front of the south facing wall and train annual running vines on it. Depending on the type of vine used, you can harvest fruit, flowers, or vegetables and at the same time shade your sunspace. Trellis and vine shading will not be effective for shading the roof of your sunspace if it is glazed. To shade the roof you will need to use some sort of insulated shading devices on the inside or a drop cloth or rolled nursery lath on the outside.

SUMMERTIME VENTILATION

Summertime cooling is a secondary, but important, function of your sunspace. The idea is to keep the sunspace shaded during the day to avoid heat buildup. Then, at night circulate cool outside air through the sunspace to cool the heat storage or thermal mass (oil drums). The mass will then remain cool enough to actually remove heat from the air in the rest of the house during the next day. The sunspace will remain cool while allowing a reduction in air conditioning load for the rest of the house.

Nighttime circulation of air is accomplished with two sets of vents in the outside walls of the solar space. One set of vents is placed low across both east and west walls. (If you have an outside door on your sunspace, it may replace the low vents on the wall in which it is located.) Vents and doors should be screened to keep insects and pests out. The second set of vents is placed high along the junction of the sunspace roof and the south wall of the house.

With both vents open at night, cool air will enter at the lower vents, become warmer as it passes the heat storage drums, rise and leave through the upper vent. This process is part of the "convection loop" illustrated in Fig. 18 . By opening the upper vents leading into the solar space from the house, you will also be able to use the convective loop to draw off warm air from inside the house. This warm air will exit to the outside through the roof vent in the solar space. As the mass gives its heat to cool night air, it is getting ready to absorb heat gained in the house the next day.

CONCLUSION

The success of your solar space as an energy source for heating and cooling your house depends on you. You will need to develop a daily routine for adjusting vents and shading devices for maximum operating comfort. You will also have to maintain any plants that you keep inside the solar space. Your new addition is not a self-sustaining energy producer. However, the effort required to operate the sunspace is small and the benefits of solar energy are great indeed

3. CONSTRUCTION

What makes a sunspace work ?

The following two "effects" explain how the sunspace works but without proper knowledge of sunspace construction techniques and principles no sunspace will work properly.

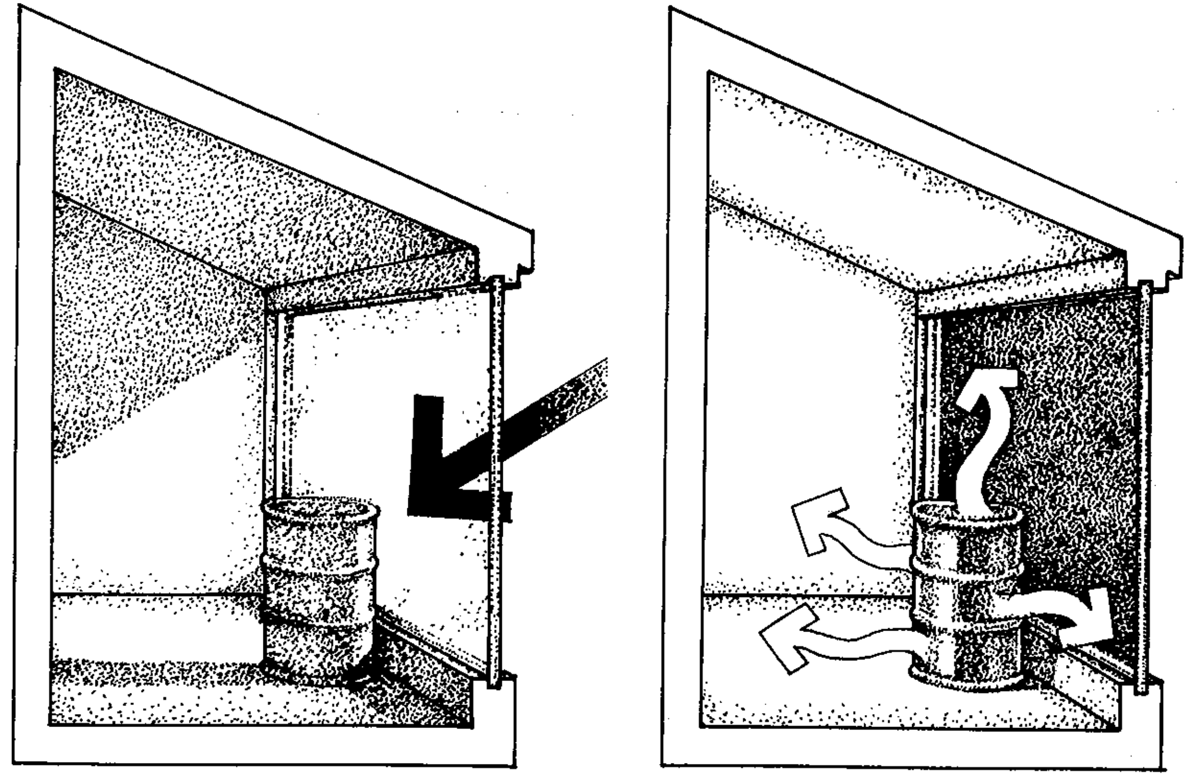


Fig. 12
the thermal mass effect

Heat, which is collected during the day, is released at night.

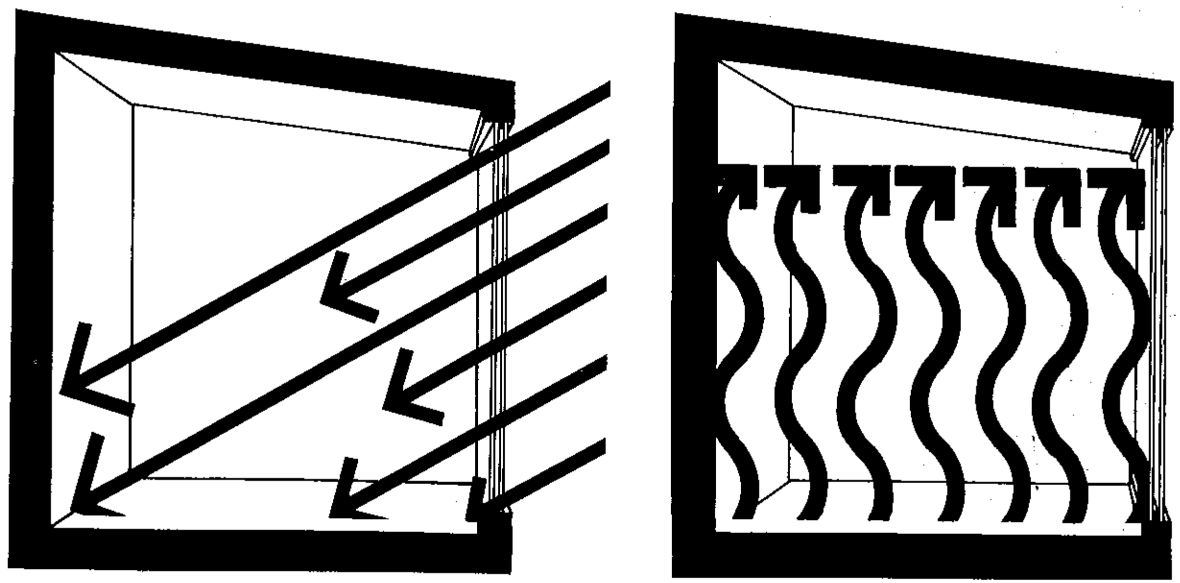
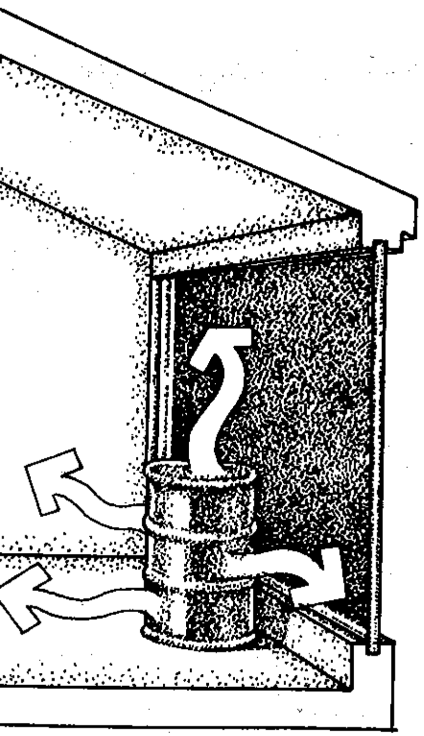
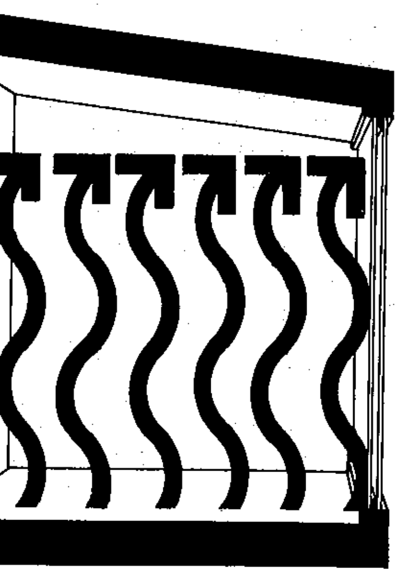


Fig. 13
the greenhouse effect

Sunlight passes readily through glass. Radiant heat, however, is blocked by the same glass.





principles of construction

Careful attention must be paid to the details which make a sunspace work. The sunspace must be air tight and well insulated. Yet it must have plenty of ventilation to keep it from overheating in the warm months. In addition the sunspace must be placed so as to receive adequate winter sunlight to heat the thermal mass stored inside and at the same time it must be provided with enough shade to keep the interior from getting any direct sunlight in summer.

This section on construction will analyze elements of structure and operation which are important in ensuring the proper heating and cooling of your sunspace. As you finish this section and go on to Chapter 4, Three Designs, apply the principles of construction to any changes which you might wish to make in the three structures. The three designs presented in Chapter 4 are not hard and fast. They can be changed in shape or size or material as long as the principles of construction and planning are adhered to.

PERFORMANCE

One of the most attractive features of a sunspace is its ability to heat itself and adjoining rooms with free sunlight. Visible sunlight is able to pass through the clear walls of the sunspace and warm the objects inside. As these objects get hot they give off long wavelength radiant heat. (This is why you can feel from a distance that something is hot without having to touch it.) However, radiant heat cannot pass through most transparent glazing materials and the energy remains trapped inside. The process of trapping heat in a sunspace is called the "greenhouse effect". Massive objects, such as drums of water or brick and concrete, are used to absorb the incoming solar energy and prevent the sunspace from overheating on a sunny day, as a car does when parked in the sun. Then, after the sun sets, , these massive materials give up heat to their surroundings and keep the sunspace warm. Masssive objects which are used to store heat are called "thermal mass".

INSULATION

A sunspace should be carefully built and insulated to reduce heat loss and insure proper functioning. The east and west walls and solid portions of the roof should be insulated just as a house is. Use at least 3 1/2 inches of fiberglass insulation, or an equivalent amount of other insulation, in walls and 5 1/2 inches in ceilings. All openings, such as vents and doors, should be caulked and weatherstriped to prevent air leaks. Glazed areas in all but the mildest climates should be double glazed. Double glazing will reduce conductive heat loss all year without affecting direct gain. If you cannot use double glazing consider using some type of movable insulation that can be put in place at night and removed to allow light to enter during the day. Anything you can do to reduce heat loss from the space will improve its solar performance.

Place vapor barriers between insulation and the interior surface of the sunspace to prevent moisture from collecting in the insulation. If you decide to insulate the wall between the sunspace and the house, apply a vapor barrier on both sides of the insulation or use a moisture proof paint on the outer surfaces of that wall.

GLAZING

Large south facing glazed areas provide solar heat gain in a sunspace. Glass can be installed in the roof, but it is difficult to seal from leaks. Glass roofs also tend to gain sunlight in the summer when the heat is not needed and require extensive use of shading devices. Unless properly angled perpendicular to the low winter rays of sunlight, glass roofs will lose more heat than they gain in cold weather.

Glazing on east and west walls contributes little winter heat and contributes some to summer overheating. East and west walls are only going to receive direct sunlight for a few hours in the morning or afternoon in winter and therefore will spend at least half of the daylight time in the shade. Of course, while the east and west walls are in shade they will be losing heat and in total will lose more heat than they gain. West wall glazing must be well shaded in summer to avoid overheating caused by the low afternoon sun.

You will be better off to insulate east and west walls than cover them with transparent material, unless you particularly like the view and are willing to sacrifice some performance.

It should be noted that partial glazing on the east wall will aid early morning warm up. However, since this wall will be in shade up to 85% of the time in winter it will lose more heat than it can recover.

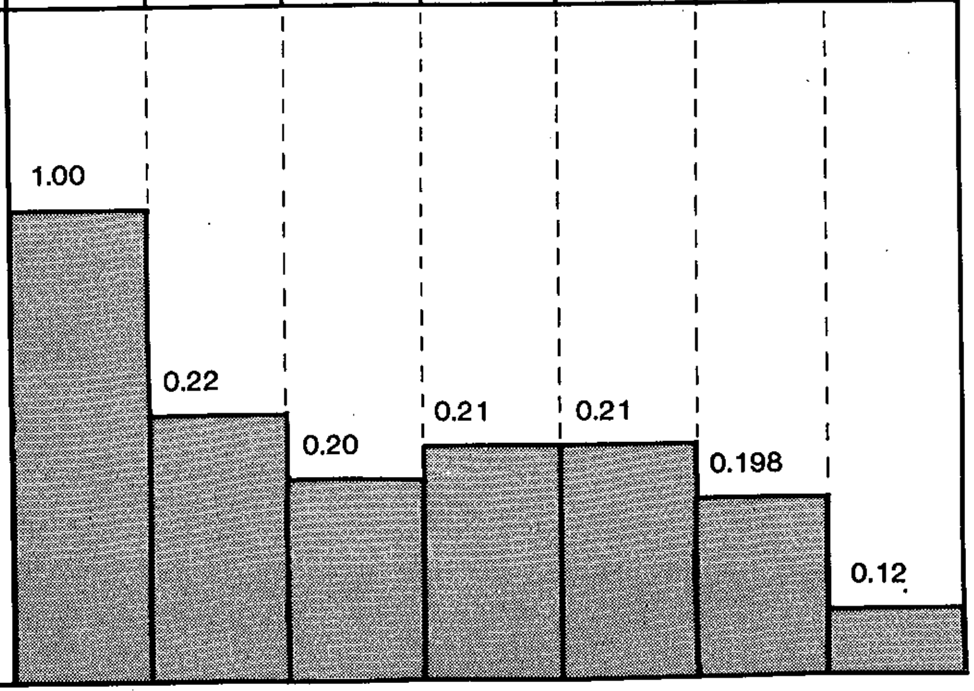
THERMAL MASS

Thermal mass is defined as any heavy object that is used to collect and store heat. Thermal mass must also conduct heat rapidly from one place to another. Most metals, water, tile, concrete, and brick all make good thermal mass. Dirt and sand are somewhat less effective but still useable. Water can be used in any size or shape container. Since water will flow in its container it heats evenly and rapidly throughout its mass. Concrete table 1

THERMAL MASS CHARACTERISTICS

MATERIAL	water	concrete	brick	earth	gravel	terra-cotta tile	steel
BTU/°F/lb. SPECIFIC HEAT	1.00	0.22	0.20	0.21	0.21	0.198	0.12

BTU/°F/lb. RATING



and masonry should not be placed in walls or floors thicker than 1 foot because it will usually take longer than a day for heat to move through an excessively thick concrete wall. This means that heat collected on a given day may not be released back into the air the following night because it is all trapped inside the thick wall. Concrete and masonry walls perform best at thicknesses between six inches and one foot.

Thermal mass will have greatest effect when it is exposed to direct sunlight. If the mass does not receive direct sunlight, more mass must be used to accomplish the same moderating effect. For the Southeast 1 cubic foot (8 gallons) of water should be used per square foot of south facing glazing. If masonry is used, 2 cubic feet per square foot of glazing should be used. Where water and masonry are both used reduce the amount of water by one cubic foot for every two cubic feet of masonry used. Table **2** illustrates the relationship of masonry and water mass to square feet of south facing glazing.

Eight gallons of water per square foot of south glazing may seem high at first but using less mass results in greater daily temperature variations (colder at night and hotter in the day) and lowered comfort levels. Chapter 4 shows floor plan layouts for three sunspaces with properly sized thermal mass located in such a way as to minimize intrusion on living and work spaces.

CONVECTION AND VENTILATION

Transfer of solar heat from the sunspace to the adjoining house can be accomplished passively by natural convection. Vents near the top and bottom of the wall between sunspace and house allow convection to occur (See Fig. **12**). Warm air from the sunspace, being less dense than cool air, rises and

table 2 calculating mass

sample problem

QUESTION:

You have 70 square feet of south facing glazing and a concrete slab which is 12' by 24' by 0.33' thick. How much additional water do you need to supply necessary mass?

ANSWER:

At first, ignore the mass in your concrete slab. Now enter the chart on the bottom line at 70 sq. ft. of glazing. Draw a line straight up until it hits the diagonal line. From this point draw a line directly to the left and read the number of cubic feet of water (70) or masonry (140) thermal mass needed.

QUESTION:

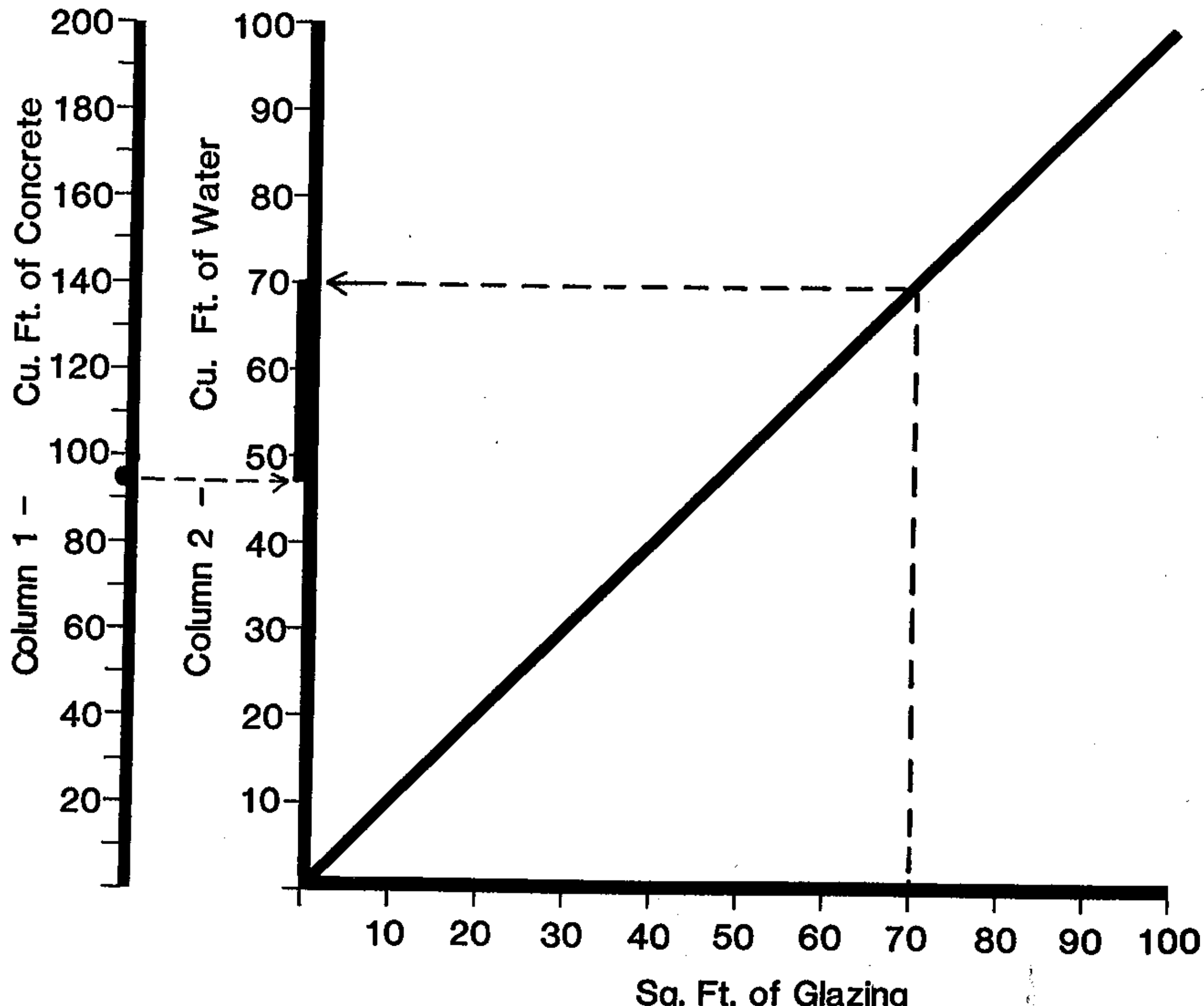
Since you already have 95 cubic feet (12 x 24 x 0.33 = 95.4) of concrete mass, how much water mass can you use now to make up the total required amount of mass?

ANSWER:

Draw a dot at 95 cubic feet of concrete on Column 1. Draw a line directly to the right and read the equivalent cubic feet of water under Column 2 (about 47 cubic feet of water). Subtract the equivalent cubic feet of water (47.5) from the total cubic feet of water (70).

70 - 47.5 = 22.5

You need 22.5 cubic feet of water in addition to your existing 95 cubic feet of masonry to have enough mass to properly modulate daily temperature changes in your sunspace. There are 7.48 gallons in a cubic foot so you will need 7.48 x 22.5 = 168.3 gallons of water.



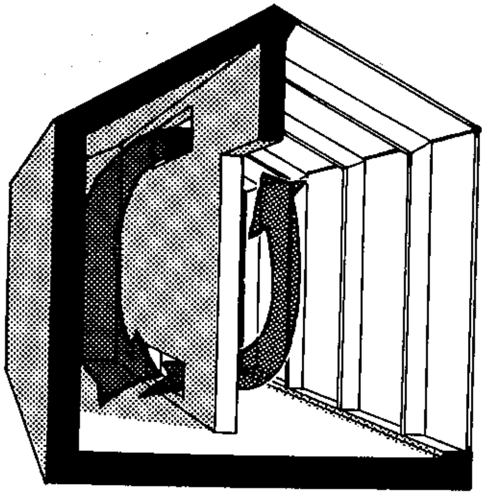


Fig. 14 Convection and Ventilation

moves into the house through the upper vents, while cooler air from the house is drawn into the sunspace through the lower vents. Doors and windows between the two areas can be used to encourage natural air flow in addition to vents. Provision for closing vents should be made to prevent heated house air from flowing into the sunspace when the sunspace is cooler than the house. Vents should be kept closed in summer to keep excessive heat and humidity out of the house.

The sunspace is self heating and provides additional heat to the house in all but the most severe winter weather. The amount of back-up heat required in winter is low and will vary according to your use of the sunspace. If the sunspace is used for growing plants, you might consider growing hardy plants which tolerate occasional root temperatures as cool as 50°F. Then, when sunspace temperatures fall below the comfort level, you simply close it off from the house, and provide additional heat only as needed for plant health.

SUMMER PERFORMANCE

In the southeastern United States backup heat is of minor concern, because it is seldom required in a properly constructed sunspace. However, summer overheating can be a major concern.

Fortunately south facing window areas pick up less sunlight in the summer than in the winter. Overhangs, shade trees, shutters, reflective film, nursery lath, trellises and other types of shading devices can be used to shield the sunspace from the hot summer sun. Also the same thermal mass which stored heat during the winter can be relied on to moderate sunspace temperature during the summer.

Even with these provisions adequate ventilation is essential. The most effective means of ventilating a sunspace is to install outlet vents near the peak of the sunspace roof which allow hot air to exit while cooler air is drawn in through lower vents on the east wall. The east wall is chosen for afternoon operation because it will be in shade during the hottest part of the afternoon and it should draw in cooler air than similar vents in west facing walls.

Try locating the outside door on the east wall if possible and use it for ventilation in place of the east wall vent. Your outside door should also have a secure screened storm door with completely removable glazing. The total vent area (outlets and inlets) should be about 1/6 the floor area of the sunspace. Provision for closing off the sunspace from the house during the warm hours of the day is also desirable.

CONSTRUCTION AND MATERIALS

There is no great mystery to building a sunspace. Construction details and techniques are little different from conventional house construction. Attention to detail and careful fitting of materials will result in a product that not only looks good but works well too.

Footings for the sunspace are generally made of poured concrete with foundation walls made of concrete or concrete block. The outside of the foundation is insulated with at least 2" of foam (polystyrene) insulation to a depth of two to three feet. Use an insulation which is rated for outdoor applications and which will not rot or become waterlogged. This reduces heat loss and allows you to take advantage of the foundation's thermal mass.

Concrete, brick, flagstone, or tiles make good, durable floors while providing mass for storing heat. Concrete floor slabs thicker than 6" do not contribute significantly to the thermal mass effect. Using crushed stone in greenhouses allows spilled water to soak through to the soil below.

Solid wall areas can be framed and constructed in a conventional manner. Be sure to insulate these areas to reduce heat loss. Wood that is in contact with the ground or subject to high amounts of moisture should be pressure treated.

A polyethylene vapor barrier should be installed on the inner surface of all stud walls and roofs between the insulation and the inner wall paneling. The vapor barrier will make the walls more nearly air tight and reduce the possibility of airborne moisture condensing on the insulation.

Interior walls of the sunspace should be light in color to reflect sunlight onto plants or thermal mass. If masonry walls are used, they should be insulated on the exterior side.

MATERIALS

There are many types of glazing materials to choose from, each with distinct advantages and drawbacks. Traditionally glass has been used in greenhouses. It transmits sunlight well and allows the occupant to see out. It is not affected by the elements, but it is prone to breakage and can be more expensive and difficult to work with than some other materials.

Another excellent material for sunspaces is translucent fiberglass. Be sure to use fiberglass intended for greenhouses or solar devices. It weathers well, can be cut to size with common tools, does not break, and is reasonably priced. It is, however, translucent, and diffuses sunlight. While plants like diffuse, even sunlight, fiberglass does not allow a clear view of the outside.

Some plastic films have been developed which withstand exposure to sunlight for a period of years. These films are easy to work with and are packaged in large widths so as to minimize the number of joints between sections. If you use a plastic film, be sure to support it adequately with framing.

NOTE: Polyethylene film does not make a good exterior sunspace glazing material. It breaks down when exposed to ultraviolet light of the sun and also allows infrared light to pass through, thereby preventing the "greenhouse effect" from working properly. Polyethylene film will work satisfactorily, however, when used in conjunction with glass or fiberglass panels to double insulate.

To spare some expense you may use a durable material such as glass or fiberglass as the permanent exterior glazing and install a less costly plastic film on the inside as shown in Chapter 4. The exterior glazing will take the abuse of the elements while the more fragile inner glazing can be periodically replaced to give you the benefits of double glazing at a lower cost.

You can build your own double insulated glass windows. You will, however, need time, a suitable workspace, and the proper materials. Some of the materials needed for insulated glass may be available only in quantity—such as special sealants and moisture absorbants. If you find that your local glass supplier can provide some materials only in bulk ask him to put you in touch with other interested people who might be willing to split an order with you. For further information on insulated glass check with sources listed in the bibliography under glazing.

Vent and door openings should be carefully framed to insure a proper fit. The doors and vents themselves should be mounted to allow easy operation but at the same time they should shut tightly to limit infiltration of air. Be sure to cover all openings with insect screening. If possible, make the vents out of insulating material also. If you are not present to open and close vents as needed, automatic vent operators can be installed for some additional expense. Check with a solar equipment supplier for information on these devices.

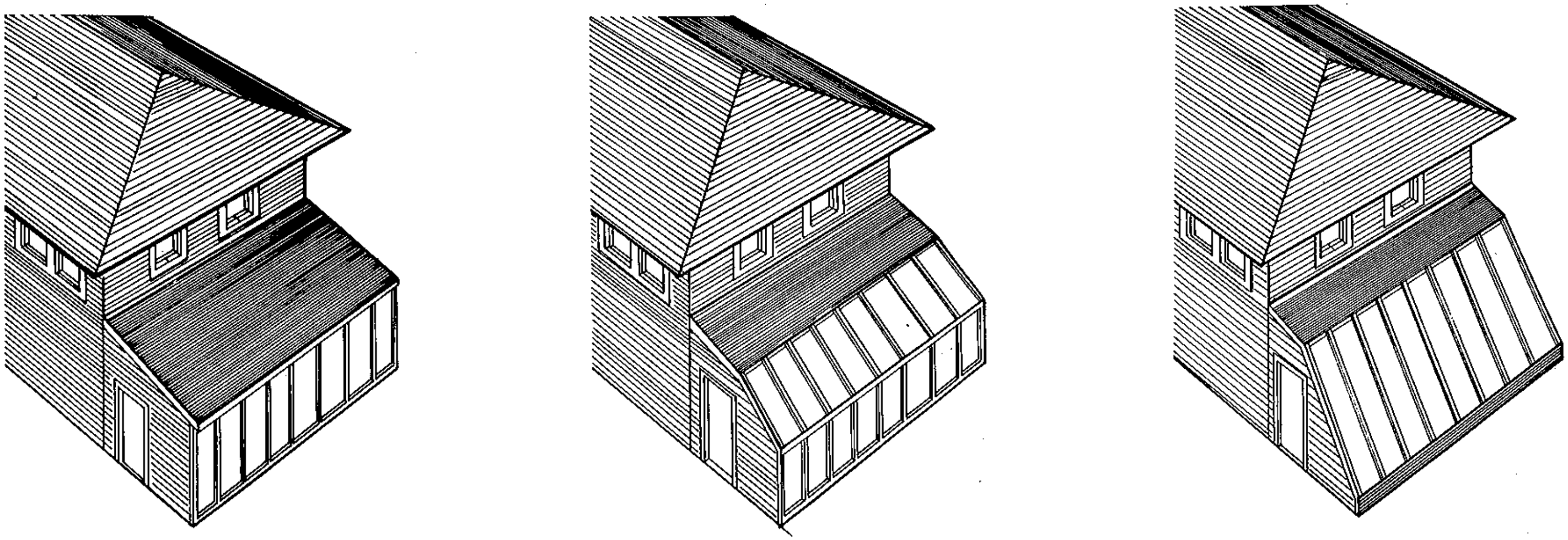
In finishing the shell of the sunspace, don't skimp on caulking. Fill all gaps with a good grade of caulking material. Even small cracks can rapidly lose your hard earned solar heat to the outside. If the sunspace is subject to high winter winds, hedges or windbreaks that don't block incoming solar rays will help reduce heat loss.

It is important that you use no penta or creosote treated lumber inside the sunspace because fumes released from these materials are toxic to plants. Roofing materials may be corrugated steel, aluminum, roll, tile, shake, shingle or anything else that will keep water out. Choice of roofing and exterior sheathing materials is left up to you.

rules of thumb

1. The area needed to properly vent your sunspace to the outside on a sunny day is 1/6th the floor area of the sunspace. High vents should be 20% larger than low vents.
2. The area needed to properly vent your sunspace to the inside of your house is 1 square foot of vent area for each 30 square feet of floor area with about 20% more area in the upper vents than in the lower vents.
3. If you have a door or window between house and sunspace, this will usually suffice for ventilation.
4. Vapor barriers always face inside the sunspace except on the wall between the house and the sunspace where 2 vapor barriers are needed.
5. Use 1 cubic foot of water mass or 2 cubic feet of concrete mass for every square foot of south facing glazing in your sunspace.
6. Use 2" perimeter insulation around the sides and to a depth of 2 or 3 feet below the bottom of your slab or foundation. No insulation is necessary under your slab or foundation.

4. 3 DESIGNS



design features

All of the 3 sunspace plans included in this section are designed to be constructed along the south wall of a house using standard building materials and construction practices. To reduce heat loss from the sunspaces, double glazed windows, insulated east and west walls, insulated roofs, and careful sealing of cracks are detailed. By insulating the perimeter of the footings or concrete floor slab, heat loss is reduced and the mass of the floor and earth below can be used to moderate the sunspace's temperature. Additional thermal mass for storing solar heat consists of water filled 30 and 55 gallon drums and the soil in the growing benches. All of this additional mass is exposed directly to the low winter sun so that it readily absorbs heat and is shaded from the higher summer sun to help keep the sunspace cooler.

Summer ventilation of the sunspaces is provided by the use of vents on the east and west walls and a continuous vent along the ridge of the sunspace through which hot air can escape. If you construct an exterior door on the sunspace, you may want to install a screened door which can be used in place of the intake vents on the east and west walls. While these measures are adequate to prevent overheating you may also want to use some kind of sun shade or plant deciduous trees to block out more of the summer sun.

Each of the sunspaces is the same size (12 feet wide by 24 feet long) and each is designed for a different use.

interchangeability of materials

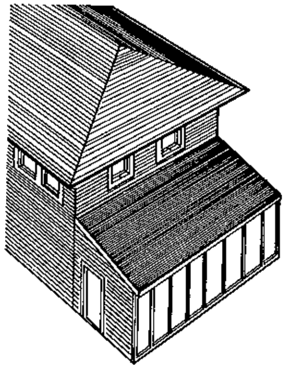
Framing materials remain the same in all three designs while flooring materials vary according to function of the featured design. The brick floor featured in the heat producing sunspace may be difficult or expensive to obtain in some areas. The bricks are therefore interchangeable with other pavers or with a concrete slab. Gravel is not an optimum material for heat storage but due to its ability to absorb spills it should be considered as the best choice for greenhouse floors. Gravel and concrete floors should be of dark color. The concrete floor of the living area sunspace may be covered with ceramic tile or brick but it should not be covered with wood, rugs, linoleum or plastic surfaces as these will act as insulation. The concrete slab floor is also interchangeable with the brick or paved floor of the heat producing sunspace but it will not perform as well without the addition of extra mass elsewhere in the space.

Glazing materials are completely interchangeable between the three designs with one exception. The greenhouse design should not have a clear glass south wall as this causes poor growth for your plants. The south wall of the greenhouse should be composed of at least one and perhaps two layers of a translucent glazing material such as fiberglass or plastic. Translucent glazing materials are also recommended over clear anywhere that a view to the outside is not necessary or desirable because they are (1) less expensive, (2) easier to handle and (3) they distribute light more evenly inside the sunspace and contribute to more even and comfortable heat production.

availability of materials

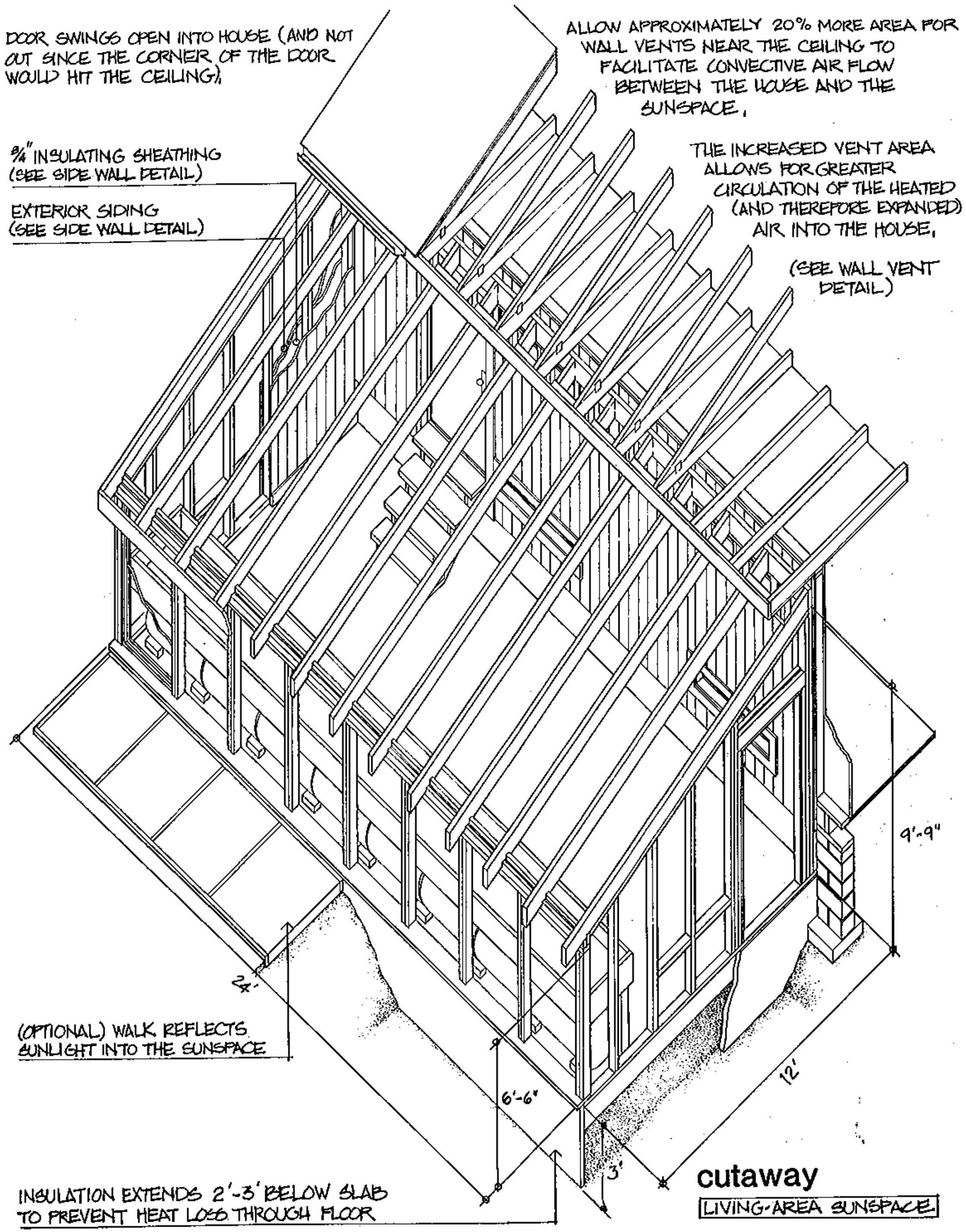
In addition to normal building materials suppliers you should check on the availibility of used and surplus materials in your area. Concrete forms are especially suited to make use of surplus building materials. Glass, because of its durability, is also well suited for recycling in new buildings. Some framing may come from recycled building materials as long as the materials are strong and free from termites or structural defects. Resources for used building materials may include local building supply companies, local manufacturing company wastes, surplus stores and second choice stores.

living area sunspace



The living area sunspace, as its name implies is designed to serve as an additional living space. A small plant bench across the front of the sunspace provides a place for growing plants year round while also providing thermal mass to store solar heat. Large south facing windows, protected by the overhang of the insulated solid roof admit winter sun while blocking out much of the hot summer sun.

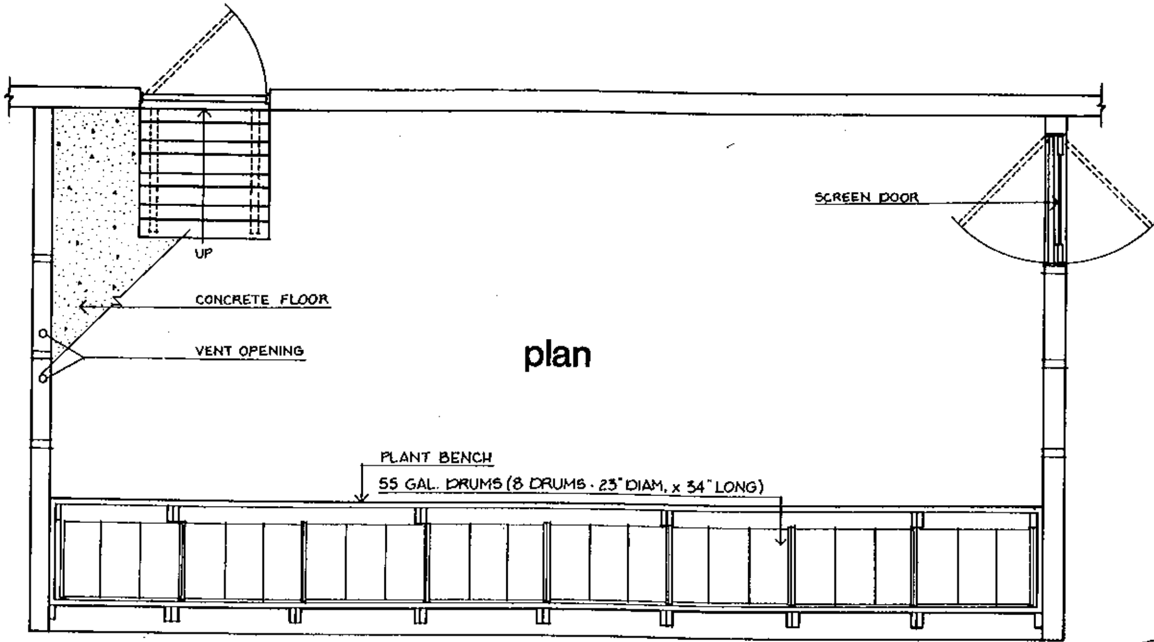
Calculations of sunspace performance show that the structure can maintain itself at temperatures above 50°F throughout the winter months. During the winter, day time temperatures should climb into the upper 70's falling slowly to a minimum of 50°F by early morning. The sunspace can provide some supplemental heat to the house in the months of April and October. Heat can be transferred from the sunspace to the house during other winter months, but this will also result in lower nightly temperatures in the sunspace. If the sunspace is to be maintained at 70° throughout the heating season, some supplemental heating will be required. Since, however, most cool temperatures will occur only late at night, the sunspace should be closed off during these times and not heated.



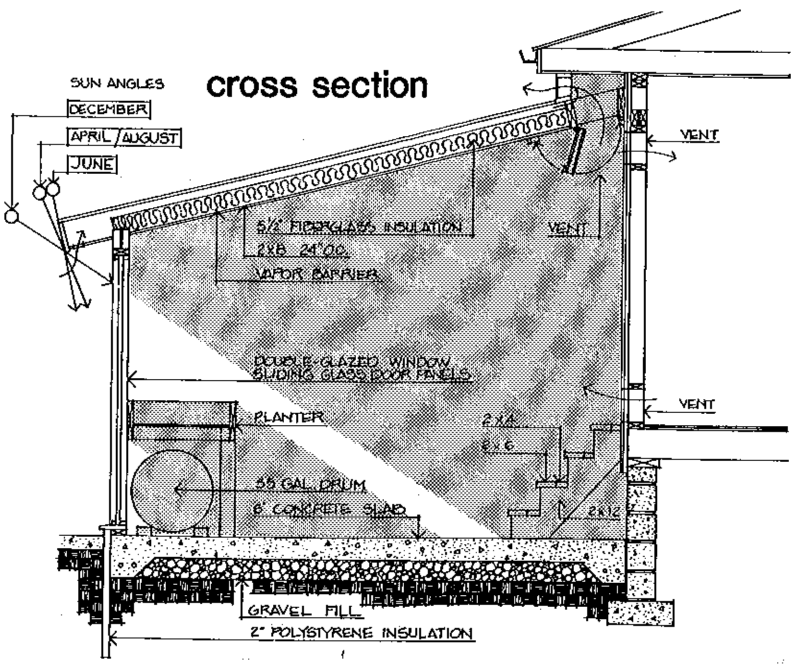
cutaway
LIVING-AREA SUNSPACE

Construction Details

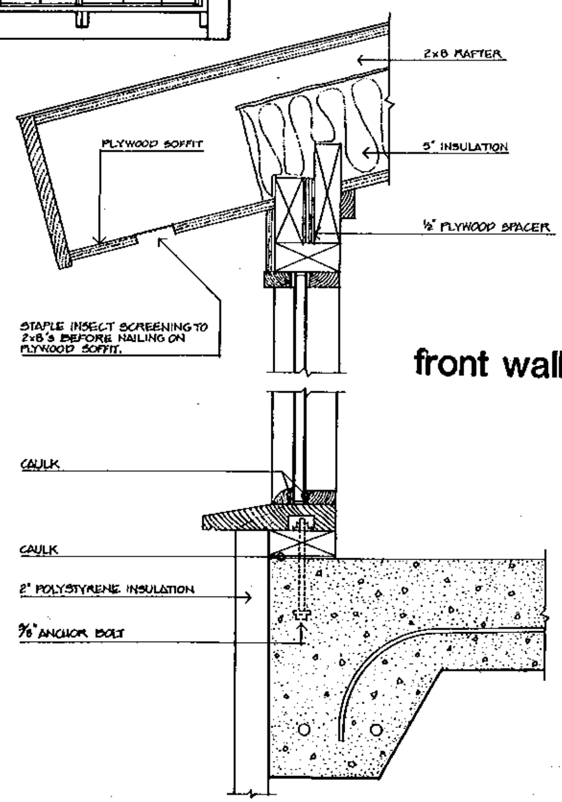
plan

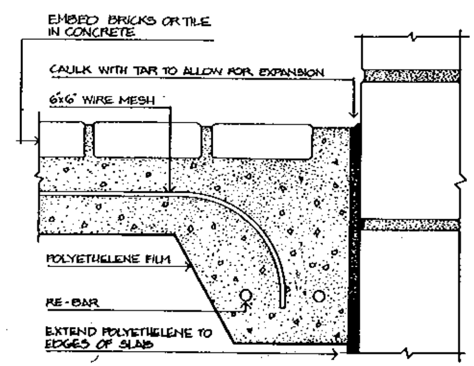


cross section

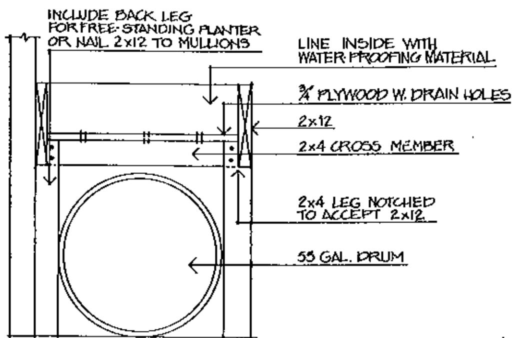


front wall section

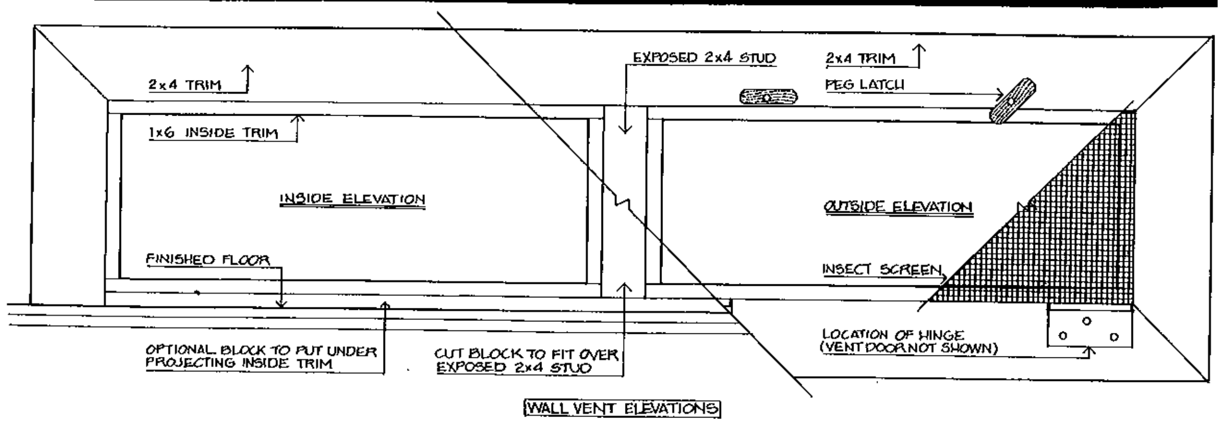


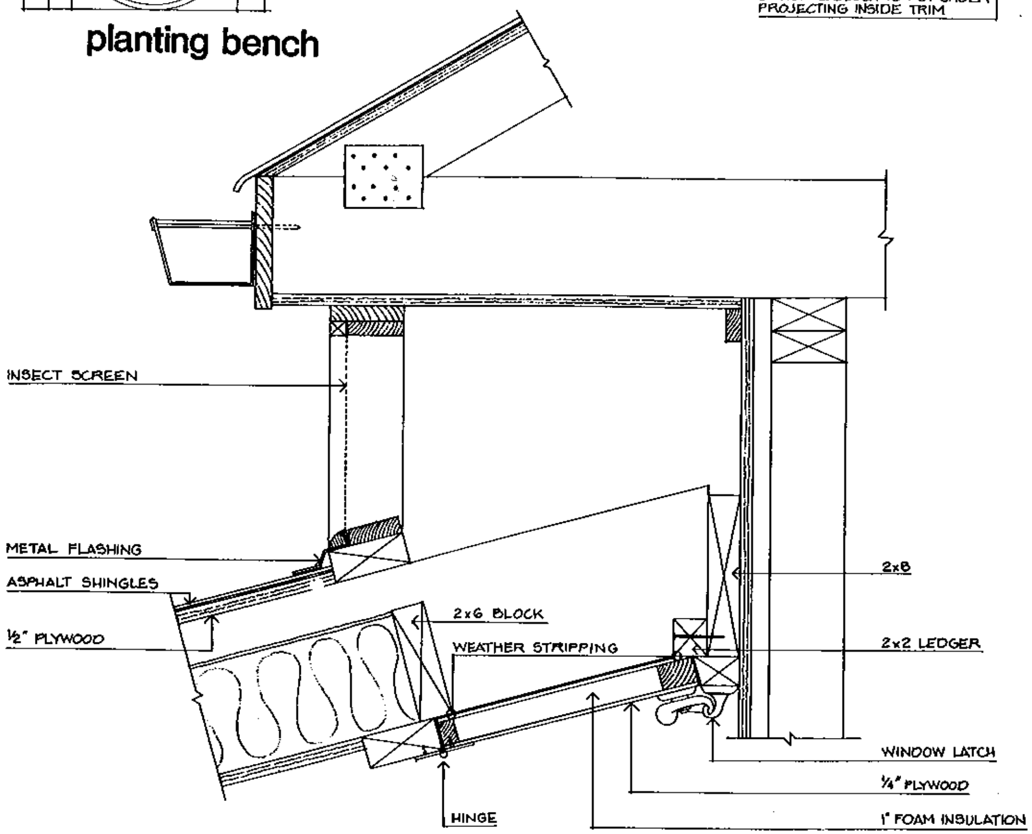


these details are found in all three sunspaces

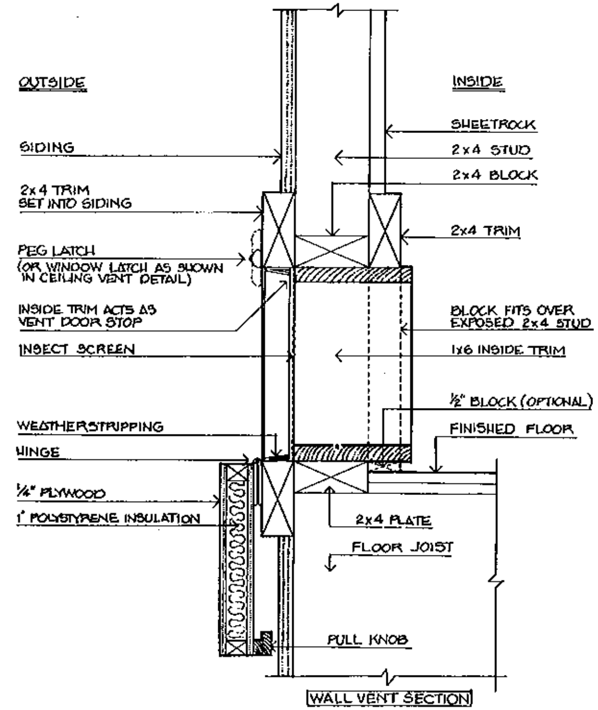


planting bench





ceiling vent section



NOTE: SAME DETAIL MAY BE USED FOR UPPER WALL VENT BY SUBSTITUTING 2x4 BLOCK FOR 2x4 PLATE AND ADDING 2x4 TRIM BELOW THE VENT OPENING ON THE INSIDE IN PLACE OF THE ½" OPTIONAL BLOCK.

wall vent section

Materials List

Living Area Sunspace

Item	Component	Quantity	Unit Cost	Cost	Notes
Concrete Slab	6" x 6" x 4' wide welded wire mesh	84'			
	1/2" Steel reinforcing rod	144'			
	Concrete	6 cu. yds.			
	Polyethylene	14' x 26'			Vapor Barrier
South Wall	2 x 4 x 8 pressure treated	3 pcs			
	2 x 4 x 8	24 pcs			
	2 x 8 x 8	3 pcs			Sill – see details
	2 x 6 x 8	3 pcs			
	1/4 round moulding	150'			
	3/4" x 1 1/2" trim	176'			
	Glass	16 pcs			Prefabricated single or double glazed or do it yourself.
End Walls	2 x 4 x 8' pressure treated	3 pcs			
	2 x 4 x 8'	7 pcs			
	2 x 4 x 10'	10 pcs			
	1/2" x 4' x 8' exterior plywood siding	7 pcs			
	3/4" x 2' x 8' T&G polystyrene Insulation	14 pcs			
	2" x 4' x 8' interior plywood siding	7 pcs			
	31/2" x 22 1/2" fiberglass insulation	105 ft			
	16d nails, 4d flat head nails, 6-8d siding nails				
Roof	2 x 8 x 14'	15 pcs			
	1 x 8 x 8'	3 pcs			
	1/2" x 4 x 8 CD plywood (exterior)	9 sheets			
	1/2" x 4 x 8' exterior plywood siding	1 sheet			
	3' wide 15# felt building paper	192'			
	asphalt shingles	300 ft^2			

Living Area Sunspace (cont.)

Item	Component	Quantity	Unit Cost	Cost	Notes
	Metal drip edge	48 ft			
	51/2" x 22 1/2" fiberglass insulation	144 ft			
	metal flashing				
	roof cement				
	roofing nails				
	1/2" x 4' x 8' interior plywood	9 sheets			
	2 x 6 x 8'	3 pcs			
	2 x 2 x 8'	6 pcs			
	1 x 4 x 8'	9 pcs			
	1/4" round moulding	60'			
	Insect screen				
Vents	1" x 2' x 8' foam insulation	3 pcs			
	1/4 x 4' x 8' plywood	3 sheets			
	1" x 3/4" wood	84'			
	hinges	16			
	weatherstripping				
	3/4" finishing nails				
	window latches	8			
Misc.	caulking – silicon for wood to wood, wood to metal, wood to concrete joint				
	caulking – latex, for wood to glass joints				
	4 mil polyethylene film, 4' wide	200 ft			
Growing Benches	2 x 12 x 8' pressure treated	8 pcs			
	2 x 4 x 8' pressure treated	5 pcs			
	3/4" x 4' x 8' plywood, exterior grade	2 sheets			
	55 gallon drums, painted black	8			
	water proofing				
	16d nails				
	8d nails				

performance characterics

LIVING AREA SUNSPACE

Item		Quantity	Weight	Storage Capacity
Mass:	Floor slab	144 ft^3	21,179#	4233 BTU/°F
	Soil	27.5 ft^3	3580#	715 BTU/°F
	55 gal drums under planter	11	5021#	5021 BTU/°F

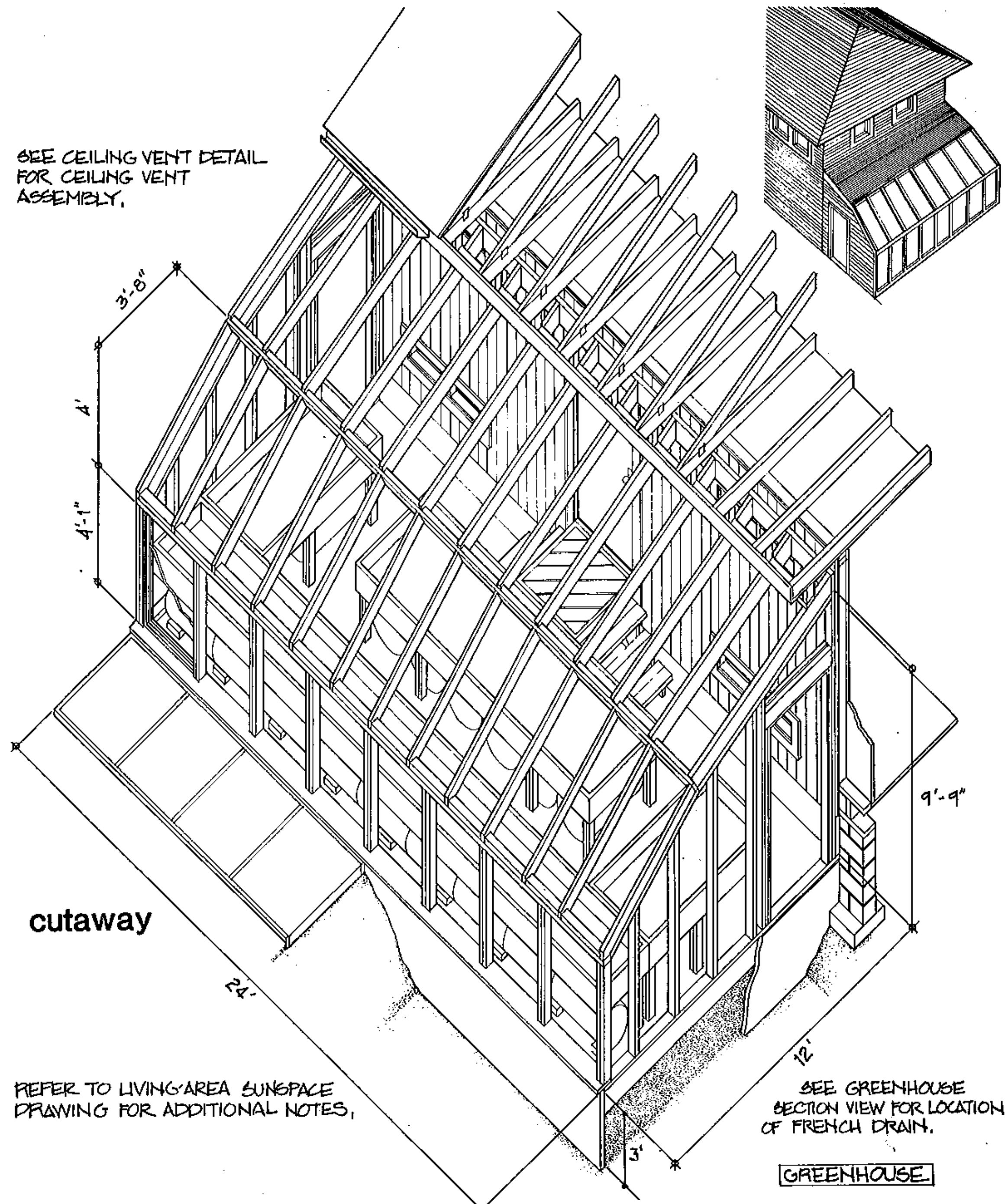
	Sun days/ Month	Degree Days 65°	Degree Days 50°	% Load above 50°	% Load above 70°
Jan_1	14.3	632	236	100	38.6
Feb_2	14.0	512	138	100	42.0
Mar_3	16.7	404	19	100	46.0
Apr_4	18.9	133	0	100	92.0
Oct_{10}	20.2	110	0	100	100.0
Nov_{11}	16.2	393	19	100	68.0
Dec_{12}	14.0	614	296	95.4	38.6
Totals	114.6				49.6

passive solar greenhouse

The Greenhouse plan is designed for growing plants. The short, glazed vertical wall and sloping glazed roof allow winter sunlight to fall on the large growing bench areas. Summer sunlight, on the other hand, does not penetrate to the back wall of the structure and summer overheating is thereby reduced. Doubling as heat storage devices, the plant benches provide space for growing a variety of vegetables and ornamental plants. Plants requiring more sunlight should be planted nearer the south wall.

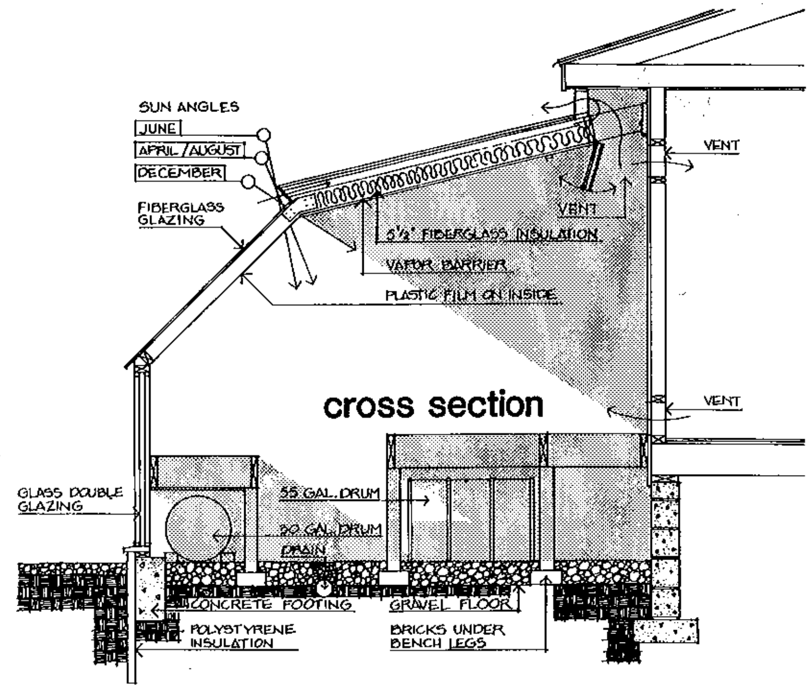
When building the greenhouse, special attention should be given to installing the polytehylene vapor barrier. This vapor barrier which covers the insulation on the inside of the sunspace, prevents moist air from passing into the insulation where it may condense and reduce the insulation's value. Avoid punching holes in the vapor barrier while installing and secure edges tightly to eliminate gaps.

Temperatures during the winter months will range from the upper 70's on sunny days to a minimum of 50°F. Consequently it should be possible to grow plants throughout the winter without the use of auxiliary heat. The Greenhouse will provide heat to the adjoining house during the months of March, April, October and November. Heat could be drawn from the greenhouse during the other winter months but lower minimum temperatures will result.

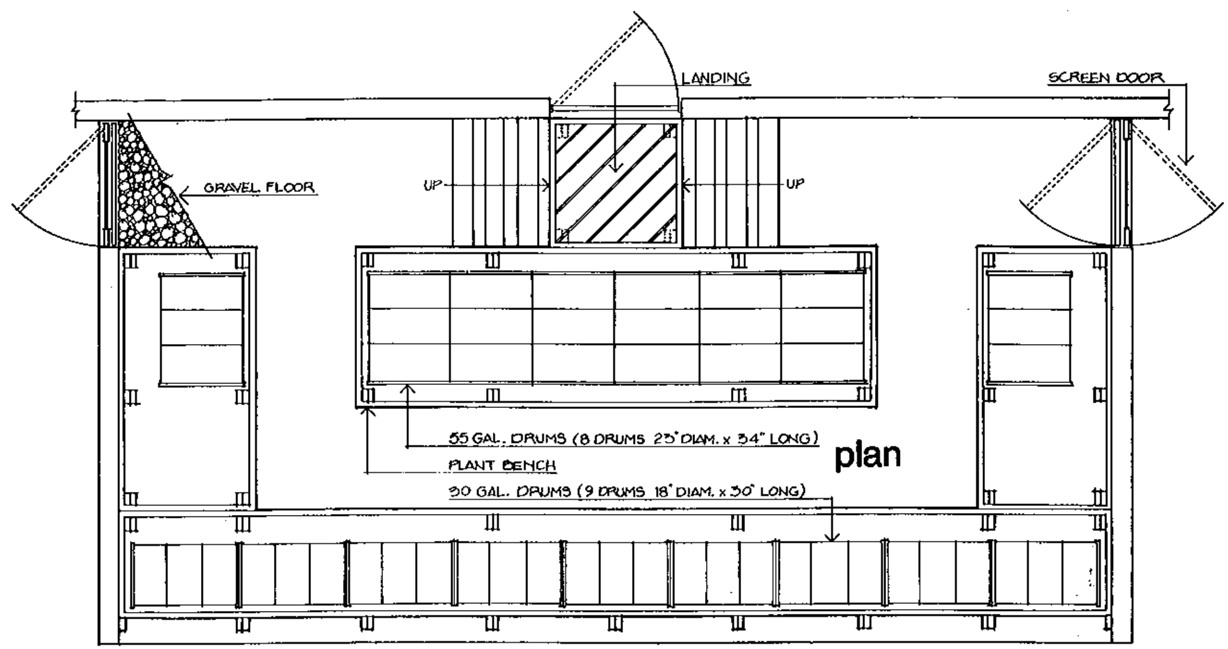


cutaway

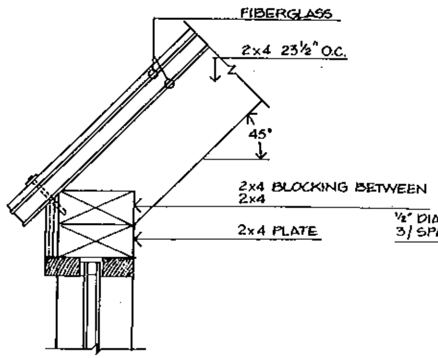
Construction Details

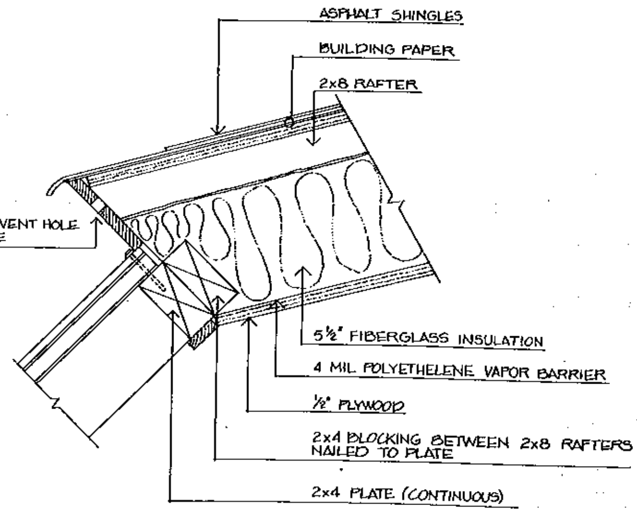


cross section

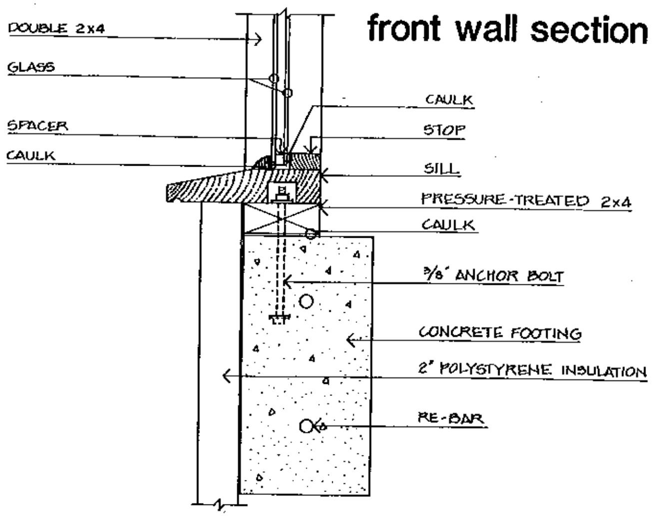


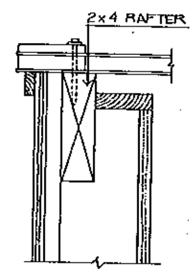
plan



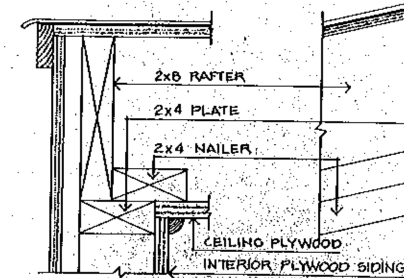


front wall section

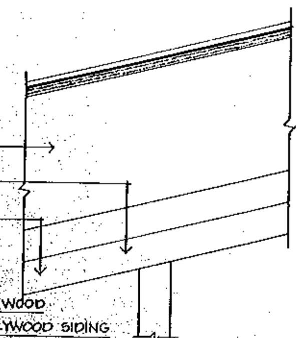




SECTION

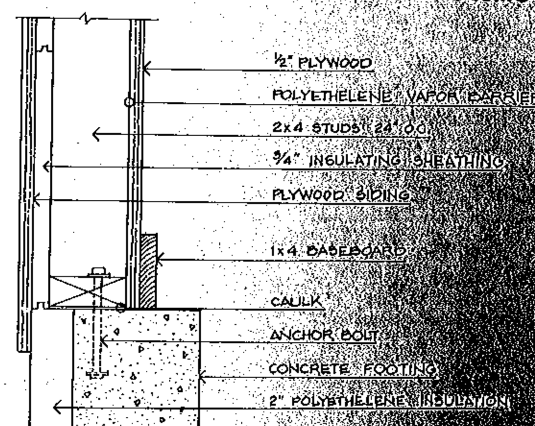


SECTION



SIDE VIEW - FRAMING

side wall details



Materials List

Greenhouse

Item	Component	Quantity	Unit Cost	Cost	Notes
Foundation	Same as for heat producing sunspace				
South wall	2 x 4 x 8' pressure treated 2 x 8 x 8' sill (see detail) 2 x 4 x 8' 2 x 6 x 8' 1/4 round moulding 3/4" x 1 1/2" trim glass metal spacer	3 pcs 3 pcs 12 pcs 3 pcs 136 ft 120 ft 16 pcs			
Glazed roof section	2 x 4 x 10' 2 x 4 x 8' 3/4 x 1 1/2" wood spacer 3/8" x 1 1/2" wood batten 4' wide fiberglass glazing material Silicon caulk 3" ring shank nails or 3" wood screws with metal and rubber washers	4 pcs 6 pcs 90 ft 90 ft 72 ft			
Solid roof section	2 x 8 x 10' 1 x 6 x 8' 1/2" x 4' x 8' C. D. plywood 1/2" x 4' x 8' interior plywood 2 x 6 x 8' 2 x 2 x 8' 2 x 4 x 8' 1 x 4 x 8' 1/4" round moulding insect screening 5 1/2" x 22 1/2" figerglass insulation	16 pcs 3 pcs 6 sheets 6 sheets 3 pcs 6 pcs 6 pcs 9 pcs 60' 84'			

Greenhouse (cont.)

Item	Component	Quantity	Unit Cost	Cost	Notes
	3' wide 15# building paper asphalt shingles metal flashing	122' 168 ft²			
Solid Roof	metal drip edge 16d, 6d, finishing, roofing nails roofing cement	38'			
End walls	2 x 4 x 8' pressure treated 2 x 4 x 8' 2 x 4 x 10' 1/2" x 4' x 8' exterior plywood siding 3/4" x 2' x 8' T&G polystyrene sheathing 1/2" x 4' x 8' interior plywood 3 1/2" x 22 1/2" fiberglass insulation 102 ft 16d, 4d flat headed, 6d–8d siding nails	3 pcs 5 pcs 8 pcs 7 sheets 14 sheets 7 sheets			
Vents	Same as Living Area Sunspace				

performance characteristics

GREENHOUSE

Item	Quantity	Weight	Storage Capacity
Mass: Gravel floor	132 ft^3	14,784#	2809 BTU/°F
30 gal. Drums under ft. bench	9	2,241#	2241 BTU/°F
55 gal Drums under bk. bench	8	3650#	3650 BTU/°F
Soil – Benches, Front	39.5 ft^2	4933#	987 BTU/°F
Back	74.25 ft^3	9652#	1930 BTU/°F

	Sun days/ Month	Degree Days 65°	Degree Days 50°	% Load above 50°	% Load above 70°
Jan_1	14.3	632	236	100	59.1
Feb_2	14.0	512	138	100	71.5
Mar_3	16.7	404	19	100	96.9
Apr_4	18.9	133	0	100	100.0
Oct_{10}	20.2	110	0	100	100.0
Nov_{11}	16.2	393	19	100	100.0
Dec_{12}	14.0	614	296	100	57.4
Totals	114.6			100	73.1

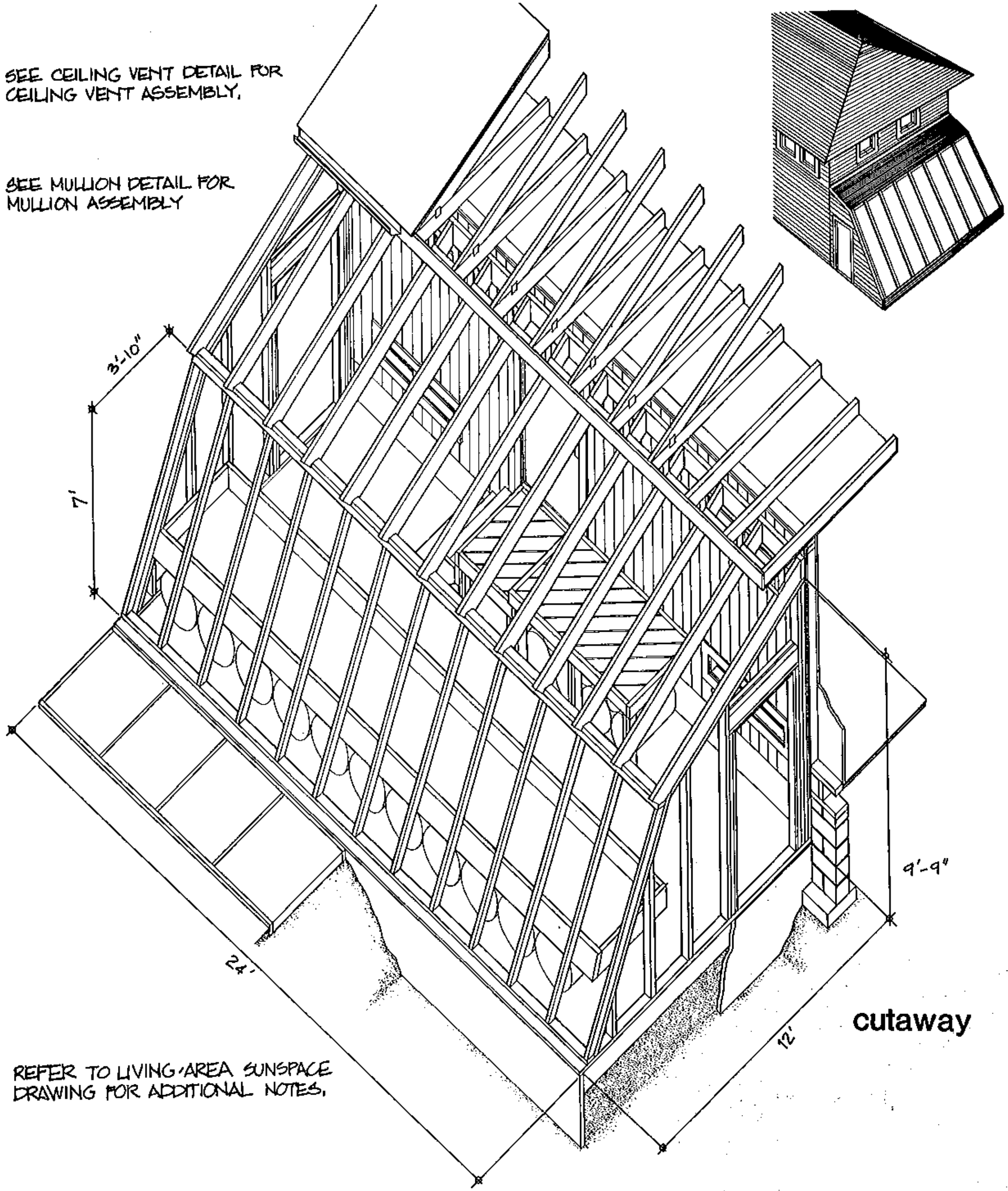
heat producing sunspace

The Heat Producing Sunspace lives up to its name by delivering heat to the adjoining house in all but the months of December and January while maintaining its own temperature above 50°F year round. A plant bench across the front of the sunspace provides some space for growing plants while again accomodating the thermal mass needed to store solar heat.

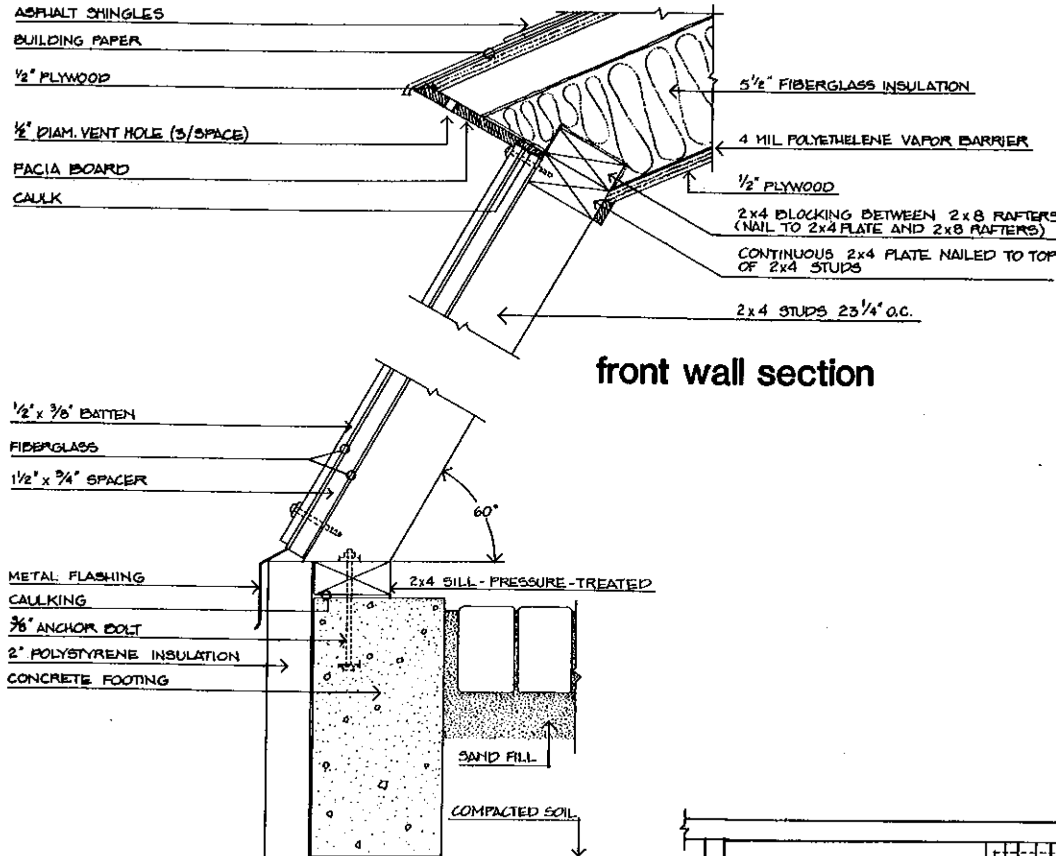
If no plants are grown in the sunspace and nightly temperatures can be allowed to drop lower, more heat may be extracted to warm the house. This is accomplished by venting the sunspace to the house during the day, allowing warm air to rise into the house. Then, at night, the vents between the house and sunspace are shut and the sunspace is allowed to cool.

The sloping south wall, glazed with 2 layers of translucent fiberglass, admits the warming rays of the low winter sun. This sunlight falls on the exposed thermal mass which in turn, absorbs the heat. During summer little of this mass is exposed to the sun so the sunspace cools more quickly. The drums stacked along the back (house) wall absorb additional heat. Their ideal location is at the east end of the sunspace so that they absorb more late afternoon sun. However, their placement is not critical and should not prevent you from making changes to better suit your site.

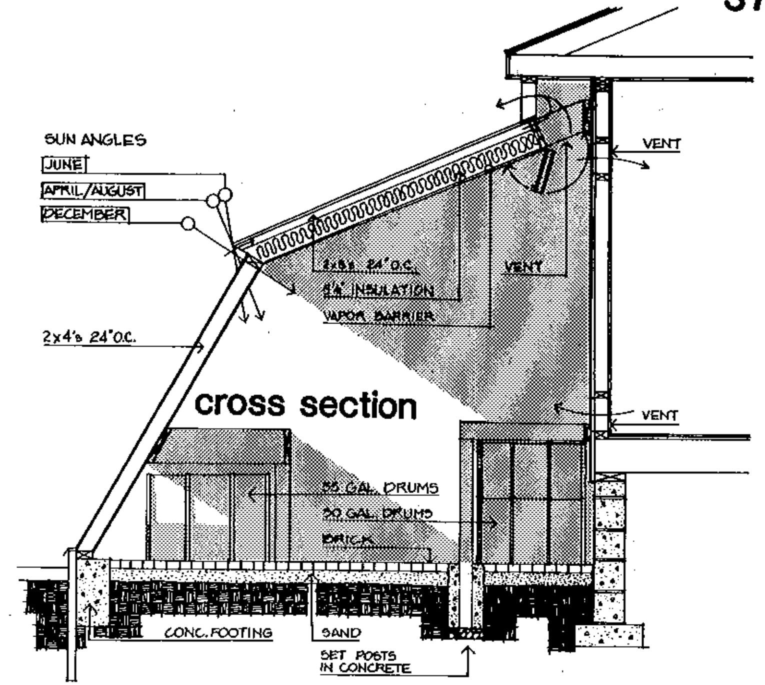
These plans are intended to illustrate how the principles discussed in the text may be incorporated into workable designs. Use them as a starting point, as a suggestion of one way to build a sunspace, then take it from here, building to suit your needs and your site.



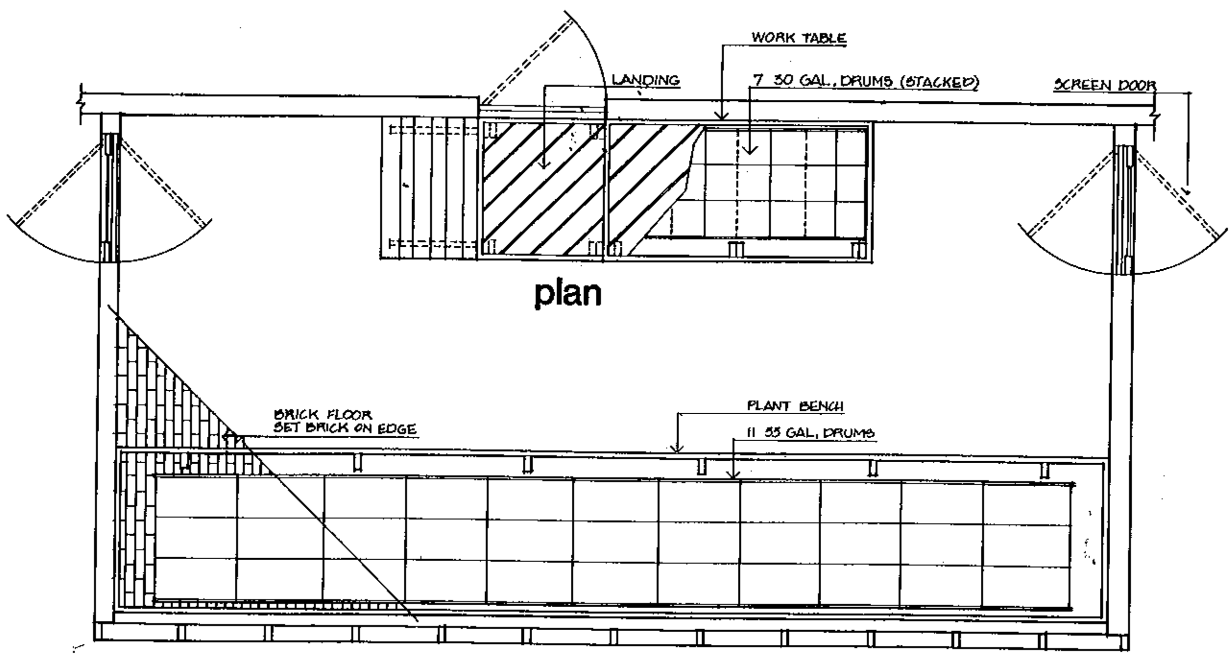
cutaway



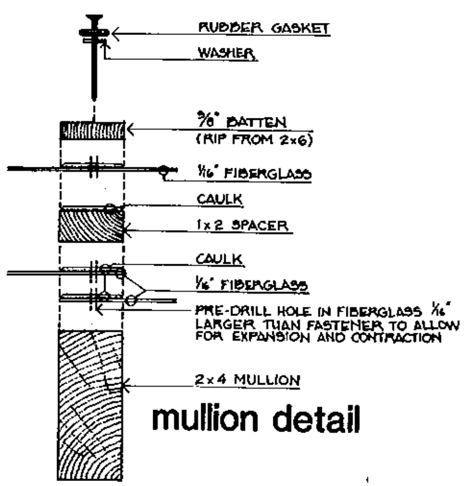
front wall section



cross section



plan



mullion detail

Materials List

Heat Producing Sunspace

Item	Component	Quantity	Unit Cost	Cost	Notes
Foundation	1/2" steel reinforcing rod	144'			
	3/8" x 6' anchor bolts with washers & nuts	20			
	concrete	1 cu yd			
	3' wide x 2" thick polystyrene insulation	48'			
	brick 4" x 2 1/2" x 8	1860			
	sand fill				
South wall	2 x 4 x 8' pressure treated	3 pcs			
	2 x 4 x 5' pressure treated	21 pcs			
	4' wide fiberglass glazing	96 ft			
	3/4" x 1 1/2" x 8' wood	19 pcs			
	3/8" x 1 1/2" x 8' wood	19 pcs			
	metal flashing				
	16d Nails				
	3" ring shank or 3" wood screws with metal and rubber washers,				
	silicone caulking				
Roof	2 x 8 x 10'	16 pcs			
	1 x 6 x 8'	3 pcs			
	1/2" x 4 x 8' C.D. plywood	6 sheets			
	1/2" x 4' x 8' interior plywood	6 sheets			
	2 x 6 x 8'	3 pcs			
	2 x 2 x 8'	6 pcs			
	2 x 4 x 8'	6 pcs			
	1 x 4 x 8'	9 pcs			
	1/4 round moulding	60'			
	insect screening				
	5 1/2" x 22 1/2" fiberglass insulation	84'			
	3' wide 15# building paper	128'			
	asphalt shingles	192 ft^2			

Heat Producing Sunspace (cont.)

Item	Component	Quantity	Unit Cost	Cost	Notes
	metal flashing metal drip edge 16d nails, finishing nails, 6d nails, roofing nails roofing cement	 40'			
End walls	2 x 4 x 8' pressure treated 2 x 4 x 8' 2 x 4 x 10' 1/2" x 4' x 8' exterior plywood siding 3/4" x 2' x 8' T&G polystyrene sheathing 1/2" x 4' x 8' interior plywood siding 3 1/2" x 22 1/2" fiberglass insulation 16d, 4d flat headed, 6d-8d siding nails	3 pcs 7 pcs 6 pcs 7 sheets 13 sheets 7 sheets 89'			
Vents	Same as with living area sunspace				

performance characteristics

HEAT PRODUCING SUNSPACE

Item	Quantity	Weight	Storage Capacity
Mass: Brick floor	84 ft^3	10,920#	2074 BTU/°F
Soil - Benches	27.5 ft^3	3580#	715 BTU/°F
55 gal drums under bench	11	5021#	5021 BTU/°F
30 gal drums under walk	7	1740#	1740 BTU/°F

	Sun days/ Month	Degree Days 65°	Degree Days 50°	% Load above 50°	% Load above 70°
Jan_1	14.3	632	236	100	64.8
Feb_2	14.6	512	138	100	80.8
Mar_3	16.7	404	19	100	100.0
Apr_4	18.9	133	0	100	100.0
Oct_{10}	20.2	110	0	100	100.0
Nov_{11}	16.2	393	19	100	100.0
Dec_{12}	14.0	614	296	100	63.3
Totals	114.6				80.4

glossary

Absorber: the blackened surface in a collector that absorbs the solar radiation and converts it to heat energy.

Active system: a solar heating or cooling system that requires external mechanical power to move the collected heat, ie. fans, pumps, etc.

Air vents: any opening other than a door or window that will allow free movement of air from one space into another through openings which can be closed or opened as desired for proper circulation of air.

Ambient air: any unconfined portion of the atmosphere; the outside air.

Backup system: a system used to augment a solar system.

Beam: any wood or steel member spaced as required for load and used primarily to support the joists. Standard specifications may include "2 x 8 beam 8' o.c."

Btu (British thermal unit): a unit used to measure quantity of heat; technically, the quantity of heat required to raise the temperature of one pound of water 1 °F. One Btu equals 252 calories. One Btu is approximately equal to the amount of heat given off by burning one kitchen match.

Caulking: making an airtight seal by filling in cracks around windows and doors.

Climate: prevailing or average weather conditions of a geographic region as shown by temperature and meteorological changes over a period of years.

Collector: a device for gathering the sun's energy — as simple as a south-facing window or as complicated as a pumped concentrating co-lector sitting on the roof.

Component: smallest identifiable element of a solar heating or cooling subsystem, such as a valve, a control, or a container.

Conduction: the process by which heat energy is transferred through materials (solids, liquids or gases) by molecular excitation of adjacent molecules.

Conductivity: the quantity of heat (Btu's) that will flow through one square foot of material, one inch thick, in one hour, when there is a temperature difference of 1 °F between its surfaces.

Controls: devices such as thermostats and temperature-sensing elements used to manipulate fans, pumps, and dampers in solar systems.

Convection: the transfer of heat between a moving fluid medium (liquid or gas) and a surface, or the transfer of heat within a fluid by movements within the fluid

Dead air space (still air space): a confined space of air. A dead air space tends to reduce both conduction and convection of heat. This fact is utilized in virtually all insulating materials and systems, such as double glazing, Beadwall, fiberglass batts, rigid foam panels, fur and hair, and loose-fill insulations like pumice, vermiculite, rock wool and goose down.

Degree-day (cooling): one day with the mean of the daily minimum and maximum ambient air temperatures one degree warmer than 65 °F (18 °C) or other specified base temperature. If the minimum and maximum ambient temperatures are 70 and 90 degrees, the number of cooling degree-days for that day is 80 minus 65 or 15.

Degree-day (heating): one day with the mean of the daily minimum and maximum ambient air temperatures one degree colder than 65 °F (18 °C) or other specified base temperature. If the minimum and m4ximum ambient temperatures are 30 and 50 degrees, the number of heating degree-days for that day is 65 minus 40 or 25.

Density: the mass of a substance which is expressed in pounds per cubic foot.

Design temperature (winter): a chosen temperature close to the lowest expected. A 97.5% winter design temperature means that the outdoor air temperature will be equal to or lower than the chosen temperature for about 2.5% of the 2160 hours in the three coldest months.

Double-glazed: covered by two panes of glass or other transparent material.

Efficiency: ratio of the useful energy output to the energy input under given conditions, expressed in percent. Reference to solar applications, this measure pertains to the

glossary

percentage of the solar energy incident on the face of the collector (glazing), that is used for space heating.

Energy conservation: reduction in the energy used.

Energy conversion: changing one form of energy into another.

Energy efficiency: amount of useful work or product, divided by the fuel or energy input. In electrical generation, it is the amount of electricity produced per unit of fuel consumed.

Footings: a load-bearing foundation member constructed of poured concrete with minimum specs. of 2500 psi at 28 days for support of outer walls of greenhouse.

Foundation slab: usually a six inch (6") concrete poured floor with end footings on a base of compacted gravel 4" to 6" thick which is laid on a compacted subsoil.

Forced convection: the transfer of heat by the flow of warm fluids, driven by fans, blowers, or pumps.

Forced ventilation: mechanically aided ventilation using some sort of fan or blower.

Gravity convection: the natural movement of heat through a body of fluid that occurs when a warm fluid rises and cool fluid sinks under the influence of gravity.

Glazing: a covering of transparent or translucent material (glass or plastic) used for admitting light. Glazing retards heat losses from reradiation and convection. Examples: windows, skylights, greenhouse and collector coverings.

Glazing, double: a sandwich of two separated layers of glass or plastic enclosing air to create an insulating barrier.

Greenhouse effect: trapping heat inside a glass or plastic enclosure, or trapping heat by the earth's atmosphere, primarily by reducing convective heat loss.

Heat: energy associated with the motion of atoms or molecules at or above the energy of surrounding areas.

Heat gain: heat gained by a building from the sun, internal heat sources, and (in warm weather) from infiltration and conduction through the building skin.

Heat source: a body which supplies heat energy. A heat pump uses air or water out-

Heat storage: a device or medium that absorbs collected solar heat and stores it for periods of inclement or cold weather.

Heat storage capacity: the ability of a material to store heat as its temperature increases.

Humidity (relative): ratio of the actual water vapor content of the air to the water vapor that would be found in the same volume of saturated air at the same temperature and pressure.

Infiltration: the movement of air into a house through cracks around windows, doors, seams, utilities, and from the opening of doors and windows. It can account for as much as one-half of the heat loss or gain in a well-insulated house.

Insolation: the total amount of solar radiation — direct, diffuse and reflected — striking a surface exposed to the sky. This incident solar radiation is measured in langleys per minute, or Btu's per square foot per hour or per day.

Insulation: material having a high resistance to the flow of heat. Types include fiberglass blanket or batt, loose fill, foam, and reflective.

Joist: wood or steel members spaced as required for load capacities and primarily used to support flooring or roofing. A standard specification may include " 2 x 6 joist 16" o.c.

Kilowatt: unit of power that measures the rate at which energy is produced or used. Ten 100-watt lightbulbs use energy at the rate of one kilowatt (equal to 1000 watts). A rate of one kilowatt maintained for one hour produces or uses one kilowatt-hour of energy (equal to 1000 watt-hours).

Natural convection: see gravity convection

glossary

Natural ventilation: ventilation using natural breezes.

Nocturnal cooling: the cooling of a building or heat storage device by the radiation of excess heat into the night sky.

Outside air: air taken from outdoors and therefore not previously circulated through the system.

Seasonal sun angles: results of the relationship of the earth's axis to the sun as it orbits about the sun. The two extremes of the axis angles are used to determine the appropriate angle of glazing. The low winter sun angle is measured at 12 noon on December 21st. This is the lowest angle the sun will appear to have in the sky. The high summer sun angle usually appears at 12 noon on the 21st day of June. This is the highest angle the sun will appear to have and is considered the least desirable sun angle due to excessive heat production.

Shading: the obstruction of the sun by an overhang, arbor, wall or landscaping. The choice of trees for shading a south wall is critical because a thick tree may block one-half of the sun even with its leaves gone.

Shading angles: sun angles that result in shadows on a specific solar device.

Solar building: one which uses solar energy for heating and/or cooling.

Solar energy: energy transmitted from the sun in the form of electromagnetic radiation in the wavelength region from 0.3 to 2.7 micrometers.

Solar heating system: assembly of subsystems and components necessary to convert solar energy into thermal energy for heating purposes, in combination with auxiliary energy when required.

Solar house, or solar tempered house: a dwelling that obtains a large part, though not necessarily all, of its heat from the sun.

Solar rights: legal protection of solar access.

Solar window: openings that are designed or placed primarily to admit solar energy into a space.

Storage capacity: amount of energy that can be stored by a solar heating system for use at a later time.

Studding: vertical wood members spaced as required for load construction of walls. Standard specifications may include "2 x 4 stud 18 in. o.c. framing."

Sun tempered: a standard dwelling that uses good solar orientation to meet much of its heating demand.

Sun path calculator: a device used to determine if surrounding trees and buildings will shade a potential sunspacesite during winter months.

Temperature: a property by which objects are ranked according to the direction of heat flow between them when they are placed in contact. An object's temperature depends on the average kinetic energy of the molecules which comprise the object. Various phase changes, such as the freezing and boiling of water, are often used as the basis of practical temperature scales, and serve as calibration points for practical thermometers that indicate temperatures by variations in length, volume, electrical conductivity, etc. of a substance.

Thermal mass: the amount of potential heat storage capacity available in a given assembly or system. Drum walls, concrete floors and adobe walls are examples of thermal mass. Thermal mass makes use of materials with high heat capacity to store energy in a structure. This mass acts as a battery to solar heat or natural cooling.

Thermostat: instrument that measures temperature, and controls devices for maintaining a desired temperature.

Translucent: the quality of transmitting light but causing sufficient diffusion to eliminate perception of distinct images.

Vapor: gaseous phase of substances that are either liquids or solids at the same temperature but higher pressure.

Vapor barrier: a component of construction which is impervious to the flow of moisture and air and is used to prevent condensation in walls and other locations of insulation.