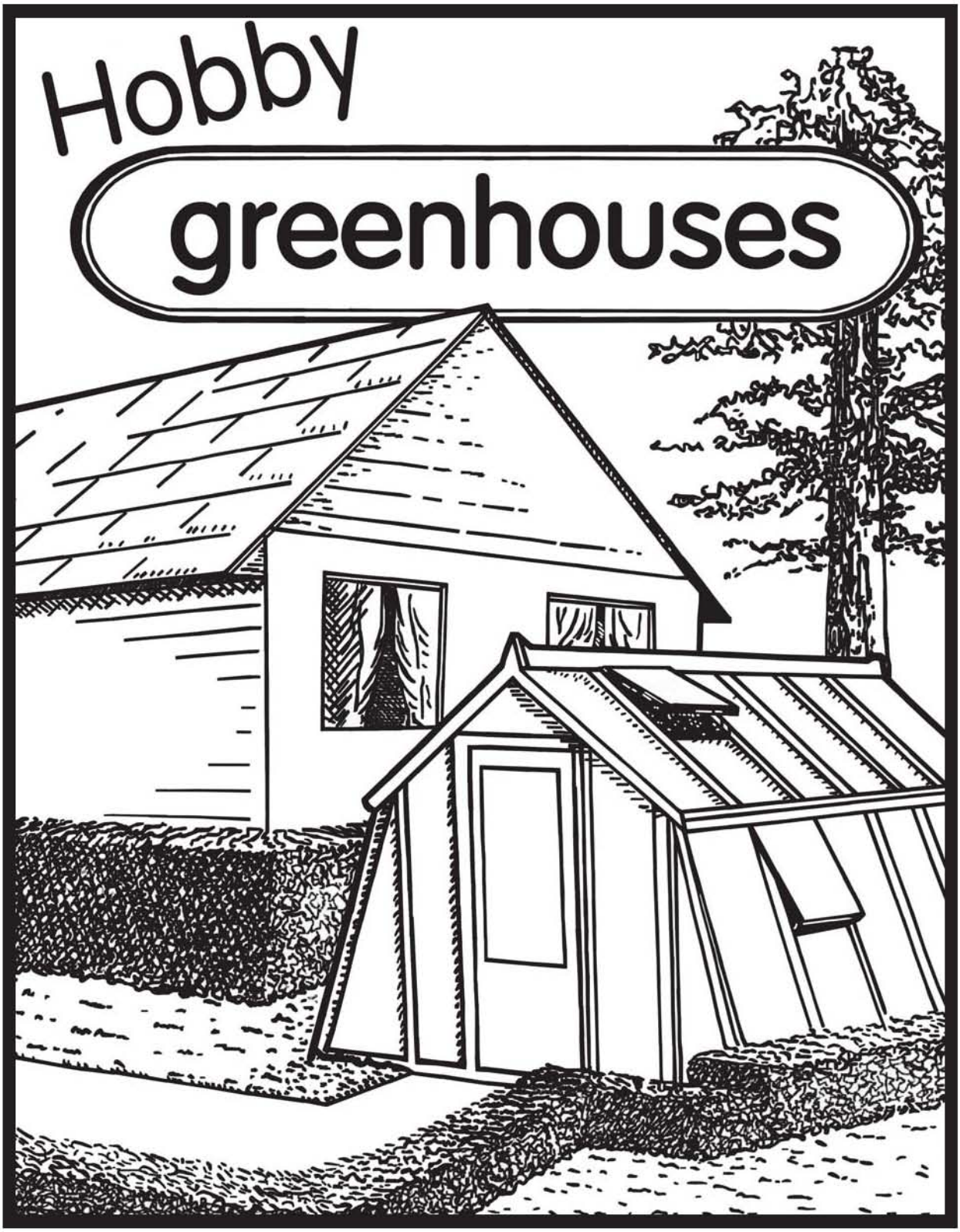
UGA extension

Hobby greenhouses



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Hobby Greenhouses

Today more and more homeowners are growing bedding plants, vegetable transplants and house plants in greenhouses. These greenhouses are called hobby greenhouses. They are usually small in size but can be as large as a small commercial grower's greenhouse.

The gardener who has a greenhouse can extend or intermingle the seasons at will. With the many types of heating and cooling systems available, temperatures can be maintained to keep you and your plants comfortable. Whether you wish to build your own greenhouse from scratch or purchase a prefabricated structure ready for assembly, there are several basics that must be met.

A hobby greenhouse can be a simple, polyethylene-covered framework that can be put together in one afternoon for less than one hundred dollars or it can be a six thousand dollar prefabricated structure.

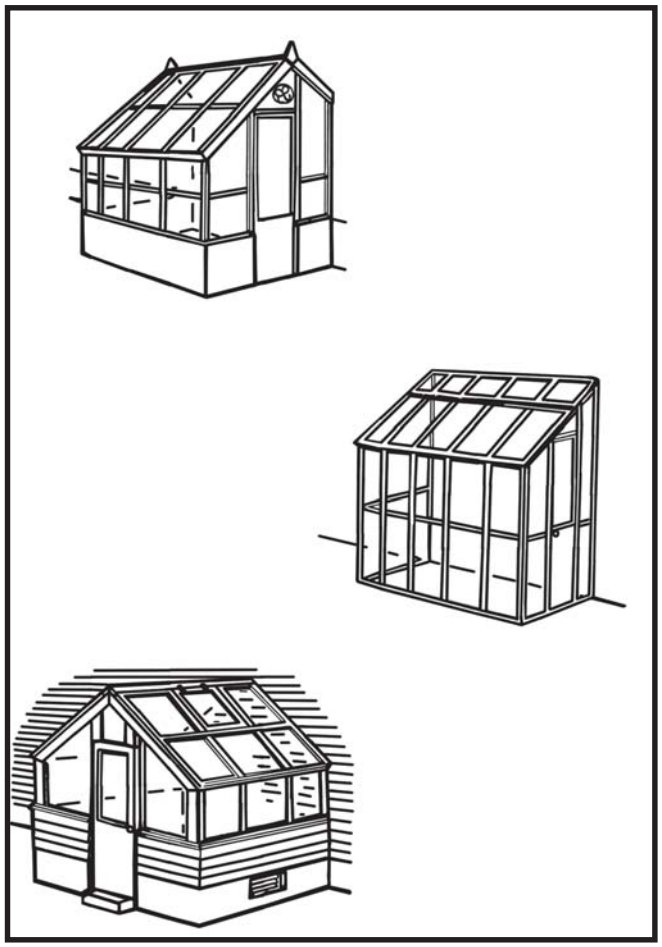


Figure 1. Attached greenhouses. This greenhouse style is popular because it blends well with many homes and is easily accessible.

No matter which size or type of greenhouse you choose, consider how much time you will have to spend in it after it is built. With automatic controls in your greenhouse and easy-care plants, maintenance can be kept to a few hours a week. Automatic controls are ideal for providing proper growing temperature, artificial light, watering, humidity and ventilation. If you have the time to regulate the environment, you can save a great amount of money by not using automatic controls.

Types of Greenhouses

There are two basic types of greenhouses: attached and freestanding. An attached greenhouse may be even-span, lean-to or window-mounted (Figure 1). A freestanding greenhouse is usually even-span (symmetrical roof) [Figure 2, page 4].

Attached Lean-To

A lean-to greenhouse is built against a building, using the existing structure for one or more of its sides. It is usually attached to a house but may be attached to other buildings.

The lean-to is limited to single or double-row plant benches with a total width of 7 to 12 feet. It can be as long as the building it is attached to. The advantage of the lean-to greenhouse is that it is usually close to available electricity, water and heat.

The lean-to has the following disadvantages:

- Limited space
- Limited light
- Limited ventilation and temperature control

Attached Even-Span

The even-span greenhouse is the standard type – the one people generally visualize when they think about a greenhouse. The even-span greenhouse is similar to a free-standing structure except that it is attached to a house at one gable end. It can accommodate two or three rows of plant benches The cost of an even-span greenhouse is greater than the cost of a lean-to type, but it has greater flexibility in design and has space for more plants. Because of its size and greater amount of exposed area, the even-span greenhouse will cost more to heat.

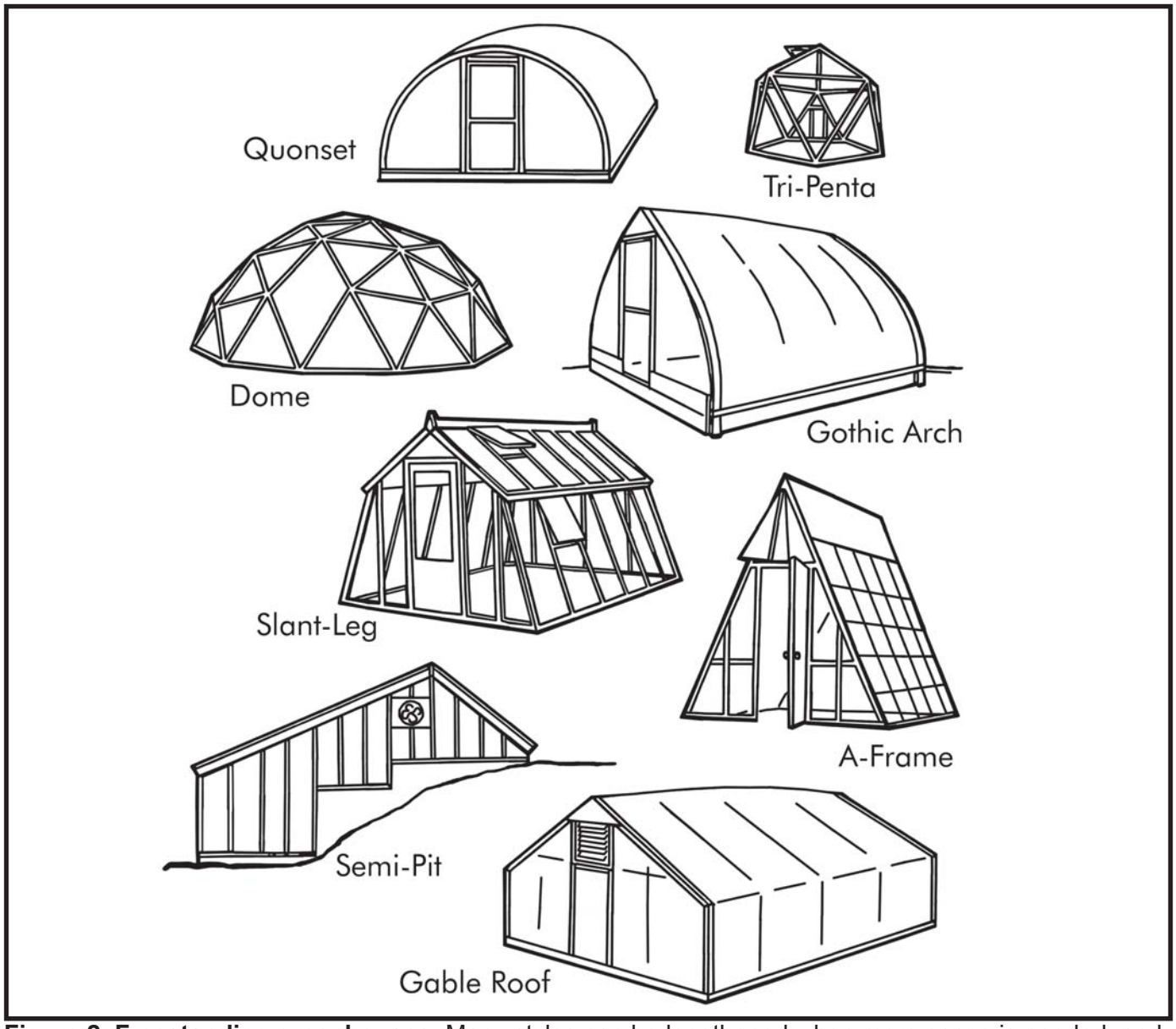


Figure 2. Freestanding greenhouses. Many styles can be lengthened when more space is needed, and they can be located to receive the best sunlight.

Attached Window-Mounted

Window-mounted greenhouses allow space to grow a few plants at relatively low cost for heating and cooling. This reach-in greenhouse comes in many standard sizes, either single units or in tandem arrangements for large windows. Simple tools are needed to remove the regular window from the frame and fasten the prefabricated window greenhouse in its place.

Freestanding

The freestanding greenhouse is a separate structure and consists of sidewalls, end walls and gable roof. It is like an even-span except that a freestanding greenhouse is set apart from other buildings to get the most sun. It can be made as large or small as desired.

A separate heating system is necessary unless the greenhouse is very close to a heated building. The freestanding greenhouse is more easily adapted to the builder's ideas of location, size and shape than attached greenhouses. It also provides more light but requires more heat at night due to the additional surface area.

Locating Your Greenhouse

After you have decided which type of greenhouse you want, you will need to determine the best location for it. You will limit the types of plants you can grow if you do not put your greenhouse in the best possible location.

The site is of the utmost consideration. It determines what type of structure is practical; the direction and intensity of sunlight the greenhouse will receive, which will indirectly affect the plants you will be able to grow; the susceptibility of the structure to storm damage; and the ease and convenience of access as well as maintenance of the plants and greenhouse.

The most desirable choice for a greenhouse site is on the south or southeast side of the house in a sunny location (Figure 3). That is where it will capture the most sunlight from November to February. The east side is the second best location. The next best locations are the southwest and west. The north side is the least desirable location.

Contrary to popular opinion, which holds that a greenhouse should receive unobstructed sunlight, it may be highly desirable to provide afternoon shade such as that given by nearby deciduous trees. In winter, once the leaves have fallen, the greenhouse will receive the additional light needed at that time of year. Be sure to take into account the possibility of falling limbs that can damage the greenhouse.

Some plants will grow in a greenhouse no matter where the location is. African violets and orchids, for example, will grow in a northern exposure greenhouse, but heating costs will be high. Sometimes you can place a greenhouse against a door, window or basement entrance of your house. This location will let you use heat from your house to grow plants. It also makes your greenhouse more accessible and may save on construction costs. Your home heating bill, of course, will increase, but it may be less than if you had to heat your greenhouse separately.

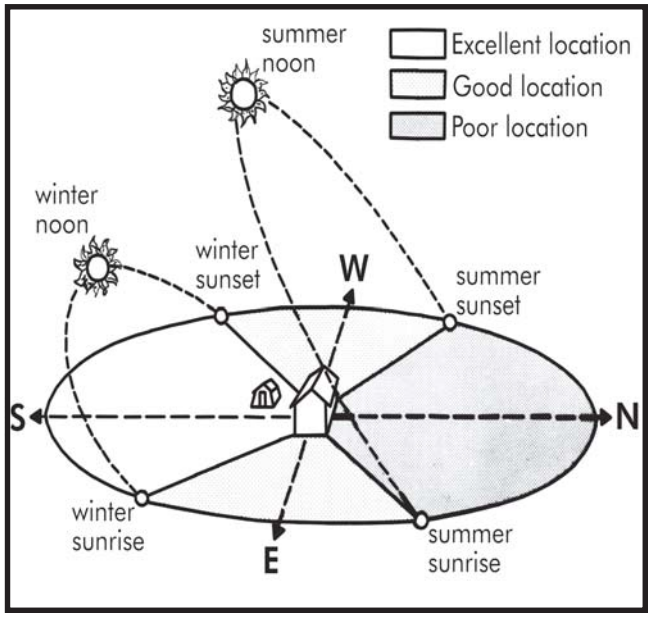


Figure 3. Location of the greenhouse. A sunny area is best.

Research has shown that a greenhouse that lies lengthwise north-south has less shade and thus more light than one that lies east-west. In a north-south oriented greenhouse, shadows move as the sun moves across the horizon, but in an east-west house the shadows tend to cover the same area throughout the day. This is not as important during the summer when light duration and intensity are high, but during the winter months sunlight duration and intensity are less. Therefore, less shadows mean more light available for plant growth.

Designing Your Greenhouse

What Size?

Having determined the type of greenhouse and its location, you should next decide on size. Select a greenhouse as large as your site and pocketbook will allow. The tendency is to start with a very small house, which quickly becomes filled to overflowing. Try to get as wide a greenhouse as possible, as it is easier to enlarge by increasing its length.

Greenhouse Width

In determining the greenhouse width, think where you plan to put benches and walkways. Side benches are serviced from only one side and should be no wider than you can reach across. For some people this will be about 2 feet, for others perhaps as much as 3 feet. Center benches are serviced from both sides and could be as wide as 6 feet. They should be no wider than what is needed for you to work comfortably.

The width of walkways in your greenhouse is determined by how the walkways are to be used. If they will be used only as a place to stand while servicing the benches, an 18 or 19 inch walk is sufficient. If a wheelbarrow will be brought into the greenhouse, the width must be greater. Wide walkways, 24 to 30 inches, will allow easy passage for visitors who may not be used to walking between rows of plants.

The paths and floor of a greenhouse can be gravel, cinders, crushed stone, concrete, brick or other material. A hard surface such as brick or concrete is cleanest, most attractive in appearance and easiest to walk upon, but a loose surface absorbs moisture better and helps to maintain desirable atmospheric humidity. The areas beneath the benches should always be water-absorbent.

Greenhouse Length

The length of your greenhouse is best determined by the number of plants you plan to grow. Most 6-inch pot plants require a minimum of 1 square foot of bench space. Therefore, if you plan to have 100 plants, you would need a minimum of 100 square feet of bench area plus space for the walkways and aisles. Usually two-thirds of a greenhouse is bench space and one-third walkways and aisles. Always make the greenhouse 25-50 percent larger than your original demands because most people keep adding plants to their collection.

Greenhouse Height

The height of the greenhouse depends on the desired height to the eave. An eave height of 5 feet is satisfactory for side benches used for low-growing plants. If you want to grow tall plants, however, you will want an eave height of 6 to 7 feet.

The pitch of the roof should be 6 feet in 12 feet of run (approximately 27 degrees). The eave height, the distance from the side wall to the center of the greenhouse, and the roof pitch will determine the height of your greenhouse at the center ridge.The height of the greenhouse should be equal to the eave height plus one-fourth the width of the greenhouse to maintain a 6 in 12 roof pitch. For instance, in an even-span greenhouse 18 feet wide, the distance from the side wall to the center of the greenhouse will be 9 feet. The difference in height between the center of the greenhouse and eave will be one-half of 9 feet or 4½ feet with a 6 in 12 roof slope. If the eave is 5 feet high, the greenhouse should be 9½ feet high at the center.

Types of Construction

Whether the greenhouse is covered with glass, fiberglass or polyethylene film, it will be advantageous to shop around. Greenhouses have a supporting framework made of wood, aluminum, iron and plastic. Some have curved eaves; others have flat eaves. Some are glass or plastic from the ground up. All types have advantages and disadvantages.

Most greenhouses constructed today are double-layered polyethylene Quonset houses. The Quonset frame is constructed from metal conduit pipe that does not block as much sunlight as does a wood frame. Wood also rots very easily, whereas a metal frame lasts much longer. Some greenhouses have a glass covering, but they usually have a metal frame to support the glass. Glass does not have to be replaced; polyethylene has to be replaced every 2 to 3 years. If you build your own greenhouse, the plumbing and electrical work should be done by professionals in accordance with local codes. Usually a building permit is required to erect a greenhouse.

Glass Greenhouse

Glass is the traditional greenhouse covering. It is available in many designs to blend with almost any style of architecture. Glass greenhouses may have slanted sides, straight sides and eaves, or curved eaves.

Aluminum, maintenance-free glass construction has very pleasing lines and will provide a large growing area. It assures you of a weathertight structure, which minimizes heat costs and retains humidity.

For amateur gardeners, small prefabricated glass greenhouses are available for do-it-yourself installation. They are sold in different models to fit available space and to fit your pocketbook.The disadvantages of glass are that it is easily broken, expensive and requires a much better type of construction than fiberglass and plastic.

Fiberglass Greenhouses

Fiberglass is lightweight, strong and practically hailproof. Corrugated panels 8 to 12 feet long and flat fiberglass in rolls are available in 24 to 48 inch widths. Thicknesses range from 3/64 to 3/32 of an inch.

Poor grades of fiberglass will discolor, and the discoloring reduces light penetration. Using a good grade, on the other hand, may make your fiberglass greenhouses as expensive to build as a glass one. If you select fiberglass, choose the clearest grade. Do not use colored fiberglass. Tedlar-coated fiberglass blocks out ultraviolet rays so the material remains clearer for a longer time.

Plastic Greenhouses

Plastic greenhouses are increasing in popularity. The reasons are:

- Construction cost per square foot is generally one-sixth to one-tenth the cost of glass greenhouses.
- Plastic greenhouses can be heated as satisfactorily as glass greenhouses.
- Crops grown under plastic have the same quality as those grown under glass.
- Plastic greenhouses are considered temporary structures and usually carry a low assessment rate for tax purposes or may not be taxed at all.

Plastic greenhouses can be made of polyethylene (PE), poly-vinyl chloride (PVC), copolymers of these materials and other readily available clear films. Polyethylene will last from 1 to 3 years depending on the

type. Other films such as PVC or co-polymers with ultraviolet (UV) inhibitors last longer. Descriptions of plastics available are provided below.

Polyethylene

The advantages of polyethylene are that it is low in cost and lightweight. It also stands up well in fall, winter and spring weather and lets through plenty of light for good plant growth. However, polyethylene constantly exposed to the sun deteriorates during the summer and must be replaced often.

Ultraviolet light energy causes polyethylene to break down. This first deterioration occurs along (or over) the rafters and along the creases where the film is folded.

Ultraviolet-inhibited polyethylene lasts longer than regular polyethylene. It has an inhibitor that prevents the rapid breakdown caused by ultraviolet light. UV-inhibited polyethylene is available in 2 to 10 mil thicknesses and up to 40 feet wide.

Polyethylene permits passage of much of the reradiated heat energy given off by the soil and plants inside the greenhouse. Therefore, a polyethylene greenhouse loses heat more quickly than a glass greenhouse both during sunny periods and after sunset. This is an advantage during the day and a disadvantage at night.

Polyvinyl Chloride (PVC or Vinyl)

Vinyls from 3 to 12 mils thick are available for greenhouse covering. Like polyethylene, vinyls are soft and pliable; some are transparent, other translucent. They are usually available in 4- to 6-foot widths only; larger widths can be made by electronically sealing several smaller widths together.

Vinyls cost two to five times as much as polyethylene. When carefully installed, 8- or 12- mil vinyl hold s up for as long as 5 years.Vinyl attracts dust and dirt from the air and has to be washed occasionally.

Acrylic

Acrylic is very transparent, very resistant to weathering and breakage, and can be used as a curved panel. However, acrylic is very expensive. Most quality fiberglass panels use a resin with 15 percent acrylic and 85 percent polyester.

Table 1. Comparison of characteristics of glazing materials with supporting framework.

General Type	Comments	Typical Trade Names	Light (PAR) Transmitting (%)	IR Transmittance (%)	Est. Lifetime (years)	$/ Square Foot
Glass	Advantages Excellent transmissivity Superior resistance to heat, U.V. abrasion Low thermal expansion/ contraction Readily available Transparent Disadvantages Difficult to site fabricate Low impact resistance unless tempered High cost Heavy	Double Strength Insulated Units Low Iron	85 1 0-92	< 3 < 3 < 3	25+ 25+ 25+	0.75-2.00 3.50-7.00 0.90-2.25
Acrylic	Advantages Excellent transmissivity Superior U.V. & weather resistance Won't yellow Lightweight Easy to fabricate on site Disadvantages Easily scratched High expansion/contraction Slight embrittlement with age High cost Relatively low service temperatures Flammability	Plexiglass Lucite Acrylite Double Wall Exolite Acrylite SDP	93 83	< 5 < 5	20+ 20+	2.00-3.00 2.50-4.00

[continued on page 8]

Table 1. Comparison of characteristics of glazing materials with supporting framework. (cont.)

General Type	Comments	Typical Trade Names	Light (PAR) Transmitting (%)	IR Transmittance (%)	Est. Lifetime (years)	$/ Square Foot
Polycarbonate	Advantages Excellent service temperatures High impact resistance Disadvantages Poor weatherability & U.V. resistence (yellows) Scratches easily Not readily available High expansion/contraction	Lexan Tuffak A Poly Glaz Double Wall Tuffak twinwall Qualex	87 75	< 6 < 6	7-10 5-7	3.00-4.00 1.75-3.00
Fiber Reinforced Polyester Fiberglass	Advantages Low cost Strong Superior weatherability only when Tedlar coated Easy to fabricate & install Disadvantages Susceptible to U.V., dust & pollution degradation Yellows with age High expansion/contraction rate	Lasolite Filon Glasteel Kalwall Doublewall roof panels	75-85 70	< 10	10-15 7-12	.85-1.75 5.00
Laminated Acrylic/Polyester Film	Advantages Combines weatherability of acrylic with high service temperature of polyester Good transmissivity Disadvantages Non-reversible, acrylic must be installed to the outside Susceptible to wind flapping Only 4' width available	Flexigard	87	9.5	10+	.45-.70
Polyethylene Film	Advantages Inexpensive Easy to install Readily available in large sheets Disadvantages Short life Low service temperature Cats LOVE to climb on it	Visqueen Tufflite II Monsanto 602 (U.V. resistent) Tufflite II Monsanto 603	< 85 87 	80 80 80	8 months 2 years 3 years	.02 .06 .08
Weatherable Polyester Film	Advantages Excellent transmissivity High service temperature Disadvantages Only available in 26"-60" widths Low impact resistance U.V. degradable unless treated	Llumar Mylar Melinex	85-88	< 30	7-10	.50-1.00

Note: Much of the technical information in this chart was taken from manufacturers' data. Actual field performance may be different. Costs are accurate as of April 1981 from regional distributors. Local prices may vary.

Types of Frames

Plastic greenhouse structures range from crude wooden frameworks to air-supported houses. If you plan to build a plastic greenhouse, careful consideration should be given to economy of size and future expansion. Because plastic is available in large widths and is lighter in weight, greenhouse rafters and supporting members can be widely spaced to permit maximum light penetration. Common types of greenhouse frames are as follows:

A-Frame

In building an A-frame structure, consider the placement of cross members. Place them at least one-third of the distance down from the ridge. Otherwise, it will be difficult to work around the cross member in applying an insulating layer of plastic.

When the cross member support is high in the peak of the greenhouse, especially in narrow greenhouses, an essentially clear span type of structure permits easy application of an inner layer of plastic. The inner layer can be applied under the cross-rafter supports, leaving a small triangular air space in the peak of the house. This space serves as an insulation for the house. Diagonal bracing wires provide added strength to an A-frame structure. This type of greenhouse is among the least difficult to build.

Rigid Frame

Rigid-frame greenhouses have been designed in widths up to 40 feet. This clear span structure has no columns to hold up the roof section. It is designed for 30-, 36- or 40-foot widths.

Prefabricated greenhouses built with curved laminated wood rafters are commercially available. They have low side walls (low head room), and for tall plants the structure must be raised higher on the foundation side walls.

Panel Frame

Panel-frame greenhouses are a modification of the sash house (a small plastic greenhouse used for growing plants for later transplanting). This structure requires accurate carpentry, and construction costs are higher than for other frames because of the added lumber and labor needed to build the panels. Advantages of panels are that they can be quickly installed and taken down and stored during the summer. This will increase the life of the plastic panels. Panel greenhouses can be easily ventilated.

Quonset

Quonset greenhouses are oval in shape. Some have been constructed of wood, but usually the frames are constructed of pipe bent into the oval shape. The advantage of this house is the ease of construction and covering. Ventilation is by exhaust fans at the ends of the houses.

Beds for Growing Small Plants

Coldframes

A coldframe (Figure 4) is a bottomless box with a removable top. It is used to protect small plants from wind and low temperatures. No artificial heat is used inside a coldframe.

Coldframes utilize the sun's heat. The soil inside the box is heated during the day and gives off its heat at night to keep the plants warm. The frame may be banked with straw or other insulating material to insulate it from the outside air and to retain heat.

With a coldframe, you can do many of the same things you do in a greenhouse. You can sow summer flowers and vegetables weeks before outdoor planting. Often, you will gain sufficient time to grow an extra crop. You can start vegetables, annual flowers for fall and winter, and perennials for next year's bloom. Plants are protected from harsh weather and will grow to transplant size quickly . You can root cuttings of deciduous and evergreen shrubs and trees, as well as softwood cuttings of chrysanthemums, geraniums and

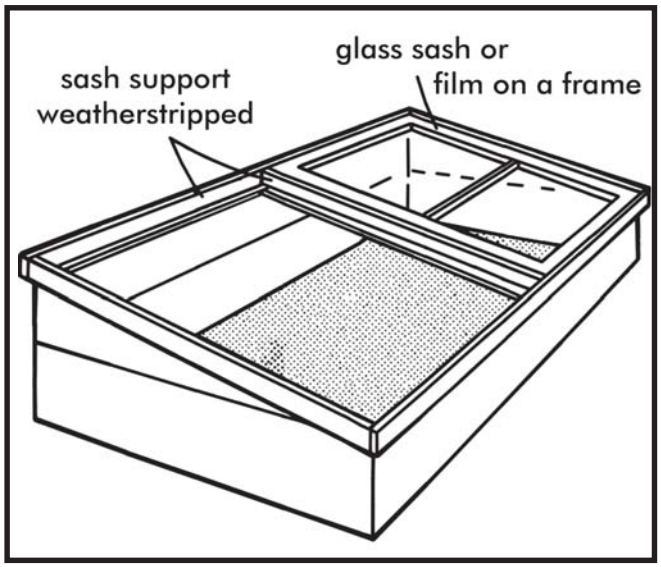


Figure 4. A cold frame is an inexpensive miniature greenhouse used to start vegetable or flower seeds early in the spring

fuschia, and leaf cuttings of rex begonnias. African violets and succulent and foliage plants take root faster in a coldframe, particularly during warmer months.

You can grow your own lettuce, chives, endives, parsley and green onions right through the winter by converting your coldframe to a hotbed.

Portable coldframes can be built in your workshop from surplus materials you may have on hand. Most coldframes can be converted to hotbeds for use in all seasons by installing electric heat and automatic clock-controlled misting or watering.

Hotbeds

A hotbed (Figure 5) is a bed of soil enclosed in a glass or plastic frame. It is heated by electricity, steam or hot-water pipes. Hotbeds are used for forcing plants or for raising early seedlings. Instead of relying on outside sources of supply for seedlings, you can grow vegetables and flowers best suited to your own garden.

Seeds may be started in a heated bed weeks or months before they can be sown out of doors. At the proper time the hotbeds can be converted into coldframes for hardening. Then the plants may be moved to the garden when outdoor conditions are favorable.

Provide between 10 to 15 watts of electric heat for every square foot of growing area in a hotbed. Soil-heating tape or cable is available in several lengths, which give a choice of wattages. If the bed is in a sunny, well-sheltered location and the climate not too severe, 10 watts per square foot should be adequate. Lining the sidewalls with moisture proof insulation is desirable. Place tape or wire screening, ¼- or ½-inch mesh, over the heating tape or cable to prevent possible damage by cultivating tools. Do not place hotbed cables of any type directly in peat. When peat dries out it acts as an insulator and may cause the cable to overheat. Use a thermostat to control temperatures automatically and make more efficient use of energy.

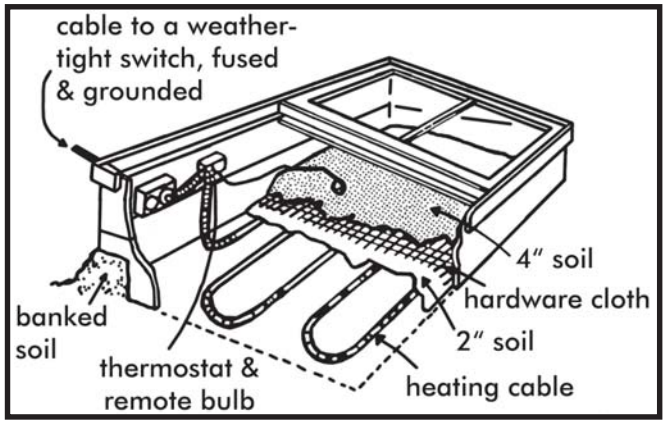


Figure 5. Layout of heating cable in a hotbed.

Because accurate temperature control is possible with a thermostat, you can grow better plants at lower costs by separating plants requiring different temperatures in different beds. Temperatures from 50 degrees F to 70 degrees F are best for hotbeds. On very cold nights cover the beds with mats, burlap, straw or other insulating materials.

Greenhouse Heating

Economics will dictate what energy source you can use to heat your greenhouse, whether it be electricity, bottled gas, natural gas, wood or fuel oil. While large greenhouses will require a fairly complicated system, package units are available for most home greenhouses. When planning the heating system, it is important to follow directions to insure adequate and uniform circulation and to allow for a safety margin in heating capacity. Consider the possibility of future expansion when selecting a unit. In many cases, especially with lean-to units, it is possible to heat the greenhouse with an extension from the home heating unit and its own thermostat, or through a window or open door with a fan that blows in warm air from the living unit. The capacity of your heating system will depend on the size of your greenhouse, whether it is covered with a single layer or a double layer of plastic or glass, and the maximum difference between inside and outside temperature.

The firm from which you buy your greenhouse can tell you what size or capacity of heater will best suit your needs. Also, you can estimate the size of the heating system you need with UGA Extension Bulletin 792, *Greenhouses – Heating, Cooling and Ventilation* (available at extension.uga.edu/publications).

Heating equipment can be a space heater, a forced-air heater, a hot-water or steam system, or electric heaters. Radiant heat lamps over plants and soil heating cables or pipes under plants are also being used.

The type of heating system you choose will depend on how much you want to spend.

Space Heaters — For low-cost heating for small greenhouses, use one or more ordinary space heaters with electric fans to distribute the warm air evenly. **Warning:** If you use a gas, oil or coal heater, be sure to have a fresh air supply and an unobstructed chimney so carbon monoxide will not build up. Remember, all greenhouse heaters should be ventilated for both plant and human health. Use high grade (low sulfur) kerosene to avoid sulfur dioxide damage; the need for high ignition temperature to avoid carbon monoxide and ethylene buildup is important.

Forced-air Heater — The best system for heating a small greenhouse is a forced-air furnace with a duct or plastic tube system to distribute heat. The polytube is best placed down the length of the greenhouse in the top ridge. The polytube evenly distributes the heat throughout the house – thus no cold spots. You can use a thermostat to control the temperature in the greenhouse.

Hot-water or Steam Heater — A hot-system with circulator or a steam system linked with automatic ventilation will give adequate temperature control. Bench heating with hot water is becoming more popular for localized heating. In some areas coal or natural gas is readily available at low cost. The fuel is ideal for a hot water or central steam system. Steam has an advantage in that it can be used to sterilize growing beds and potting soils.

Electric Heater — Overhead infrared heating equipment combined with soil cable heat provides a localized plant environment that allows plants to thrive even though the surrounding air is at a lower than normal temperature. Electric resistance types of heaters are used as space heaters or in a forced system. Electric heat can be very costly and is usually used only in very small greenhouses.

Temperature

For most greenhouse plants a night temperature of 55-65 degrees F in the greenhouse is adequate. The minimum temperature in most situations is 40 degrees F, and the maximum temperature is 85 degrees F. The general rule, however, is not to have a higher temperature than is necessary.

As a gardener you will be concerned with two temperatures – the air temperature required in the greenhouse and the minimum outside temperature that your heating equipment must overcome. The temperature we are most concerned with is the minimum night temperature, but we also want to know what is the ideal day-time temperature to keep the greenhouse. On bright sunny days it is best to have day temperatures 10 to 15 degrees Fahrenheit higher than night temperatures. Day-time temperatures on dull, cloudy days is usually kept about 5 degrees F above the night-time temperatures.

If you want a temperature of 60 degrees F, install heatersthat will provide that temperature. If you want no more than frost protection, set the thermostat at 40 degrees F. Higher temperatures on plant benches can be provided with soil-warming equipment.

In any greenhouse you will find microclimates such as those found near the outside walls, fartherest from the heater or closest to the floor. There are always cooler areas where certain plants will do better than others. By selecting plants for certain locations, you will get better use of your greenhouse. Remember that heat is lost from a greenhouse by radiation, conduction and convection through the covering, the walls and other non-glass parts of the structure, the floor or soil, ventilation, door openings and cracks.

Greenhouse Ventilation and Cooling

Ventilation and cooling are equally important, especially in southern climates. Ventilation-cooling systems range from manually operated vents to fully automatic systems regulated by an in-house thermostat. In these days of escalating fuel and electrical costs, it might be wise to grow those plants that tolerate a cooler temperature during the winter and to switch to heat tolerant plants during the summer.

Ventilation

A greenhouse is a heat trap. Much of the radiant energy from the sun enters the greenhouse, but the reflected energy from interior surfaces, such as walls and benches, is trapped in the form of heat energy. Some of the heat is lost through the walls and roof. But when the outside temperature is almost the same as the inside temperature, very little heat is lost. Without ventilation the air temperature inside the greenhouse may become so high that plants are injured or killed.

Even during cold weather a greenhouse can get too warm on bright sunny days. So an adequate ventilation system must be built into your greenhouse to control temperatures in all seasons. If you use hand operated roof vents, they will have to be opened and closed periodically during the day. As outdoor weather changes, sashes must be opened and closed manually to keep plants from getting too hot or too cold. An automatic ventilation system eliminates the manual work and is the best way to control temperature and humidity in a greenhouse.

A thermostat will respond to changing air temperature and activate the ventilation system to keep temperatures in an acceptable range. Fans are needed to provide good ventilation in both large and small greenhouses. In recent years exhaust fans have replaced flow-through ventilation as the major means of cooling hobby greenhouses. Exhaust fans should be large enough to change the air in the greenhouse one to one and one-half times every minute.

Fans and duct (sometimes known as polytube) venti-

lation can also be used for automatic greenhouse heating and ventilation. Polyethylene ducts are suspended by wires or straps from the roof of the greenhouse. The fan-heater-louver unit gives positive air flow and the polyethylene duct distributes the incoming air evenly throughout the house.

Shading Your Greenhouse

When protection from the sun is needed, use roll-up screens of wood (lath fence) or aluminum, vinyl, plastic shading, or paint-on-materials. Roll-up screens are available with pulleys and rot-resistant nylon ropes. These screens are attractive and can be easily adjusted from outside as weather and sunlight vary.

Vinyl plastic shading is made of a flexible film that reduces light from 55 to 65 percent. The material comes in rolls and installs easily against the glass inside your greenhouse. To apply, just wash the glass with a wet sponge and then smooth the plastic onto the wet glass. When smoothed into position, it adheres to the glass. It can be pulled off and used again. Shading compound can be applied on the outside of greenhouses to lower temperature and light intensities. These compounds usually come in choices of white or green. A shading compound that mixes with water is easy to use and readily available from greenhouse supply firms. Some people use a readily available latex paint from the local paint store, mixed 1 part latex paint to 20 parts water. However, it is much better and safer to buy a commercially prepared greenhouse shading compound.

Evaporative Cooling

An evaporative cooler (or fan and pad system) cools incoming hot air and adds beneficial humidity to the greenhouse atmosphere. The exhaust fan pulls hot, dry air from the greenhouse, the replacement air is cooled passing through the wet pads, humidity is increased and watering needs are reduced. You can select a cooling system of the right size by following directions in UGA Extension Bulletin 972, *Greenhouses – Heating, Cooling and Ventilation.* In hot, dry climates an evaporative cooling sys-tem can reduce incoming air temperature from 10 to 30 degrees. In wet, humid climates the cooling is less, with the most effective cooling coming in the hottest part of the day.

Other Greenhouse Necessities

It is advisable not only to have both hot and cold water outlets handy but to have regulating valves leading to a common outlet to provide room temperature water throughout the year. The number of outlets should be proportional to the size of the greenhouse and number of benches.

Benches themselves should be comfortable to work with. This means a working height of 36 inches and a width of no more than 40 inches. Naturally, a center bench can double this width. Bench construction can be of wood, aluminum, and other materials. The best wood for benches is redwood or cypress. Other woods must be thoroughly treated with preservative. Other suitable materials can be sheet metal, corrugated asbestos sheet with a pea-gravel top layer, stretched hardware fabric, or a very permanent structure such as poured concrete. Galvanized pipe legs and braces are an ideal framework for the benches. Regardless of the construction used, be sure that the benches are level, as this facilitates watering and stability of potted plants.

Automatic controls are important in greenhouses. Lights, fans, pumps, heaters and mist systems must be turned on and off at prescribed times. Without automatic switching, precise control can be a complicated and laborious task. Time clocks, photocells, thermostats and other automatic controls are available commercially. Individual controls or combinations of controls provide interval control as desired.

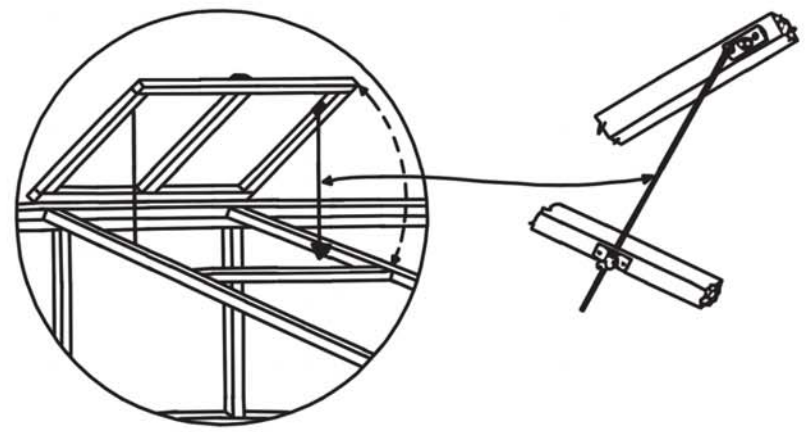
Automatic controls can do many jobs. A thermostat can turn the heater on when the temperature drops to a certain point. Humidistats are available to regulate humidifiers automatically. Automatic ventilators, controlled by a thermostat, open the vents and turn on the fans. Automatic misting is also very important if you propagate many of your plants. Automatic watering devices can also be used. The water requirements of plants vary so much that this segment is going to require very close attention. Remember, automatic controls are costly and you may want to add some of them after you get started.

Plans

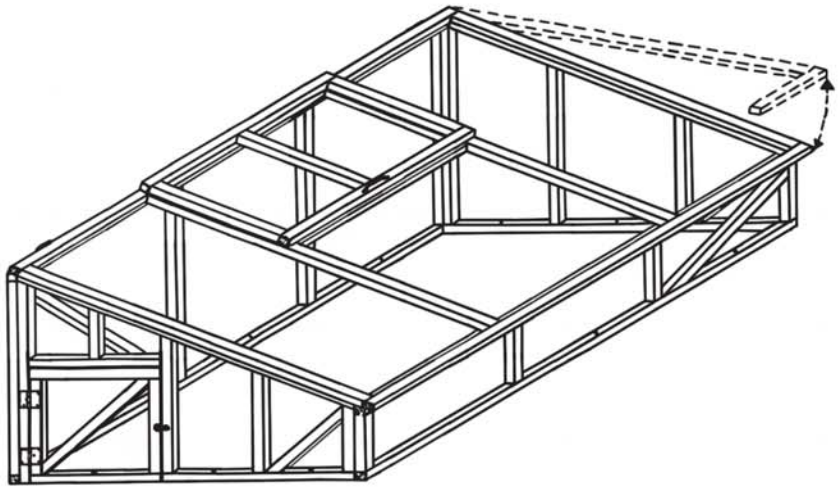
Hotbeds and Cold Frames

Greenhouses

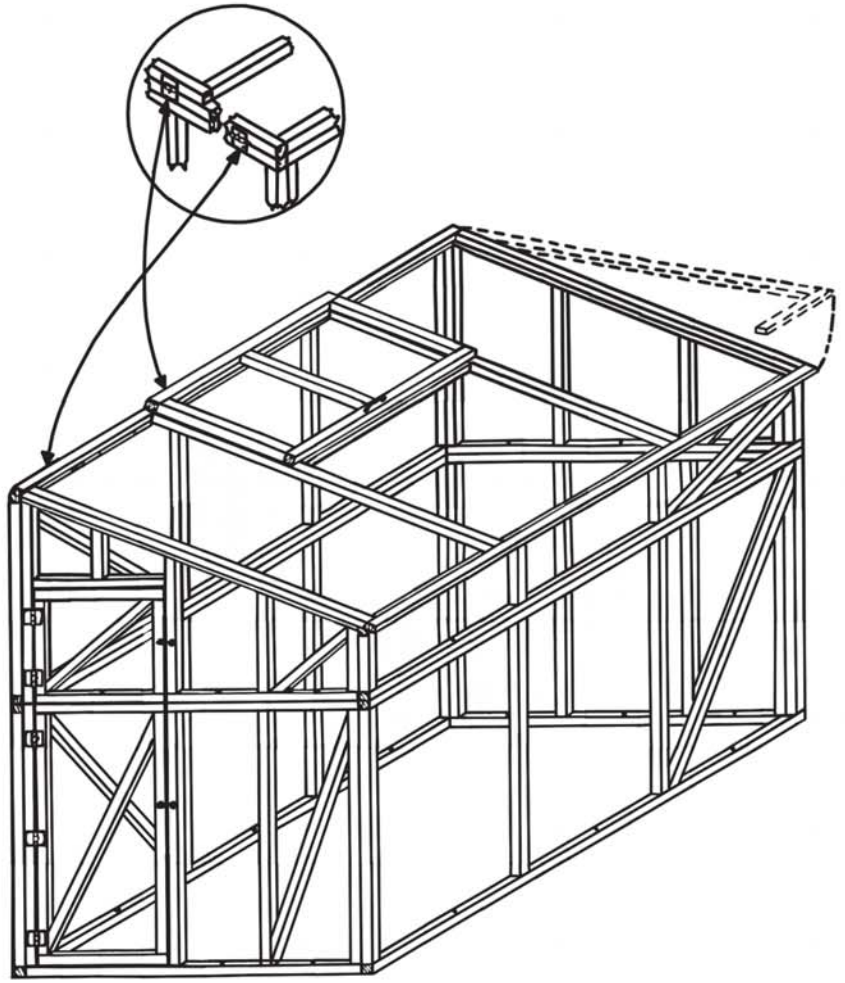
Miscellaneous



Vent Open

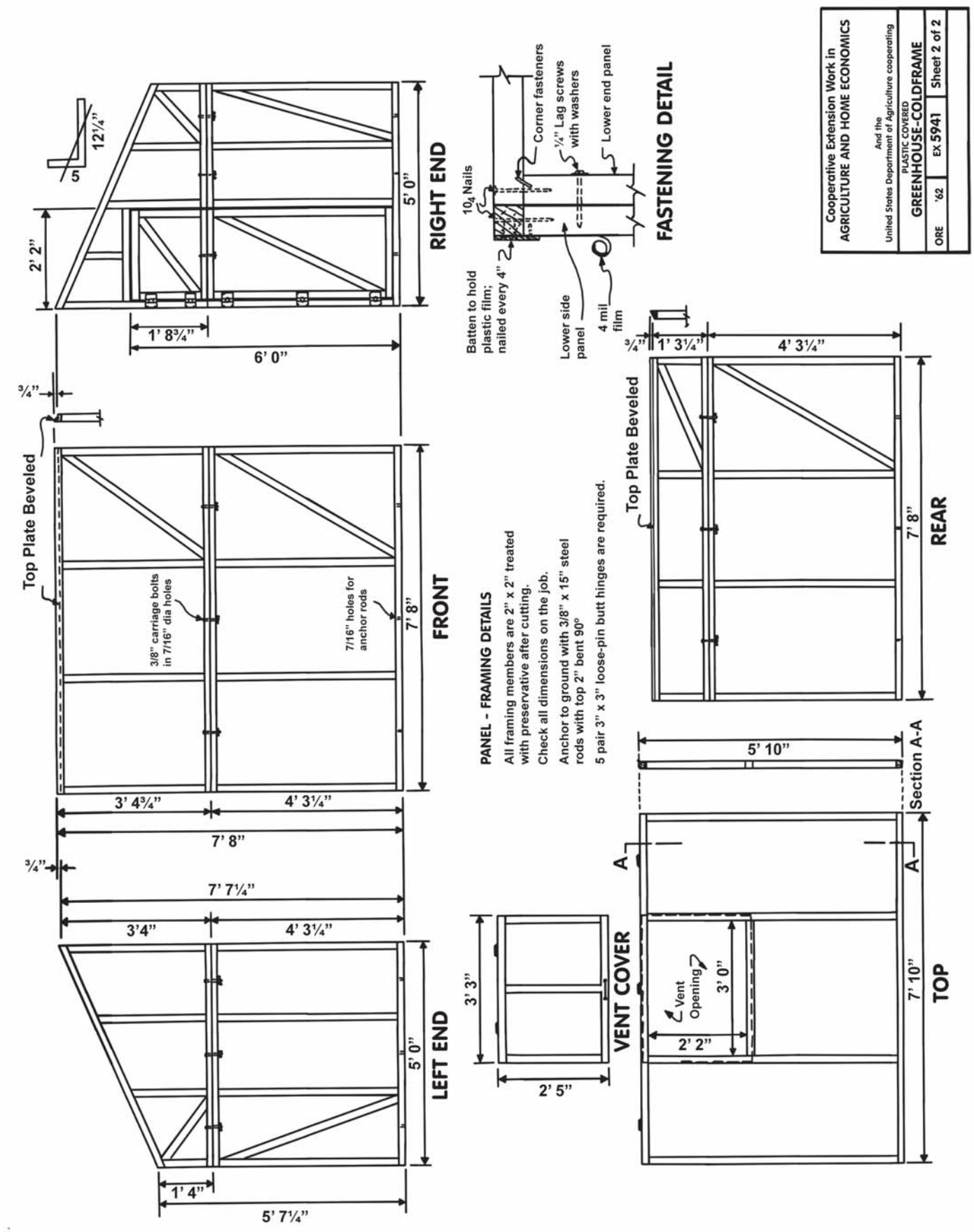


Coldframe Unit



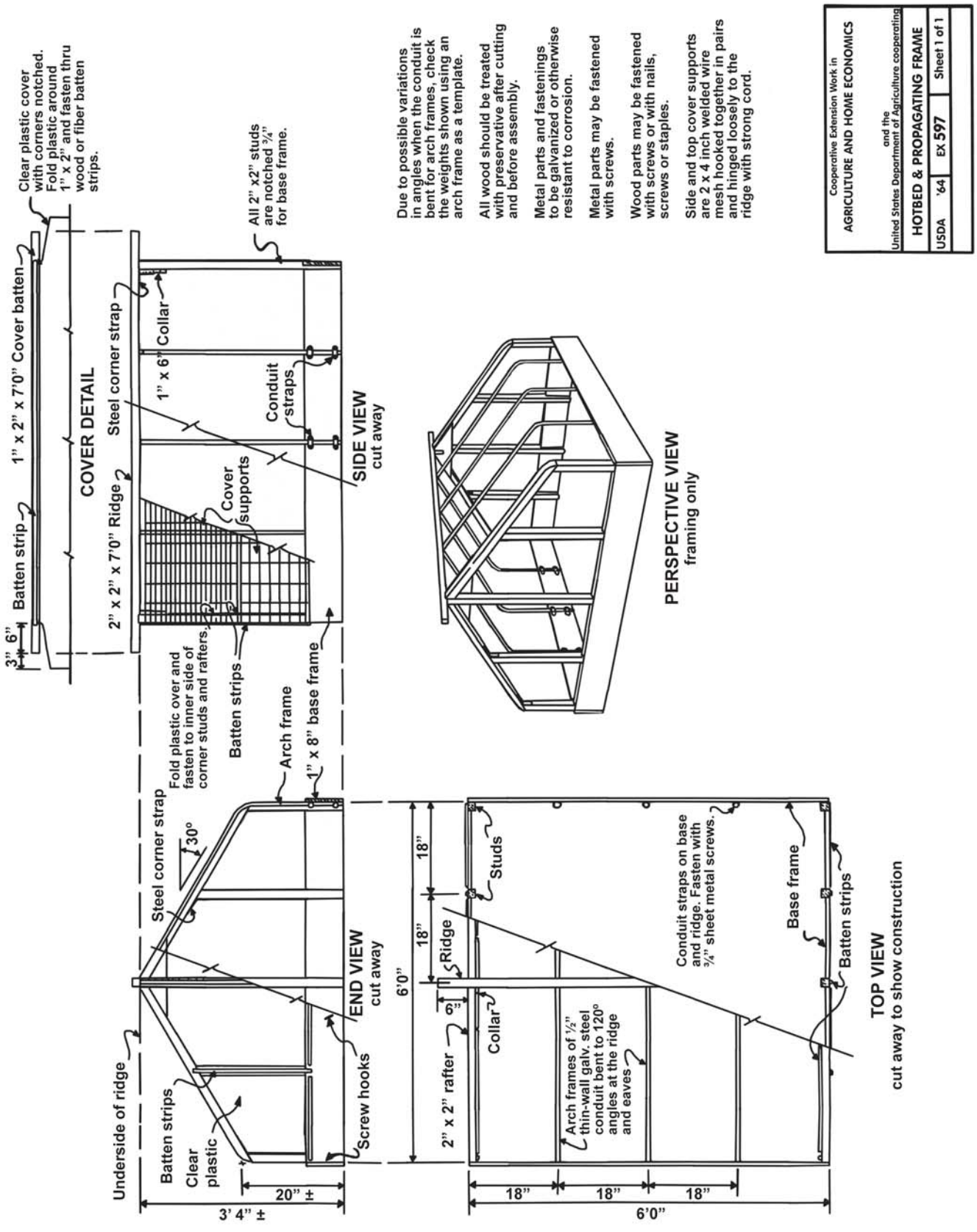
Greenhouse Assembly

Cooperative Extension Work in AGRICULTURE AND HOME ECONOMICS			
and the United States Department of Agriculture cooperating			
Plastic Covered GREENHOUSE-COLDFRAME			
ORE	'62	EX 5941	Sheet 1 of 2

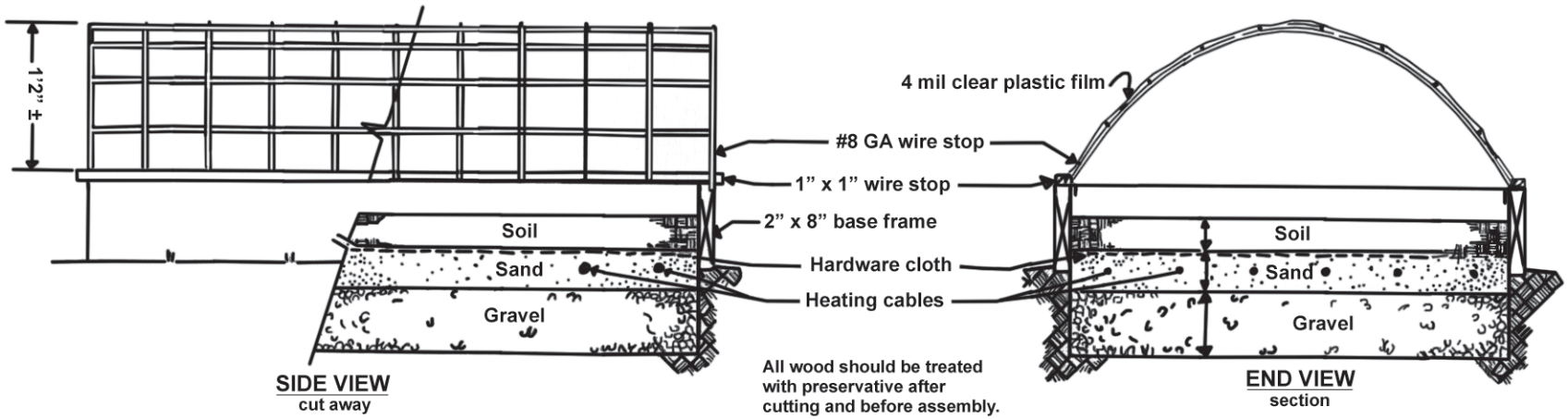


Greenhouse-Cold Frame [cont.]

Hotbed and Propagating Frame



Mini-Hotbed and Propagating Frame



SIDE VIEW
cut away

END VIEW
section

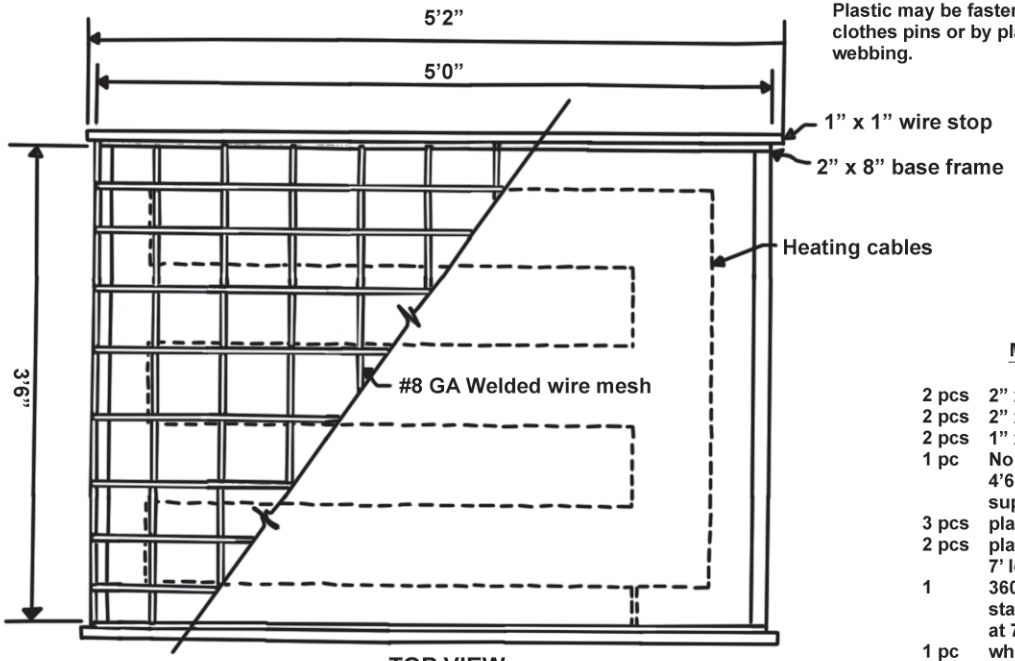
NOTE: Separation of heating cables is variable to amount of heat needed per sq. ft. according to geographic location. Refer to USDA leaflet no. 445.

All wood should be treated with preservative after cutting and before assembly.

Metal parts and fastenings to be galvanized or otherwise resistant to corrosion.

Wood parts may be fastened with screws or with nails.

Plastic may be fastened by clothes pins or by plastic webbing.



TOP VIEW
cut away

PERSPECTIVE VIEW
not to scale

Designed in cooperation with
Crops Research Division

MATERIAL LIST

2 pcs	2" x 8", 5' long for sides
2 pcs	2" x 8", 3'6" long for ends
2 pcs	1" x 1" wire stop, 5'2" long for sides
1 pc	No 8 gauge 6" x 6" welded wire, 5' long 4'6" wide for top of wood frame to support plastic film
3 pcs	plastic webbing 2" wide, 5' long
2 pcs	plastic film, 4 mil clear 3' wide 7' long
1	360-watt soil heating cable, thermostatically controlled to shut off at 70°F
1 pc	white plastic film, 4 mil,, 5' x 8' for covering frame during winter
2 pcs	cheesecloth, 3' x 7'
4 in	sand 2" above, 2" below heating cable
1 pc	½" hardware cloth, 5' x 3½'

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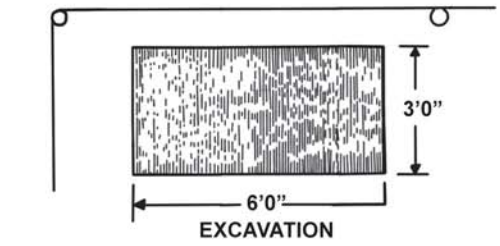
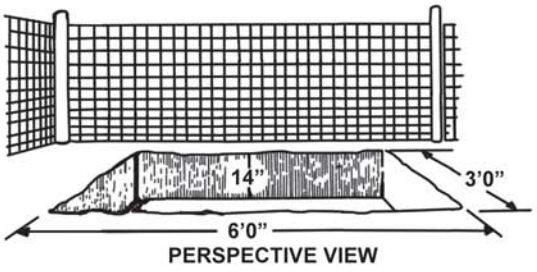
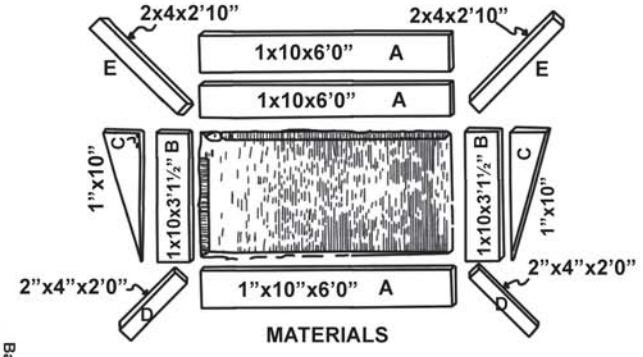
MINI-HOTBED AND PROPAGATING FRAME

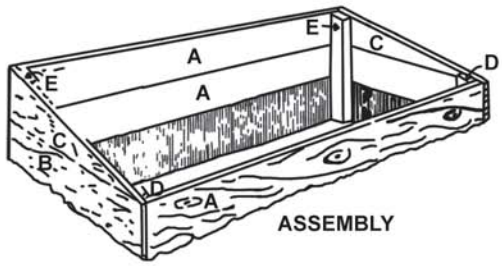
USDA '69	6080	Sheet 1 of 1

FOR AVERAGE HOME GARDEN







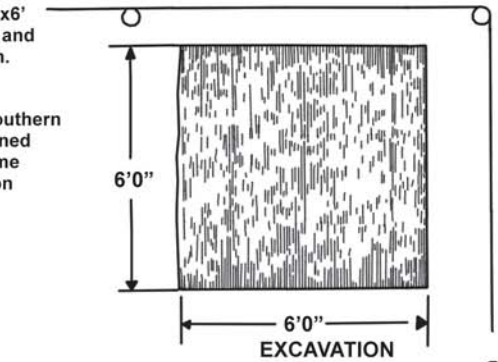


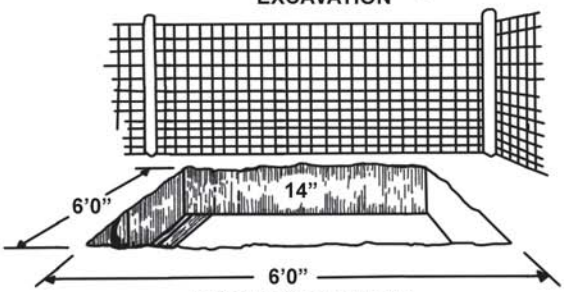
Based on Miss State Univ Plan 6080A

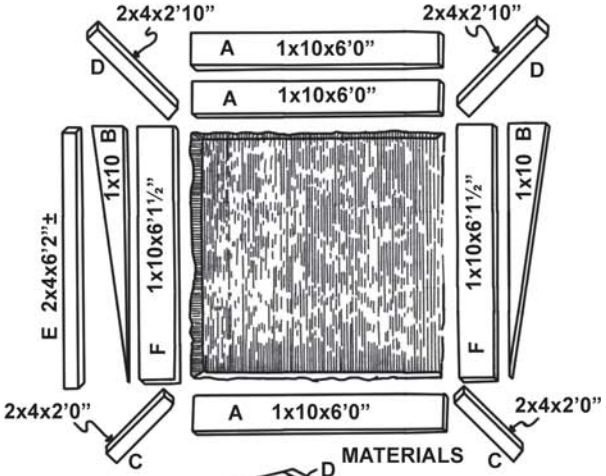
Hot beds larger than 6'x6' should be built 6' wide and multiples of 3' in length.

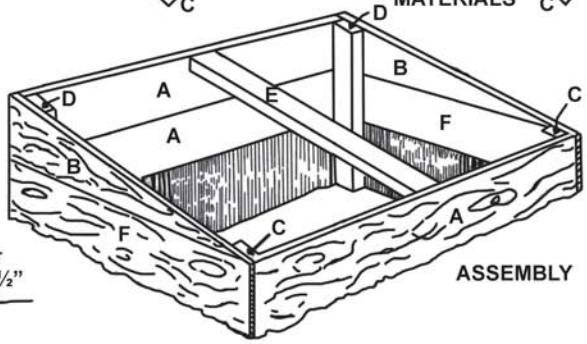
Location — A sunny southern exposure in a well-drained location is needed; some windbreak protection on north is desirable.

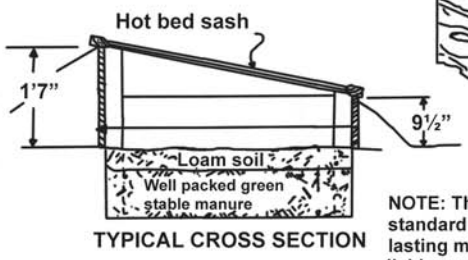
FOR AVERAGE GARDEN & SURPLUS FOR SALE









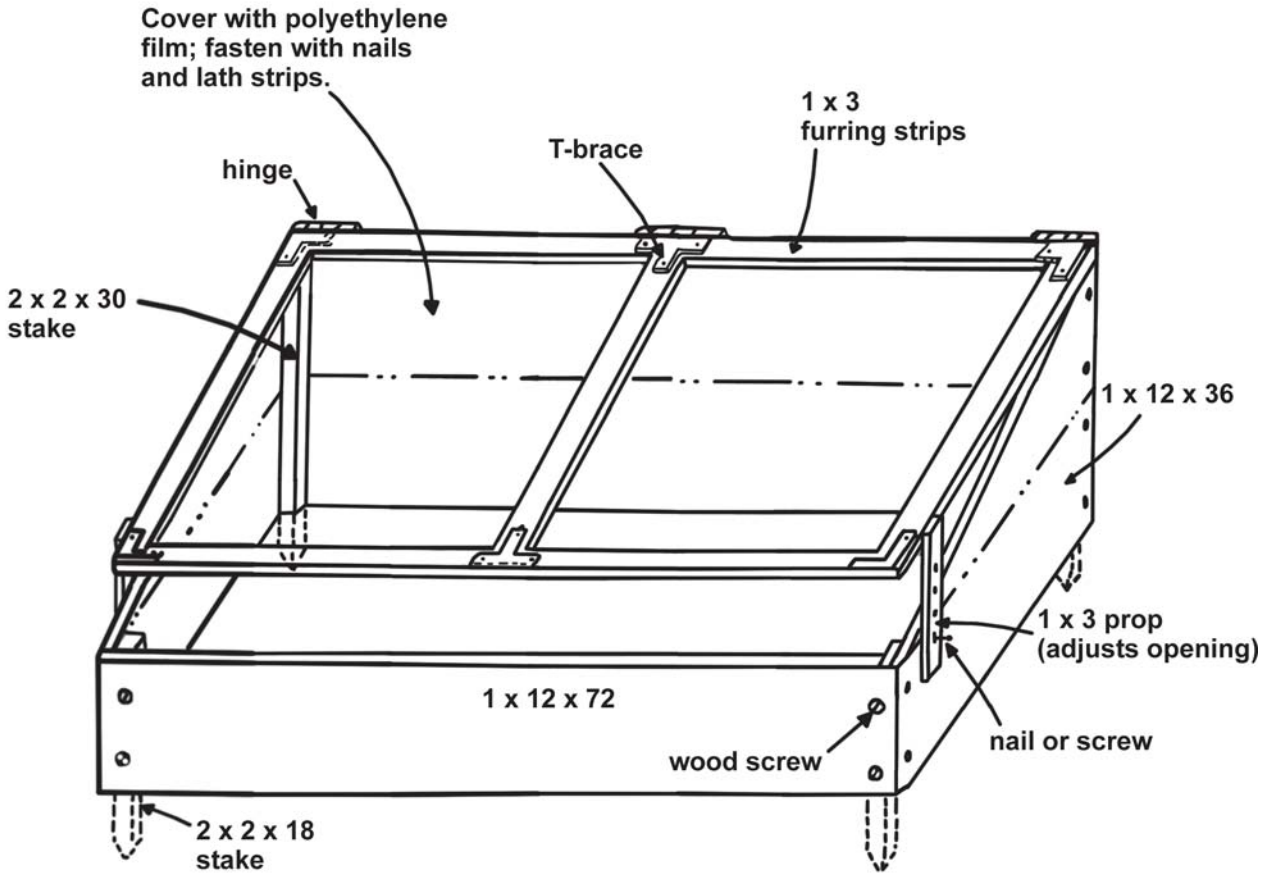


SCALE: ½" = 1'0"

Cooperative Extension Work in AGRICULTURE AND HOME ECONOMICS		
United States Department of Agriculture cooperating and the	Miss	74
HOT-BED	6206	Sheet 1 of 1

NOTE: The sash cover can be made of one of several materials. The standard glass hot bed sash is 3' x 6' in size. It represents the ideal cover — lasting many years. It is somewhat expensive. If old discarded window sashes are available, use them. Build frame to fit sash. Inexpensive covers can be made with 4 or 6 mil plastic tacked on a light homemade frame. It can be made in many different sizes. This is satisfactory from standpoint of light but is short-lived, usually two seasons.

Hotbed



MATERIALS

Lumber

5 pcs	1x12-inch pine or spruce, 6 ft. long
1 pc	2x2-inch fir, 8 ft. long
4 pcs	1x3-inch furring strips, 6 ft. long
4	lath strips

Hardware & Miscellaneous

4	3x3-inch steel corner angles with screws
2	3x3-inch steel Tee braces with screws
30	No. 10 x 1½-inch FH wood screws
3	¾x3-inch wire nails
3 oz.	¾-inch wire nails
4'x6'	6 mil polyethylene film
½ gal.	copper naphthanate wood preservative
1 qt.	white paint

CONSTRUCTION NOTES

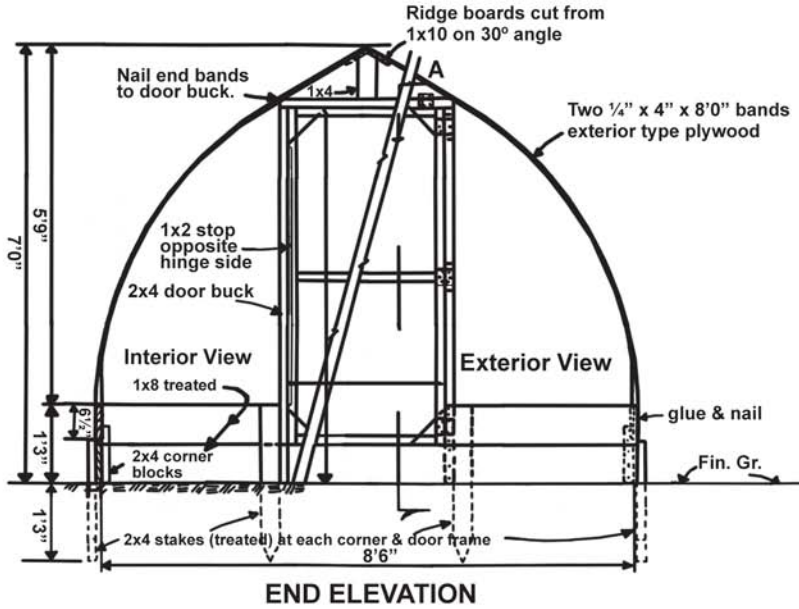
1. Treat all lumber with 3 coats of copper naphthanate (20%) wood preservative.
2. Paint wood white after treating, if desired.
3. Cold frame may be disassembled and stored after growing season.

COLD FRAME

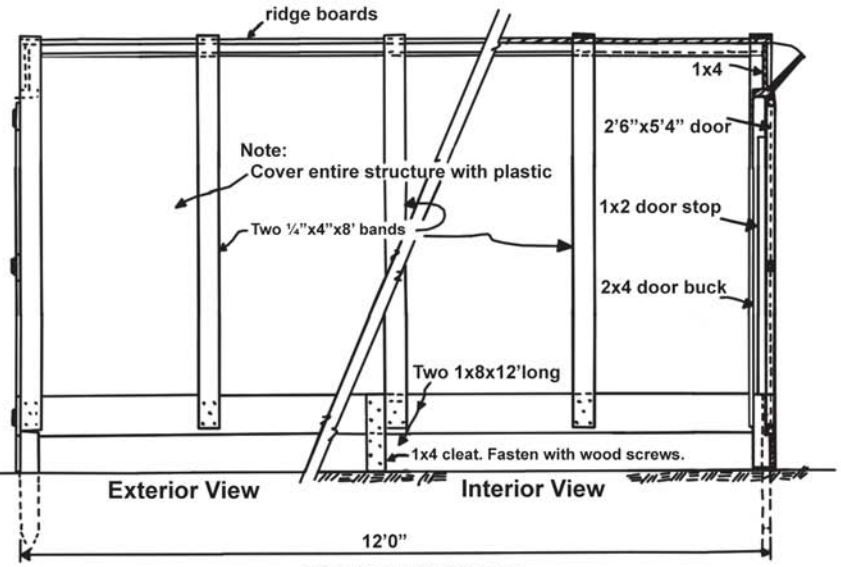
University of Connecticut
Plan No. SP 598 (1975)

All dimensions in inches

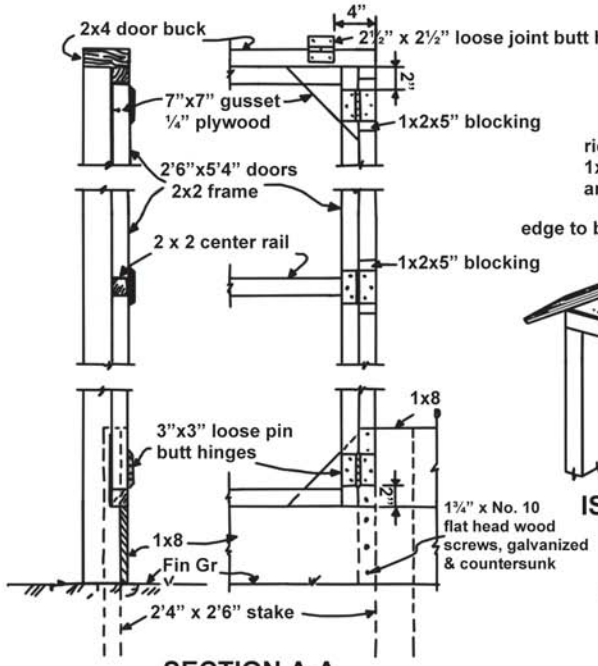
Cold Frame



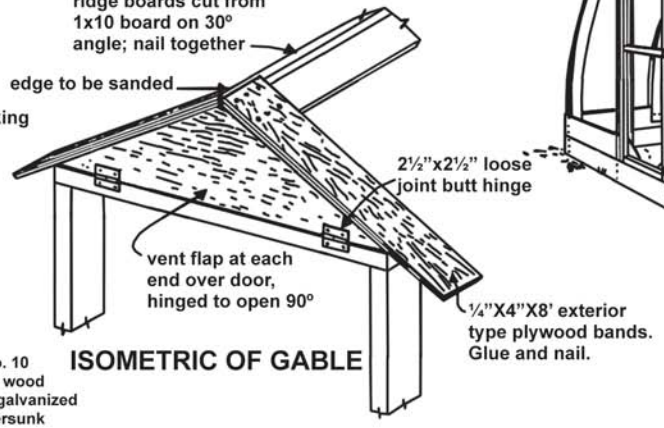
END ELEVATION



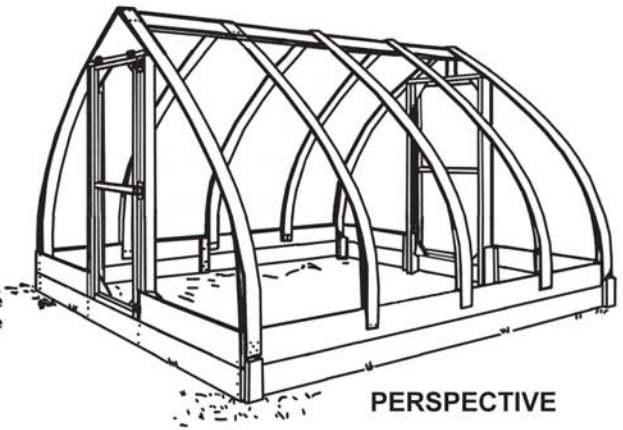
SIDE ELEVATION



SECTION A-A



ISOMETRIC OF GABLE



PERSPECTIVE

Note Cover door with plastic.
Fasten entire structure together with
wood screws unless otherwise
noted, all screws to be galvanized

Cooperative Extension Work in AGRICULTURE and HOME ECONOMICS and the United States Department of Agriculture cooperating			
PORTABLE PLASTIC GREENHOUSE			
USDA	'63	EX. 5946	Sheet 1 of 1

A-Frame Home Greenhouse

GENERAL

Select a level, well-drained site near water and electricity.
Treat base with two coats of a copper naphthenate wood preservative.
Screw anchors into ground, slot base and tighten anchor to base.

FRAME

Use construction grade fir.
Paint frame with an exterior white paint.
Doors can be placed in one or both end walls.

COVERING

For year-round use, two layers of plastic should be used.
For spring and fall use, single layer is sufficient.
To reduce labor or replacing plastic, a 4-5 year ultraviolet resistant vinyl plastic should be used on the outside.
Inner layer can be polyethylene and can be attached with either batten strips or 3/8" staples over heavy twine.

WALKS AND BENCHES

A center walk of stones or bricks laid in sand can be added after the greenhouse is built.
Benches 30-32 inches high and treated with a copper naphthenate wood preservative can be added for convenience.

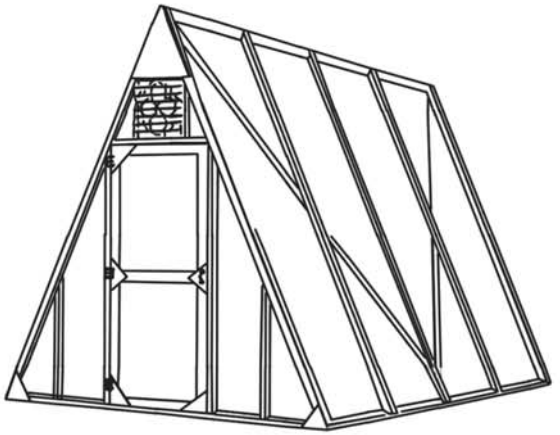
VENTILATION

A 10-inch diameter fan with automatic louver and thermostat should be placed above door on one end wall.
Locate a 10- or 12-inch intake louver above door on opposite end wall.
Place thermostat along side wall near plant level.

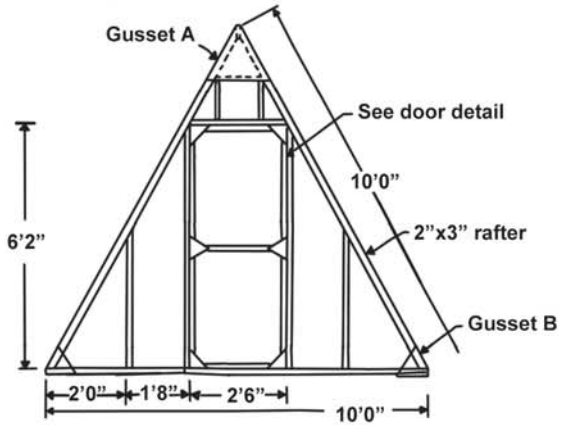
HEAT

Heat may be supplied from the home heating system or from a separate heater. Output required can be obtained from the following table.

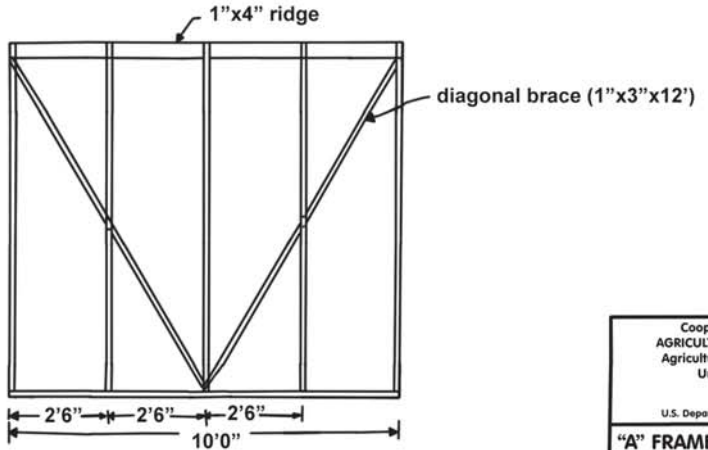
Minimum Outside Temperature	Single Layer Plastic BTU/Hr.			Double Layer Plastic BTU/Hr.		
30°	6800	10200	13600	3800	5700	7600
20°	10200	13600	17000	5700	7600	9500
10°	13600	17000	20400	7600	9500	11400
0°	17000	20400	23800	9500	11400	13300
-10°	20400	23800	27100	11400	13300	15200
	50°	60°	70°	50°	60°	70°
	Minimum Inside Temperature					



PERSPECTIVE



END VIEW
Scale: ½" = 1'0"



SIDE VIEW
Scale: ½" = 1'0"

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AGRICULTURE AND HOME ECONOMICS
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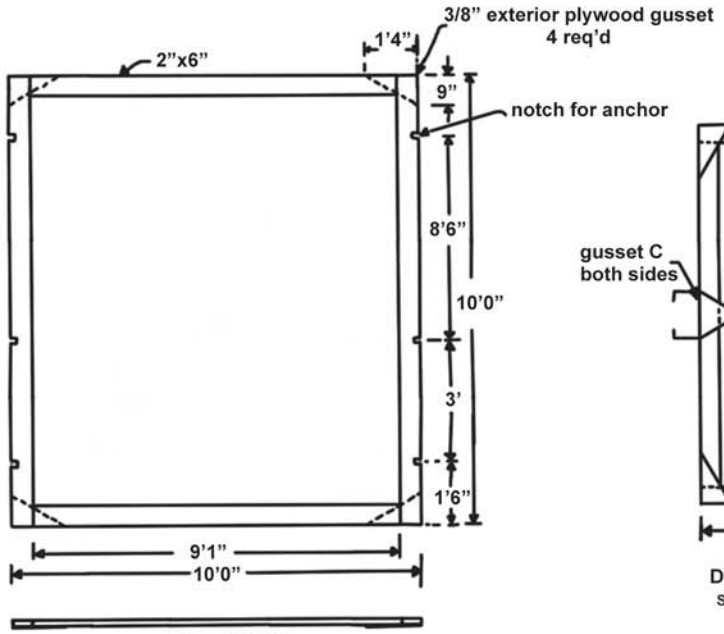
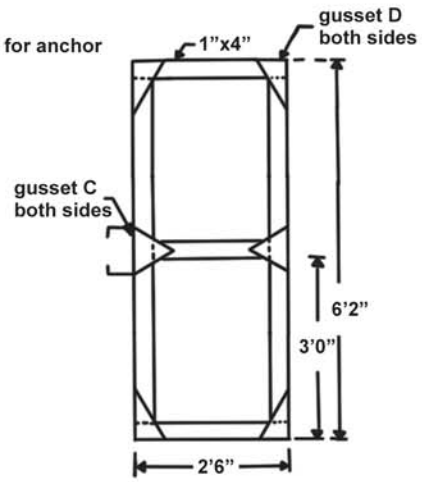
"A" FRAME HOME GREENHOUSE

Dr by JWB	Ck by REP	Sheet 1 of 2
Scale shown	Date 7-3-67	Plan 238



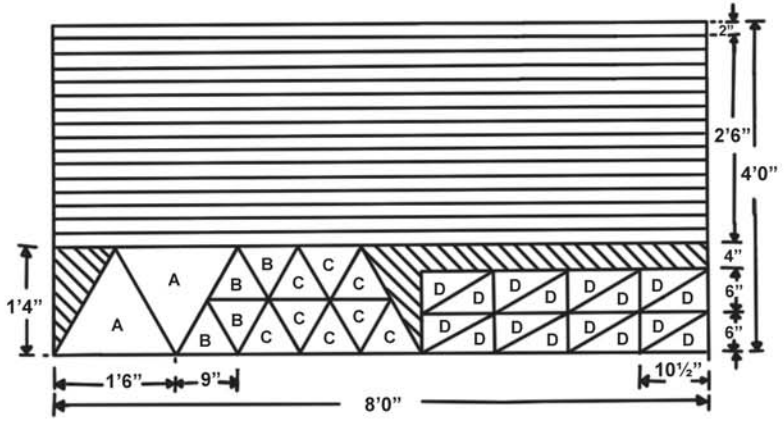
BASE DETAIL
Scale: ½" = 1'0"



DOOR DETAIL
Scale: ¾" = 1'0"

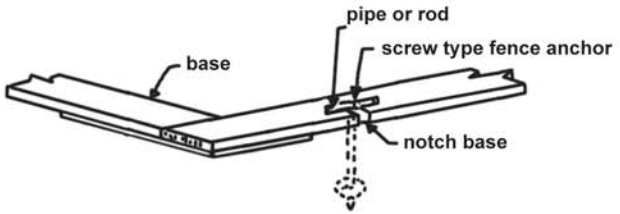
BILL OF MATERIALS

Quantity	Item	Location
4 pcs	2"x6"x10'	base
15 pcs	2"x3"x10'	rafters, end walls & door frames
7 pcs	1"x4"x10'	ridge & doors
4 pcs	1"x3"x12'	diagonal brace
2 shts	4'x8'x¼" ext. plywood	batten strips & gussets
3 pr.	3" steel butt hinges	door
½ gal.	copper naphthenate wood preservative	base
1 gal	white exterior paint	all framework
6	3" dia. x 15" lg. screw type fence anchors	tie down
2	door latches	door
70'	50" wide x 8 mil poly-vinyl w/ultraviolet inhibitor	outside covering
1 pc	10'x35'x4 mil polyethylene	inside covering
3 lbs	4d common nails	
1 lb	8d common nails	



PLYWOOD CUTTING DIAGRAM
Scale: 1" =1'0"

NOTE: Use ¼" exterior plywood
Cut 1 sheet into 2" strips 8' long as shown



ANCHOR INSTALLATION
No scale

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University of Connecticut
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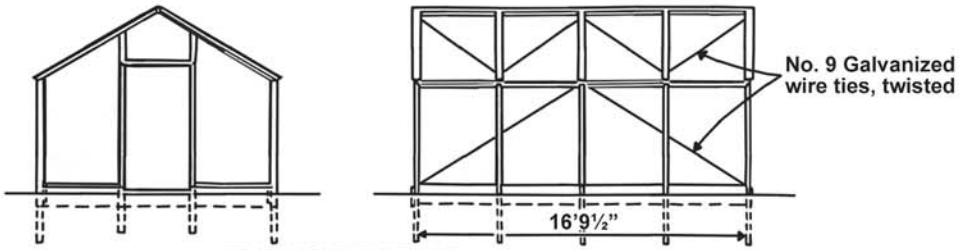
U.S. Department of Agriculture cooperating

"A" FRAME HOME GREENHOUSE

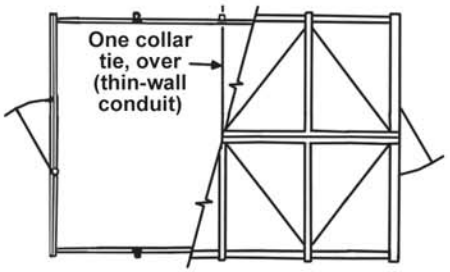
Dr by JWB	Ck by REP	Sheet 2 of 2
Scale SHOWN	Date: 7-3-67	Plan: 238

Plastic Greenhouse



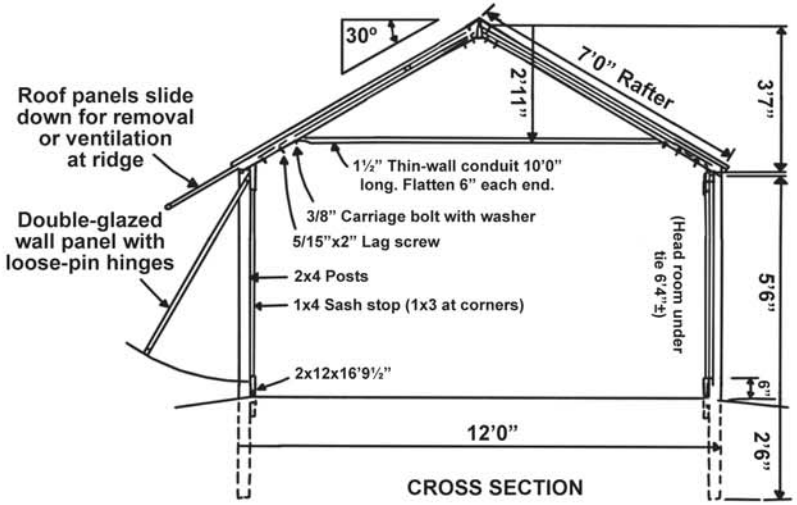
FRAMING ELEVATIONS

12" 0 1' 2' 3' 4'

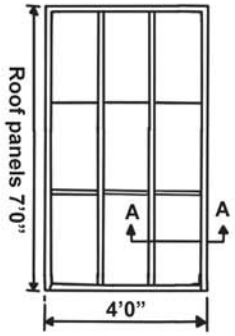


FRAMING PLAN

12" 0 1' 2' 3' 4'

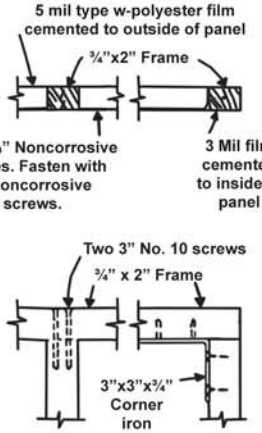


CROSS SECTION



ROOF SASH PANEL

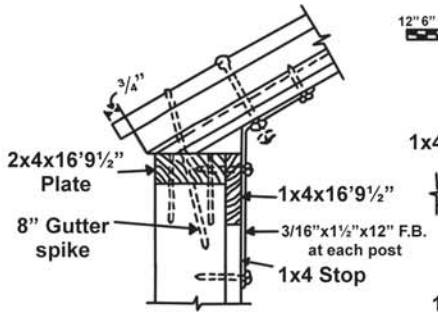
12" 6" 0 1' 2'



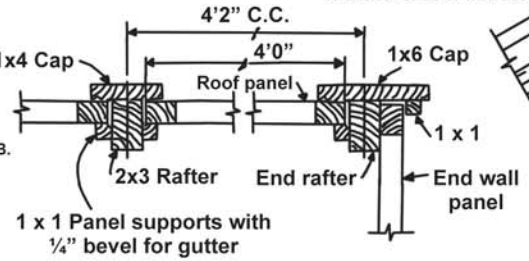
SECTION A-A

Not to scale

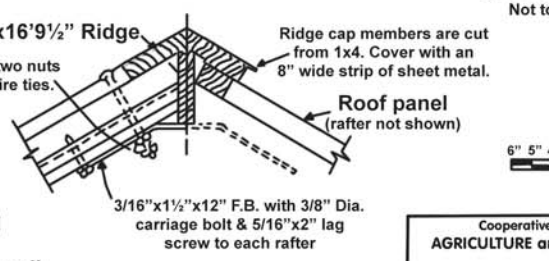
12" 6" 0 1' 2'



EAVE CONNECTIONS



RAFTER DETAILS



RIDGE DETAIL

6" 5" 4" 3" 2" 1" 0

NOTE:
Consult local health and building code authorities before starting construction.

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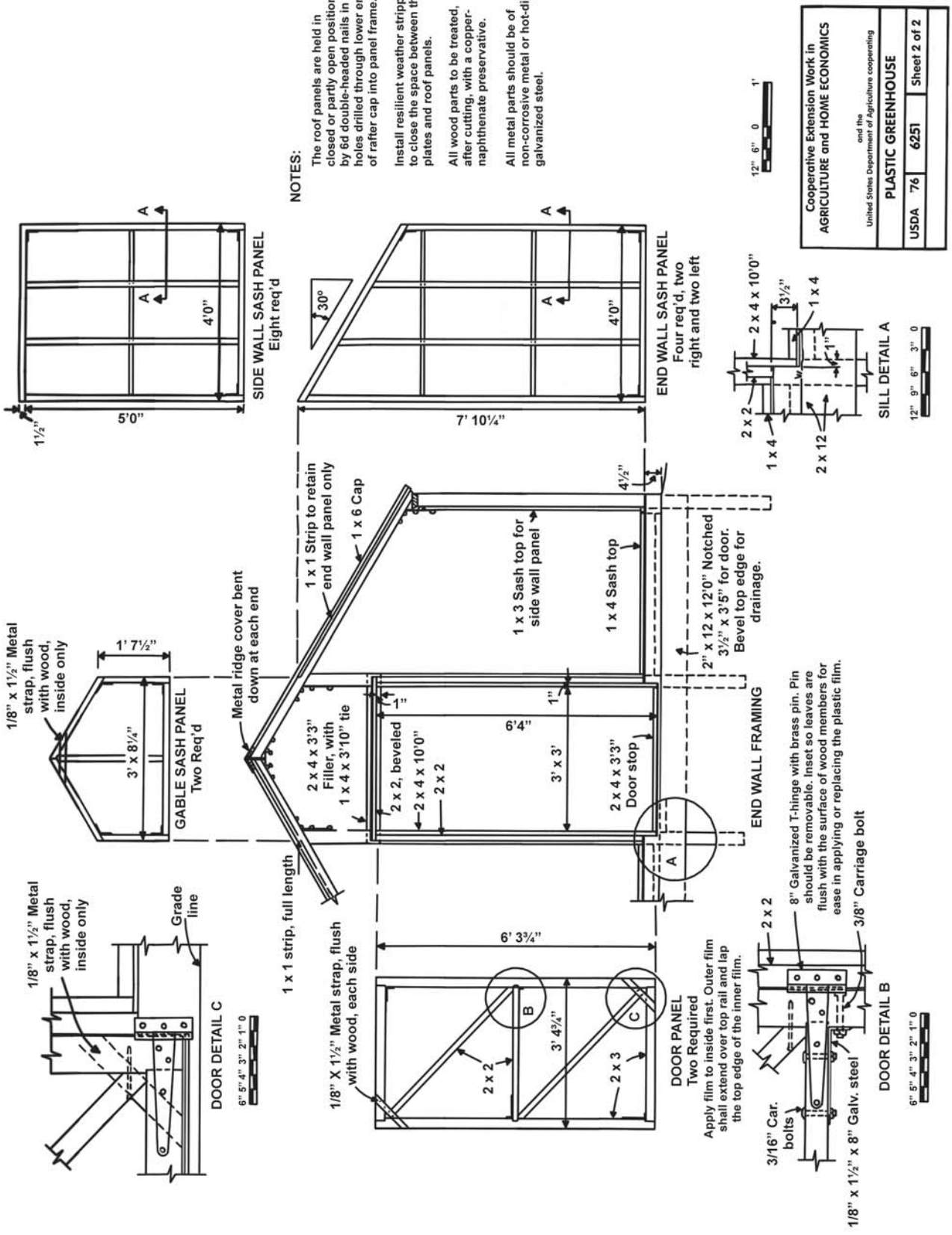
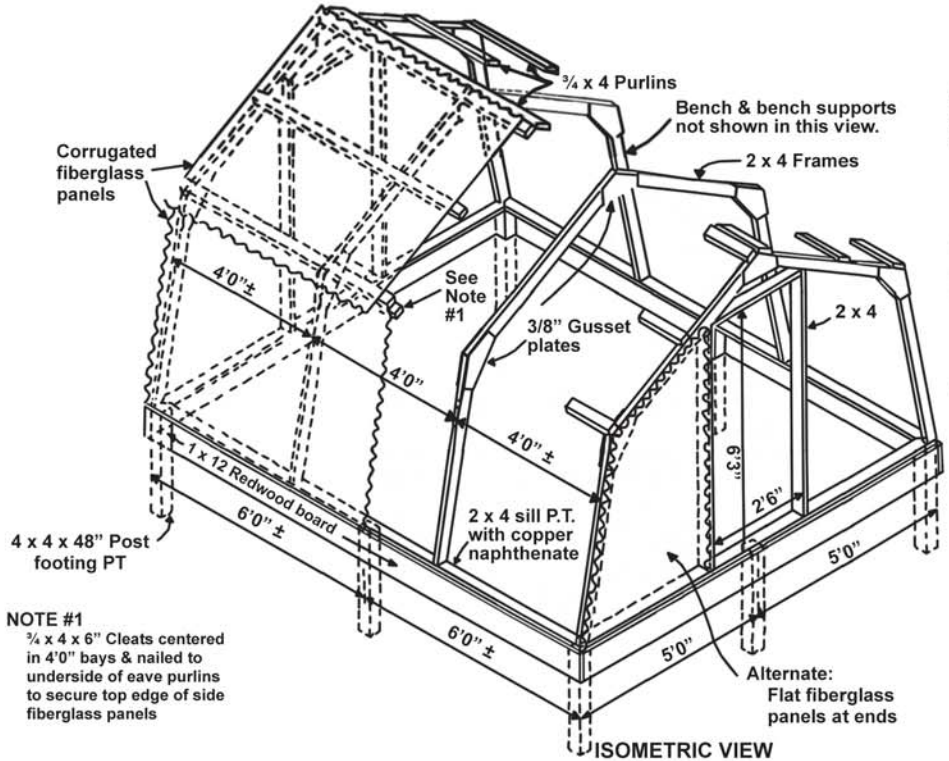
PLASTIC GREENHOUSE

USDA	'76	6251	Sheet 1 of 2

Plastic Greenhouse [cont.]

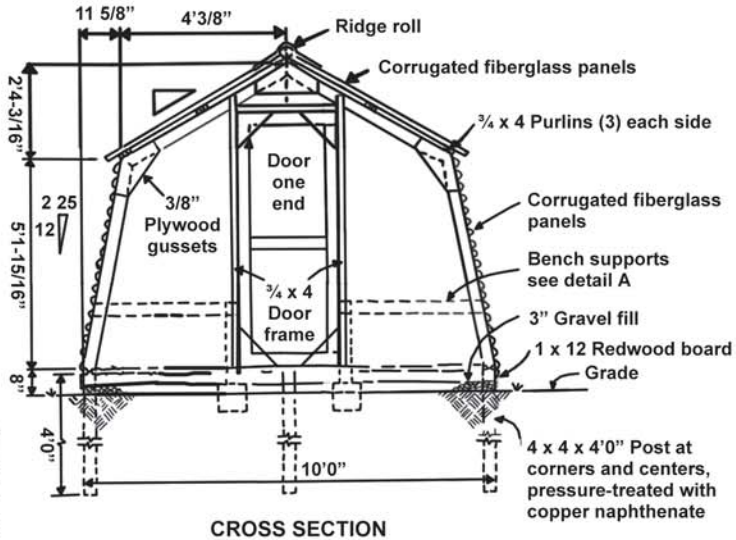


Home Greenhouse

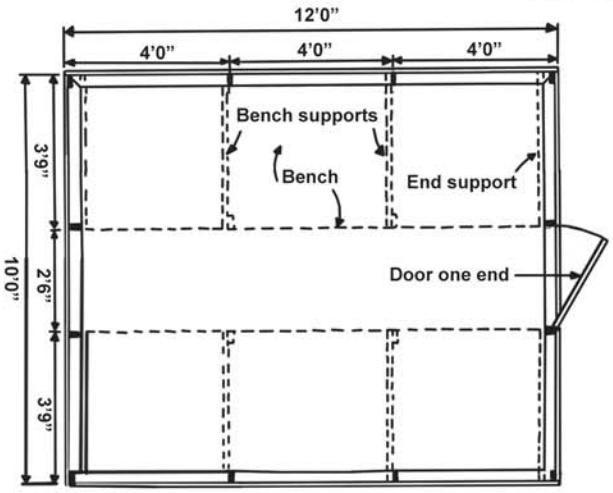


ISOMETRIC VIEW

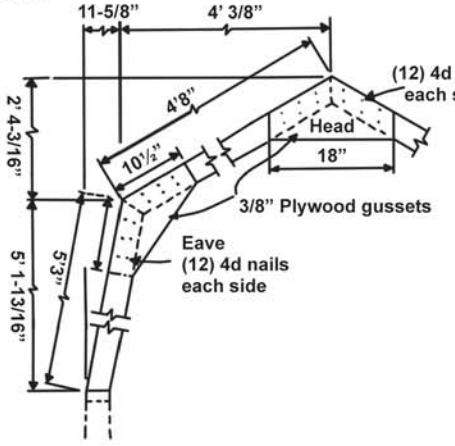
NOTE #1
¾ x 4 x 6" Cleats centered in 4'0" bays & nailed to underside of eave purlins to secure top edge of side fiberglass panels



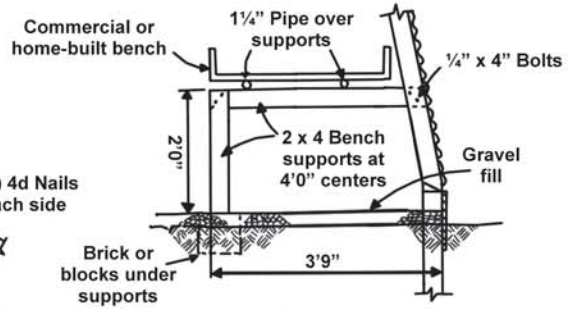
CROSS SECTION



PLAN



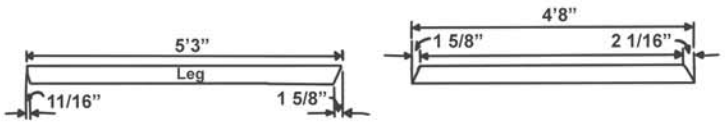
FRAMING MEASUREMENTS



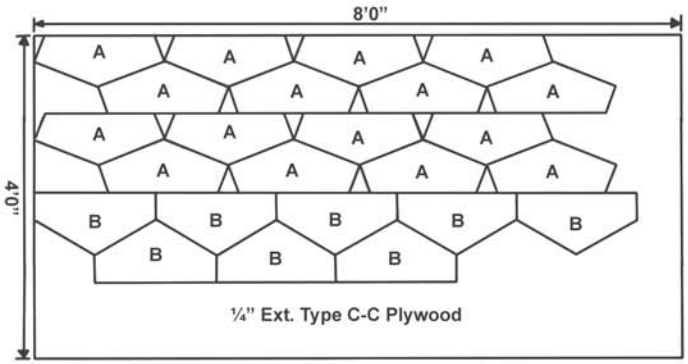
DETAIL A

Based on Univ of Illinois Cir 880
& Rutgers Plan No. 158

Cooperative Extension Work in AGRICULTURE and HOME ECONOMICS and the United States Department of Agriculture cooperating		
HOME GREENHOUSE		
N.J. '74	6181	Sheet 1 of 2



FRAME CUTTING LAYOUT (cut from [8] 2 x 4 x 10')



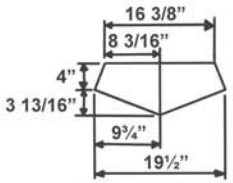
PLYWOOD SHEET CUTTING DIAGRAM

BILL OF MATERIALS

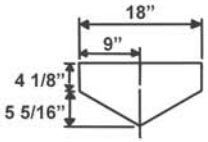
Corrugated fiberglass reinforced panels (F.R.P.)*
5 oz. coating:

Roof panels	(6) 2' x 10' cut in half
Side panels	(5) 2' x 12', 2 sheets each side 5th sheet cut lengthwise
End panels	(9) 2' x 8', of which 5 are located at end with no door
Ridge roll	(1) 12' length

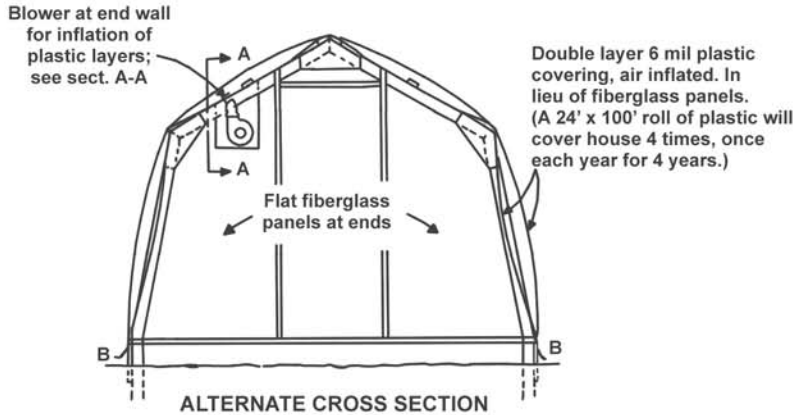
Lumber:
(8) 2 x 4 x 10' to make frames
(2) 2 x 4 x 10' sill at ends (P.T. copper naphthenate)
(2) 2 x 4 x 12' sill at sides (P.T. copper naphthenate)
(2) 2 x 4 x 16' end framing
bench supports not included
(8) ¾ x 4 x 12' for purlins and door
(2) 4 x 4 x 16' P.T. post for footing
(2) 1 x 12 x 12' and (2) 1 x 12 x 10' redwood boards
(1) 4' x 8' x ¼" exterior type CC plywood sheet for plywood gussets. See cutting diagram.
* Check with fiberglass supplier for necessary related hardware & covering instructions.
Nails, hinges & latch



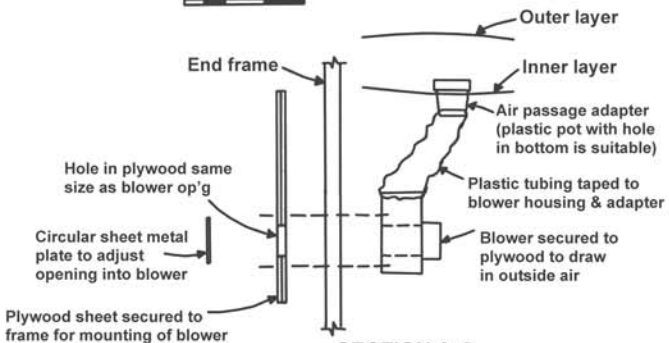
SIDE GUSSETS
16 req'd



HEAD GUSSETS
8 req'd



ALTERNATE CROSS SECTION



SECTION A-A

ENVIRONMENTAL CONTROL

Heating:

To maintain a temperature difference of 60° between inside and outside —
30,000 BTU/hr. single covering
20,000 BTU/hr. double covering
Connection to home heating system is most desirable. If not possible, use gas or oil heater vented to the outside. Electric heaters are easy to install and clean but expensive to operate. When using oil or gas, be sure to provide a fresh air supply directly to the heater to supply oxygen for combustion.

Ventilating:

Require a two-speed fan rated at 1000 CFM. An automatic air inlet of 2 sq. ft. is required. The fan can be mounted in one gable end and the air inlet in the other. Both should be controlled by a thermostat.
For more information, see USDA Bulletin Number 357, "Building Hobby Greenhouses."

Cooperative Extension Work in
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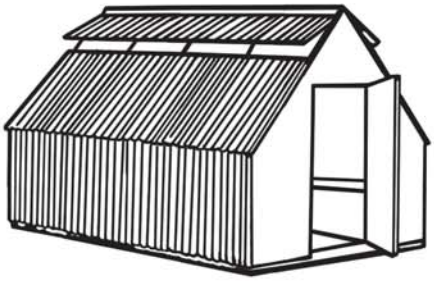
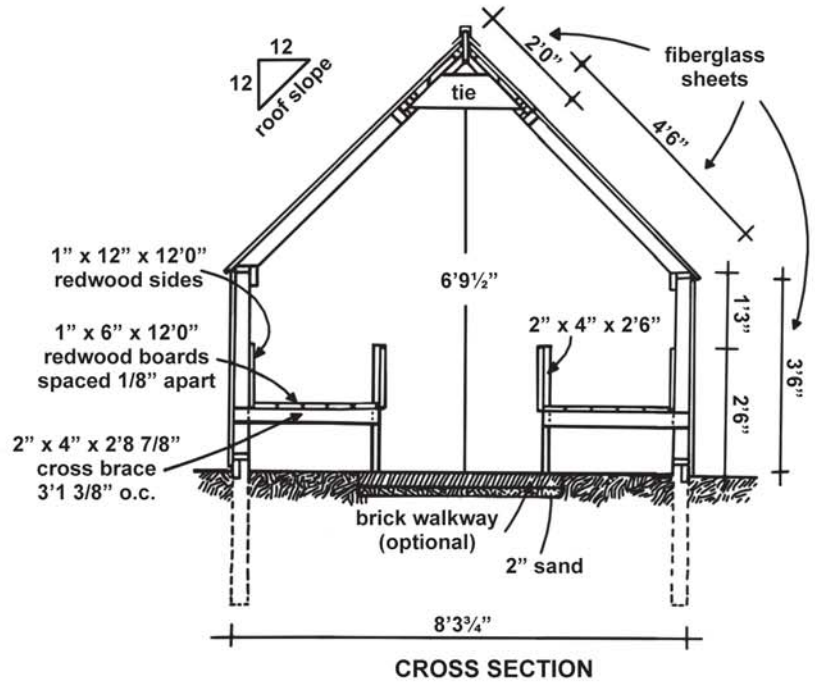
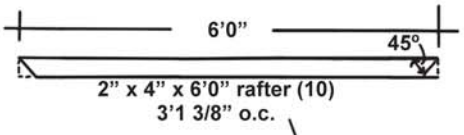
HOME GREENHOUSE		
N.J. '74	6181	Sheet 2 of 2

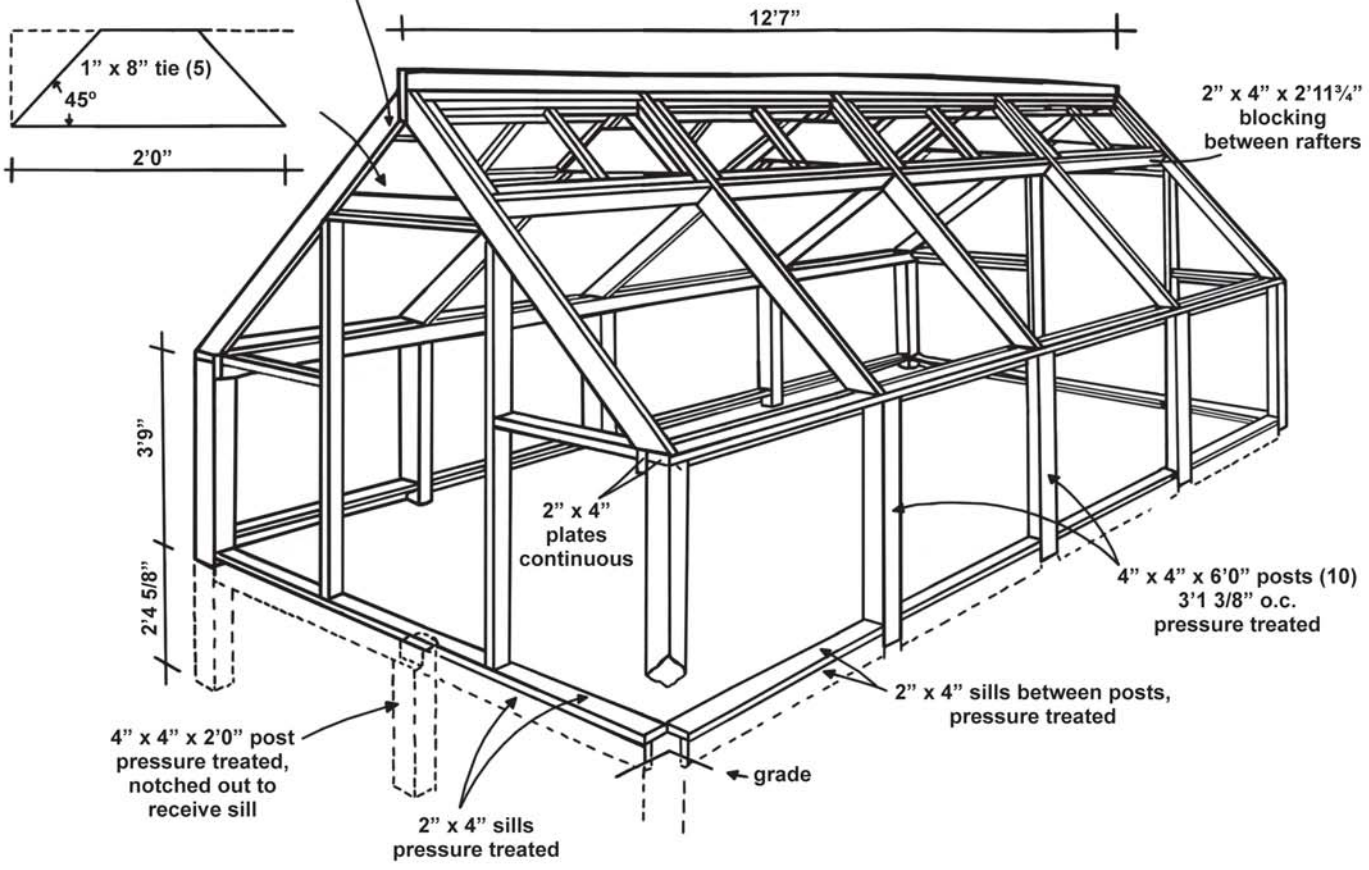


FIBERGLASS GREENHOUSE



CROSS SECTION





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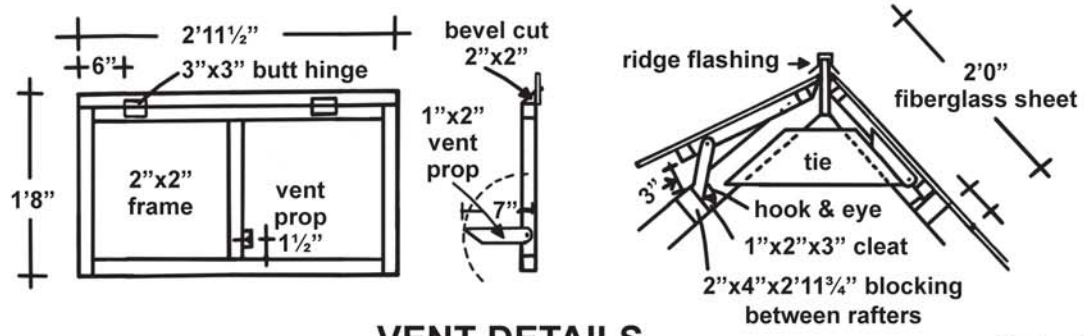
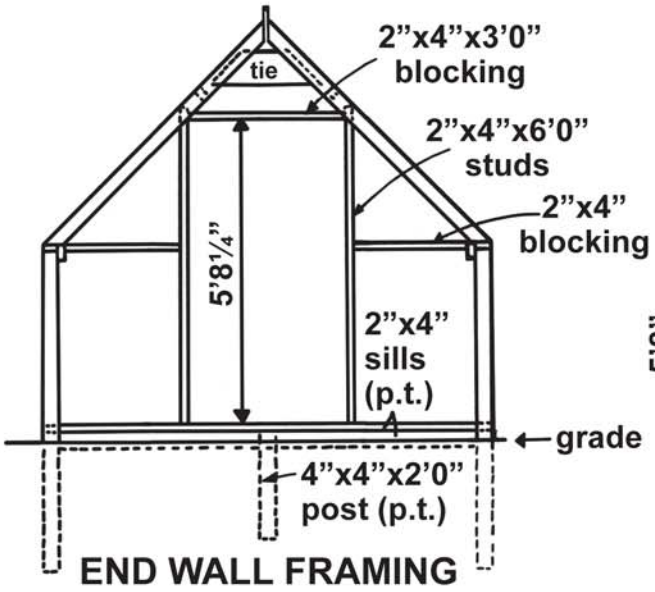
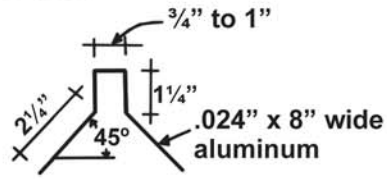
Fiberglass Greenhouse



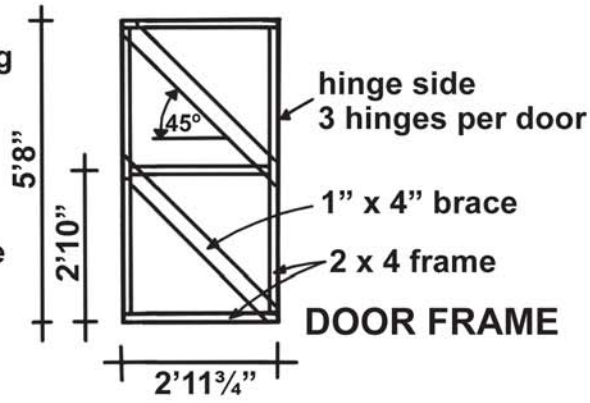
VENT DETAILS



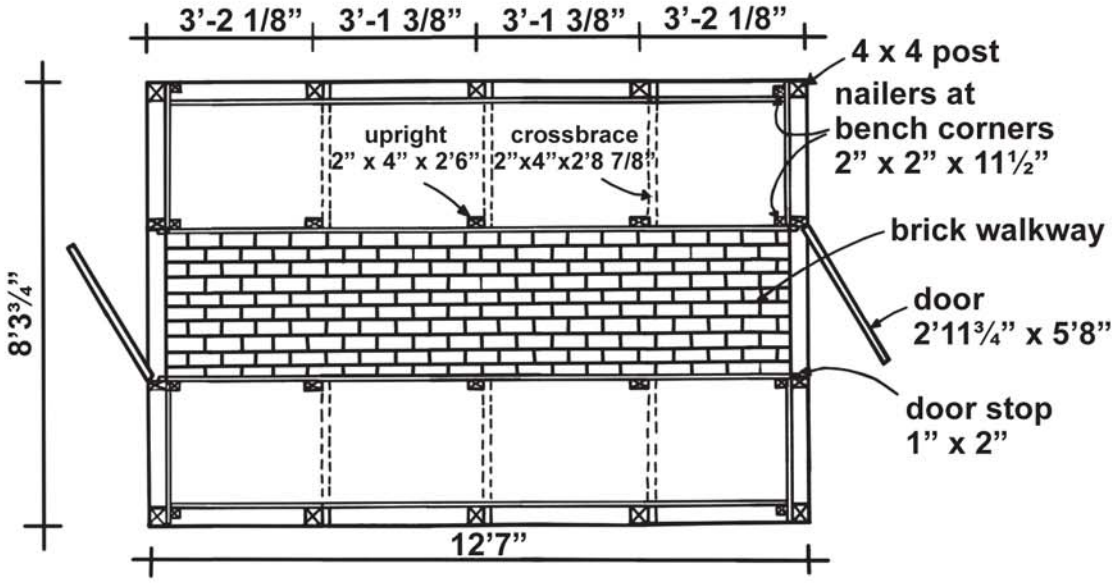
END WALL FRAMING



RIDGE FLASHING



DOOR FRAME



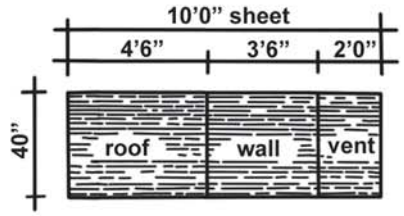
PLAN

CT 210
page 2 of 3

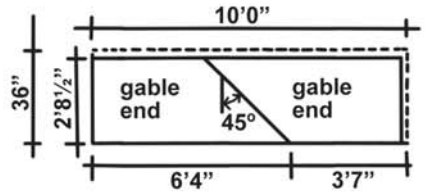
Fiberglass Greenhouse [cont.]

FRP SHEET CUTTING DIAGRAMS

Corrugated



Flat



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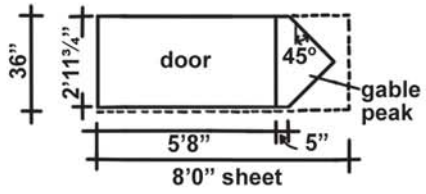


MATERIALS

Item	Lumber Dimensions		Pieces	Board feet
	Nominal Size, in.	Length		
Framing				
posts (pressure treated)	4x4	6'	11	88
sills (pressure treated	2x4	6'	8	32
	2x4	8'	4	21
rafter plates	2x4	14'	4	37
rafters, blocking studs	2x4	6'	19	76
end wall blocking	2x4	10'	1	7
ridge	1x8	14'	1	9
door brace	1x4	10'	2	7
rafter ties	1x8	10'	1	5
cross brace (bench)	2x4	14'	2	19
upright (bench)	2x4	8'	2	11
bench bottom	1x6	12'	10	60
bench sides & ends	1x12	12'	5	60
nailer (bench corners)	2x4	8'	1	5
door & vent framing	2x2	6'	13	26
	2x2	14'	4	19
door stop & vent prop	1x2	6'	6	6
			Total	488

	Size	Quantity
Fiberglass Sheets		
corrugated	2½"x40"x10'0"	8
flat	36"x10'0"	2
flat	36"x8'0"	2
Hardware		
hinges (door & vent)	3" butt type	11 pair
flashing (aluminum)	.024"x8" wide	13 lineal ft.
nails (aluminum)	1¾" screw shank	550
nails (framing)		
Miscellaneous		
corrugated filter strip (purchased from the fiberglass supplier)		150 lineal ft.
mastic (non-hardening type)		

CONSTRUCTION NOTES

Refer to page 16 for fastening details

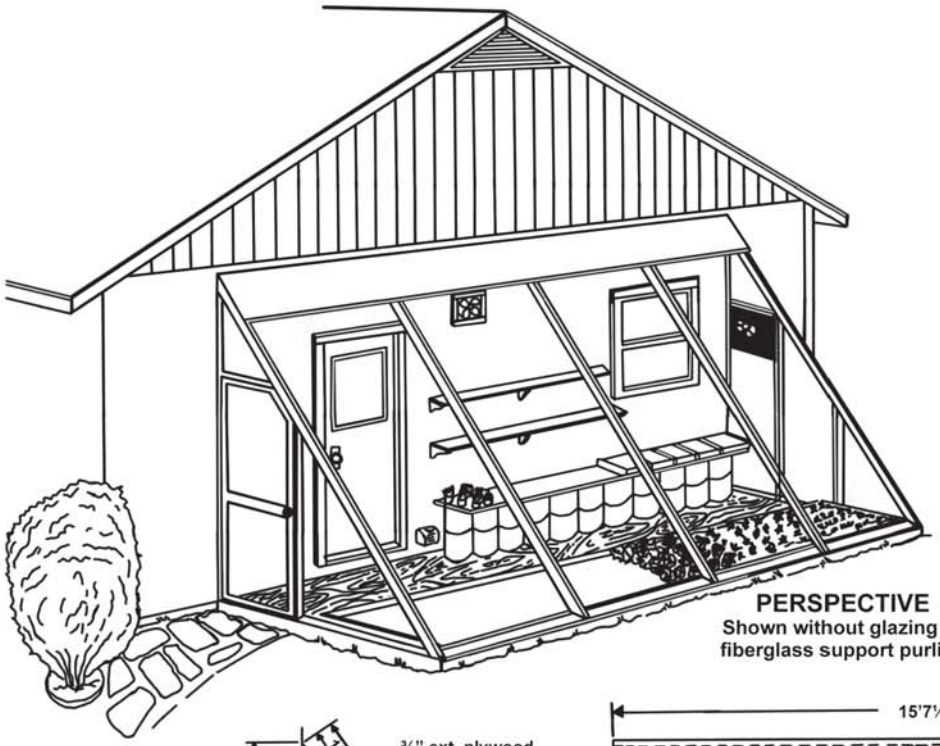
FIBERGLASS GREENHOUSE

based on Plan No. 210
University of Connecticut

CT 210
page 3 of 3

Fiberglass Greenhouse [cont.]

Attached Greenhouse and Solar Collector



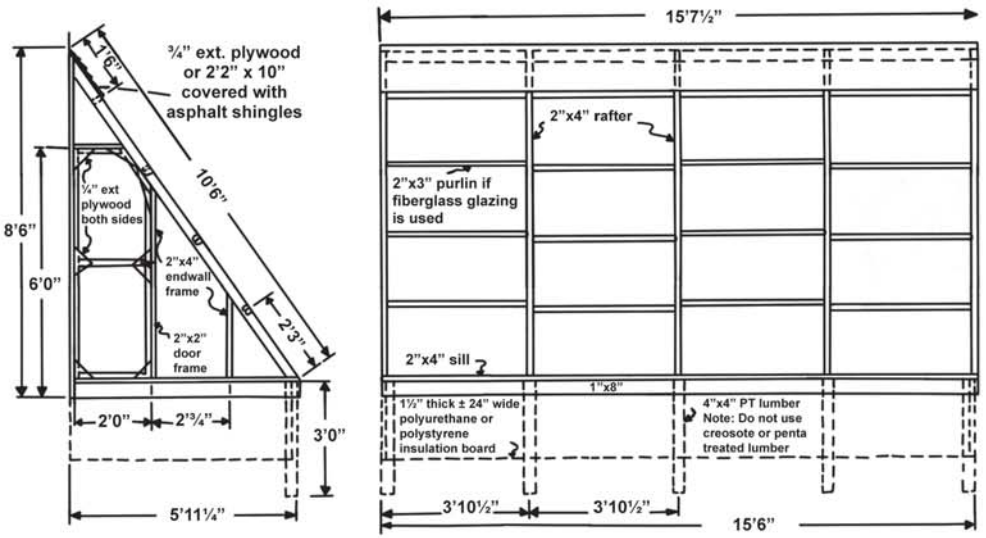
PERSPECTIVE
Shown without glazing or fiberglass support purlins

MATERIALS LIST

14	2"x4"x10'	Rafters — door — endwall — sill
1	2"x4"X12'	Sill
1	4"X4"X16'	Posts
8	2"X3"X8'	Purlins (if fiberglass glazing used)
2	1"X8"X8'	Foundation
3	1"X8"X12'	Foundation (ground bed)
4	1"X10"X8'	Roof
2 shts	4"X8"X11½"	Polystyrene insulation
1 pr	4"	Butt hinges
1		Door latch
		Assorted common nails — 6d, 8d, 16d

GLAZING

4 shts	4'x8' - 5 oz	Clear corrugated fiberglass reinforced plastic
1 roll	4'x25' - 4 oz	Clear flat fiberglass reinforced plastic
300	1¼"	Aluminum nails with neoprene washers
30'		Corrugated rubber sealing strips
		or
1 roll	10'x100' 6 mil	Greenhouse grade polyethlene film
200'	1"x3"	Furring strips to attach poly outside & inside

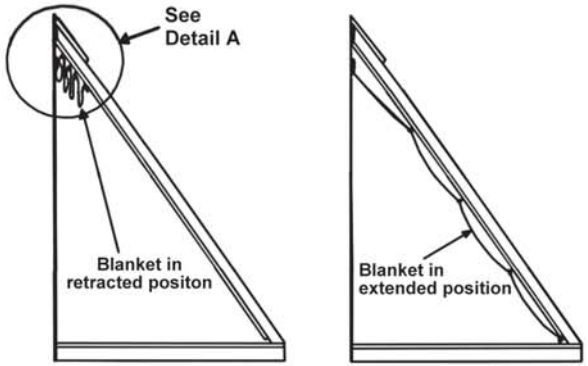


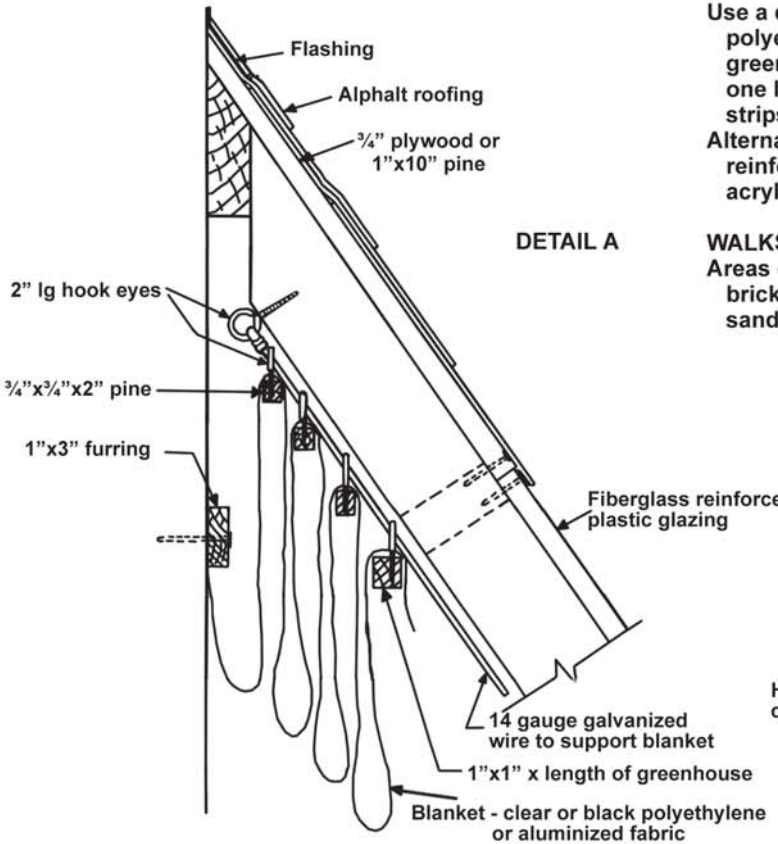
Cooperative Extension Work in
AGRICULTURE and HOME ECONOMICS
Agricultural Engineering Department
University of Connecticut
Storrs, Connecticut
and
U.S. Department of Agriculture cooperating

ATTACHED GREENHOUSE & SOLAR COLLECTOR

DR by J. Barton	CK by R. Aldrion	Sheet 1 of 2
Scale: as shown	Date: 4-82	Plan 252

Attached Greenhouse and Solar Collector [cont.]





DETAIL A

CONSTRUCTION NOTES

GENERAL
Obtain building permit if required.
Select a site with south, southeast or southwest exposure.
Provide adequate drainage.
Use pressure treated lumber or treat wood in contact with the ground with copper naphthenate wood preservative.
Paint frame with an exterior white paint.
Door can be located at either end.
Use flashing between house and greenhouse roof.

COVERING
Round and smooth all edges.
Use a double layer of 6 mil greenhouse grade polyethylene plastic, available from greenhouse suppliers. One layer inside, one layer outside. Fasten with furring strips.
Alternate coverings - clear fiberglass reinforced plastic (FRP), double wall acrylic or polycarbonate.

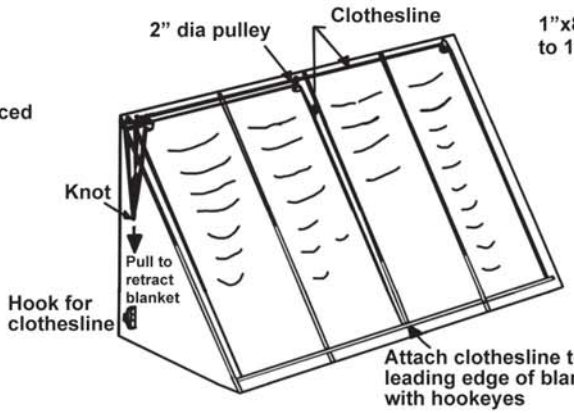
WALKS
Areas other than beds can be covered with bricks, flagstone or pea stone over sand base.

VENTILATION
A 10" - 1/20 hp shutter mounted fan with intake louver and thermostat should be used for summer ventilation. Shade thermostat from direct sunlight.
Tobacco netting or polypropelene saran shade can be used to reduce summer heat.

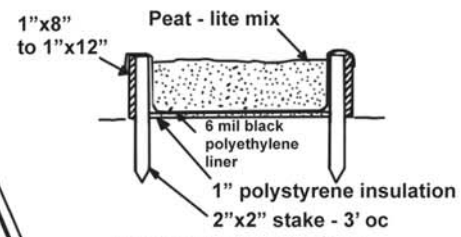
ENERGY CONSERVATION
Fixed or removable polystyrene insulation panels can be used on all or part of endwalls.
Caulk all cracks.

HEAT STORAGE
If greenhouse is to be used for growing plants provide 150 to 200 gal of water in 1 or 5 gallon containers.
If greenhouse is to be used for heating the home, no storage is necessary; and heat transfer can be accomplished with an 8- or 10-inch diameter room to room fan located near the ceiling and an 8- to 10-inch square wall louver near the floor.

SUPPLEMENTAL HEAT
To maintain greenhouse temperature at 50°F at 0°F outside during extended periods of cloudy weather, a heater with an output of 6000 to 8000 BTU/hr is needed.

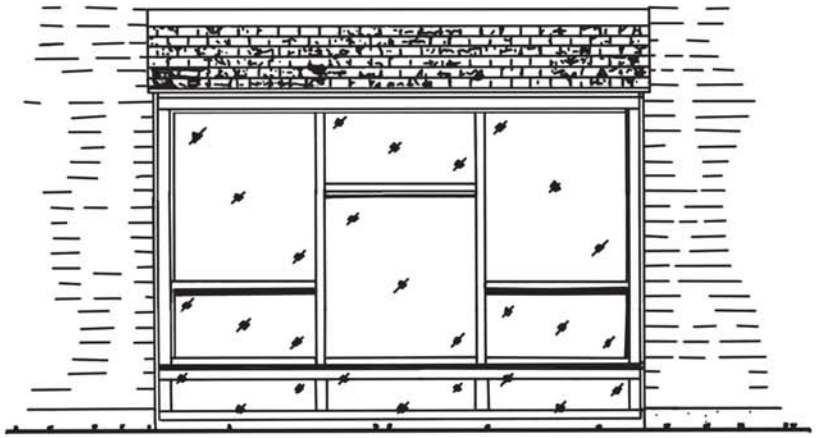


BLANKET RETRACTION SYSTEM

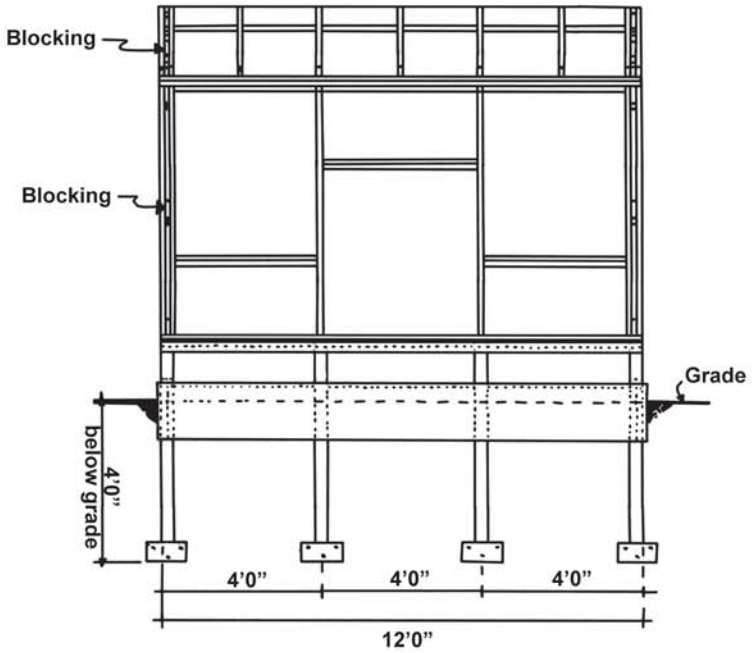


BED CONSTRUCTION

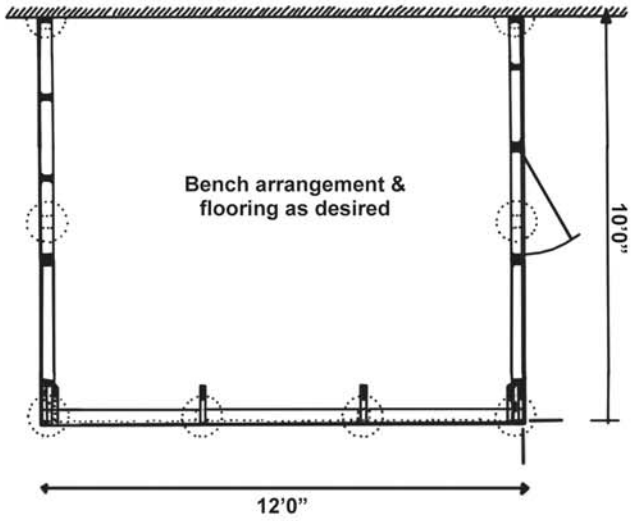
Cooperative Extension Work in AGRICULTURE and HOME ECONOMICS Agricultural Engineering Department University of Connecticut Storrs, Connecticut and U.S. Department of Agriculture cooperating		
ATTACHED GREENHOUSE & SOLAR COLLECTOR		
Dr by J Barton	CK by R. Aldrion	Sheet 2 of 2
Scale: None	Date: 4-82	Plan 252



SOUTH ELEVATION



SOUTH WALL FRAMING



BASIC FLOOR PLAN
length may be expanded in 4' increments

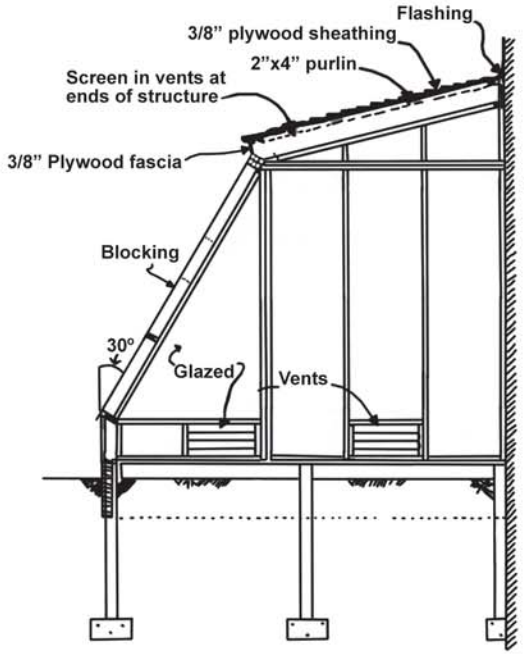
CONSTRUCTION NOTES:

1. Basic framing is 2x4 construction unless otherwise noted. Use only construction grade lumber.
2. Any lumber in contact with soil should be pressure treated. Creosote or pentachlorophenol should NOT be used.
3. Unglazed interior walls and ceiling to be insulated and covered.
4. All exposed lumber should be protected with a coat of primer and/or an oil-base paint. The final coat of paint should be white.
5. If treated lumber is cut, make sure cut surfaces are protected or not inserted into the ground.
6. Compacted crushed gravel or concrete footings may be recommended.
7. Use flashing and/or caulking to protect all joints.
8. Sidewall framing may be adjusted to suit doors, vents, fans, etc.

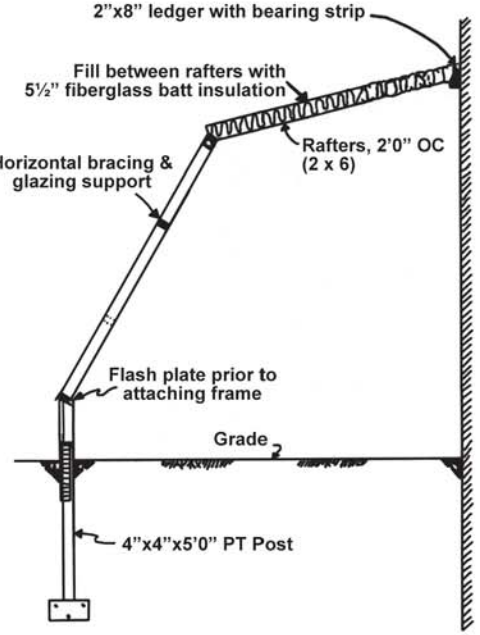
Check with your building inspector before construction.

Cooperative Extension Work in AGRICULTURE and HOME ECONOMICS Food Engineering Department University of Massachusetts and the United States Department of Agriculture		
10'x12' ATTACHED SOLAR GREENHOUSE		
Scale: as shown	MC 2802	Sheet 1 of 3
Drw by RFR	Ck by RJG	RFR

Attached Solar Greenhouse [cont.]



WEST WALL FRAMING



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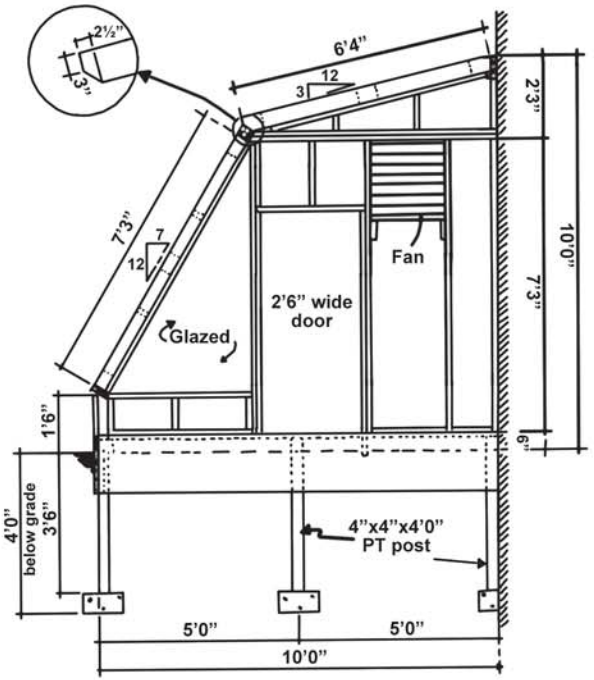
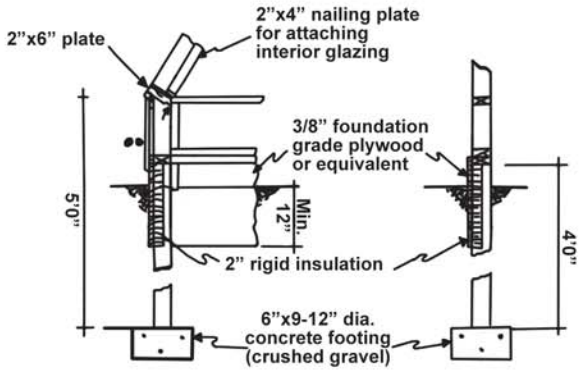


EAST WALL FRAMING



KNEEWALL and FOUNDATION DETAILS

- Cut top of kneewall posts at a 30° angle as shown.
- Kneewall can be glazed as shown or covered with foundation grade plywood and insulated as shown with dotted lines.

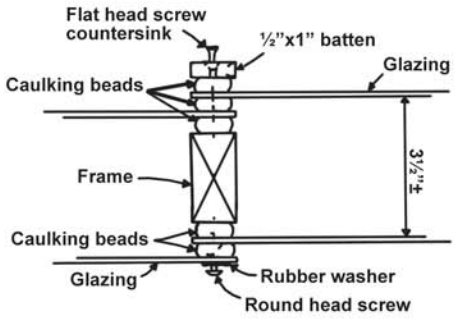
IMPORTANT NOTE:

Exterior/interior finish materials, plumbing, wiring, etc., are owner/builder's responsibilities. Take into account the unique characteristics of the greenhouse environment when making these decisions

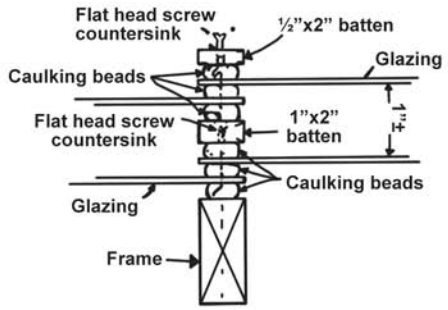
A supplemental narrative is available in conjunction with this plan.

Cooperative Extension Work in AGRICULTURE and HOME ECONOMICS FOOD ENGINEERING DEPARTMENT UNIVERSITY OF MASSACHUSETTS and the United States Department of Agriculture cooperating		
10'x12' ATTACHED SOLAR GREENHOUSE		
Scale: As shown	MC 2802	Sheet 2 of 3
Drw by RFR	Ck by HJG	RJR

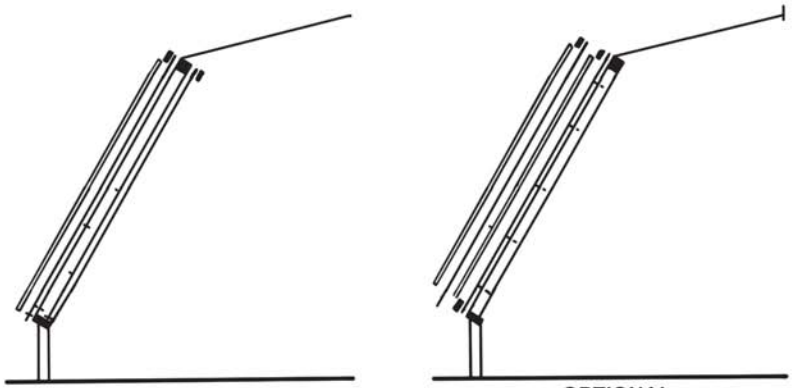
• Space screws alternately with screws in middle batten



METHOD A



METHOD B



EXPLODED VIEWS OF GLAZING DETAILS
No Scale

GLAZING NOTES

1. Recommend 2 layers of greenhouse (solar) grade fiberglass, preferably flat.
2. Caulk all joints to discourage air and moisture leaks.
3. Allow the outer layer of glazing on south wall to overhang kneewall for runoff of precipation.
4. Aluminum battens may be used in place of wood battens.
5. Double walled panels may be substituted for fiberglass. However, frame spacing must be altered to accomodate thermal expansion of panels.

INSULATION NOTES

1. 3½" fiberglass batt insulation is recommended in opaque walls and 5½" in ceiling.
2. Use foil-backed insulation or seal with 4-mil polyethylene vapor barrier.
3. Moveable insulation such as insulated shutters or thermal blankets are recommended for glazed areas.
4. Recommend 2" extruded polystyrene (styrofoam) along foundation curtain wall. Bury 12"-16" below grade.

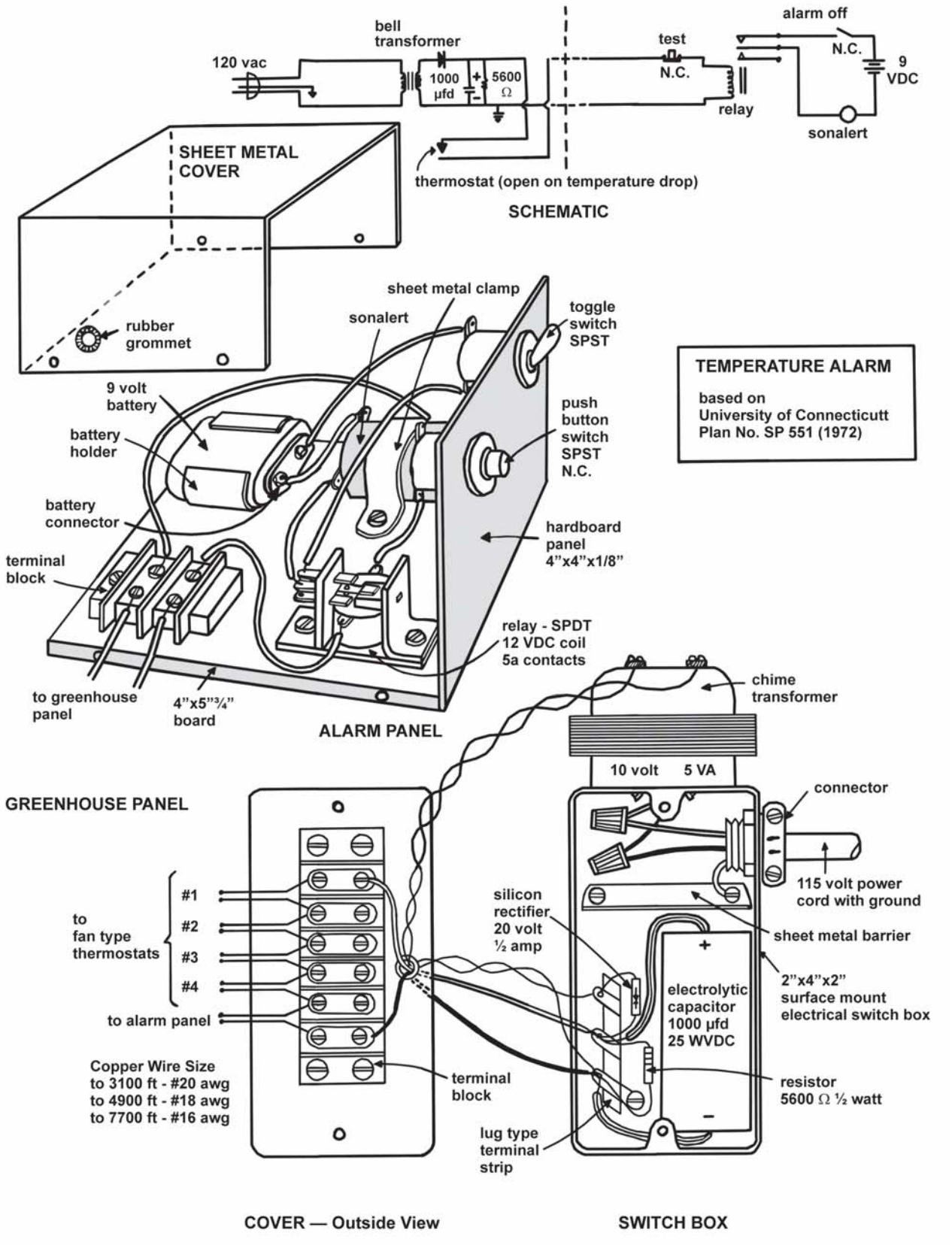
VENTILATION NOTES

1. Use forced ventilation (fan) for summer coolling. Provide 10-12 CFM per sq. ft. of floor area. Choose a fan rated at 0125" static pressure.
2. Winter ventilation can be provided by exchanging air with main structure through a door, window or small fan (approx. 100 CFM).
3. Inlet vents may be hinged or louvered. Provide approximately 13 sq. ft. of opening per 1000 CFM of fan capacity.
4. Automatic controls such as thermostats are highly recommended for fans, vents and auxilliary heat.
5. Greenhouse door can be used during mild weather in conjunction with vents for adequate ventilation without operating fan. DO NOT HAVE DOOR OPEN WHEN FAN IS OPERATING.
6. Purlins on rafters provide for venting space above ceiling insulation. Screen in, DO NOT COVER, openings at ends with hardware cloth.
7. Summer shading may be necessary to reduce over-heating of structure.

FURTHER CONSTRUCTION NOTES

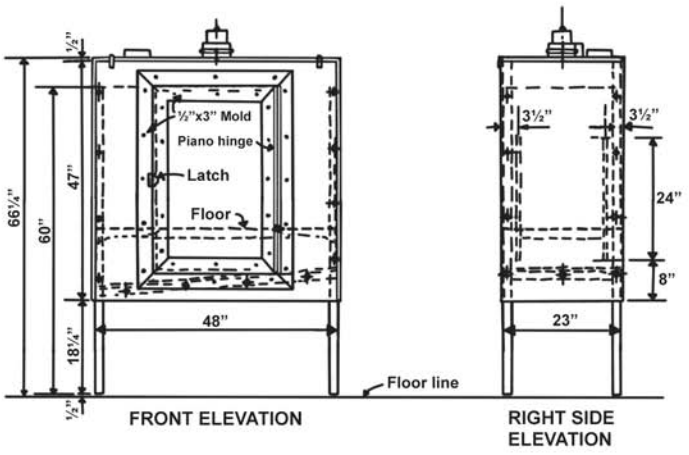
1. Exterior wall and roof sheathing should be at least 3/8" exterior grade plywood or equivalent.
2. Fasterners should be made of aluminum, brass or galvanized steel.
3. Joist hangers & framing anchors may be used to simplify construction.
4. If more insulation is desired, 2"x6" ± may be substituted for 2"x4" ± used in side wall framing.

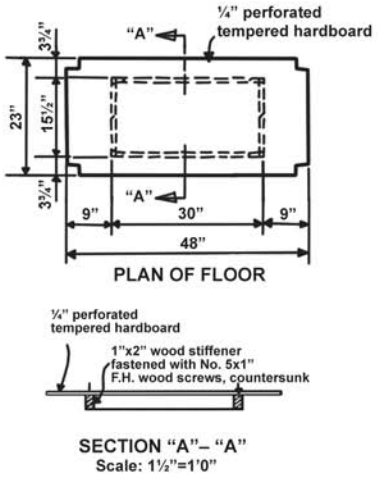
Cooperative Extension Work in AGRICULTURE AND HOME ECONOMICS FOOD ENGINEERING DEPARTMENT UNIVERSITY OF MASSACHUSETTS and the United States Department of Agriculture cooperating		
10'X12' ATTACHED SOLAR GREENHOUSE		
Scale: As shown	MC 2802	Page 3 of 3
Drw by RFR	Ck by HJG	RJR

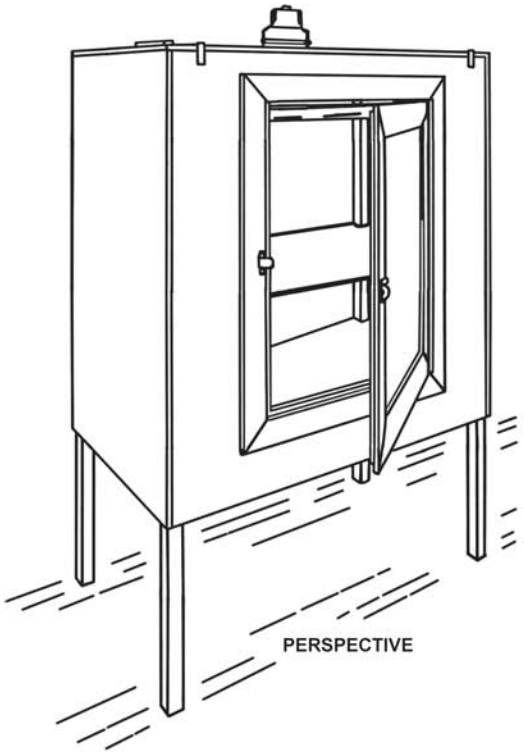


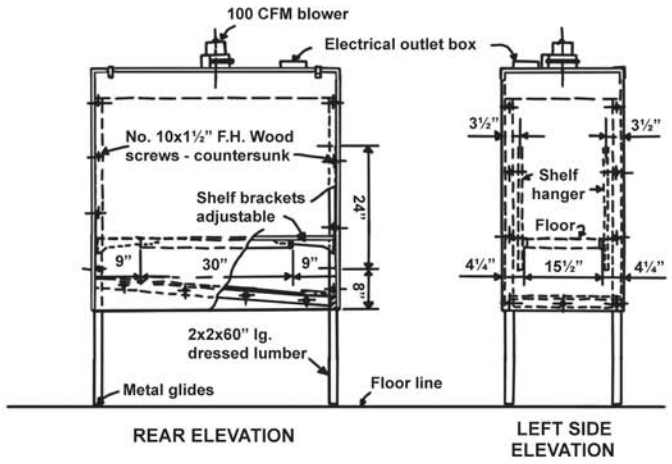
Temperature Alarm

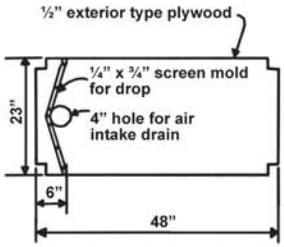
Plant Growth Chamber Roomette











NOTES:

Screws throughout to be flat headed (F.H.) and countersunk.

All framing members to be 2"x2" dressed lumber.

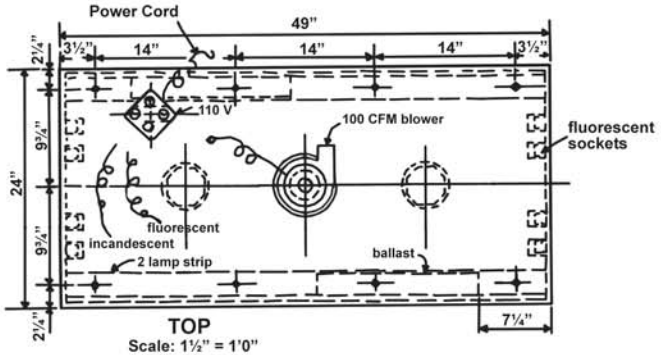
Bottom of chamber slopes to drain off any spillage of water.

Floor is adjustable.

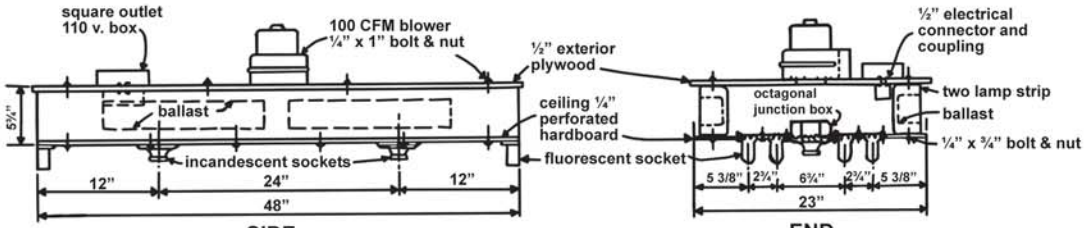
Scale: ¼"=1'0" unless otherwise noted

Cooperative Extension Work in AGRICULTURE and HOME ECONOMICS and the United States Department of Agriculture cooperating		
PLANT GROWTH CHAMBER ROOMETTE		
USDA '66	EX 5980	Sheet 1 of 2

Plant Growth Chamber Roomette [cont.]

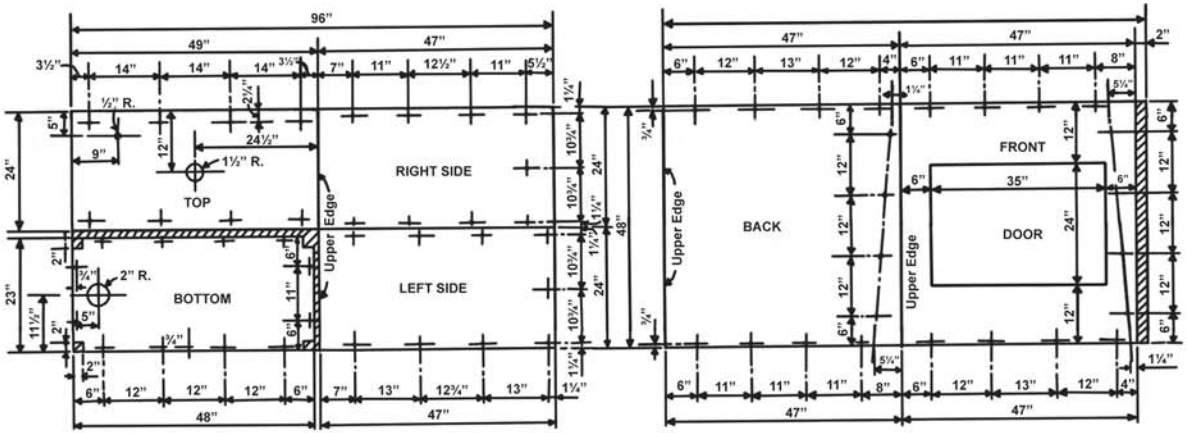


TOP
Scale: 1½" = 1'0"



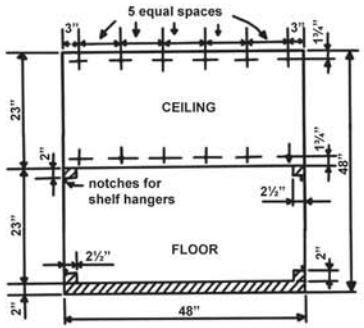
SIDE
Scale: 1½" = 1'0"

END
Scale: 1½" = 1'0"



CUTTING DIAGRAM
½" exterior type plywood

NOTE:
+ Denotes location of countersunk screws.



CUTTING DIAGRAM
¼" performated tempered hardboard

MATERIAL LIST

2 pieces exterior plywood ½"x4'x8'
1 piece perforated tempered hardboard ¼"x4'x4'
2 pieces molding ½"x3"x12'
1 piece screen molding ¼"x¾"x2'
1 piece wood stiffener 1"x2"x8'
2 pieces dressed lumber, legs & frame, 2"x2"x12'
1 piece dressed lumber, frame, 2"x2"x8'
4 shelf hangers, 24" long
4 shelf brackets 12" long
1 piano hinge 36" long, brass coated
1 door latch complete with screws
4 metal glides or casters
1 100 CFM blower
1 square outlet box
1 square outlet face plate
1 outlet box 4"x2 1/8"x1 7/8"
1 electrical connector & coupling ½"
2 fluorescent lamp strips
4 fluorescent lamp sockets
2 octagonal junction boxes
2 incandescent sockets
4 steel angles 2"x2"x¾"x1/8"
8 F.H. wood screws No. 3 x ½"
36 F.H. brass coated wood screws No. 3 x 3/8"
14 F.H. wood screws No. 5 x 1"
54 F.H. wood screws No. 10 x 1½"
32 F.H. wood screws No. 5 x 7/8"
8 bolts & nuts ¼" x 1"
12 bolts & nuts ¼" x ¾"

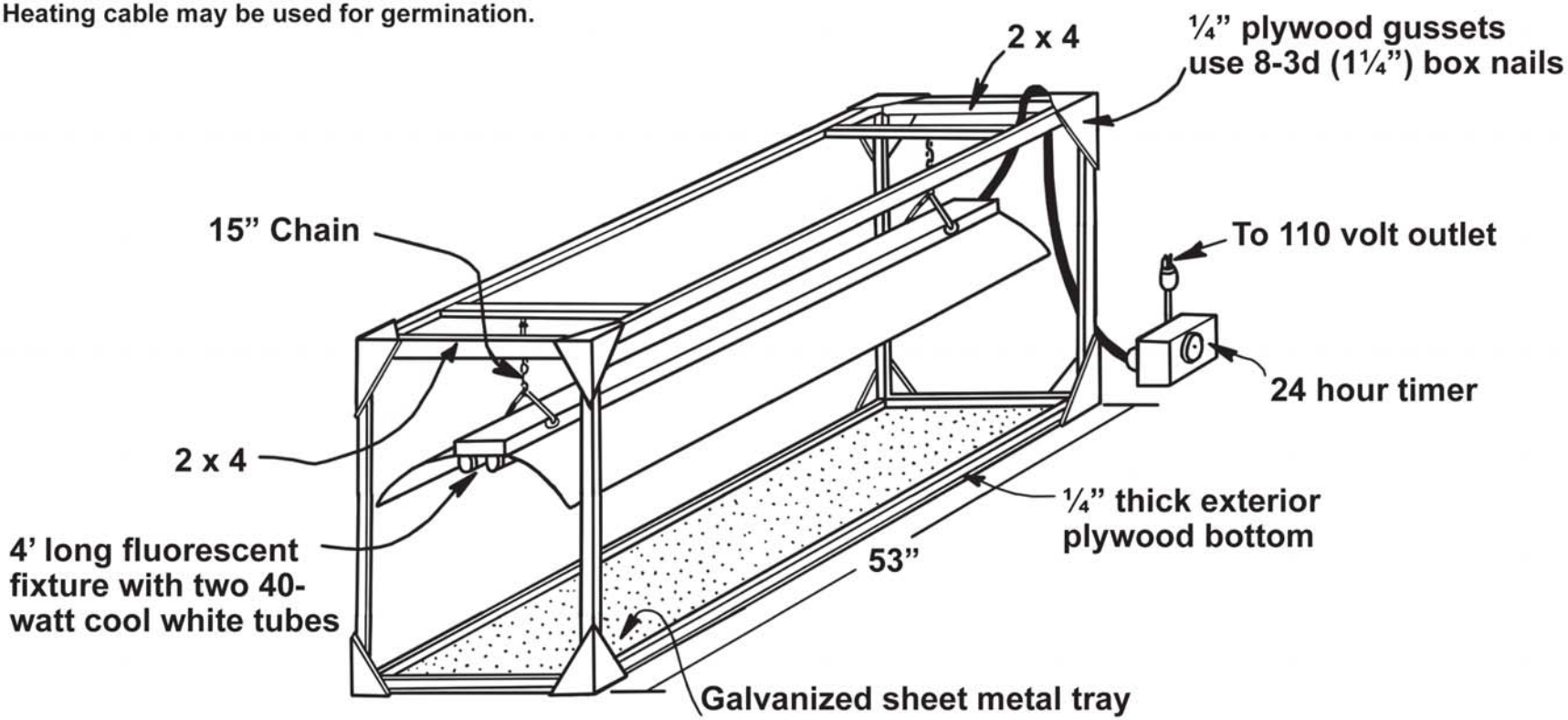
Scale: ¾" = 1'0" unless otherwise noted.

Cooperative Extension Work in AGRICULTURE and HOME ECONOMICS and the United States Department of Agriculture cooperating		
PLANT GROWTH CHAMBER ROOMETTE		
USDA '66	EX. 5980	Sheet 2 of 2

NOTES

1. All lumber is 2"x2" except as noted.
2. If strip fluorescent fixtures are used, cover with aluminum foil to reflect light.
3. Paint all wood white.
4. Cover entire unit with polyethylene to retain moisture.
5. Heating cable may be used for germination.

Number of Light Units	Width	Height
1	14"	21"
2	24"	24"
3	36"	24"



GERMINATION GROWTH UNIT

CT - SP 596

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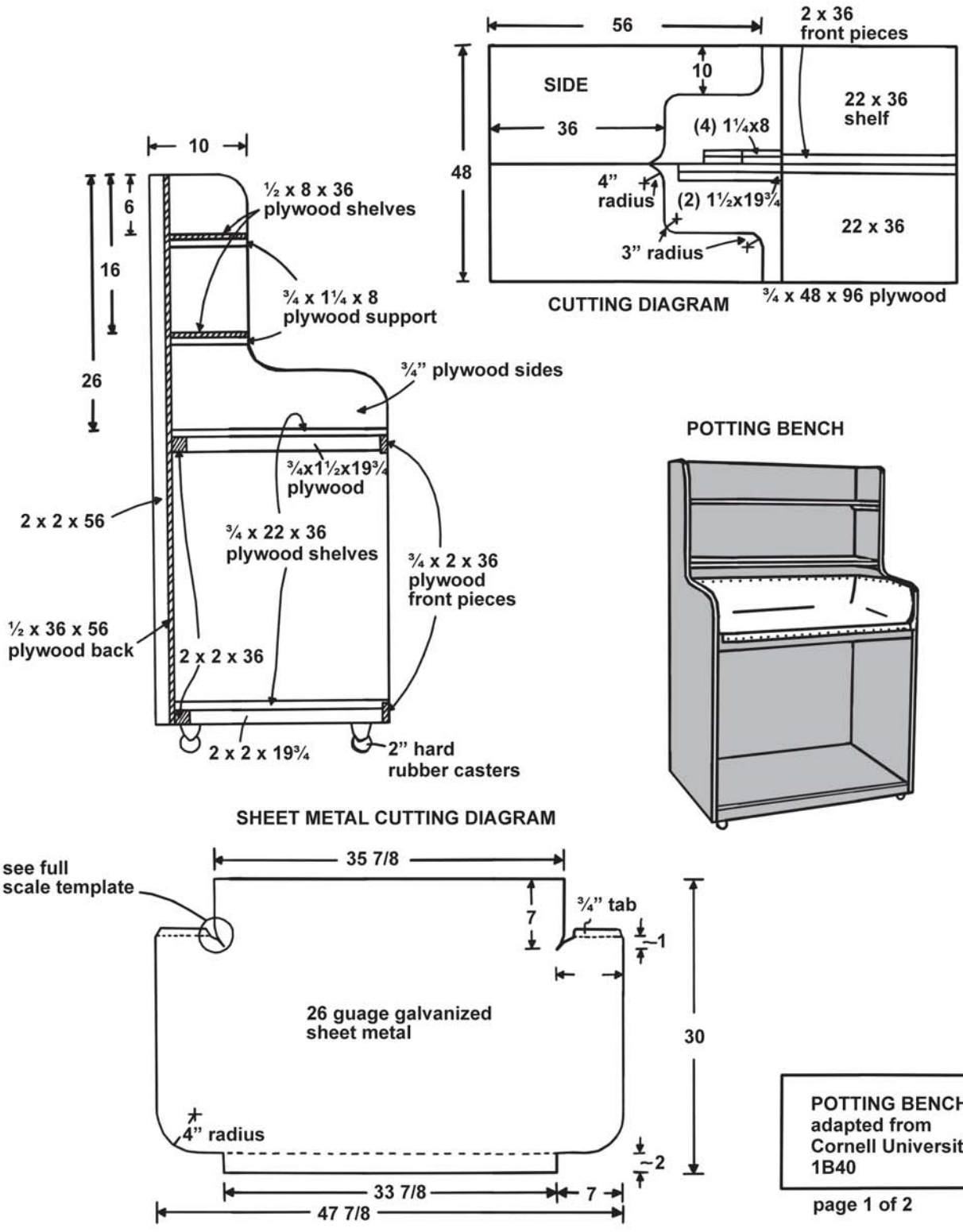
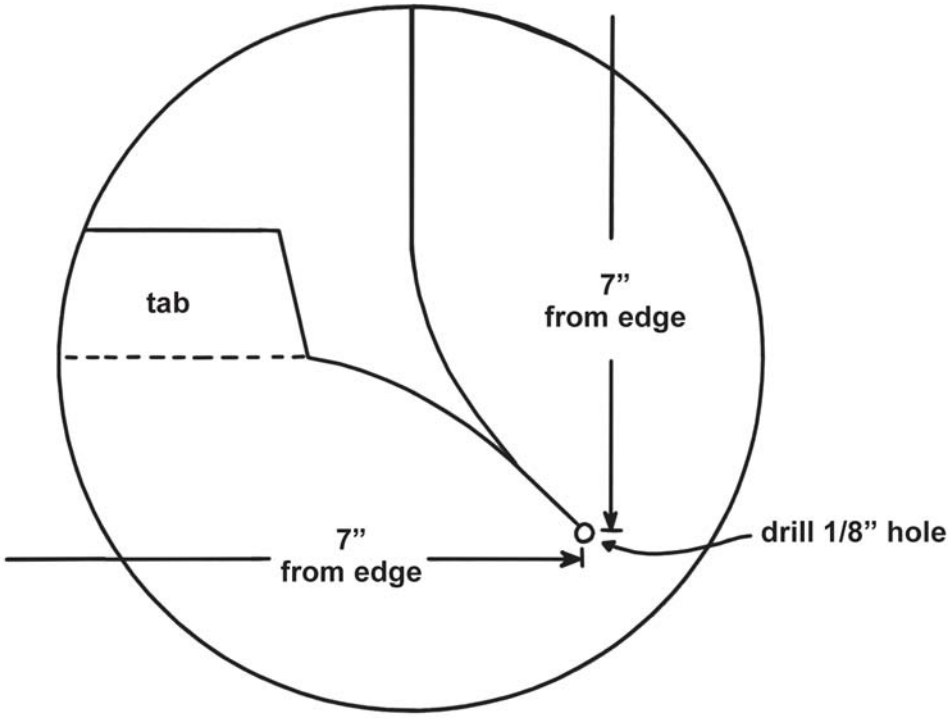


Potting Bench



FULL SCALE CUTTING TEMPLATE FOR BACK CORNERS OF SHEET METAL TOP

MATERIALS

LUMBER

2 pieces	2x2 Fir or Pine 8’ long
1 sheet	¾” A-C exterior plywood
1 sheet	½” A-C exterior plywood

HARDWARE

¼ lb 6 d nails
¼ lb 4 d nails
5/8” x 16 gauge wire nails
Resorcinol glue (waterproof)

MISCELLANEOUS

1 piece 26 gauge galvanized sheet metal 30x48 in.
Solder
4 2” dia. x ¾” wide wheel casters
16 No. 10 x 1” RH wood screws to fasten casters

POTTING BENCH
adapted from
Cornell University
1B40

Potting Bench [cont.]

References

Aldrich, R.A., W.A. Bailey, J.W. Bartok Jr., W.J. Roberts, and D.S. Ross. 1978. *Hobby Greenhouses and Other Gardening Structures.* NE-77 Northeast Regional Agricultural Engineering Service, Cornell University. Ithaca, New York.

Badger, P.C., and H.A. Poole. 1979. *Conserving Energy in Ohio Greenhouses.* Extension Bulletin 651, Cooperative Extension Service, Ohio State University, Columbus, Ohio.

Bailey, W.A., R.C. Liu, and H.H. Klueter. 1977. *Building Hobby Greenhouses.* Agricultural Information Bulletin Number 357, U.S. Government Printing Office, Washington, DC.

Bartok Jr., J.W., D.S. Ross, J. White, W.J. Roberts, C.A. Aldrich, and R.A. Parsons. 1982. *Solar Greenhouses for the Home.* NRAES-2, Northeast Regional Agricultural Engineering Service, Cornell University, Ithaca, New York.

Roberts, W.J., J.W. Bartok Jr., E.E. Fabian, and J. Simpkins. 1985. *Energy Conservation for Commercial Greenhouses.* NRAES-3, Northeast Regional Agricultural Engineering Service, Cornell University, Ithaca, New York.

Worley, J. 2014. *Greenhouses – Heating, Cooling and Ventilation.* Bulletin 792, Cooperative Extension, University of Georgia, Athens, Georgia.

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