HOBBY GREENHOUSES
and other gardening structures

NRAES

This book was prepared under the direction of the greenhouse subcommittee of the Northeast Regional Agricultural Engineering Service.

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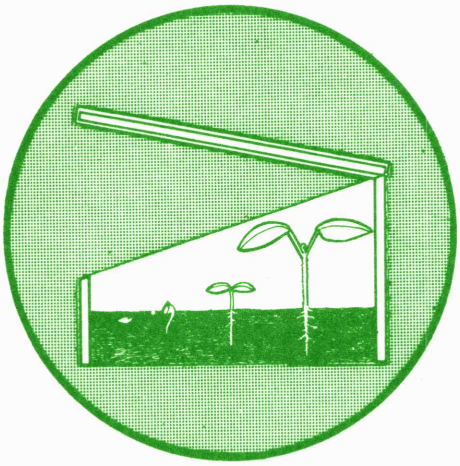
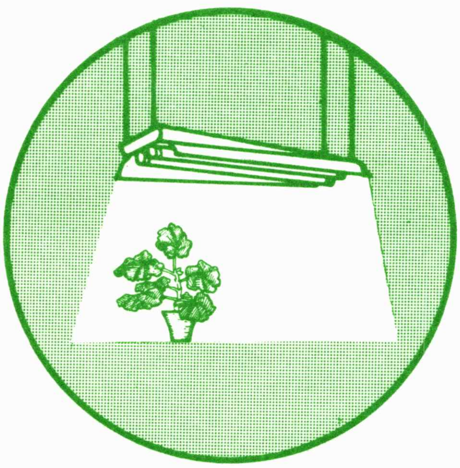




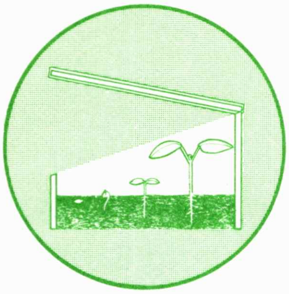
The opportunity to accelerate or control plant growth is both exciting and useful. However, the choice of structure and equipment used can be confusing. Everything from cold frames to greenhouses is available. Before making a choice you should decide what type of gardening you want to do.

If you are a plant lover with very little time for gardening, an area or room in the home can become an aesthetic, low cost greenhouse for indoor plants. Many gardeners find that fluorescent light fixtures are an inexpensive addition that can be used to light indoor plants or to start seedlings. A cold frame may be a good choice if you want to start a few seedlings in the spring. Heating cable can be added to the cold frame for better control of the plant environment.

Another option some people prefer is an inexpensive plastic covered greenhouse to shelter seedlings, in part because it is pleasant to be inside protected from the blustery, rainy days of spring. A heater and ventilation fan makes this same greenhouse useful for a longer season and for a greater variety of plants. The plastic covered greenhouse in kit form or owner designed also provides a moderately priced way to learn how to greenhouse garden and if you like it.

But, for many gardeners, only the glass greenhouse is acceptable. Certainly the glass greenhouse can be a permanent, attractive addition to the home landscape. Inside, the clear glass gives a feeling of open space and makes greenhouse gardening a pleasant experience. On the other hand, a glass greenhouse and its associated equipment does cost several thousand dollars, which is too expensive for many people.

This booklet can help you choose a plant growing structure to fit your gardening needs. A number of plans for plant growing structures and equipment are also included. Information on plant culture is not included, but can be obtained by contacting your state's land grant university or your local cooperative extension office.



Cold Frames and Hotbeds

A cold frame or its heated version, the hotbed, is a miniature greenhouse used to start vegetable or flower seeds in the early spring. Heat for a cold frame comes from the sun. During the daytime the soil is heated. At night the cover slows the loss of heat. Ventilation is accomplished by raising or lowering the cover.

The versatile cold frame can also be used to extend greenhouse space, root cuttings, or grow an extra crop of vegetables. By converting it to a hotbed, lettuce, green onions, or parsley can be grown through the winter. It fact, a hotbed is a better choice for the gardener who is considering buying a greenhouse smaller than 5′ x 8′. It is much cheaper to build or buy, costs much less to heat, and can grow almost as much as a tiny greenhouse.

Construction

Figure 1 illustrates a typical cold frame. Old storm windows make an excellent cover. Paint wood parts with a primer and one or two coats of exterior white paint to preserve the wood and reflect light to the plants. Some people apply a wood preservative, such as copper naphthenate, before painting. Do not use creosote or pentachlorophenol preservatives because they release vapors that are toxic to plants.

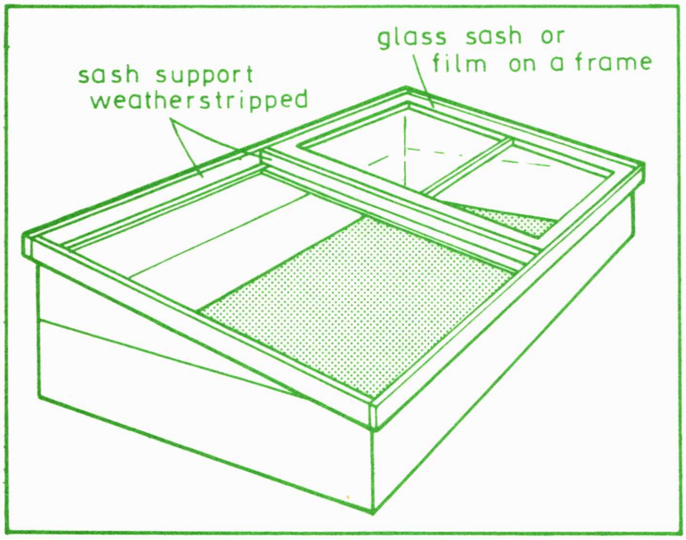


Figure 1. A cold frame is an inexpensive miniature greenhouse used to start vegetable or flower seeds early in the spring.

Polyethylene film is an inexpensive covering that will last several seasons if stored away from the sun during the summer. Clear vinyl film or rigid fiberglass panels will last longer. Two layers of polyethylene or vinyl spaced ¾″ apart to create a dead air space hold heat better than a single layer.

Location

Locate hotbeds and cold frames on well-drained soil that is sloped to remove rainwater runoff. The bed area must be level. A site with southern exposure giving maximum sunlight and wind protection on the north and west is ideal. Locating the frame near the house has several advantages. It is close to water and electricity, and it is easy to reach for the frequent attention needed by young plants. Frames that are built slightly below ground or that have soil banked up on the outside are warmer.

Cold Frame Operation

An easily read thermometer is an essential part of a cold frame. Cool-season crops thrive in 50° to 60°F day temperatures, and warm season crops do well at 65° to 75°F. When temperatures in the cold frame become too warm for best growth the top should be opened. Then as outside temperatures fall, such as in late afternoon, close the top to trap heat for the night. Often, good temperature control requires remembering to do it. A maximum-minimum thermometer can show whether you are opening the top the right width during the day.

Joints should be tight and weatherstripped to retain heat. Also an inch of foam-board insulation can be attached to the sides. During extremely cold weather the top can be covered temporarily with straw or other insulating material.

Watering is particularly important. The nearly airtight cold frame slows evaporation so it is easy to overwater. Keep the bed moist, but not soaked, at all times. Apply water in the morning so plant foliage can dry before evening.

Heating

The earliest hotbeds were heated by placing them over 12" to 24" of animal bedding and manure. The composting manure then heated the frame. Where animal bedding and manure is abundant this method is still used, but an electric heating cable is more commonly used for supplemental heat today. Heating cable is available from some hardware stores and greenhouse or garden suppliers.

In northern areas of the United States supply 12 to 16 watts of heating cable per square foot of bed area. For a 3' x 6' frame a cable rated at 250 watts can be used. Cables are available in several lengths and wattage ratings. Lay the cable on the soil at the bottom of the bed and uniformly spaced across the bed. The spacing between the edge of cold frame and the cable is one-third to one-half the spacing between the cables. Cover this with 2" of sand. Then place ½" mesh hardware cloth on the sand to protect the cable from mechanical damage. Finally, add a 4" layer of soil, or soil mix, for the growing bed. Sometimes 2" of vermiculite insulation is placed below the cable to conserve heat.

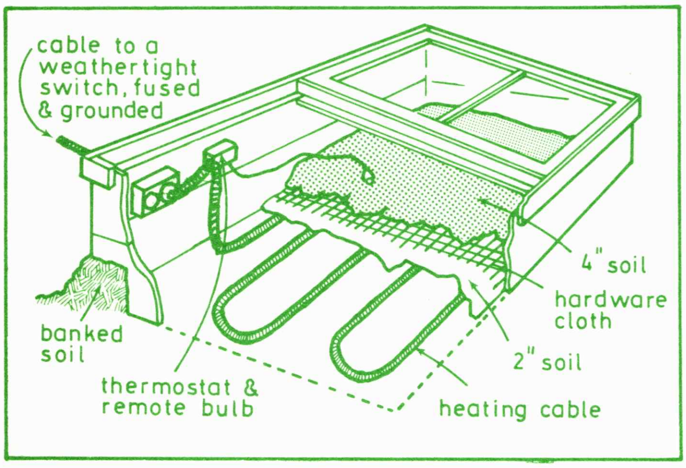


Figure 2. Layout of heating cable in a hotbed.

Caution: Lay the cable with care. Kinks may break the cable. Do not cross the cable over itself or another cable. Do not shorten the cable or it may burn out. Use weatherproof wiring and service entrances. The newest electrical code requires that outdoor wiring have a ground fault interrupter (GFI). This safety device will trip off the circuit when even a small current runs to ground. A qualified electrician should install all wiring.

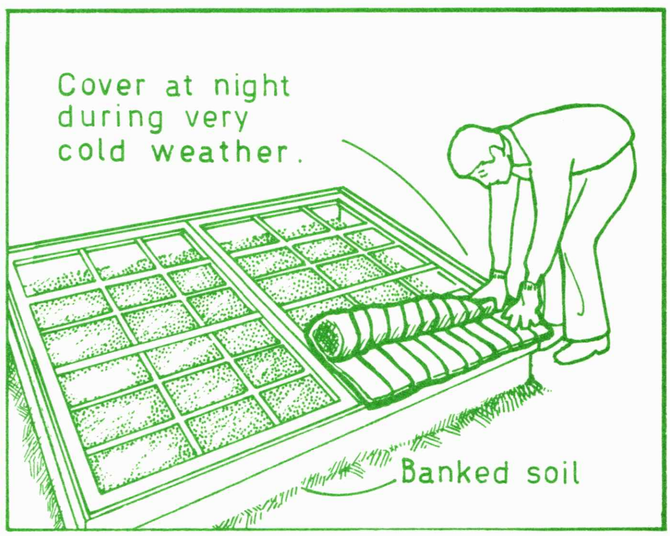
Use a thermostat to control temperature. A soil temperature of 70° to 75°F is ideal for germination of most seeds. Check that the thermostat is working properly by placing a thermometer so the bulb senses the temperature at seed depth. The cost of operating an electrically heated bed depends on the time of year, weather conditions, location, and construction. A 3' x 6' bed will use from 1 to 2 kilowatt-hours of electricity per day.

Operating the Hotbed

A hotbed is operated much like a cold frame. The heating cable simply accelerates plant growth. Use a thermostat to control soil temperature. A soil temperature of 70° to 75° is ideal for germination of most seeds. Check that the thermostat is working properly by placing a thermometer so the bulb senses the temperature at seed depth.

After the seeds germinate adjust the temperature to suit the particular plant. Cabbage, cauliflower, and lettuce grow well in an air temperature of 60° to 65°F during the day. Eggplant, peppers, tomatoes, and melons are warm season crops that grow best at 65° to 75°F or more.

Careful operation and good maintenance conserve heat to reduce operating costs. For example, repair any holes in the cover, insulate and weatherstrip. The cost of operating an electrically heated bed depends on the time of year, weather conditions, location, and construction. A 3' x 6' bed will use from 1 to 2 kilowatt-hours of electricity per day.



Lighting

Indoor electric gardening is an inexpensive alternative to a greenhouse for starting seedlings, propagating cuttings, and lighting indoor plants. Electric lighting can also add a whole new dimension, and cost, to greenhouse gardening. Dull winter days can be brightened or lengthened to accelerate the growth of many plants, or day-length can be altered to control blooming. The potential for experimentation and manipulation of plant growth is unlimited. In fact, researchers are still trying to learn more about how flowers and other plants respond to light.

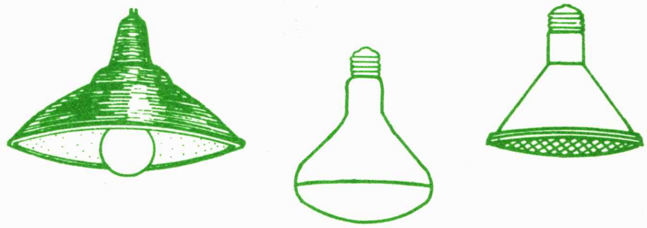
Two types of lighting are used to control plant growth, **supplemental lighting** for photosynthesis and **photoperiodic** lighting. Supplemental lighting adds to the sunlight that is needed for growth of all green plants. A relatively high light intensity is needed. Duration of lighting is also important for photosynthesis. Most flowering plants and seedlings need 12 to 16 hours of light, for example. Green plants can live, but grow slowly, with only 4 to 10 hours. Many people grow shade loving plants such as African violets or begonias inside under supplemental fluorescent lighting.

Photoperiodism refers to the effect of the length of periods of darkness and light on plants. Some plants, such as chrysanthemums, wait for days to grow shorter before they flower. These are called long night or short day plants. Some plants respond to short nights (long days). Many annuals are in this category. Others, such as roses or African violets, are not affected by day-length .

Sunlight is a mixture of both visible and invisible colors, or wavelengths, of light. Research is continuing to find how the color of light affects plant growth. In general, intensity and duration, rather than color, of currently available light sources affect plant growth most. Orange and red light causes germination and growth as well as photosynthesis. Infrared (far red) can reverse actions started by red light. Ultra violet light produced by sun lamps or germicidal lamps is harmful to plants.

Supplemental Lighting Sources

Incandescent lamps (light bulbs) are the least costly light source to install but the most costly to operate. They are very inefficient, converting around 6% of the energy input into light. This inefficiency is converted to heat; plants placed close to incandescent lamps can be burned. Also, some lamps will break if water is accidently splashed on them.



Much of the energy of the incandescent lamp is in the red-far red spectrum so they are good for photoperiod lighting.

Fluorescent lamps are

- good supplemental light sources;
- poor for photoperiod control because they emit little or no far-red light;
- three times more efficient than incandescent lamps; (They cost less to run but fixtures cost more than incandescents.)
- long lived with a typical service life of 7500 to 13000 hours (incandescents burn about 750 hours);
- cool operating. (Plants won't burn even if they touch the lamp. Water accidentally splashed on the lamp will not break it.)

Fluorescent lamps produce light with a stream of electrons that collide with atoms of mercury vapor and argon gas. Different fluorescent powders are used to vary color. Some of the white fluorescent lamp colors available are cool white, deluxe cool white, warm white, deluxe warm white, daylight, soft white, and natural white. Special fluorescent lamps designed for plants are also available. Generally, these lamps emit less light and do not stimulate growth any more than the less expensive, standard cool white lamp. Plant growth lamps are good for display of flowers though, because color is enhanced.

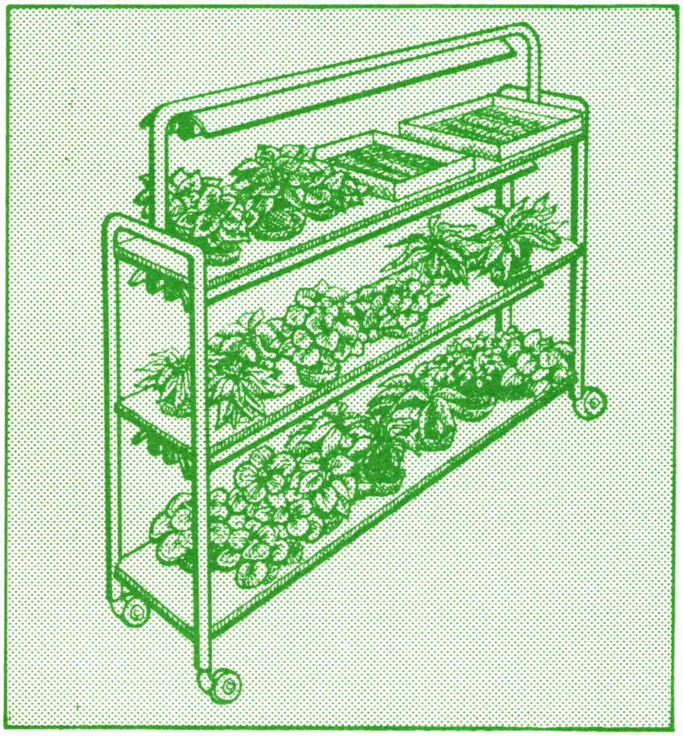
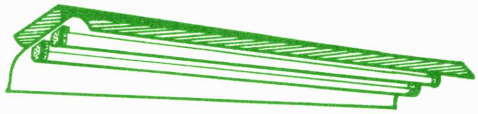


Figure 3. A lighted cart for plants. Fluorescent lamps can supplement indoor lighting to make an area of the home an attractive greenhouse.

You might experiment with different light combinations to see what works best for you. The daylight lamps are good in the violet-blue spectrum and the warm white, natural, and soft white lamps have good orange-red output. The cool white has good light output throughout the visible spectrum. A growth lamp and a cool white lamp make a good combination for viewing plants.

Standard industrial or strip fixtures can be used to mount and power the fluorescent lamps. Four foot long shop fixtures with a white reflector that hold two 40-watt lamps are popular and often sale priced in many



hardware stores. Special high light output lamps and fixtures are available, but they are expensive. They can be ordered from electrical supply firms, but you may have to buy a case (12 lamps) and wait several weeks for delivery.

What does it cost to run lights? A standard four foot, two lamp fluorescent fixture consumes about 100 watts. In many areas electricity costs four cents or more per kilowatt hour, so if the light is burned 16 hours a day the cost is 6½¢ a day. For the same illumination levels, incandescent lamps cost about three times more to operate than fluorescent lamps. Lighting systems can be controlled with a 24-hour clock for convenience and to keep them from burning more than necessary.

High Intensity Discharge (HID) lamps are normally used for street and parking lot lighting. These high wattage lamps (175 to 1000 watts) would rarely be found in a small greenhouse. Fixtures are expensive and light is very intense. Several types are available, but mercury, metal halide and high-pressure sodium lamps are most often used for supplemental light for plant growth.

Light Intensity

Light intensity is measured in footcandles or, in the metric system, in lux (1 lux = 10.76 footcandles). The natural light level on a bright, clear day can reach 10,000 to 12,000 footcandles and on a heavy overcast, rainy day it may be as low as 200 footcandles.

Most sun loving plants will grow very slowly with 1000 footcandles of illumination. Of course they will grow faster with more light. Fifty footcandles is the minimal light level for plants that love heavy shade. Many indoor house plants grow well with 250-600 footcandles. A two lamp fluorescent lighting fixture emits about 250 footcandles 18" below the lamps, and 600 footcandles 6" below the fixture.

Our eyes make us poor judges of light intensity because the pupil opens in the shade to let more light enter and closes in bright sunlight. Therefore the eye receives the same energy whether the sun is shining or it is cloudy.

Moderately priced incident light meters are available to measure light intensity (General Electric Type 213 is one). Photographic light meters are normally built to measure reflected light rather than the intensity of the light source, that is, the meter is aimed at the scene to be photographed and not at the incident light source. Some photographic meters, however, can be used to measure incident light. By placing such a meter in the plant area and aiming at the light source, the light intensity can be estimated.

Most light meters measure the spectrum the eye sees and not the light a plant responds to. Meters can give an indication of intensity, but cannot indicate how the plant will grow under that intensity of light.

Lamp Maintenance

The light output of any lamp decreases with age. Light intensity at the end of a lamp's life may be 20 to 30% less than when it is new. Dirt rapidly reduces light output, so lamps and reflectors should be cleaned every month or so. Incandescent lamps must be replaced often so it is tempting to replace with long-life bulbs. Long-life, soft white, or special shapes cost more and put out less light per watt than the standard, indoor frosted lamp, though.

Indoor Seedling Germination and Propagation

Germinating seeds and cuttings being propagated need light levels of about 600 to 2000 footcandles to grow well. Four 40-watt cool white fluorescent lamps mounted 4" away from plants in a white reflector on 2" centers will provide about 1000 footcandles of illumination. Special high wattage fluorescent lamps must be used to achieve higher levels at greater distances. For example, four 48", 1500 milliampere (ma), 105 watt fluorescent lamps, and two 100 watt incandescent lamps will furnish 2000 footcandles inside the plant growth chamber shown in figure 4 if the interior is painted flat white. The incandescent lamps are used to boost the orange-red light levels.

Sometimes incandescent flood lights with internal reflectors are sold for lighting a flat of seedlings. You should spend a little more for a fluorescent fixture and lamps instead. The difference in price is made up as soon as the first lamp burns out. Also, the intense heat from the incandescent lamp rapidly dries out the seed bed.

Ingenuity and care are required to maintain optimum temperatures and humidity for propagation or germination under electric lights. Many plants do well when daytime temperatures are 80°F and night temperatures are 10° to 15° less. Night temperatures should not drop below 60°F.

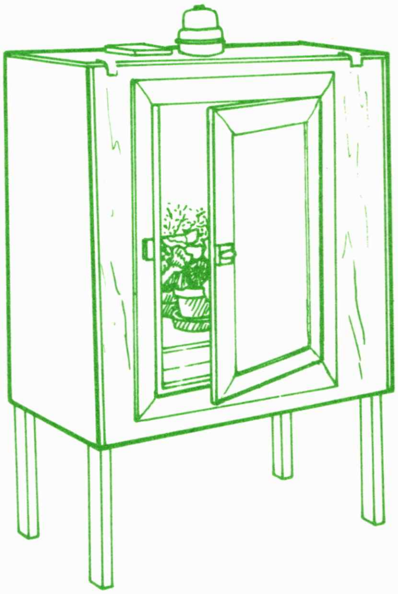


Figure 4. Plant growth chamber. The high light intensity in this unit accelerates the growth of many sun-loving plants.

Lighting the Greenhouse

Supplementing sunlight with electric light is expensive and seldom done in either the commercial or hobby greenhouse. Light can be added to extend the day length or interrupt the night to control bud initiation of some flowers. Sometimes fluorescent lighting is installed to grow plants under benches. The technical lighting books listed in the reference section have more information on greenhouse lighting.

Caution: The greenhouse is a damp, well-grounded area. Poor wiring can be deadly. Be sure any wiring meets national and local electrical codes. A ground fault interrupter (GFI) should be installed to prevent a shock and possible death. A licensed electrician can be hired to wire the greenhouse if you are not familiar with electrical codes and wiring.

Greenhouses

Many home gardeners find a small greenhouse relaxing as well as very useful. The greenhouse can be used to root cuttings and germinate seeds for the outdoor garden or to raise specialty flowers or ornamentals. If you like to garden, a greenhouse will extend your hobby for year-round pleasure. A greenhouse gives you much more control over growing conditions, but it can be costly. Rising fuel costs have increased the cost of growing plants in a greenhouse during winter months. Although starting seedlings or cuttings for spring planting can be economical, growing vegetables in a greenhouse in the winter is more costly than buying them in the supermarket.

Choosing the Structure

Many people design and build their own greenhouses, so shapes and styles vary as much as the imagination. One fancier built a greenhouse shaped like a boat! Many are built from salvaged materials, old storm or picture windows and lumber scraps from other projects. Gothic arch, A-frame, lean-to, gable roof, dome, or inflatable plastic are just a few of the designs. Greenhouses can be either attached to the house or freestanding, away from any building.

Attached Greenhouses

The attached greenhouse is popular where space is limited and because it blends well with the home and landscape. It is conveniently accessible from the house, so one does not have to trudge through cold weather or snow to get to the greenhouse. Water, electricity, and heating facilities from the house are often shared. The attached greenhouse uses less heat then a freestanding one with the same floor area because the side attached to the house is not exposed. Often, though, an additional heater or larger house heater is required because the greenhouse loses heat 5 to 10 times faster than the equivalent exposed area of the home. The lean-to is a popular style; gable roof, arch or slant-sided shapes are commonly available.

Generally, less light is received by attached greenhouses. Temperature control is sometimes difficult unless fans are used for ventilation. The attached greenhouse requires a solid foundation similar to the house foundation to prevent the two buildings from separating. Joining and sealing the greenhouse to the house is difficult.

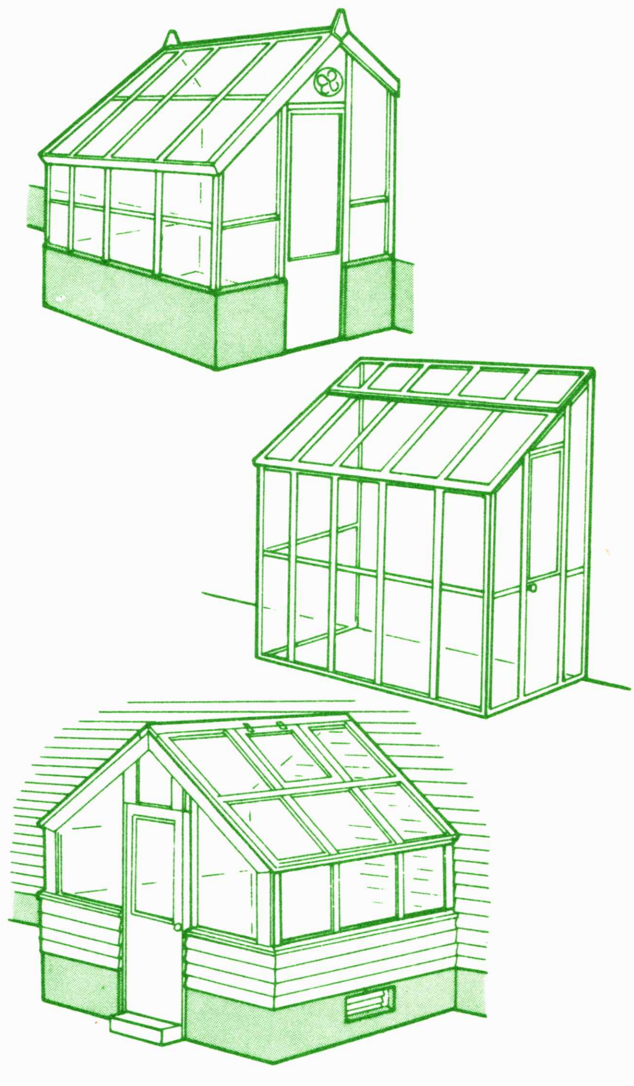


Figure 5. Attached greenhouses. This greenhouse style is popular because it blends well with many homes and is easily accessible.

The pit greenhouse is built partially below ground (4' or so), often attached to another building, roofed with transparent material that faces south, and normally heated only by the sun (fig. 6). It is less expensive to build and heat than many of the above ground styles. The surrounding earth will keep it cool, but usually above freezing. Ventilation is poor so this greenhouse is not best for summer use. Properly installed drain tile or a sump pump should be installed for drainage.

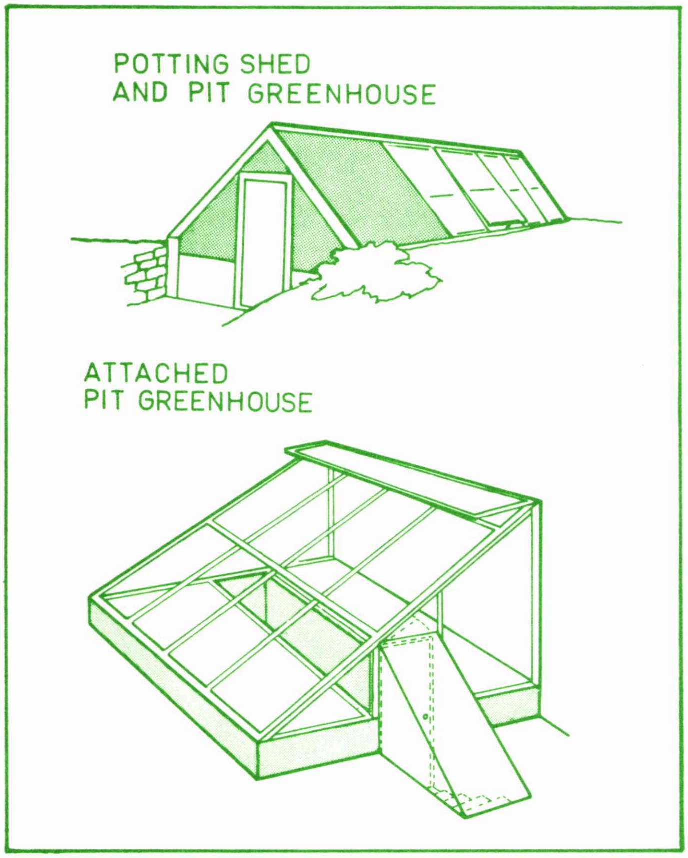


Figure 6. Pit greenhouses. The attached shed serves as storage, a workroom, and shelter for the heating unit.

Window greenhouses are miniature versions of the attached style. These attractive indoor gardens are convenient; but growing space is very limited. They can be built by extending the window or by attaching a new structure to it. Glass, screen or wooden shelves built across the window hold potted plants and flowers.

Most window greenhouses open directly into and are heated by a room in the home. It is difficult to maintain a greenhouse climate different from the room, though. In summer, the window greenhouse can become very hot, so careful ventilation control is required. If it can be opened for ventilation, good caulking and weatherstripping is important.

Figure 7. Window greenhouses.

Freestanding Greenhouses

Freestanding greenhouses allow more flexibility than the attached styles because they can be larger and located to receive more sunlight. Many different shapes are available.

The conventional gable roof greenhouse uses interior space best, and temperatures are generally more uniform in it than in greenhouses with other shapes.

Quonset and gothic-arch shapes are attractive and almost as popular as the gable roof. These shapes are more difficult to ventilate than the gable roof shape, though. The A-frame is easy to build, but the sides are hard to reach. Heating is difficult also.

Domes are difficult to build, but they give a pleasant feeling of spaciousness. They cannot be enlarged and benches are hard to build and install, however.

Inflatable greenhouses are new, commercially-made minigreenhouses that are really oversize row covers used like a cold frame to start plants early in the spring. They are made with double walls of polyethylene or vinyl film plastic. The greenhouse is inflated like an air mattress so it will stand up. The double layer holds heat well, but this small style is not adapted to conventional heating systems.

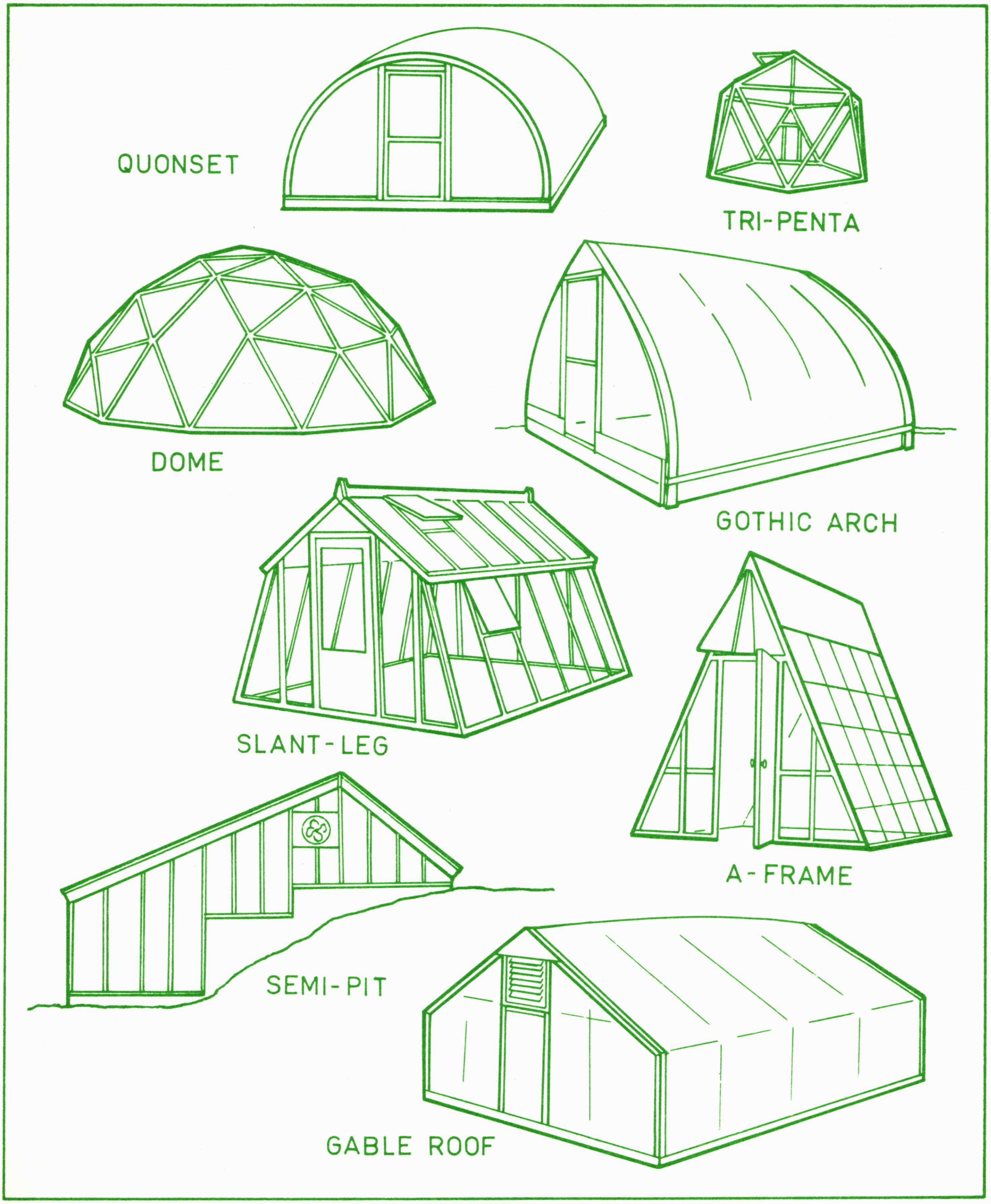


Figure 8. Freestanding greenhouses. Many styles can be lengthened when more space is needed and they can be located to receive the best sunlight.

The myriad shapes, styles and materials available for greenhouses give you a bewildering wealth of ideas for design. Before you start building you might consider using salvaged materials: leftover lumber from other projects, old storm windows, materials from a salvage yard. Sometimes used greenhouses are available and a want-ad in the paper may locate one of these. Kits are readily available, but they vary widely in price. The yellow pages of phone books or advertisements in garden magazines can help you locate these.

If possible, try to see as many kinds of greenhouses as you can before deciding which kind to build or buy. A greenhouse is a long term investment that should be attractive and blend well with your home and landscape. Be sure you see a model if you decide to buy a kit. Generally, the glass and fiberglass models are not difficult to assemble. The less expensive houses tend to be difficult to erect.

Location

Usually you have little location choice. If you have some choice, a sunny spot is best. Sunlight is particularly important for growing seedlings during January, February, and March. A southern or southeastern exposure is best for maximum winter light. A northern exposure is only good for shade-loving plants. (If possible, keep the greenhouse away from trees.)

The orientation of greenhouses is not too important. If the ridge of the greenhouse and the benches run east-to-west, slightly more sunlight will be received.

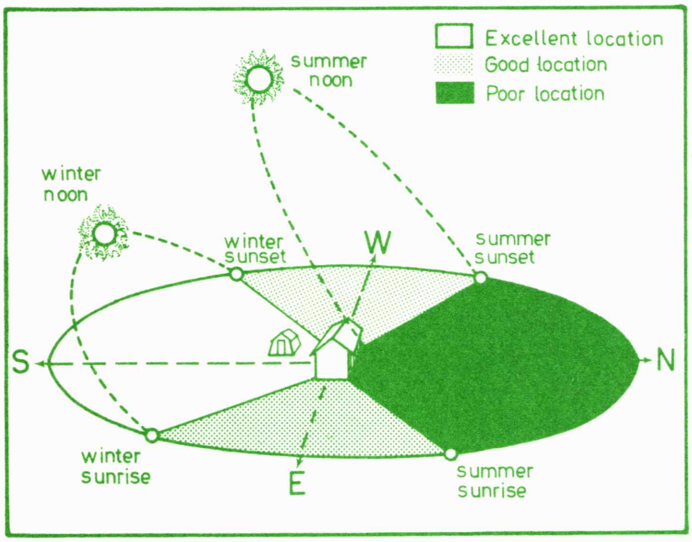


Figure 9. Location of the greenhouse. A sunny area is best.

The greenhouse should be convenient to water, fuel for heating, and electricity. Be sure the area drains well. Build up the foundation area or slope the soil away from the greenhouse to drain rainwater away.

Other factors that affect location are appearance, future expansion, and use. Consider how the greenhouse will look to neighbors if it is located near them. Will it enhance the beauty of the home, or will it be an eyesore? Try to choose an area that will allow for expansion. If the greenhouse will be expanded into a small business locate it so customers can get to it easily.

Choosing a Size

Usually available space and cost more than need or desire dictate greenhouse size. All too often this problem leads to the purchase of a flimsy, tiny box that never seems to function properly as a greenhouse. Temperature fluctuates rapidly in a small greenhouse and heat losses can be almost as high as in a larger house. A 6′ x 6′ greenhouse can better be replaced by a 3′ x 6′ hotbed at a quarter of the price and a tenth the fuel cost.

When choosing a size ask yourself how you will use the greenhouse. Are you really an avid gardener that can use the space a greenhouse offers? Can you spend the time needed to maintain it? If you are an avid gardener and have a choice, select a size somewhat larger than you think you will need. If you are only starting a few seedlings for the summer flower and vegetable garden, perhaps a hotbed is a better choice. Remember that costs of heat, plants, fertilizer, other chemicals, and your time will soon exceed the initial cost of the greenhouse itself.

Benches serviced from one side can be 2′ to 3′ wide. Minimum aisle width is 1½′. If you bring in carts or a wheelbarrow, aisles should be 2′ to 3′ wide. Add at least 6″ to each side for sidewall and air circulation around solid benches. No sidewall space is needed for wire bottomed benches. Minimum outside width for a greenhouse with two side benches and a center aisle is 6½′. Eight feet is better.

Length depends on available space and money, but 10′ is minimum for a freestanding house. Attached lean-to houses are sometimes smaller. Small greenhouses are often proportioned so that length does not exceed twice the width.

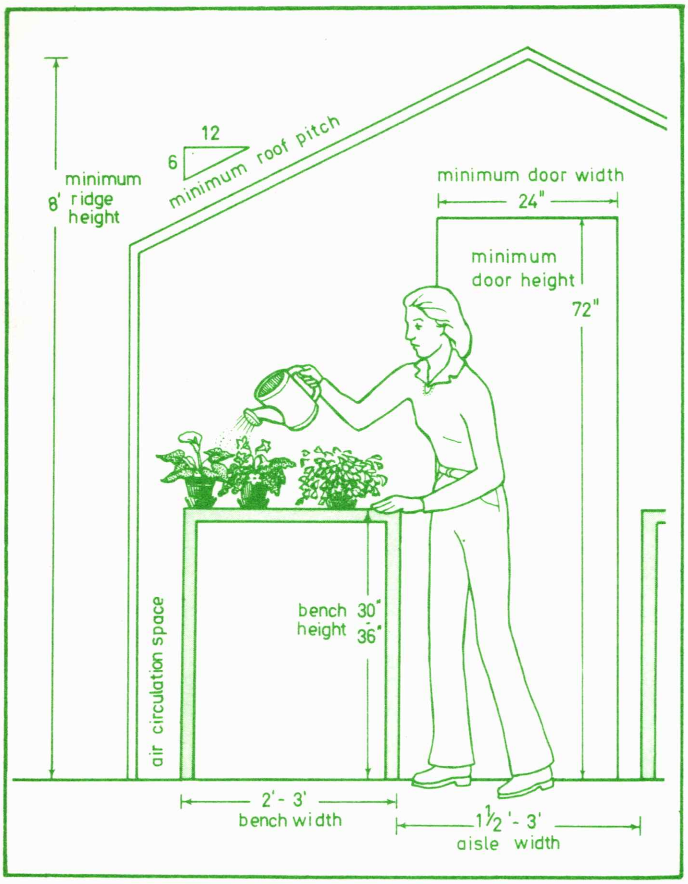


Figure 10. Suggested minimum dimensions for a greenhouse.

Small greenhouses often do not have enough headroom and are hard to work in. Taller houses heat and ventilate more uniformly, so they require no more, or little more, heat than the shorter house. Eave height of gable roof houses should be at least 5½′ and ridge heights at least 8′. Doors should be 24″ x 72″ or larger. Standard doors are 32″ or 36″ wide and 78″ tall. Roof pitch for glass covered greenhouses should be 6″ of rise per foot of width (27 degrees) to prevent condensation on the covering from dripping onto the plants. Fiberglass and polyethylene covered houses must have steeper roof pitches of 7″ to 8½″ of rise per foot to prevent drip.

Benches

Benches raise the garden to a more convenient working height. Plants are better handled in containers than planted directly into soil in the benches. Bench soils need sterilizing, require heavy construction, and are more difficult to manage. Benches can be constructed of many materials to handle various sizes and shapes of containers.

The open, wire bench provides good heat distribution at low cost. Redwood is a good construction material for benches, but may not be readily available.

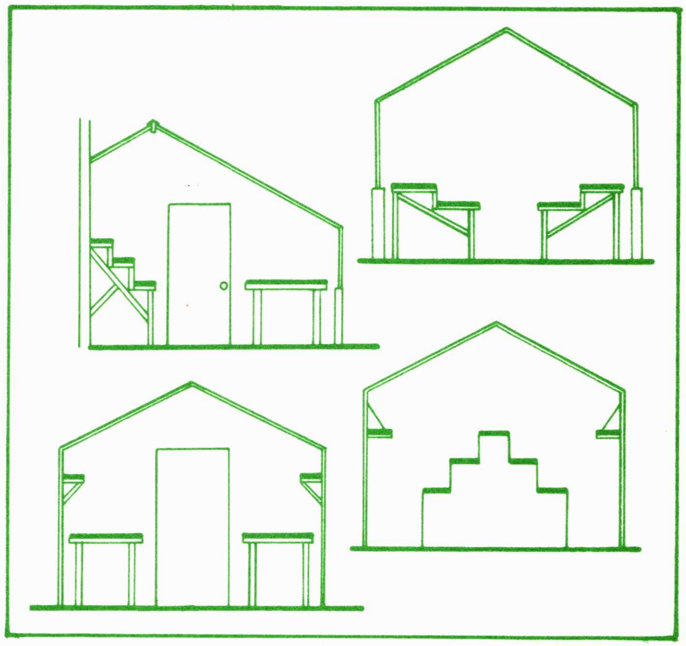


Figure 11. Typical bench arrangements.

Wood that is treated with a salt-type preservative or copper naphthenate is also good for bench construction. Creosote and pentachlorophenol preservatives are toxic to plants and should never be used on materials in the greenhouse.

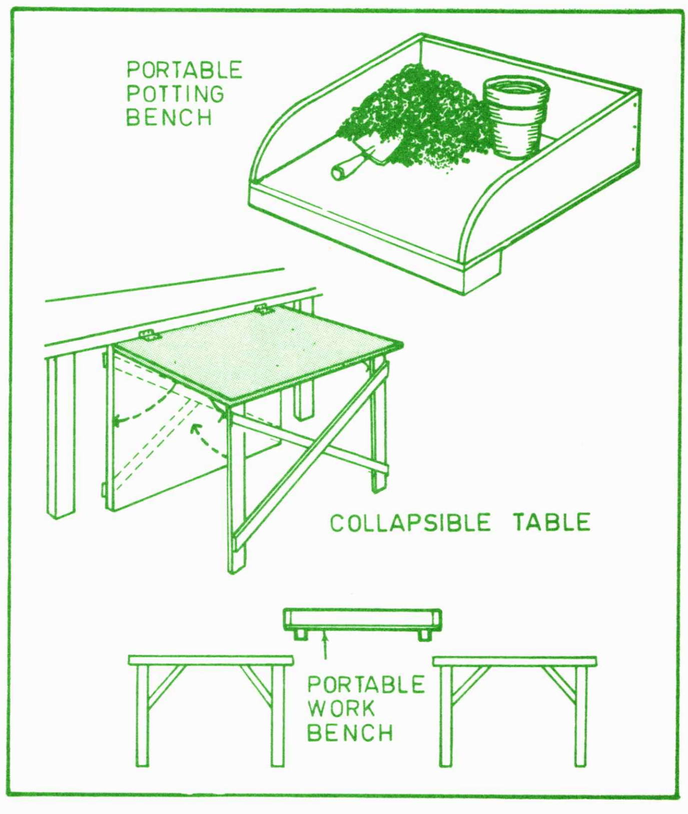


Figure 12. Workbenches.

Benches should be only as wide as you can reach. Side benches can be 2′ to 3′ wide. Center benches that are reached from both sides may be as wide as 6′. Standard bench heights are 30″ to 32″, but they can be modified to suit your height.

A portable or hinged workbench can be lifted when not in use to let light reach plants placed under it. If the work area is stationary there is a tendency to put plants and materials on it, and its usefulness is lost.

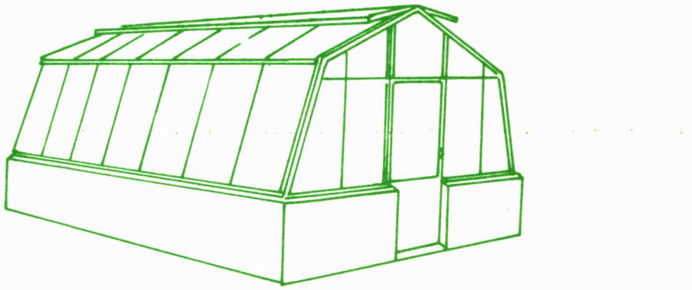
Storage

Greenhouse plants require tools, fertilizers, chemicals, containers, potting soil materials, etc. You will need to plan a storage area for all these materials when you plan the greenhouse. The high humidity of the greenhouse, which is beneficial to plants, ruins tools and chemicals. Greenhouse storage should be separate but nearby. If the greenhouse is heated, extra space for storage in the greenhouse means more costly heating. A potting bench in the storage area is handy to mix growing media and fill pots.

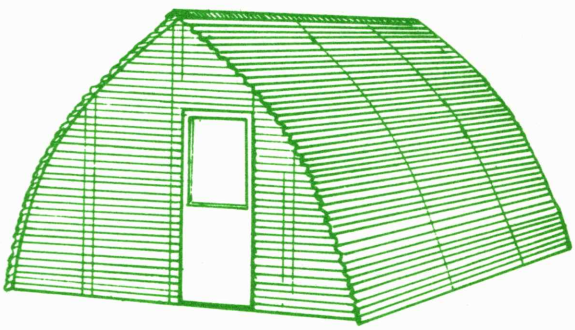
> **Caution:** Pesticides and other chemicals should be kept in a separate, locked cabinet. Also, always keep a first-aid kit handy.

Covering Materials

Glass is the standard against which other materials are measured. Glass houses are attractive, permanent, and expensive. Glass transmits light best, but may need shading in summer. It is durable but does break. Double strength glass is normally used for greenhouses. Tempered glass on widely spaced supports allows more light to enter. Glass-covered houses should be built by a greenhouse manufacturer or purchased in kit form because they are difficult to fabricate.



Houses covered with **rigid fiberglass panels** (FRP) are durable, attractive, and moderately priced. FRP is stronger than glass. It transmits slightly less light, however, and weathering further reduces light transmission. Panels are easier to cut and fit than glass and they can be used to cover almost any house. Either corrugated or flat panels are available. Corrugated panels require commercial sealing strips to stop drafts between corrugations. Flat FRP is attractive but needs support every 18″ to 24″ or it sags. Supports create more shade. Fiberglass, like any plastic, does burn. Flame retardant coated panels are available, but sunlight rapidly reduces the retardant's effectiveness.

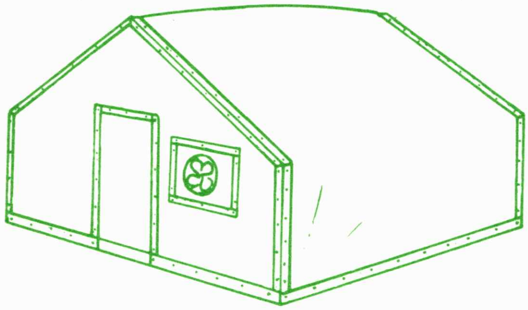


Fortunately, except for heaters, little flame producing or flammable material is used in greenhouses. In short, be careful with fire near fiberglass.

Only buy fiberglass that is made for greenhouse use. Store fiberglass vertically and in a dry, well ventilated area. Moisture caught between sheets of fiberglass can stain them. Tedlar coated or acrylic coated fiberglass is best and should last for 10 years or more. Do not use colored or lower grade panels. Plants do not receive enough light through colored panels and low grade panels darken rapidly with age.

Polyethylene film covered greenhouses are inexpensive, but temporary. Polyethylene houses are less attractive and need more maintenance than other styles. Clear polyethylene, 4 or 6 mils (0.004" to 0.006") thick, is used because it is inexpensive and readily available. Unfortunately polyethylene will last only one winter if applied in the fall because it is destroyed by ultraviolet (UV) radiation from the sun. Polyethylene treated with a UV inhibitor will last 3 to 6 months longer.

A new polyethylene, M602, has been developed that lasts 2 years as a greenhouse cover. This plastic is available from some greenhouse suppliers.



Wind and poor installation also reduce the life of polyethylene. Replacement is fairly easy, but many people replace with rigid fiberglass.

A new polyethylene greenhouse style that is gaining popularity is both attractive and reduces heat loss. Two polyethylene sheets are fastened to the house so the edges are sealed. A small fan forces the layers apart creating a dead air space that cuts heat loss by one-third over the house having a single polyethylene layer. Polyethylene may also be fastened with 1" to 1½" spacers to make a double layer with an existing cover of glass, fiberglass, or polyethylene.

Glass and fiberglass do not transmit the energy radiated from the warm plants and soil in the greenhouse. This property of glass is sometimes called the "greenhouse effect". Some plastics, particularly polyethylene, do transmit a large portion of this radiation. This property causes polyethylene covered houses to cool faster at sunset. Often condensation forms on the plastic and reduces this radiant loss.

Acrylic (Plexiglas) is very transparent, very resistant to weathering and breakage, and can be used as a curved panel. However, acrylic is very expensive. It is seldom used for home greenhouses. Most quality fiberglass panels use a resin with 15% acrylic and 85% polyester. Some manufacturers of greenhouses that use fiberglass panels may call them acrylic panels.

Polyvinyl chloride (PVC) is a rigid, clear plastic that darkens rapidly from sunlight. After 2 to 4 years of service PVC becomes too dark for greenhouse use.

Clear **vinyl** film is used with many commercial greenhouse kits. Vinyl is electrostatic and attracts dirt, so light transmission is rapidly reduced. Cleaning is hard and must be done often. Vinyl lasts 2 to 5 years.

Polyester (Mylar) film is moderately expensive but transmits light well and lasts 3 to 5 years. The material is only available in narrow widths and may be difficult to find. Fiberglass and polyethylene have largely replaced this material.

Construction Pointers

Laying Out the Foundation

Before erecting any greenhouse make sure it meets local building codes and zoning requirements. Carelessness in checking setbacks from property lines could lead to future legal problems.

Once the site is established, clear and level the area. Check the level with a carpenter's level placed on top of a long, straight board. Sight along the edge to check the straightness of the board. A square and level foundation makes the job of building or installing a greenhouse much simpler.

Locate and mark one corner of the greenhouse with a stake. Drive a nail in the top of the stake as a reference point. Measure from the stake and set a second corner stake. Drive a nail into the stake at the exact length of the building. Using a carpenter's square, measure out from the two corner stakes and drive in the last two corner stakes. Next check squareness by measuring corner-to-corner diagonals. If the corners are square the diagonal lengths are equal. Check the squareness of any corner by measuring 6′ down one side and 8′ down the other. The diagonal length across to these two points should measure exactly 10′. Finally, recheck length to each corner.

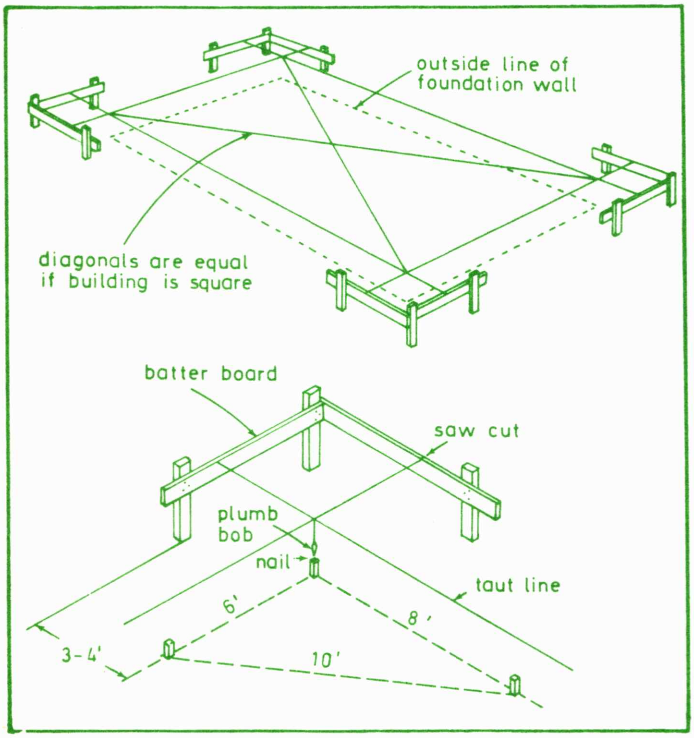


Figure 13. Staking and laying out the foundation. A square and level foundation makes the job of installing the greenhouse easier.

After corners are located and squared, drive three two-by-four stakes at each corner as shown in figure 13. Locate these stakes 3′ to 4′ outside the actual foundation line. Then nail 1″ x 6″ batter boards horizontally so that their top edges are level and at the same height above ground level. Hold a heavy string (surveyor's cord) across tops of opposite batter boards at two corners. Using a plumb bob, adjust the line so it is exactly over the nails in the two corner stakes. Cut saw kerfs ¼″ deep where the line touches the batter boards so that the strings may be easily replaced if broken or disturbed.

Repeat the procedure to string the other three lines. When all four lines are positioned, the outside foundation line is accurately established. Next comes the hard part, digging holes for the foundation.

Masonry Foundations

All greenhouses should be anchored to a solid and level foundation, but attached greenhouses **must** have a solid foundation, like the house, to keep the two from separating. Concrete block or concrete are commonly used. You can build your own masonry foundation, but it is heavy work. Most building suppliers have booklets on how to do it, if you want to tackle this job.

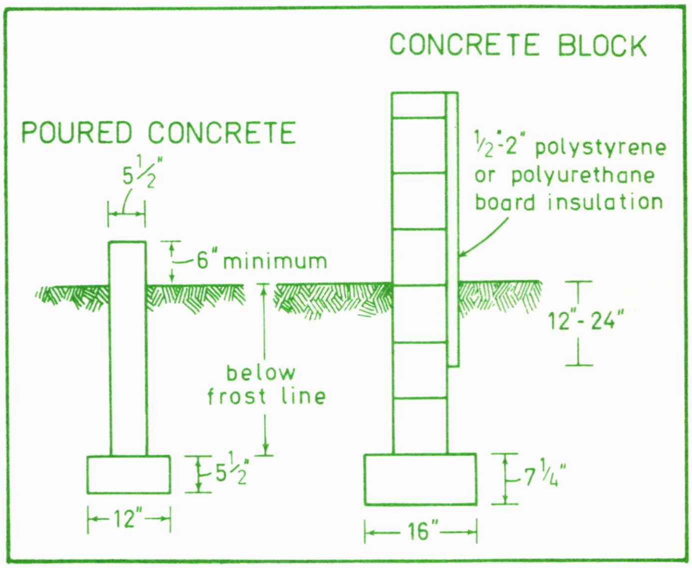


Figure 14. Typical masonry foundations.

Brick, stone, redwood, and asbestos board can be used for sidewalls. Use a material or siding that is attractive or matches the home. The wall can be extended to bench height to reduce heat use. One inch thick polyurethane or 1½″ polystyrene insulation board can be glued to walls for better insulation. Extend this insulation at least one foot into the ground.

Post Foundations

Wood posts or galvanized steel pipe set 18" or more in soil or concrete make a simple, low cost foundation for small greenhouses. Wood must be treated with a preservative to prevent rotting. A commercial pressure preservative treated post is best, because it has been placed in a pressure chamber where a preservative is forced into it. Posts can be soaked at home for a day or more in a preservative but they have a shorter life than pressure treated woods. Paint or a preservative that is brushed on is not effective. Top quality redwood or cedar heartwood and home soaked preservative treated wood last about 7 to 15 years. Pressure treated wood lasts 25 years or more. Posts and wood that touch the ground should be treated with copper naphthenate or a salt-type preservative. Erdalith, Tanalith, Celcure, and Osmose are typical preservative tradenames.

Caution: Do not use creosote or pentachlorophenol preservatives because they release vapors harmful to plants.

After the building layout is completed mark the post holes with stakes. A posthole digger or rented power auger can be used to dig the holes. Also dig a narrow trench for the insulated curtain wall. Remove string lines before digging. Remove loose dirt and water from the bottom of the holes for the pad. If you dig too deep, fill with concrete - never soil. Let the concrete cure for a day.

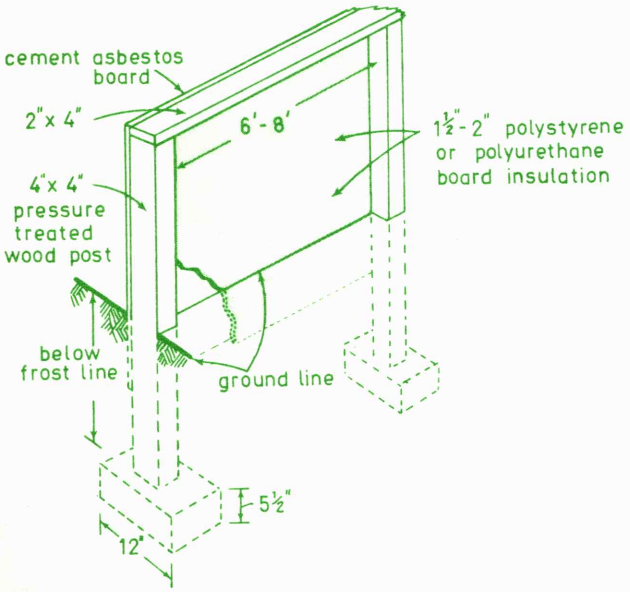


Figure 15. Post foundation with a curtain wall.

Next, set the posts and tamp the soil around them until the hole is one-third full. Use string lines attached to batter boards as a guide. Put the curtain walls in place. Finally fill the postholes and the trench with 8" layers of damp soil and tamp each layer.

Floors

Four inches of crushed rock or gravel under the benches and concrete walks make a nice floor for a greenhouse. Full concrete is expensive and should not be used because it does not drain well. Also it can make the house too hot and dry in the summer.

A very satisfactory, low-cost floor is one made of several flagstones laid along the aisle. The rest of the area below the benches is simply soil, and it can be planted directly. The aisle can also be dug up and filled with 4" of gravel or crushed rock. Weeds are a slight problem in soil areas.

Some people prefer the flexibility of wood and use a slatted wood deck walkway. Wood is less durable and more difficult to clean, but is less tiring to stand on over long periods. Inexpensive two-by-fours can be used to make the deck. Preservative treated wood can also be used for longer life.

Frames

A wood greenhouse frame is the first choice of those who design and build their own greenhouse. Wood is easy to work with and costs less than other materials. The high greenhouse humidities and constant exposure to water mean that wood requires more maintenance than metal. Wood should be painted with a primer and a white exterior greenhouse paint to preserve it and improve light in the greenhouse. Any wood that touches the ground should be pressure treated with a copper salt preservative. Use construction grade or better lumber when you build your greenhouse. Good lumber costs a little more, but it is easier to work with and stronger than lower grade material. Often poor lumber has more waste because it is warped and has many large knots. Low or ungraded lumber is often attractively sale priced, but should only be used for rough or simple home projects.

Installing Fiberglass Reinforced Panels

Corrugated fiberglass panels may be installed several ways. The corrugations on roof panels should slope down so water will run off. Sidewall panel corrugations can run either direction.

Fasten with special aluminum- or zinc-coated, screw-shank or ring-shank, nails, 1¾" long, with fiberglass or neoprene washers attached. Predrill nail holes in the fiberglass about 8" apart or through the top of every third corrugation to keep water out.

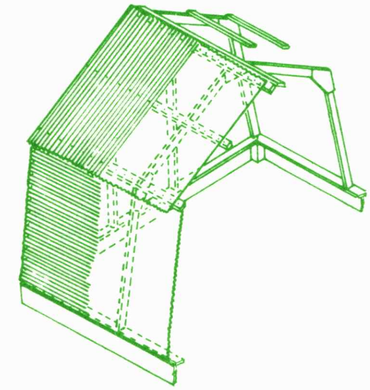


Figure 16. Corrugated fiberglass panel covered greenhouse. Panels should be cross-supported every 2½' to 3' of length.

Roof panels should be supported and nailed to cross supports or purlins every 2½' to 3' of length. Corrugated wall panels can be supported every 4' or so. Use corrugated foam-plastic filler strips under the edge or ends of panels to reduce air infiltration. Flat roof panels should be supported on the sides and every 18" to 24" across the roof. Wall panels can be supported every 2' to 3'.

Corrugated sheets should overlap 1 to 1½ corrugations at the sides. Use clear, flexible sealer (generally sold by the fiberglass supplier) where panels overlap. Sometimes houses are designed to nail the sides of panels to the frame. This design is

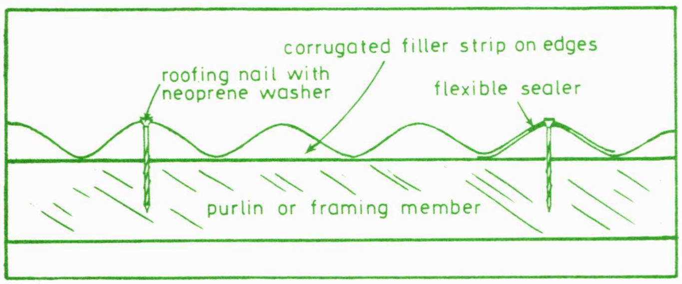


Figure 17. Fastening detail of corrugated fiberglass panels. Special nails with neoprene washers are used to fasten panels. Nail holes are predrilled through the top of corrugations to keep water out.

somewhat stronger and tighter than one with panels just fastened to the crossbraces. Because the frame must be carefully measured and built so nails can be driven through the top of a corrugation and into the frame, this construction method is not used often.

Polyethylene Film Installation

Some practice is required to make polyethylene fit and wear well. Apply the film on a calm, warm day. Pull the film to remove sags, but do not stretch too tightly because it shrinks in cool weather. Polyethylene tears first at folds and along rafters. Tape or smooth the supporting surfaces to reduce wear. Also, try to buy an unfolded roll that is wide enough to cover the greenhouse with no exposed folds. Fasten by nailing a thin strip of wood, slightly wider than the rafter, over the film and rafters. To further reduce wear cut a 2" strip of smooth roll roofing and nail it to the rafter between the polyethylene and lath strips. Nail every 12". Double-headed nails are sometimes used because they are easy to remove. Polyethylene should be fastened to rafters and wall columns so it is supported at least every 4' of greenhouse length.

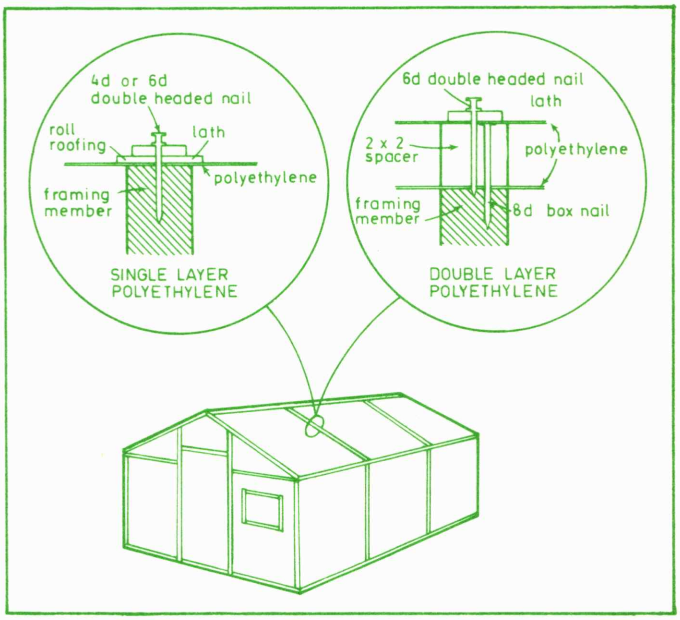


Figure 18. Fastening details of single layer and double layer polyethylene covering. The double covering can cut heat loss by one-third. Polyethylene must be fastened every 4' of greenhouse length to prevent wind damage.

A double layer of polyethylene can be installed to save heat. One way to install two layers is to cover the greenhouse with one sheet and fasten with 1" to 1½" wood spacers and 6d or 8d box nails. Then apply a second sheet of poly over the spacers and fasten with wood strips and nails.

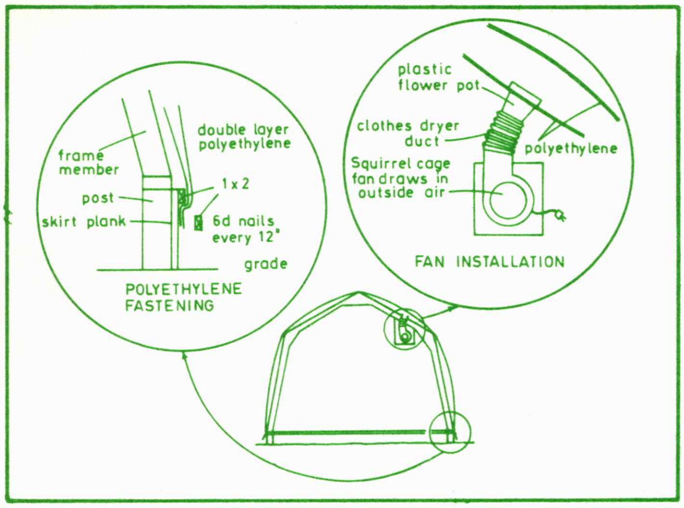


Figure 19. Details of an air inflated polyethylene covered greenhouse. The low pressure air separates the two layers to reduce heat loss and keeps the plastic rigid to reduce wind damage. Only the edges are fastened on this style of covering.

A double layer of polyethylene can be held apart with a small squirrel cage fan that blows air between the layers. Drape two sheets of polyethylene over the entire house and nail, every 12", with wood strips at the bottom, on the sides, and on each end (fig. 19). Rafters are needed for support every 4′ or 5′, but the plastic does not have to be secured to them. The fan will keep the "plastic bag" tight and keep the wind from working and tearing it. The fan should deliver 50-100 cubic feet of air per minute (cfm) at 0.5 inch of water column pressure. A clothes dryer duct and plastic flower pot with a hole in the bottom can be used to duct air between the plastic layers (fig. 19). A sheet metal valve is needed on the fan intake to adjust the inflation pressure. Mount the fan above snowline and on the endwall so air can be drawn from outside the greenhouse.

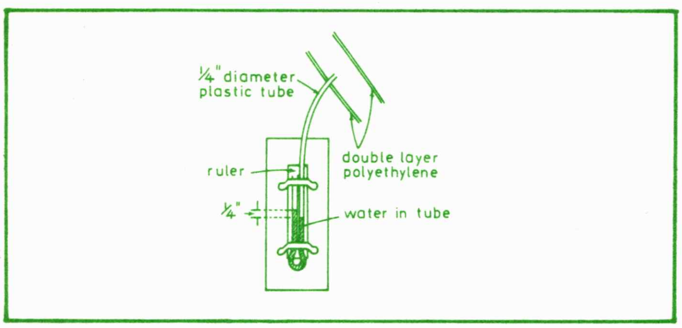


Figure 20. Improvised pressure gauge to measure air pressure between polyethylene layers of an air inflated greenhouse.

After the fan is installed check the inflation pressure. A clear, ¼" diameter, plastic tube, bent to form a U and a 6" ruler can be used to measure the pressure (fig. 20). Fill the tube with water to about the middle of the ruler and insert one end through the inner layer of plastic. Adjust the intake valve until a water column difference of ¼" is measured in the tube. This pressure should not change unless leaks develop. Patch holes in the plastic with tape. On very windy days you might increase the pressure to ⅜".

Before you decide

Before you buy, estimate the cost to operate a greenhouse. How much will property taxes be? Will your present homeowners' insurance cover the greenhouse or will you need additional insurance? How much will heating cost? Fertilizer? Plants? Your time? All these costs are part of a hobby greenhouse, yet many people find them small in relation to the recreational value of the greenhouse.

Construction should be sturdy to withstand wind and snow. Make sure you know what is included in the price. Get complete costs for both the structure and equipment. If benches are included be sure they are sturdy enough to support heavy pots. Does the price include delivery, foundation materials or erection?

When designing a greenhouse use the minimum size guidelines suggested here. Consider how the house will be used in the future. Will you want to expand? Remember, many greenhouse owners find they could use more space after they have built. How will you be using your greenhouse? Will you need benches? Do you need extra aisle space for carts? Do you want a soil potting area in the greenhouse? How much maintenance are you willing to do? Even with the cost of replacing polyethylene every year or so, plastic greenhouses are much cheaper than the relatively maintenance-free glass houses.

Heating and ventilation equipment can cost more than the greenhouse so it is normally not sold with a greenhouse kit. If you want this equipment, be sure the greenhouse is large enough to hold both it and the plants. Do not support heavy heating equipment from the greenhouse frame unless it is designed to carry this extra load.

Heating

Hot Air

Greenhouses must be heated for use during most of the fall, winter and spring months. Heat can be distributed throughout the greenhouse in four ways: forced hot air, natural convection from small space heaters, hot water or steam pipes, and direct radiation. Forced hot air heats most rapidly, but unless the heater is properly installed and accurately controlled, the temperature may fluctuate widely. Low relative humidity, not best for plant growth, may be a problem in winter with any heating system; but may be worse with forced air heating.

The **electric heater** is convenient to use in the small greenhouse, either alone or to supplement heat from other sources. Electric heat is clean, efficient, and easy to install but is more expensive than other fuels. The heater should have a built-in thermostat and circulation fan. Adequate electrical supply and wiring is required, and the size of the existing electrical service may limit the number of new branch circuits which can be added to service the greenhouse.

Space heaters are commonly used to heat small greenhouses. Some are completely self contained units with fan and heat exchanger that burn either natural gas or fuel oil. Some use electrical resistance heaters. Others, not commonly used in small greenhouses, have a fan and heat exchanger but use hot water or steam from a central boiler as the heat source. Space heaters are often hung overhead, but some fit through the wall so little space is lost and no special venting is required. The frame of some small greenhouses may not be strong enough to support a heater. A separate frame or mounting bracket can be used instead. Units with fans that blow air horizontally give more uniform temperature distribution than heaters that blow air vertically.

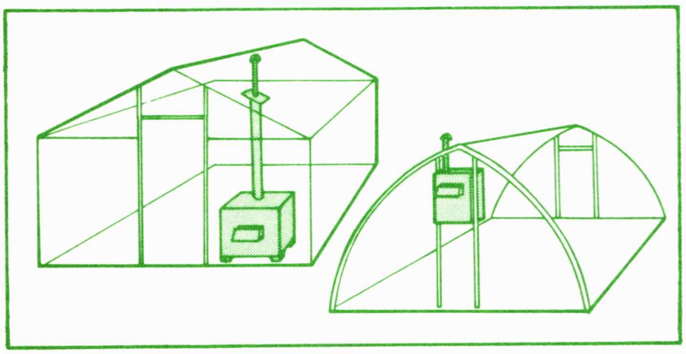


Figure 21. Space heaters. These simple, low cost heaters are handy for greenhouse heating. They must be vented to the outside.

Caution: Fuel burning heaters must be vented to the outside because some of the products of combustion are toxic to both people and plants. Be sure air for combustion comes from outside the greenhouse. Portable oil fueled space heaters, such as used on construction projects, should not be used in greenhouses.

Small kerosene, propane, or natural gas burners are sold to heat small greenhouses. These low cost, handy units have no fan or thermostatic control, so temperatures fluctuate and are less uniform than in houses with more expensive heating systems. Even these small heaters should be vented to the outside. In tightly constructed houses these heaters can use enough oxygen to cause incomplete combustion which generates toxic gases. In addition, water vapor, formed as part of any combustion process may cause high humidities and potential disease problems.

The **extension of a home heating system** to a small greenhouse is possible if the home furnace capacity is adequate. However, the rate of heat loss will differ for the home and the greenhouse, and separate control systems are needed. A heating contractor should be hired to make the modifications needed.

Forced warm-air heaters, like those in the home, can be used in the greenhouse. If the greenhouse is attached to the home, the furnace can be placed in the basement of the home and the heated air ducted into the greenhouse. A horizontal furnace can be placed under a bench.

Hot Water or Steam

Natural convection hot water and steam pipes generally give more steady and more efficient heating than hot air. Hot water provides even heat but is slower than steam to respond to sudden changes in outside temperatures. Steam heating systems are usually too complex and expensive for the small greenhouse. Hot water seems to give the best overall results. Many boilers for hot water systems are built to generate small quantities of steam to pasteurize soil.

A typical hot water or steam heating system consists of a boiler piped to smooth or finned pipes mounted along the walls.

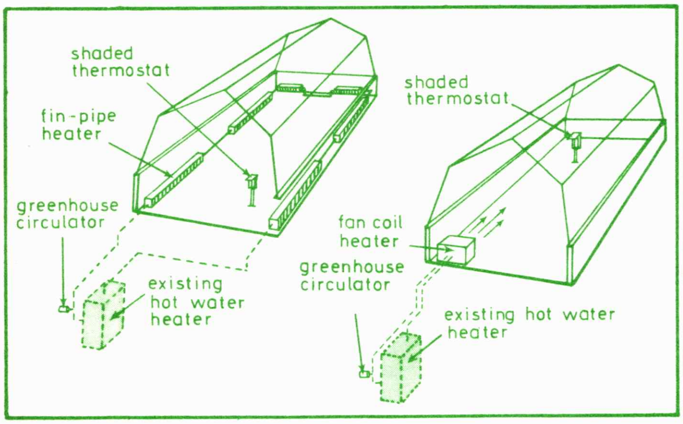


Figure 22. Hot water heating systems. This equipment is expensive to buy, but heating is efficient and uniform.

Direct Radiation

Radiant energy is supplied by electrically or gas heated panels hung over each bench or floor area. This type of heating can be very efficient and uniform for small areas, although equipment may be expensive and hard to find.

Caution: Heat lamps should be suspended by chains and not by the electrical cord.

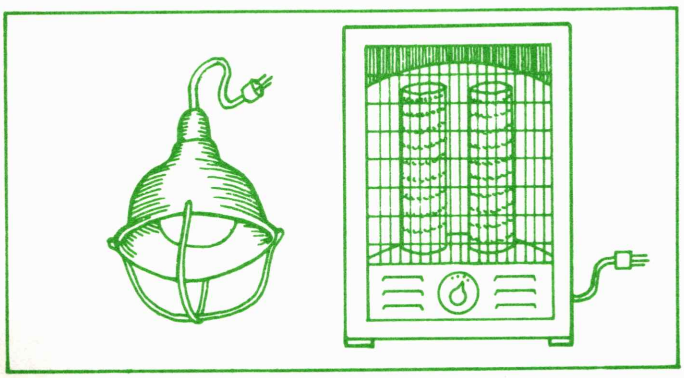
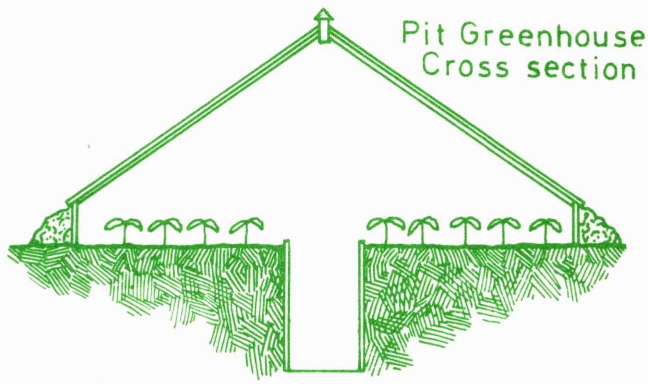


Figure 23. Radiant heaters. These heaters warm the plants with little warming of the surrounding air.

Infrared lamps have been used to heat bedding plants grown in a greenhouse in the spring. These low cost lamps are simple to install overhead so they do not require floor space. Soil can be heated with heating cable as in a hotbed. A 150 to 200 watt heat lamp suspended 32" above the bed will heat a 3' x 3' area 15° to 20° above the outside air temperatures. A thermostat can be installed to turn off lamps at 45° to 50° F.

Recently, several ideas for **solar heating** of greenhouses have been tried. Large amounts of gravel or water is heated during the day and this stored heat is withdrawn at night or during cloudy weather. Many of these systems are still experimental, but hold some promise for the small greenhouse.

The pit greenhouse is a form of solar greenhouse that uses heat stored in the soil to keep it above freezing.



Comparing Fuels

The fuel you select will depend on convenience, availability and price. Table 1 can be used to compare the cost per 100,000 Btu's for several fuels. To compare price per 100,000 Btu of heat output for typical heaters, multiply the fuel units in the last column by the fuel cost per unit. If you know the efficiency of your heater, use that value when calculating fuel cost.

Table 1. Comparison of heat output from various fuels.[a]

Fuel	Selling Unit	Heat Content Btu/Unit	Typical Heater Efficiency	Fuel Units per 100,000 Btu Heat Output
#2 Oil	Gallon	140,000	70%	1.02 gal
Coal	Pound	12,500	65%	11.3 lb
Natural Gal	Cu. Ft.	1,000	80%	125 cu. ft.
LP Gas	Gallon	92,000	80%	1.36 gal
Electricity	KWH	3,413	100%	29.3 KWH

[a]To compare price per 100,000 Btu's of heat output for typical heaters multiply the fuel units in the last column by the fuel cost per unit. If you know the efficiency of your heater use that value when calculating fuel cost.

Heater Size

The amount of heat required for a greenhouse depends mainly on the temperature difference between inside and outside, surface area of the greenhouse, quality or tightness of construction and wind. For most construction the heater size can be estimated by multiplying the surface area of the transparent greenhouse covering by the maximum temperature difference to be maintained and a conversion or U factor shown in Table 2.

Table 2. Heat Loss Factor, U, for typical small greenhouse construction

Greenhouse Covering	Heat Loss Factor (U)[a] Calm Area	Windy Area
Polyethylene or fiberglass	1.2	1.4
Glass	1.5	1.8
Double layer plastic or glass	0.8	1.0

[a]Heat loss is Btu/hr. - sq. ft. - °F.

An example of how heat requirements are calculated is shown in figure 24. In this case a gabled-roof single layer plastic covered 10′ x 12′ greenhouse is heated to 60°F.

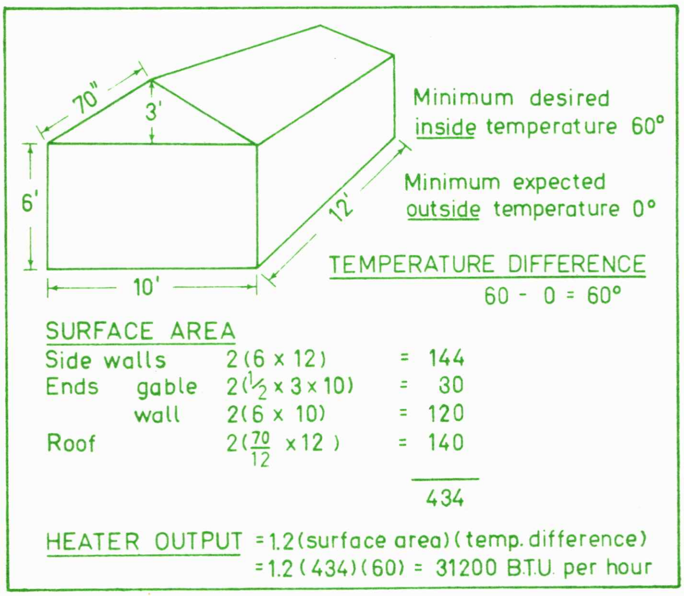


Figure 24. Sample calculations of heating requirements for a typical greenhouse.

Calculating the exact surface area of greenhouses with unusual shapes is difficult, so approximations can be used instead. Often the roof and sidewalls are rectangular areas where the area is calculated by multiplying width and length. The area of the end wall may be estimated by assuming the end wall is a simple geometric shape, such as a rectangle that is slightly shorter than the greenhouse. Figure 25 shows an example of how the end area may be estimated.

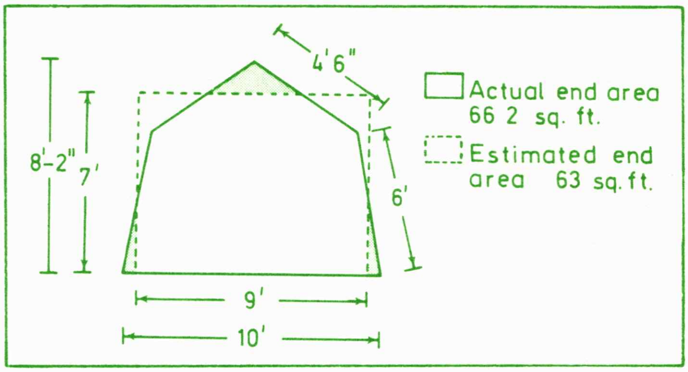


Figure 25. The area of a complex shape, such as the end of a greenhouse, can be estimated by assuming it is a simple geometric figure.

For those who hate calculations, Table 3 and Table 4 can be used to size heaters for typical gable roof, freestanding greenhouses. For example, the heater capacity required for an average 8′ x 10′ greenhouse, single layer covered, that is to be kept at 60°F in an area where temperatures dip to 0°F is 24,300 Btu per hour.

Table 3. Greenhouse Heater Sizes. Heaters are for typical gable roof, free-standing, **single** layer covered greenhouses.

Greenhouse Size: Floor Dimensions, ft x ft	Uninsulated Wall Height, ft.	Surface Area sq. ft.	Temperature Difference, °F: 30°	40°	50°	60°	80°
			Heater Capacity, Btu/hr[a]				
6 x 8	5.5	242	8,700	11,600	14,500	17,400	23,200
8 x 10	6.0	338	12,200	16,200	20,300	24,300	32,500
10 x 12	6.5	452	16,300	21,700	27,100	32,600	43,400
12 x 16	6.5	615	22,100	29,500	36,900	44,300	59,000

[a]To convert to kilowatts, divide heater capacities shown by 3400.

Table 4. Greenhouse Heater Sizes. Heaters are for typical gable roof, free-standing, **double** layered greenhouses.

Greenhouse Size: Floor Dimensions, ft x ft	Uninsulated Wall Height, ft.	Surface Area sq. ft.	Temperature Difference, °F: 30°	40°	50°	60°	80°
			Heater Capacity, Btu/hr[a]				
6 x 8	5.5	242	5,800	7,700	9,700	11,600	15,500
8 x 10	6.0	338	8,100	10,800	13,500	16,200	21,700
10 x 12	6.5	452	10,900	14,500	18,100	21,700	28,900
12 x 16	6.5	615	14,700	19,700	24,600	29,500	39,300

[a]To convert to kilowatts, divide heater capacities shown by 3400.

Distributing the Heat

Heat can be distributed from the heating unit with fans, ducts, or radiating pipes. A good distribution system will give more uniform temperatures and reduce moisture condensation and associated disease problems.

Fans can be used to move the warm air throughout the greenhouse. One or two small circulating fans capable of moving one-fourth the air volume of the house per minute can be used. The volume of a small greenhouse is an average height of 7′ times the floor area. An 8′ x 10′ greenhouse has a volume of 8′ x 10′ x 7′ or 560 cu ft. Fans should move 560 x ¼ = 140 cu ft/min (cfm) for good heat distribution. Many space heaters and electric heaters include a fan as a part of the unit.

Ducts are sometimes used to obtain more even distribution of the warm air and conserve heat. Houses less than 100 to 150 square feet in area are usually too small for ducts. Permanent galvanized steel ducting installed along the sidewalls works well. The ducts should have openings spaced every 1 to 2 feet with manually set dampers to adjust openings for best air distribution. Perforated polyethylene tubing makes excellent inexpensive ducts.

The heater and tubing can be mounted overhead to provide a blanket of warm air over the plants or they can be placed along a sidewall. Greenhouse suppliers are the best source for this tubing. You can make your own by taping a polyethylene sheet to form a tube, or you can buy polyethylene tubing from a plastic bag supplier. Holes can be punched or burned with a heated tin can into the tube every foot or two for air outlets.

Finned pipe baseboard units are used to distribute heat from a hot water system. A single line around the perimeter will generally supply the required amount of heat. This system uses the least greenhouse space and gives good temperature control. Black iron pipe can also be used to distribute hot water heat. Four to six lines around the perimeter and one or two overhead lines may be needed to provide enough hot surface, though.

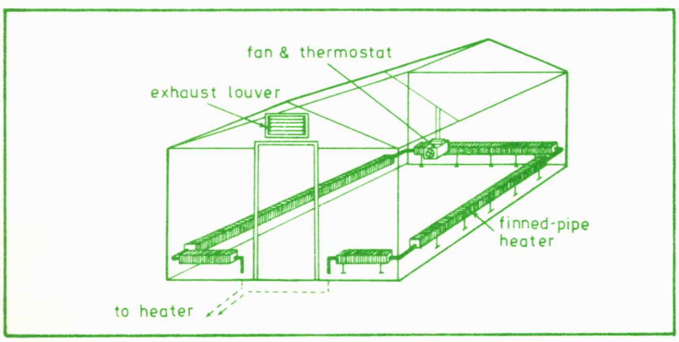


Figure 26. Finned pipe, hot water heating system.

Saving Heat

Because the thin greenhouse covering materials offer little resistance to heat loss, heating can be very expensive. Some ways to reduce this large heat loss are:

- Close the greenhouse from December 1 to March 1. This practice reduces fuel use to one-half of that needed for a full year's operation. If the greenhouse is closed in the winter remove heavy snow from the roof so it will not collapse. Water pipes should also be protected from freezing.

- Lower the thermostat setting. Table 5 shows potential fuel savings when the greenhouse temperature is lowered. For example, by lowering the thermostat from 65° to 55° in an area where the average monthly temperature is 28° fuel use is reduced 26%.

Table 5. Percent reduction in fuel use when greenhouse temperatures are lowered.[a]

	Present Greenhouse Temperature						
	65°F			60°F		55°F	
	New Greenhouse Temperature						
Monthly Average Temp. (°F)	60°F	55°F	50°F	55°F	50°F	50°F	45°F
	Percent Reduction in Fuel Use						
20	11	22	33	12	24	14	28
24	12	24	36	14	28	16	32
28	13	26	39	16	32	19	38
32	15	30	45	18	36	22	44
36	17	34	51	21	42	26	52

[a]Source: Harrison and Roberts. *Florist Notes.* Cook College, Rutgers University, December 1973.

- Clean and adjust heaters every year. This simple step can reduce heat bills 5 to 20%.

- Cover with a double layer of polyethylene film. A second covering reduces heat loss by one-third that of a single layer, yet light transmission is only reduced by 5 to 10%.

- Install greenhouse covering tightly and with no gaps or holes. To reduce heat loss by 3 to 10% patch any tears in plastic and replace broken glass. Weather strip the door and keep it closed. Lubricate any ventilation louvers so they close tightly.

- Install the proper heating system. A heating system that is too large or installed so heat is not directed toward the plants can use twice as much heat as a well designed and properly installed system.

- Build a pit greenhouse and grow cool temperature crops.

● Insulate walls below raised benches. Fuel savings of 5% to 10% are possible. Use 1" polyurethane or 1½" polystyrene insulating board. Sandwich the board between cement asbestos panels or glue to concrete or cement block foundation walls. The insulation should extend 12" to 24" into the ground.

● Build an attached greenhouse. Because less of its surface is exposed, an attached greenhouse uses less heat than a freestanding house with the same floor area. Some owners insulate the north side of the greenhouse and cover it with reflective material to increase light during the winter.

● Cover over the outside of the greenhouse or cover the plants inside the greenhouse at night. The cover can be any material from black polyethylene film to a fiberglass blanket. If insulated covers are used, be sure snow does not build up and collapse either the cover or the greenhouse.

Choosing a Heating System

Choosing a heater is often more difficult than choosing the greenhouse. Electric heaters are convenient, easy to install, and cost less to buy than other heaters. Operating costs, however, are much higher than for any other heater. In a year or two the lower initial cost for equipment is overcome by high monthly electric bills.

Table 6a. Typical greenhouse heating costs. Costs are for a 10' x 12' greenhouse (Plan 6181) heated with either LP gas or electricity.[a]

		LP Gas[c]				Electric[d]			
		Single Cover		Double Cover		Single Cover		Double Cover	
	Degree[b] Days	60°	55°	60°	55°	60°	55°	60°	55°
October	439	$17	$ 8	$12	$ 6	$34	$15	$24	$11
November	659	32	22	23	15	62	43	43	30
December	851	43	34	30	24	85	66	60	46
January	960	50	40	35	28	97	80	67	56
February	952	50	42	35	29	99	81	70	56
March	618	29	19	20	13	56	38	39	27
April	401	15	5	11	4	29	11	21	8
Total	4880	$236	$170	$166	$119	$462	$334	$324	$240

[a]Sun assumed to provide 25% of the required energy.

[b]Degree days are the average outdoor temperature for the day subtracted from 65°F. If the average outside temperature is 40° the degree days accumulated for that day is 25 degree days. Each day's total is added together to obtain the monthly total. Degree days based on 1972-73 winter at New Brunswick, New Jersey.

[c]LP gas assumed to cost 60¢ per gallon. Costs are higher in some areas.

[d]Electric cost is 4¢ per kilowatt hour.

Table 6b. Heater capacity for 10' x 12' greenhouse (Plan 6181).[a]

Fuel	Single Layer Plastic 60°F Inside Temp.	Double Layer Plastic 55°F Inside Temp.
LP Gas	25,000 BTU/hr	16,000 BTU/hr
Electric	7.5 kilowatts	5 kilowatts

[a]Minimum outside temperature expected is 0°F.

Sometimes the home heating system can be tapped to heat a very small or attached greenhouse. If this solution is possible, it is very convenient. In many cases 15% to 30% of the home heat may be needed to heat even a small attached greenhouse. Often it is easier to install a separate heater than to try to balance the home heating system so the greenhouse is not too cold or the house too hot.

Space heaters are an intermediate choice favored by many greenhouse operators. Cost and availability of the fuel for these heaters must be considered. In some areas new natural gas or propane service is not being supplied so fuel oil is the only choice. Oil-burning heaters are usually so large they must be mounted outside or on the floor and the hot air is ducted into the greenhouse.

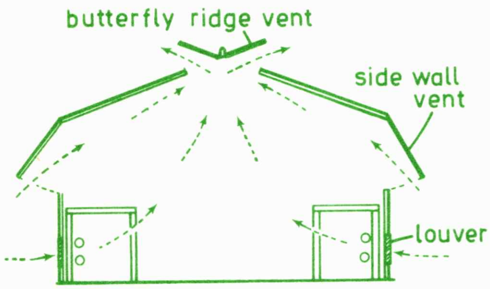
Finned-pipe and hot water heat is a very good system for uniform, efficient heating, but the equipment is the most expensive of all heating systems. Again cost and availability of fuel should be considered when buying a boiler.

Many greenhouse suppliers can help you choose and install a good heating system. Often they can supply a good heating system at a lower cost than a firm not customarily dealing in greenhouses.

A heater should be controlled by a thermostat for convenient operation. Oversize hot-air heaters tend to waste heat, so size the heater carefully. If you plan to expand in the future, consider this in choosing and sizing your heating system.

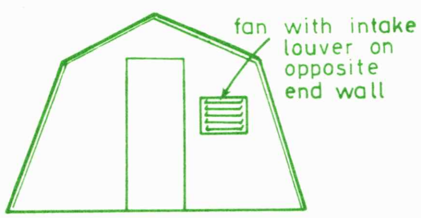
Ventilation and Cooling

Ventilation is the exchange of air inside the greenhouse with outside air. Ventilation is needed for cooling, to reduce high humidity, and to replenish carbon dioxide. Ventilation can be achieved by opening vents and doors in the greenhouse or by using fans.



Fans

Exhaust fans in combination with inlet louvers are a good ventilation system recommended by many greenhouse operators. Fans are particularly convenient because they can be automated by simply wiring them to a thermostat. In addition, they give positive air exchange and can be sized to the seasonal requirements for a given greenhouse. The inside temperature can be kept within 3 to 10° F greater than the outside air temperature. A two-speed fan is desirable because, during spring and fall, the low speed reduces the air exchange rate to about half. The exhaust fan and inlet louver should be placed at opposite ends of the greenhouse. A motorized inlet louver works well as it is controlled by the same thermostat starting the fan.

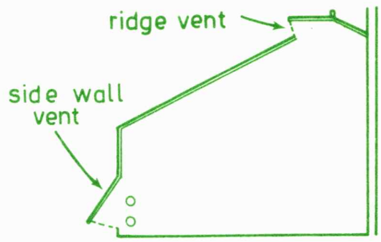


A small greenhouse having an air volume of 5,000 cubic feet or less should have an air exchange rate of at least 12 cubic feet per minute (cfm) per square foot of floor area to remove the summer heat load. Air inlets resist the flow of air, so the fan must work against a slight pressure. To compensate for this pressure loss, use a fan that delivers the required cfm at 0.1″ to 0.125″ of water pressure. If the pressure rating for the fan is not known, reduce the listed cfm rating by 20%. For example, a 10′ x 12′ greenhouse needs a fan that delivers 1440 cfm [(10 x 12) 12] at 0.1″ static pressure or 1800 cfm when no pressure rating is shown. A 12″ to 16″ diameter fan will deliver this air flow. A kitchen exhaust fan can be used in small greenhouses.

Ridge Vents

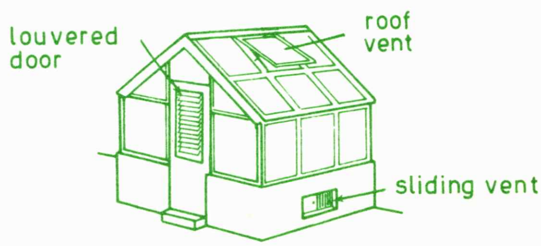
A continuous vent along the ridge or top of the greenhouse provides the best natural ventilation. The ridge vent operates on the principle that warm air inside the greenhouse rises out the top of the house and cooler air enters to take its place. Ridge vents in small greenhouses are 1′ to 2′ wide. The wind should not blow cold air directly in onto the plants to chill them. Place the vent on the side away from the wind if the house is a lean-to or has the vent on only one side of the ridge.

Automatic vent controllers that open and close the ridge vent according to temperature are available and can be installed when it is difficult to constantly monitor and tend the greenhouse.



Side Vents and Doors

Side vents and doors are often used in combination with ridge vents for good natural air flow. Cool air enters through the side vents and doors while the warm air rises and escapes through the ridge. Side vents are not often used in greenhouses less than 12′ long, since an open door or a few holes at each end allow enough air to enter on hot days. Small foundation vents, screened doors, and jalousie vents can be used for cross ventilation. The size of the vent openings should be adjustable to handle varying weather conditions.



Air Circulation

Exhaust fans or vents normally provide fairly uniform temperature in small greenhouses less than 15′ to 20′ long. Small circulating fans can be used to circulate air for slightly more uniform temperatures. Generally this added air circulation is needed only when little or no outside air enters the greenhouse, when heating or on cool days.

Shading

Shades, besides reducing light, reduce the heat load in greenhouses. They are commonly used on the hobby greenhouse. Shading plus moisture evaporation from soil and plants can lower greenhouse temperatures 10° to 15° F.

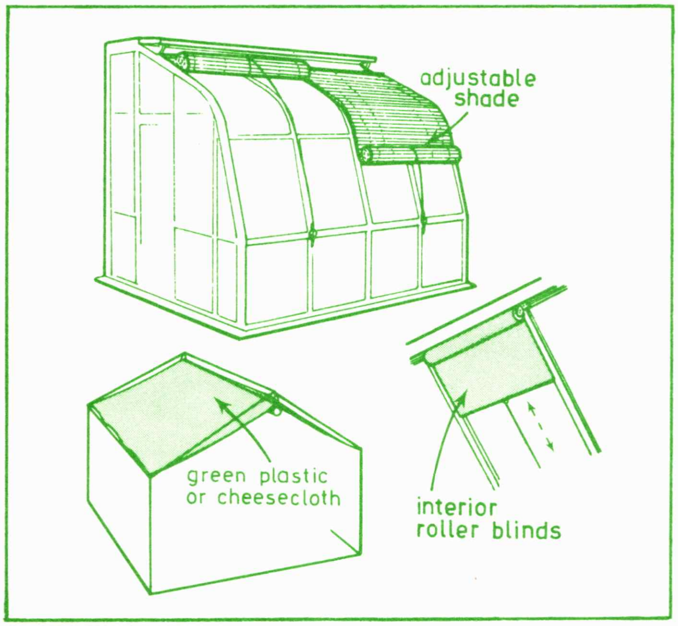


Figure 27. Shading devices will keep the greenhouse cool during most summer days.

Specially formulated compounds that can be washed off in the fall can be sprayed or painted onto the greenhouse cover and are available from greenhouse suppliers. Many companies sell roll-up shades made of plastic, wood, aluminum, or fiberglass that can be attached to the outside of the greenhouse roof.

Evaporative Cooling

Air can be cooled by drawing it through wetted aspen wood excelsior pads. Where temperatures exceed 90° for more than 10 to 15 days a year evaporative cooling can be worthwhile. Generally evaporative cooling is not needed in New England and northern New York. In the Northeast expect no more than 10° or 15° of cooling below outside air temperature by evaporation. A fine mist nozzle can be used to cool plants during the few really hot days. Frequent wetting of plants and walkways is not too effective for cooling.

Unit evaporative coolers are convenient for small greenhouses. Buy a unit that has a cfm (cubic feet per minute) air rating of at least 12 times the floor area of the greenhouse. An 8′ x 10′ greenhouse needs at least a 960 cfm (8′ x 10′ x 12′) unit.

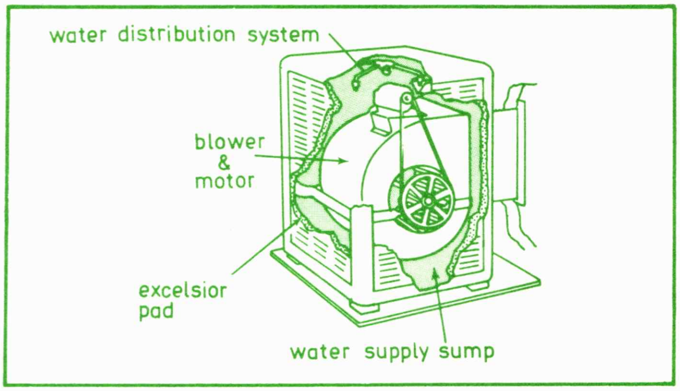


Figure 28. An evaporative cooler is used for greenhouse cooling in warm areas. Northern areas seldom use this cooling method.

Unlike refrigerated rooms, a door or vent must be **open** when using package evaporative coolers. Air must exchange freely for evaporative cooling to work. At least two square feet of opening for every 1000 cfm of cooler capacity is needed.

Perforated polyethylene tubing can be used to uniformly distribute the cooling air in greenhouses larger than 150 sq. ft. in area. This equipment can be purchased from greenhouse suppliers or you can make your own tube. Buy polyethylene film large enough to make a tube that will fit around the cooler outlet. Punch or burn holes every 1 to 2 feet along the tube. The area of all holes, in square inches, should be about 0.15 times the cfm rating of the cooler. Total hole area for a 1000 cfm cooler is 150 sq. in. (1000 x 0.15). If 30 holes are punched each hole should have an area of 150/30 = 5 sq. in. (2½″ diameter).

Houses larger than 500 to 1000 sq. ft. sometimes use a pad and fan evaporative cooling system. A wetted aspen wood excelsior pad is mounted along one wall, and exhaust fans along the opposite wall cool the air by drawing it through the pad. The air then passes through and cools the house. Greenhouse suppliers sell pad and fan equipment and can help size and install it.

Use a two stage thermostat to control the evaporative cooler. At 70° to 80° the thermostat turns on the fan. At 80° to 90°, the pump that circulates water to the pad is started.

If an evaporative cooler is well maintained, it cools the greenhouse very effectively. It can be a maintenance headache, though. Pads must be replaced once or twice a year. Deposits must be removed from the water system periodically. An algacide may have to be added to the water occasionally to keep algae growth under control.

Humidity Control

Particularly in spring and fall months, moisture often condenses on plants, causing disease, such as botrytis, to grow and spread. Little can be done to prevent this problem except to remove some of the moist air from the greenhouse and replace it with colder, drier outside air. Cold air holds less water vapor than warm air, and accordingly, the cold outside air has less water vapor than that inside. When this drier outside air is warmed it lowers the humidity and reduces the danger of moisture condensing on the slightly colder plants. Unfortunately, ventilation requires more heat, but is the only practical way to reduce humidity.

Reducing humidity in the actual greenhouse is much more difficult than describing how to do it. Usually condensation occurs at sunset when plants and greenhouse cool rapidly. One suggestion is to start heating before sunset and gradually close the ridge vent until it is just barely open ¼" or so. You should experiment to see how to reduce humidity in your greenhouse.

Sometimes the humidity is so high on warm nights that condensation occurs then. Because there is very little or no temperature difference between the inside and outside of the greenhouse, little can be done to help. Sometimes higher ventilation rates will reduce the problem.

During the winter and on hot summer days humidity may become too low for best plant growth. Water sprayed on the plants raises humidity for only 15 to 30 minutes and mineral deposits from the water can discolor them. Fine mist or high pressure oil burner nozzles can be used to spray a humidifying mist into the air. An electric solenoid valve and intermittent timer should be used to control the amount of mist.

Evaporative coolers or humidifiers can also be used to humidify the air. Humidistats that sense humidity like thermostats sense temperature can be used to operate humidifiers. Unfortunately humidistats lose their accuracy quickly and must be calibrated about every month. Hand or thermostat control is still the best way to control any of these systems.

Automation

Watering, heating, cooling, fertilizing, and humidifying can all be done automatically. Only the budget limits how many chores are automated. Some people prefer to control all of these operations themselves, considering this part of the enjoyment of the greenhouse. Some jobs, however, are better handled by automatic controls. Heaters and ventilation fans should be controlled by a thermostat. Adjust thermostats to provide a smooth transition from heating to cooling. All thermostat sensing elements should be at one location and shaded from the sun. They are generally mounted 3 to 5 feet high or in the plant canopy.

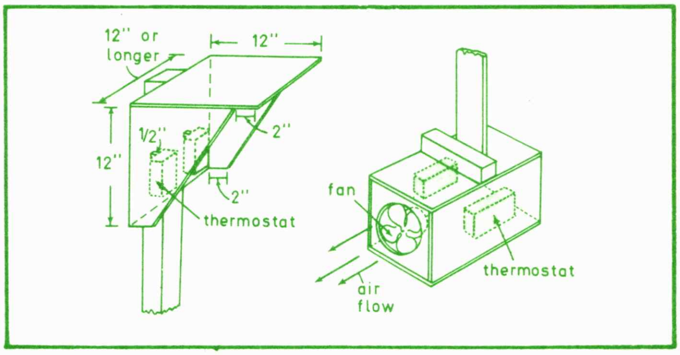


Figure 29. Thermostats should be shaded or fan ventilated to more accurately control greenhouse temperatures.

Thermostats should be located near the center of the greenhouse and away from doors, cold air drafts, and in the direct path of heated air. For most accurate control a small blower can be used to draw air over the sensors. Because thermostats are often poorly calibrated, place one or two thermometers in the greenhouse to check both the thermostat and the temperature distribution. A high-low thermometer provides a very good check of temperatures while you are away.

A control sequence for the perimeter heat, unit cooler system shown in figure 28 is shown in Table 7.

The temperature sequence for a greenhouse with one fan and a heater might be:

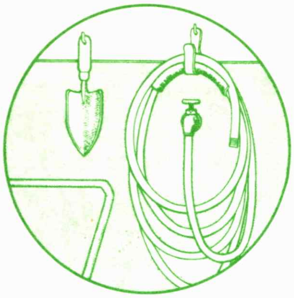
- stage 1 (60° F), heater on
- stage 2 (62° F), heater off
- stage 3 (72° F), fan on.

In general, keep a 10° difference between heating and cooling.

Temperature alarms are used to warn you when some part of the heating or cooling system is not working. Alarms can be purchased from greenhouse and some electronic equipment suppliers. A plan for a temperature alarm is included in the plans section.

Table 7. Sample control sequence for a greenhouse with both a heater and evaporative cooler. A 10°F temperature difference between heating and cooling stages prevents the exhaust fan from running when the heater is on.

Stage	Temperature	Operation
1	60°	Heating, valve opens to supply hot water to the finned pipe
2	62°	No heating or cooling
3	72°	Cooling begins, exhaust louver opens, unit cooler blower starts on low speed
4	76°	Unit cooler blower switches to high speed
5	80°	Water starts circulating over the evaporator pads



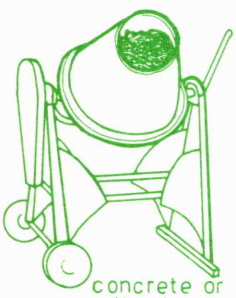
Labor Saving Equipment

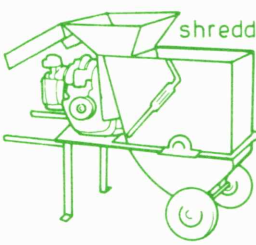
Relatively few tools are needed for the hobby greenhouse. A trowel, knife, pruning shears, sharpening equipment, kitchen shears, scoops, pails, and a hose are some of the items you will need. Pots, flats, label stakes, string or plastic ties may also be needed, depending on the type of plants you are growing.

Besides these almost standard items you might consider some specialized labor saving equipment. Some chores can be done better with a machine, leaving you more time for other activities. Greenhouse suppliers sell most of the equipment described below.

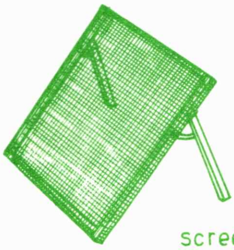
Growing Media Preparation

Growing media can be purchased ready to use or can be mixed in custom batches. Normally soil, peat, vermiculite, perlite, lime and fertilizer are components of the growing media. A soil shredder can be used to prepare top soil, loosen baled peat and mix the

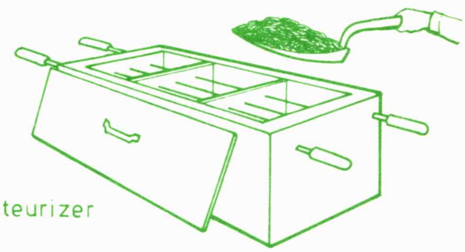




components. Shredders are available in capacities from about 4 cubic yards per hour. They are powered by either an electric motor or with a gas engine. A small portable concrete mixer is an excellent soil and peat-lite mixer. A ½ HP electric motor or 2 HP gas engine can be used to power it. A small screen is handy for removing stones and clumps from soil and is simple to make. It can be folded and stored in the headhouse or garage.



Soil should be pasteurized before it is used to kill disease organisms, pests, and weeds. Heating is the most common and effective method used. A temperature of 140°F for two hours or 180°F for 30 minutes will destroy most disease organisms and weeds. Best results are obtained if the soil or mix is loose and slightly moist at the time of pasteurization.



To conserve energy, only the soil needs to be pasteurized. It can then be mixed with peat, vermiculite, perlite or other disease free components. An electric roaster works well for pasteurizing small amounts of soil. It will do about one flat at a time. Small commercial soil pasteurizers that process ⅛ and ¼ cubic yard per batch are available. These also operate on electricity and use from 6 to 12 kilowatt hours per cubic yard.

It is important that soil or mix be stored in containers or in an area where it will not be re-contaminated. The commercially prepared peat-vermiculite mixes are usually stored in their shipping containers until used.

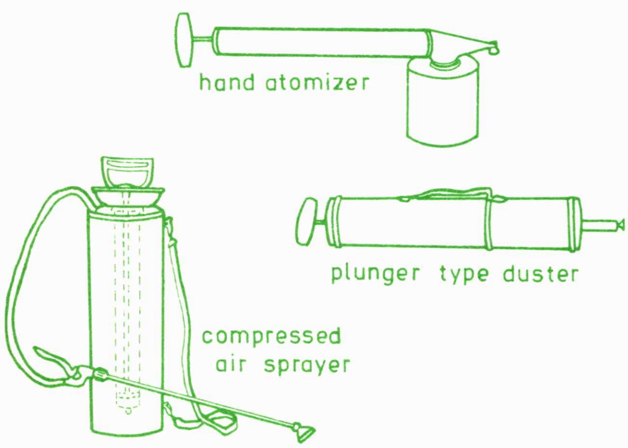
Plant Treatment

Battery-powered and electric seeders aid in seeding. Seed is poured into the scoop and held over the bed or flat. The unit vibrates to feed the seed evenly.

Heating pads and mats under the soil mix in the bench provide additional heat for the propagation of cuttings and seedlings. They are available in several sizes. A built-in thermostat controls the temperature level.

The effectiveness of an insecticide or fungicide depends to a large extent upon the thoroughness of the application of the material. The hand atomizer is commonly used to apply insecticides to small areas. They are available in capacities of from ½ pint to 2 quarts. This sprayer is inexpensive so several can be purchased, one for each type of spray material used.

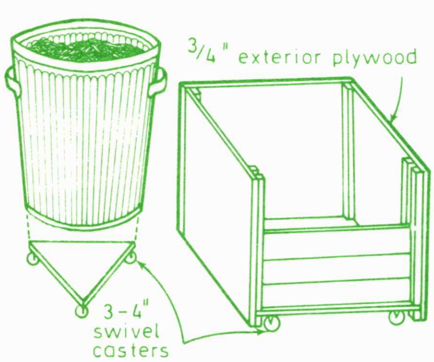
The compressed air sprayer provides better atomization and spray coverage especially to the underside of leaves. It is available in capacities from 1 to 5 gallons. Since these sprayers are not equipped with an agitator, they must be shaken frequently when wettable powders are sprayed. The plunger type duster is commonly used to apply insecticide and fungicides in powder form.



> **Caution:** Chemicals used in the greenhouse should be stored in a locked cabinet to protect children from accidental poisoning. The cabinet should be located in a dry area so that chemicals in powder form do not cake.

Materials Handling

Single and double wheel carts are handy in the home greenhouse when materials need to be moved. Look for large wheels for easy rolling and make sure the cart is narrow enough to go through the door.



storage bins for growing media

Watering and Misting

Daily hand watering with a **garden hose** is the most common watering system. Short hoses and several faucets are more convenient than one long hose. You should probably install more than one faucet if the greenhouse is longer than 12'. Water breakers attached to the hose will keep soil from being compacted or washed out of the pot or bench. Water potted plants until water begins to flow from the drainage hole. More water only saturates the soil or reduces the amount of air in the soil; air in the soil, as well as water and fertilizer, is necessary for good plant growth. Plants should be segregated in the greenhouse according to their water needs as well as their growth cycles. Cacti should be separated from moisture-loving subtropical plants, for example.

Overhead watering should only be done in the summer, if at all. Water early in the morning so plants can dry before evening. Water droplets will cause spotting on some plants and increase fungus disease. A **watering can** is particularly handy for watering potted plants in a small greenhouse. The spout, with sprinkler head removed, easily reaches beneath plant leaves to water the soil.

Automated watering systems are very convenient for the busy gardener. Plastic nozzles are used to water plants grown in benches or directly in the soil. Normally, a polyethylene pipe is clamped or laid on both sides of the bench. Nozzles that spray in a half circle (180°) are inserted every 30" along the pipe.

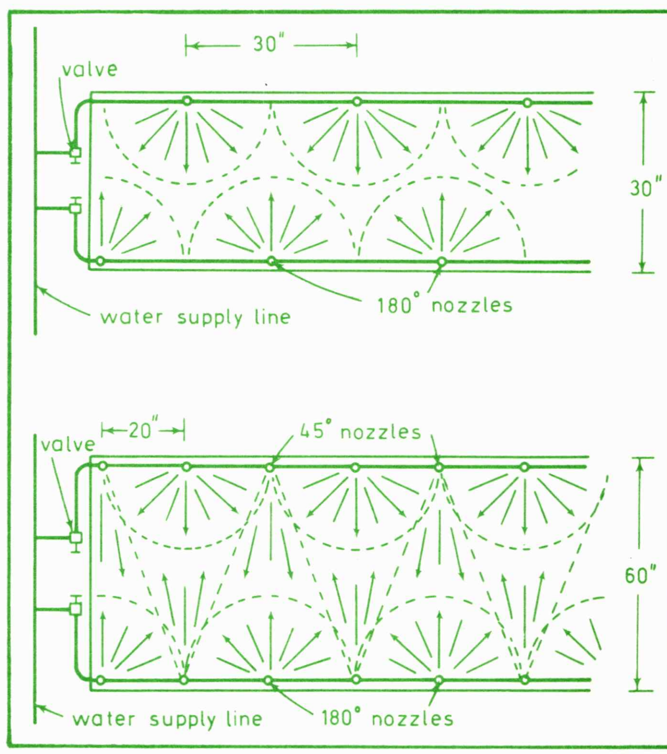


Figure 30. Layouts for plastic nozzle watering systems. Automated watering saves time for other projects.

Benches wider than 30″ may need to alternate 180° nozzles and 45° nozzles spaced 20″ apart to cover the area (fig. 30).

The spaghetti-tube system conveniently waters potted plants. The thin tubes are inserted into a main, ½″ diameter, polyethylene tube that runs down the center of the bench. Tubes are held in place with a lead weight, a short piece of ½″ polyethylene tubing, or are tied to a label stake.

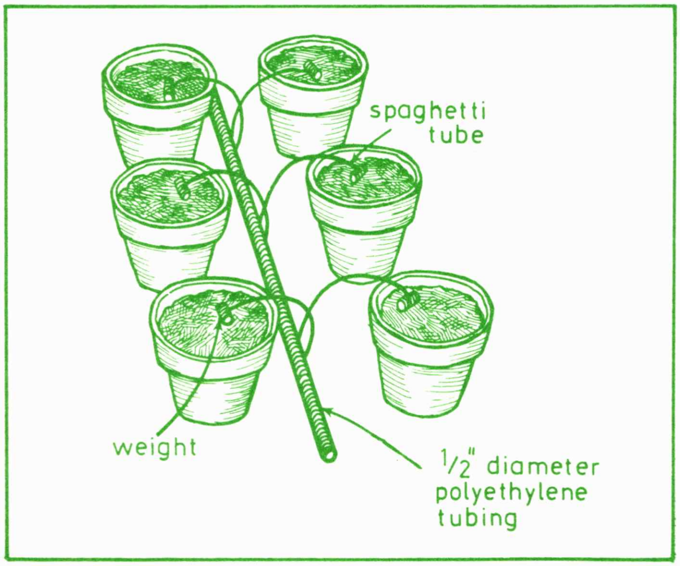


Figure 31. Spaghetti tube watering systems are convenient for potted plants.

A **time switch** wired to a **solenoid valve** automates these systems. Some experimentation is needed to decide how long the water should run. The amount of water needed will depend on the season and the light and temperature conditions.

A **line strainer** should be used with any automatic watering system. The strainer filters out any sand or dirt that might clog up the small holes in the nozzles or tubes.

In winter, some plants may not grow well when watered with cold water. The next day's water supply can be stored in a tank or other container so it will warm to room temperature. If you use a hose or automated system a hot water line and mixing valve can be installed.

Overhead misting increases humidity and cools the greenhouse. High humidities are particularly important for rooting cuttings or, in some cases, germinating seed. Misting nozzles, controlled with a time switch, produce a fine spray to keep humidity high. Nozzles are normally mounted 24″ to 30″ above the bench and spaced 4′ apart. Water pressure of 30 to 60 pounds per square inch is required for proper operation. Usually the nozzles are timed to operate at a ratio of 1 on to 60 off, such as 6 seconds on and 6 minutes off. Air movement, temperature, and water pressure will modify this ratio somewhat. The timer controls a solenoid valve and a day-night timer or manual switch turns off the system at night. A line strainer is essential to avoid plugging the nozzles.

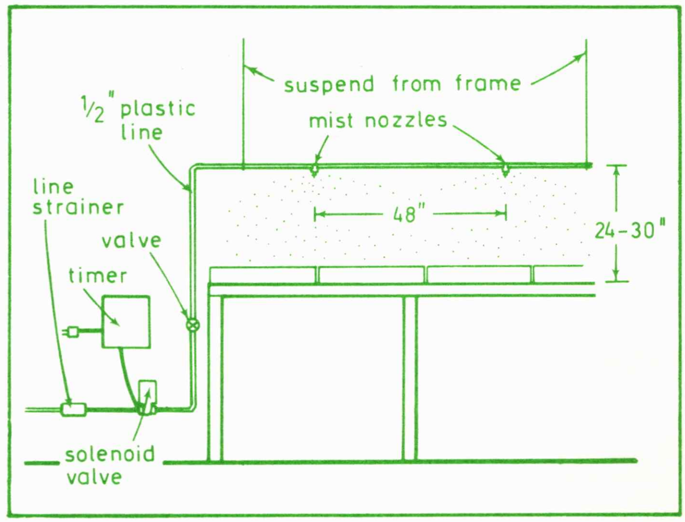
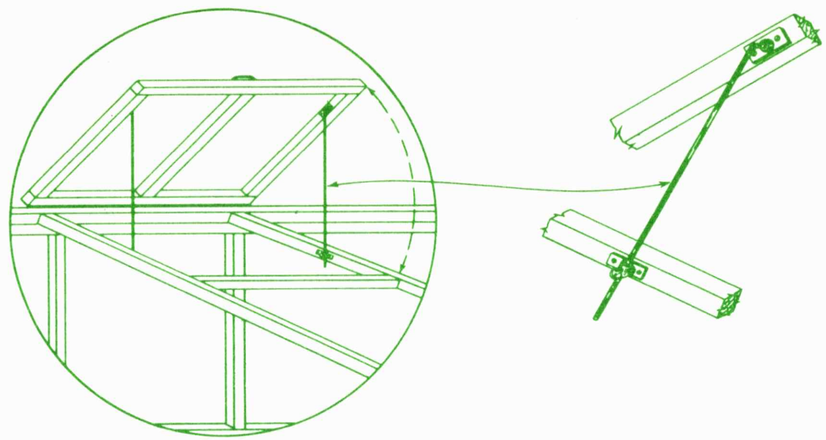


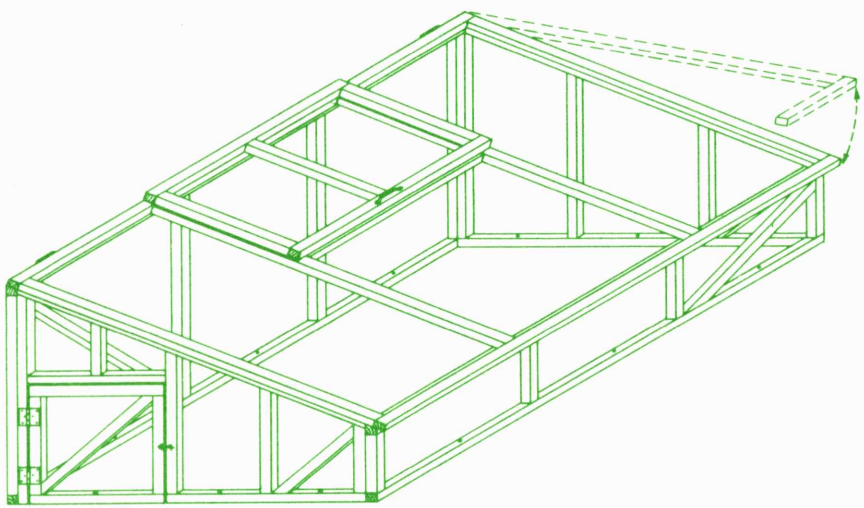
Figure 32. Overhead misting that is automated with a time clock is useful for propagating and summer cooling.

Interest in **hydroponic greenhouse culture** has received renewed interest in recent years. Often hydroponic culture is promoted as a "scientific" method that dramatically increases production. This claim is not generally true. Plant roots are supported in a bed of gravel, sand, or dry inert material. An automated system periodically flushes water with chemical nutrients through the bed. After the bed is filled the pump stops and the solution drains so oxygen, vital to the roots, can filter into the bed. The nutrient solution must be carefully formulated and the frequency of application must be monitored for good plant growth. Hydroponic culture is a precise culture. The inert material in the bed retains nutrients for only a short time, and unlike soil, it will not buffer a solution with too much nutrient chemical. Each plant has different nutrient needs, so only one variety, such as tomatoes, can grow well in a single nutrient solution. Tomatoes and cucumbers are commercially grown with hydroponic culture. It is primarily a curiosity.

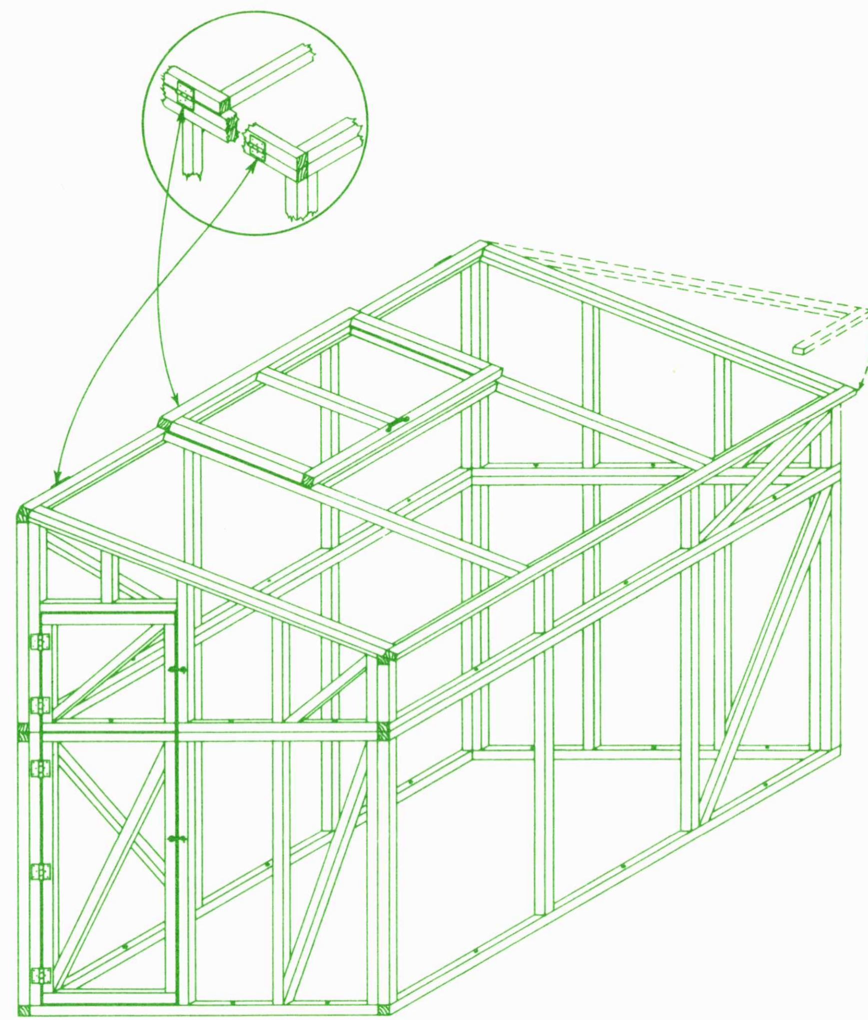
Plans



VENT OPEN



COLDFRAME UNIT



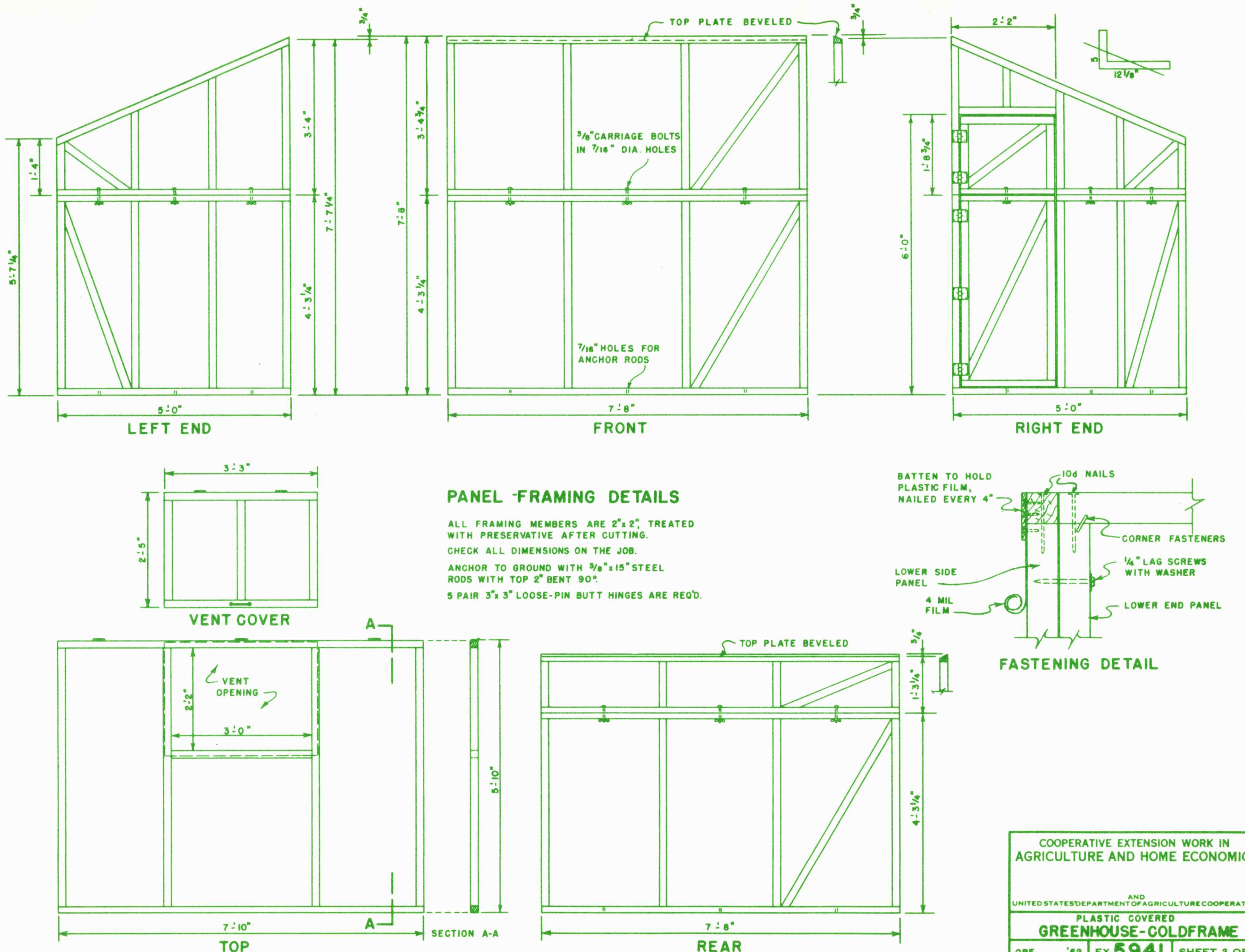
GREENHOUSE ASSEMBLY

COOPERATIVE EXTENSION WORK IN
AGRICULTURE AND HOME ECONOMICS

AND
UNITED STATES DEPARTMENT OF AGRICULTURE COOPERATING

PLASTIC COVERED
GREENHOUSE-COLDFRAME

ORE.	'62	EX. 5941	SHEET 1 OF 2



PANEL - FRAMING DETAILS

ALL FRAMING MEMBERS ARE 2"x 2", TREATED WITH PRESERVATIVE AFTER CUTTING.

CHECK ALL DIMENSIONS ON THE JOB.

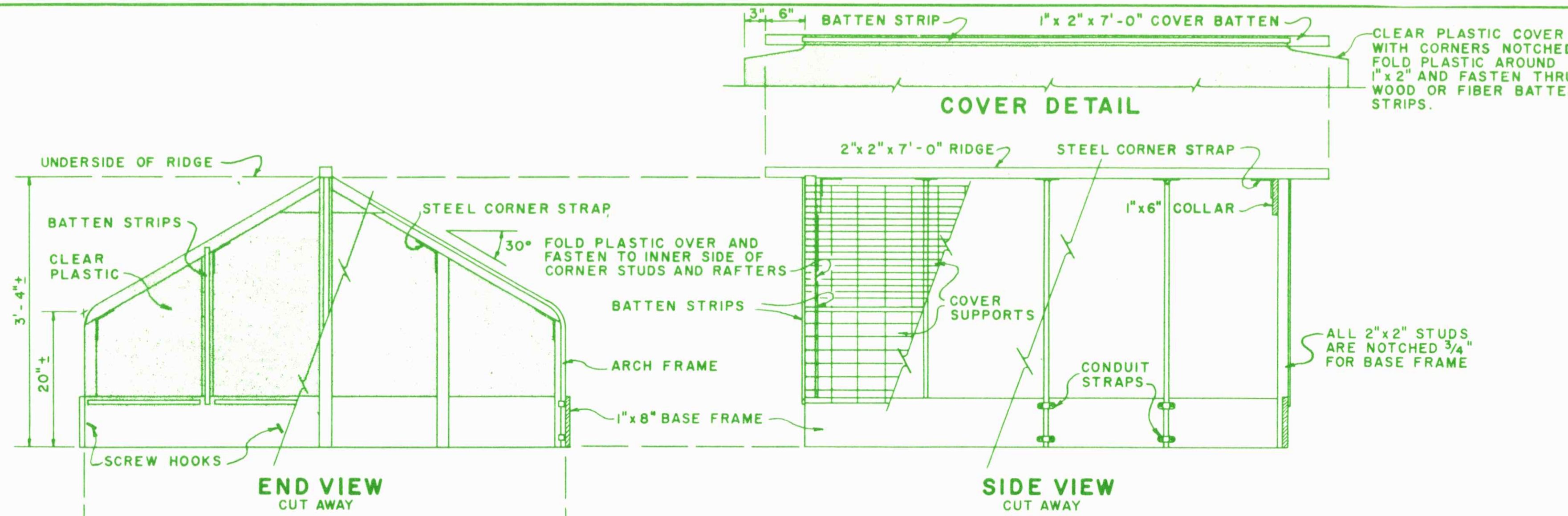
ANCHOR TO GROUND WITH 3/8"x 15" STEEL RODS WITH TOP 2" BENT 90°.

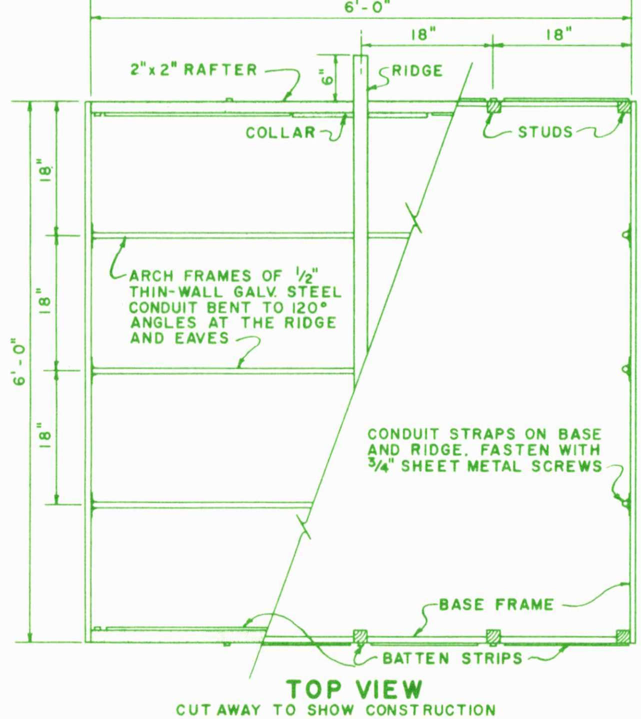
5 PAIR 3"x 3" LOOSE-PIN BUTT HINGES ARE REQ'D.

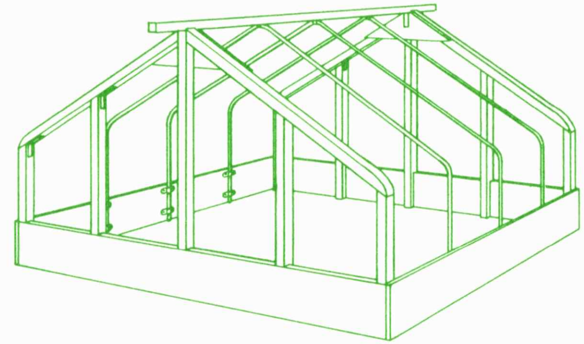
COOPERATIVE EXTENSION WORK IN AGRICULTURE AND HOME ECONOMICS
AND
UNITED STATES DEPARTMENT OF AGRICULTURE COOPERATING

PLASTIC COVERED
GREENHOUSE-COLDFRAME

ORE. '62 | EX. 5941 | SHEET 2 OF 2







PERSPECTIVE VIEW
FRAMING ONLY

MATERIAL LIST

ITEM	QUANTITY	SIZE
BASE FRAME	4 PCS	1" x 8" — 6'-0" LONG
COLLARS	1 "	1" x 6" — 2'-8" "
RIDGE	1 "	2" x 2" — 7'-0" "
RAFTERS	4 "	" — 3'-6" "
STUDS (CENTER)	2 "	" — 3'-4" "
" (OTHER)	4 "	" — 4'-0" "
COVER BATTENS	4 "	1" x 2" — 7'-0" "
ARCH FRAMES	3 "	1/2" DIA. 10'-0" "
CONDUIT STRAPS	15 "	1/2"
CORNER STRAPS	10 "	1/8" x 1" x 6"
PLASTIC (ENDS)	2 "	3'-0" x 6'-6" "
" (COVERS)	2 "	6'-0" x 7'-6" "
COVER SUPPORTS	2 "	3'-0" x 6'-0" "
" "	2 "	1'-4" x 6'-0" "
BATTEN STRIPS		62'-0" "
SCREW HOOKS	8	
FASTENINGS	SEE NOTES	
SOIL HEATING CABLE	1 — 360 W.	120'-0" "

DUE TO POSSIBLE VARIATIONS IN ANGLES WHEN THE CONDUIT IS BENT FOR ARCH FRAMES, CHECK THE HEIGHTS SHOWN USING AN ARCH FRAME AS A TEMPLATE.

ALL WOOD SHOULD BE TREATED WITH PRESERVATIVE AFTER CUTTING AND BEFORE ASSEMBLY.

METAL PARTS AND FASTENINGS TO BE GALVANIZED OR OTHERWISE RESISTANT TO CORROSION.

METAL PARTS TO BE FASTENED WITH SCREWS.

WOOD PARTS MAY BE FASTENED WITH SCREWS OR WITH NAILS, CLINCHED WHERE POSSIBLE.

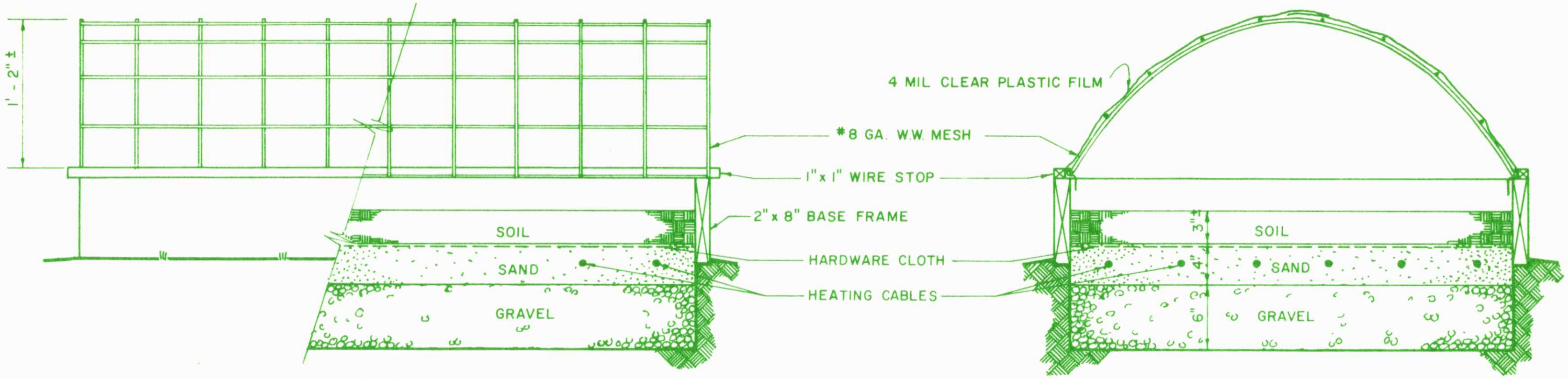
PLASTIC MAY BE FASTENED THRU THE BATTEN STRIPS WITH NAILS, SCREWS OR STAPLES.

SIDE AND TOP COVER SUPPORTS ARE 2 x 4 INCH WELDED WIRE MESH, HOOKED TOGETHER IN PAIRS AND HINGED LOOSELY TO THE RIDGE WITH STRONG CORD.

COOPERATIVE EXTENSION WORK IN AGRICULTURE AND HOME ECONOMICS
AND
UNITED STATES DEPARTMENT OF AGRICULTURE COOPERATING

HOTBED & PROPAGATING FRAME

USDA '64 | EX. 5971 | SHEET 1 OF 1



SIDE VIEW
CUT AWAY

END VIEW
SECTION

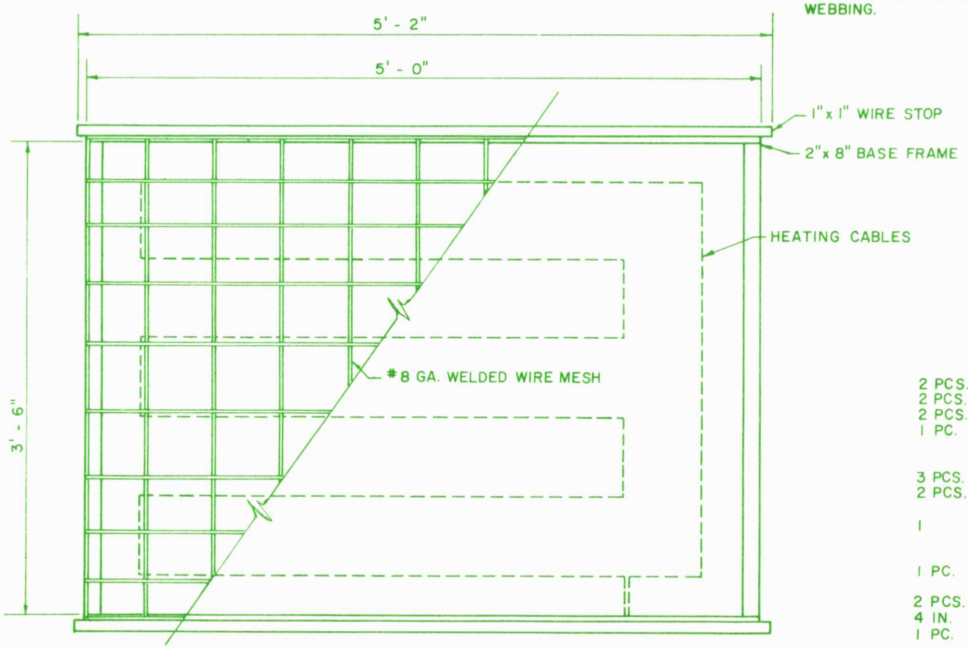
NOTE: SEPARATION OF HEATING CABLES IS VARIABLE TO AMOUNT OF HEAT NEEDED PER SQ. FT. ACCORDING TO GEOGRAPHIC LOCATION. REFER TO LEAFLET NO. 445 U.S.D.A.

ALL WOOD SHOULD BE TREATED WITH PRESERVATIVE AFTER CUTTING AND BEFORE ASSEMBLY.

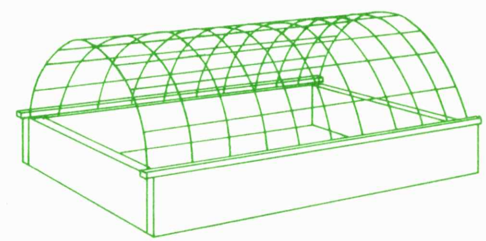
METAL PARTS AND FASTENINGS TO BE GALVANIZED OR OTHERWISE RESISTANT TO CORROSION.

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

MATERIAL LIST

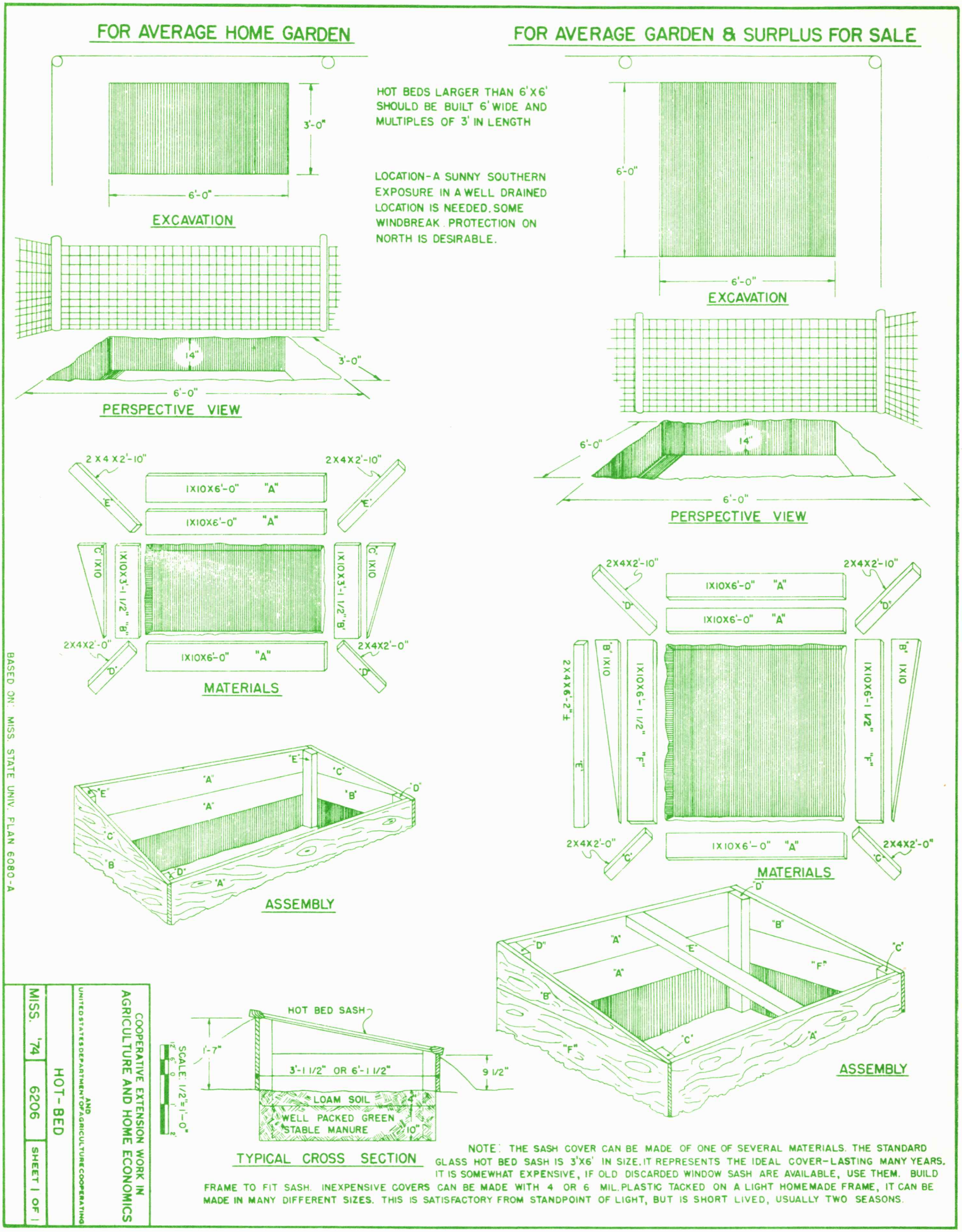
2 PCS.	2"x 8"- 5' LONG FOR SIDES
2 PCS.	2"x 8"- 3' - 6" LONG FOR ENDS
2 PCS.	1"x 1" WIRE STOP - 5'-2" LONG FOR SIDES
1 PC.	NO. 8 GAUGE 6"x6" WELDED WIRE, 5' LONG 4' - 6" WIDE FOR TOP OF WOOD FRAME TO SUPPORT PLASTIC FILM.
3 PCS.	PLASTIC WEBBING 2" WIDE - 5' LONG
2 PCS.	PLASTIC FILM, 4 MIL, CLEAR 3' WIDE 7' LONG.
1	360-WATT SOIL HEATING CABLE, THERMOSTATICALLY CONTROLLED TO SHUT OFF AT 70°F.
1 PC.	WHITE PLASTIC FILM, 4 MIL, 5'x8' FOR COVERING FRAME DURING WINTER.
2 PCS.	CHEESECLOTH, 3'x7'
4 IN.	SAND - 2" ABOVE, 2" BELOW HEATING CABLE
1 PC.	1/2" HARDWARE CLOTH, 5' x 3 1/2'

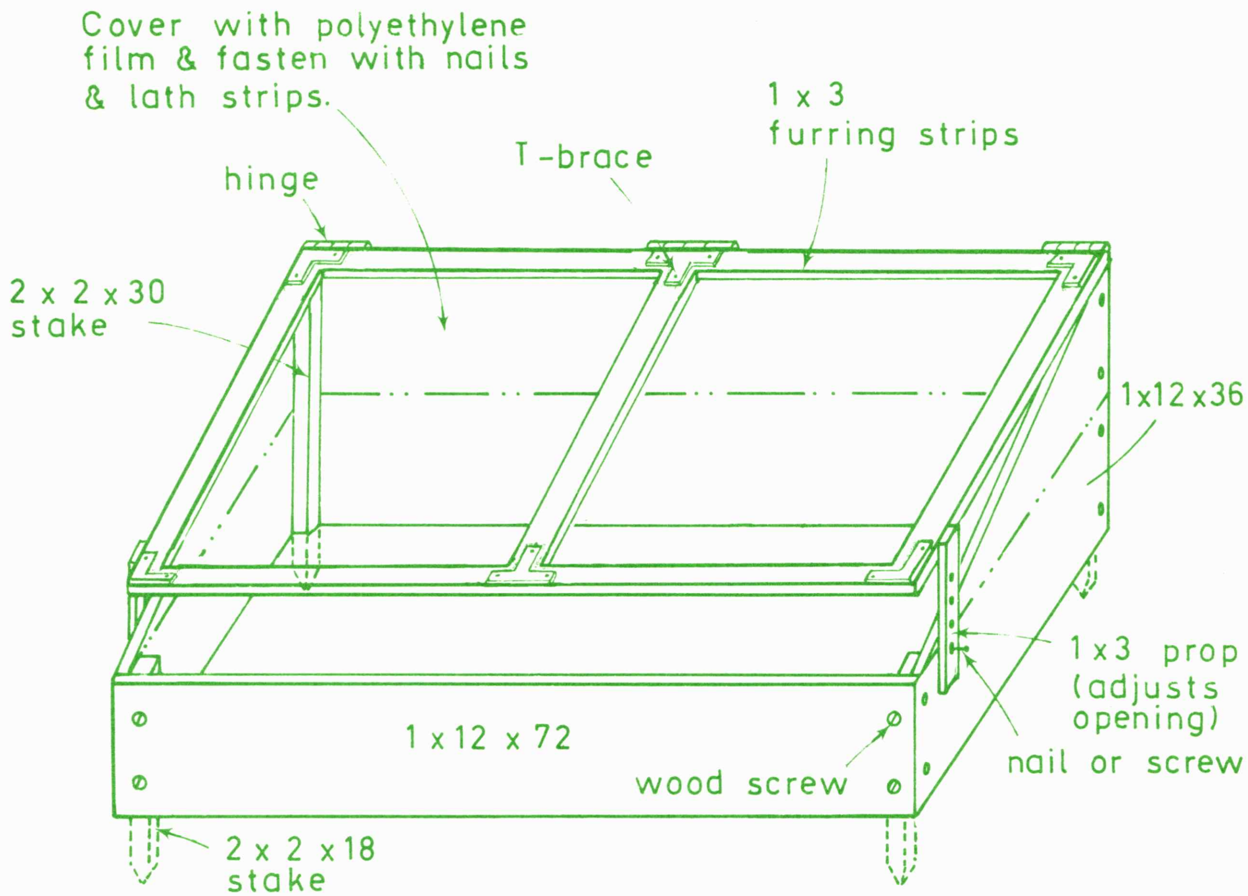
DESIGNED IN COOPERATION WITH: CROPS RESEARCH DIVISION

COOPERATIVE EXTENSION WORK IN AGRICULTURE AND HOME ECONOMICS
AND
UNITED STATES DEPARTMENT OF AGRICULTURE COOPERATING

MINI-HOTBED AND PROPAGATING FRAME

U.S.D.A. '69	6080	SHEET 1 OF 1


FOR AVERAGE HOME GARDEN
FOR AVERAGE GARDEN & SURPLUS FOR SALE
3'-0"
6'-0"
EXCAVATION
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.
6'-0"
6'-0"
EXCAVATION
14"
3'-0"
6'-0"
PERSPECTIVE VIEW
6'-0"
14"
6'-0"
PERSPECTIVE VIEW
2X4X2'-10"
2X4X2'-10"
1X10X6'-0" "A"
1X10X6'-0" "A"
'E'
'E'
'C' 1X10
1X10X3'-1 1/2" 'B'
1X10X3'-1 1/2" 'B'
'C' 1X10
2X4X2'-0"
'D'
1X10X6'-0" "A"
2X4X2'-0"
'D'
MATERIALS
2X4X2'-10"
2X4X2'-10"
1X10X6'-0" "A"
1X10X6'-0" "A"
'D'
'D'
2X4X6'-2"±
'E'
'B' 1X10
1X10X6'-1 1/2" "F"
1X10X6'-1 1/2" "F"
'B' 1X10
2X4X2'-0"
'C'
1X10X6'-0" "A"
2X4X2'-0"
'C'
MATERIALS
BASED ON: MISS. STATE UNIV. PLAN 6080-A
'E'
'C'
'D'
'A'
'B'
'A'
'E'
'C'
'B'
'D'
'A'
ASSEMBLY
'D'
'B'
'A'
'E'
'C'
"D"
"F"
'A'
'B'
"F"
'C'
'A'
ASSEMBLY
COOPERATIVE EXTENSION WORK IN AGRICULTURE AND HOME ECONOMICS
UNITED STATES DEPARTMENT OF AGRICULTURE COOPERATING AND
HOT-BED
MISS.
'74
6206
SHEET 1 OF 1
SCALE: 1/2"=1'-0"
HOT BED SASH
1'-7"
3'-1 1/2" OR 6'-1 1/2"
9 1/2"
LOAM SOIL
4"
WELL PACKED GREEN STABLE MANURE
10"
TYPICAL CROSS SECTION
NOTE: THE SASH COVER CAN BE MADE OF ONE OF SEVERAL MATERIALS. THE STANDARD GLASS HOT BED SASH IS 3'X6' IN SIZE. IT REPRESENTS THE IDEAL COVER-LASTING MANY YEARS. IT IS SOMEWHAT EXPENSIVE, IF OLD DISCARDED WINDOW SASH 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.



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 1 1/2-inch FH wood screws
3	3/4x3-inch butt hinges
3 oz.	3/4-inch wire nails
4'x6'	6 mil polyethylene film
1/2 gal	copper naphthanate wood preservative
1 qt.	white paint

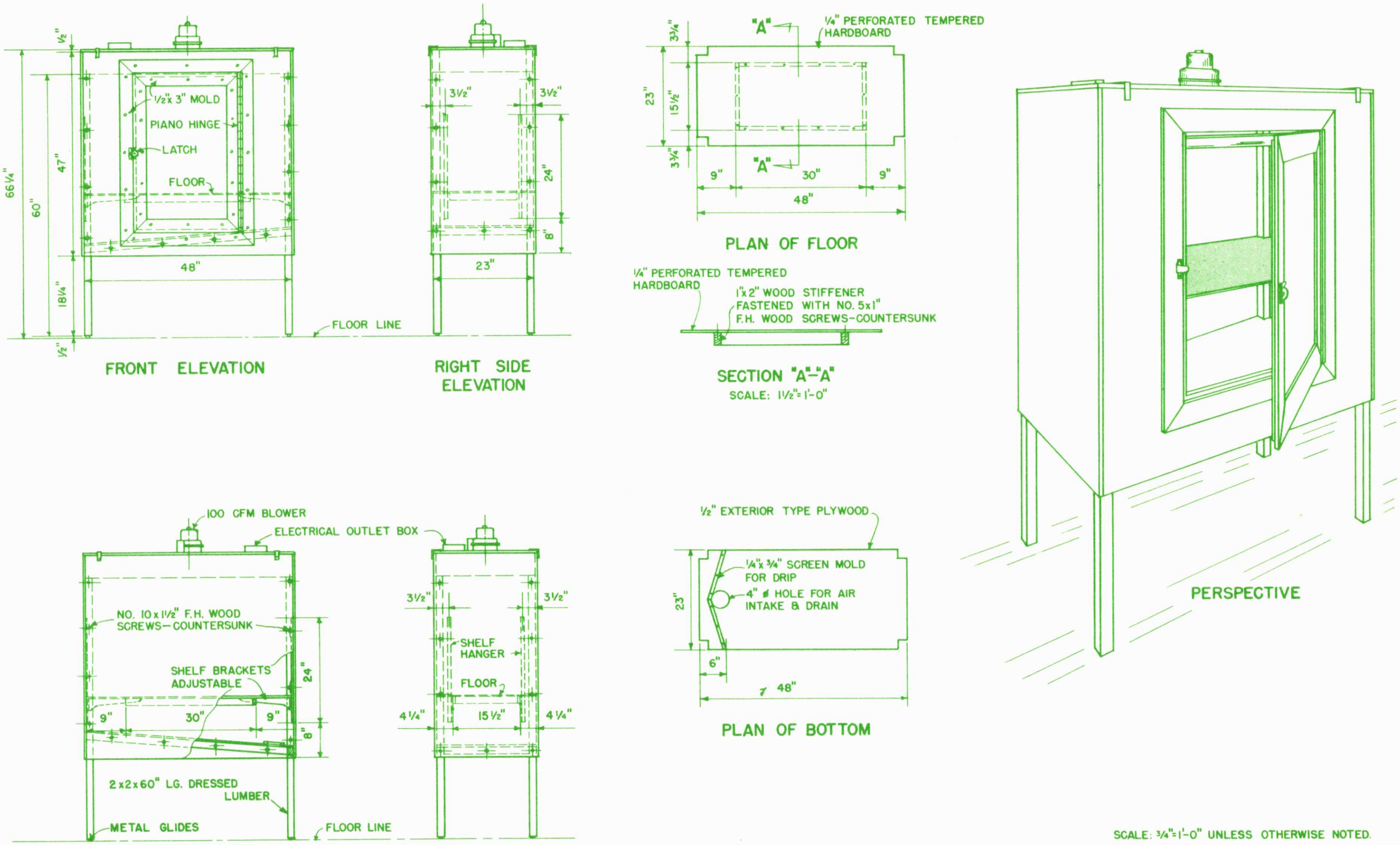
CONSTRUCTION NOTES

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)

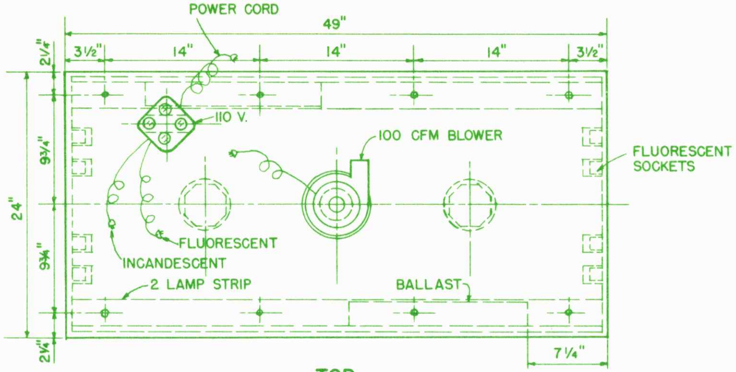
All dimensions in inches.



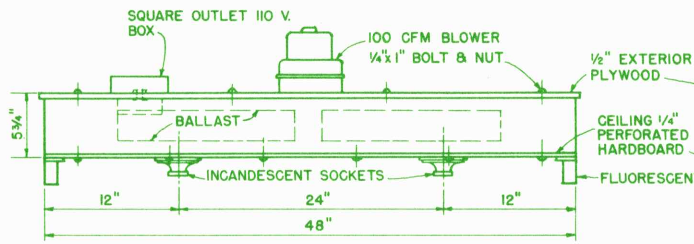
NOTES:
SCREWS THRU-OUT TO BE FLAT HEADED (F.H.) AND COUNTERSUNK.
ALL FRAMING MEMBERS TO BE 2"x2" DRESSED LUMBER.
BOTTOM OF CHAMBER SLOPES, TO DRAIN OFF ANY SPILLAGE OF WATER.
FLOOR IS ADJUSTABLE.

SCALE: ¾"=1'-0" UNLESS OTHERWISE NOTED.

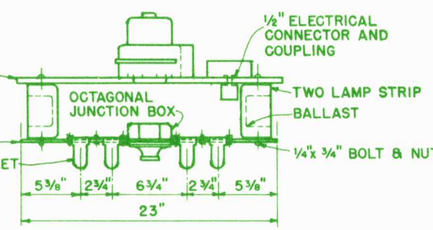
COOPERATIVE EXTENSION WORK IN AGRICULTURE AND HOME ECONOMICS AND UNITED STATES DEPARTMENT OF AGRICULTURE COOPERATING
PLANT GROWTH CHAMBER ROOMETTE
USDA '66 EX. 5980 SHEET 1 OF 2



TOP
SCALE: 1½"= 1'- 0"



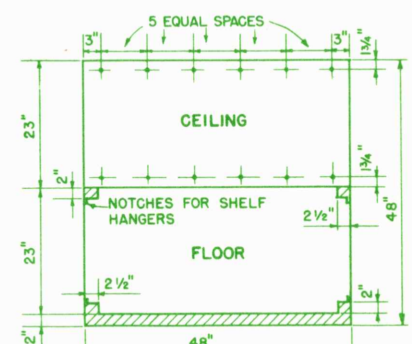
SIDE
SCALE: 1½"= 1'-0"



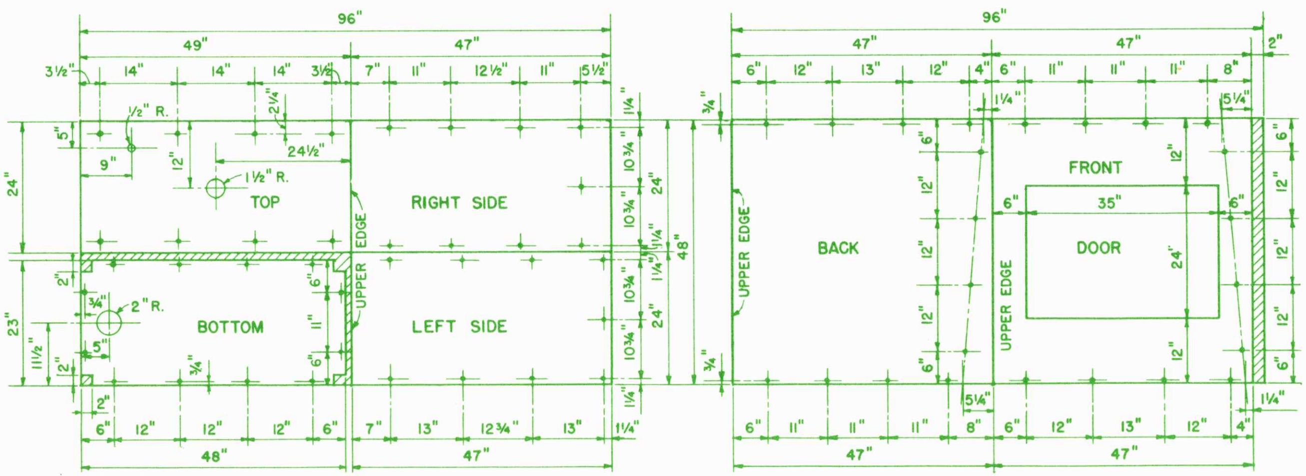
END
SCALE: 1½"= 1'-0"

MATERIAL LIST

2 PIECES EXTERIOR PLYWOOD ½"x 4'x 8'
1 PIECE PERFORATED TEMPERED HARDBOARD ¼"x 4'x 4'
2 PIECES MOLDING ½"x 3"x 12'
1 PIECE SCREEN MOLDING ¼"x ¾"x 2'
1 PIECE WOOD STIFFENER 1"x 2"x 8'
2 PIECES DRESSED LUMBER, LEGS & FRAME, 2"x 2"x 12'
1 PIECE DRESSED LUMBER, FRAME, 2"x 2"x 8'
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"x 2⅛"x 1⅞"
1 ELECTRICAL CONNECTOR & COUPLING ½"
2 FLUORESCENT LAMP STRIPS
4 FLUORESCENT LAMP SOCKETS
2 OCTAGONAL JUNCTION BOXES
2 INCANDESCENT SOCKETS
4 STEEL ANGLES 2"x 2"x ¾"x ⅛"
8 F.H. WOOD SCREWS NO. 3 x ½"
36 F.H. BRASS COATED WOOD SCREWS NO. 3 x ⅝"
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 ⅞"
8 BOLTS & NUTS ¼"x 1"
12 BOLTS & NUTS ¼"x ¾"



CUTTING DIAGRAM
¼" PERFORATED TEMPERED HARDBOARD

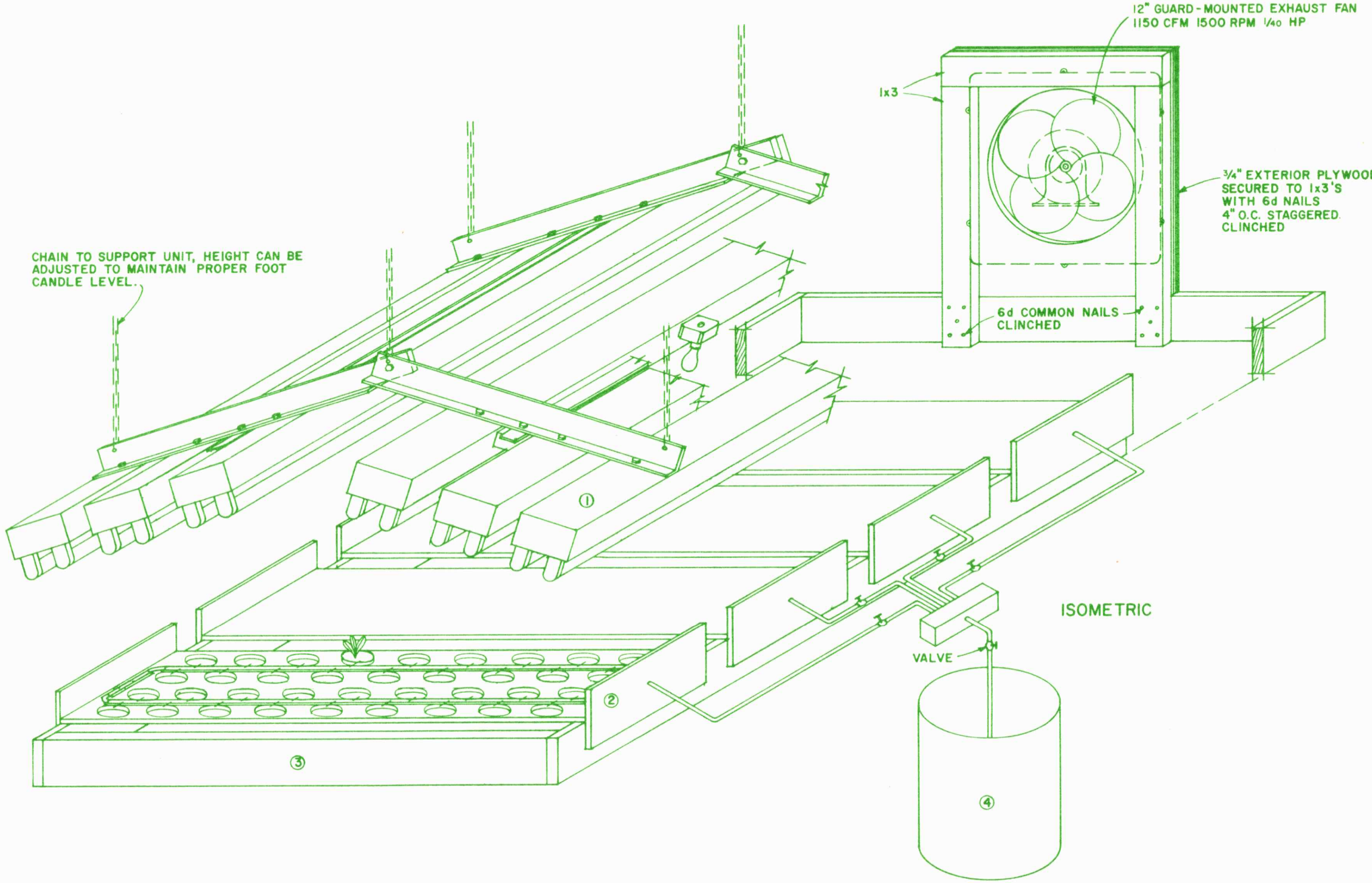


CUTTING DIAGRAM
½" EXTERIOR TYPE PLYWOOD

NOTE: ✛ DENOTES LOCATION OF COUNTERSUNK SCREWS.

SCALE: ¾"=1'-0" UNLESS OTHERWISE NOTED.

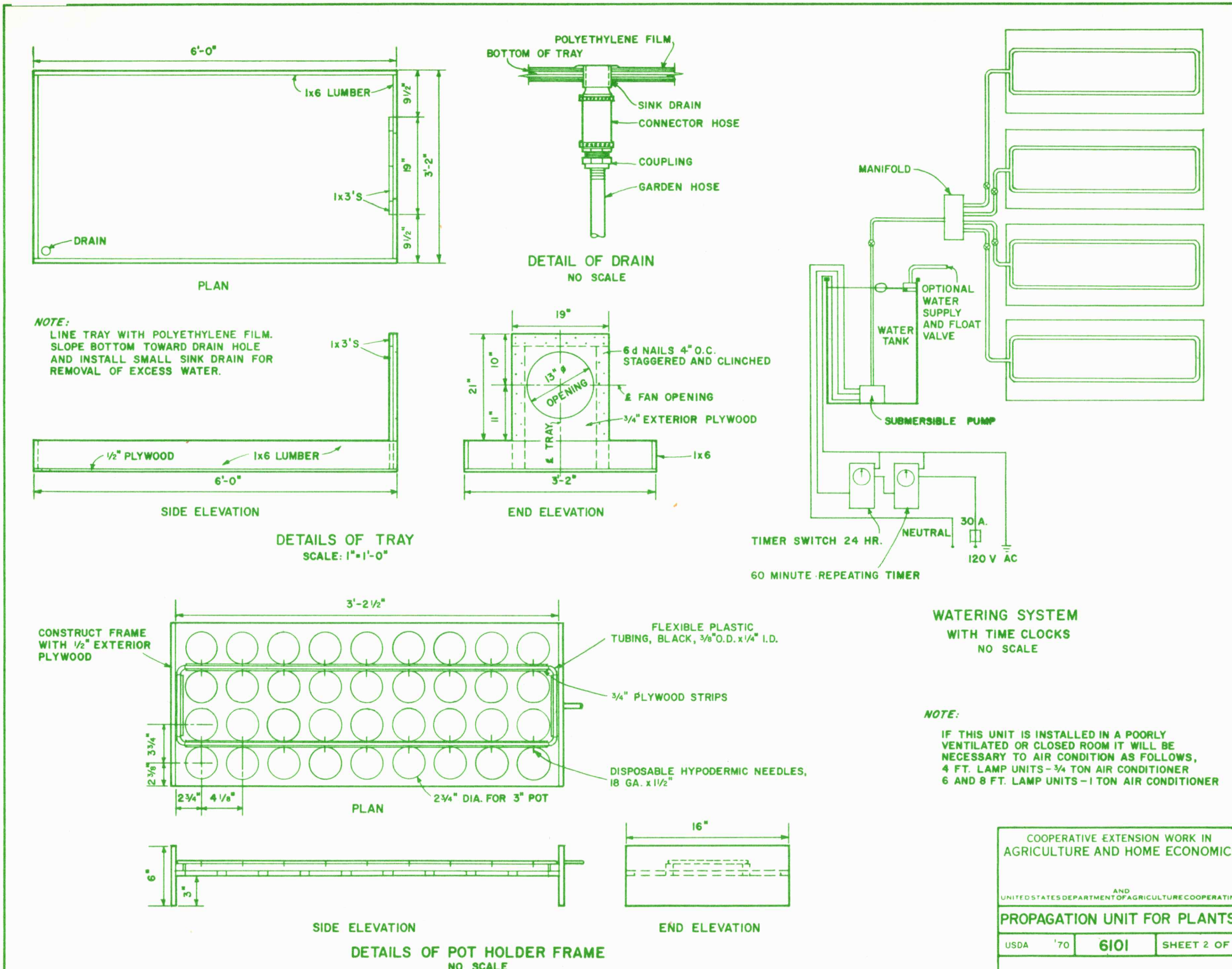
COOPERATIVE EXTENSION WORK IN AGRICULTURE AND HOME ECONOMICS AND UNITED STATES DEPARTMENT OF AGRICULTURE COOPERATING
PLANT GROWTH CHAMBER ROOMETTE
USDA '66 | EX. 5980 | SHEET 2 OF 2

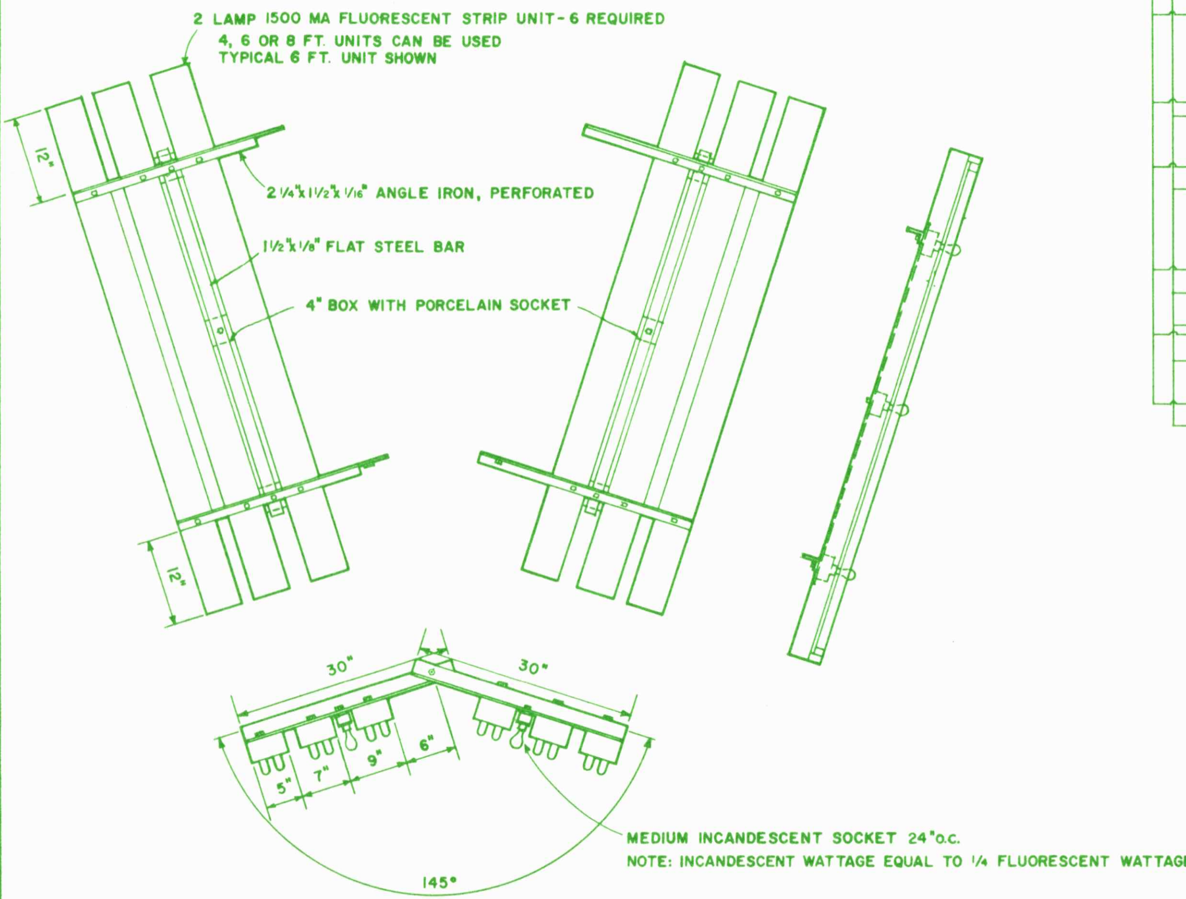


NOTES:

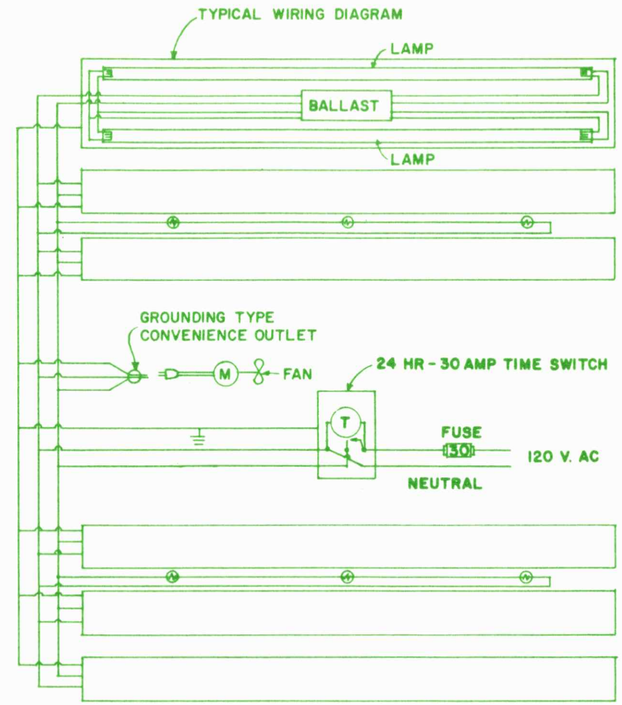
① LAMP UNIT WITH TIME CLOCK (SEE SHEET 3)
② POT HOLDER FRAME (SEE SHEET 2)
③ TRAY (SEE SHEET 2)
④ WATERING SYSTEM WITH TIME CLOCK (SEE SHEET 2)

COOPERATIVE EXTENSION WORK IN AGRICULTURE AND HOME ECONOMICS AND UNITED STATES DEPARTMENT OF AGRICULTURE COOPERATING		
PROPAGATION UNIT FOR PLANTS		
USDA '70	6101	SHEET 1 OF 3


6'-0"
1x6 LUMBER
9 1/2"
19"
3'-2"
1x3'S
DRAIN
PLAN
NOTE:
LINE TRAY WITH POLYETHYLENE FILM. SLOPE BOTTOM TOWARD DRAIN HOLE AND INSTALL SMALL SINK DRAIN FOR REMOVAL OF EXCESS WATER.
1/2" PLYWOOD
SIDE ELEVATION
DETAILS OF TRAY
SCALE: 1"=1'-0"
POLYETHYLENE FILM
BOTTOM OF TRAY
SINK DRAIN
CONNECTOR HOSE
COUPLING
GARDEN HOSE
DETAIL OF DRAIN
NO SCALE
10"
11"
21"
13" ϕ OPENING
6 d NAILS 4" O.C. STAGGERED AND CLINCHED
℄ FAN OPENING
3/4" EXTERIOR PLYWOOD
℄ TRAY
1x6
END ELEVATION
MANIFOLD
OPTIONAL WATER SUPPLY AND FLOAT VALVE
WATER TANK
SUBMERSIBLE PUMP
TIMER SWITCH 24 HR.
NEUTRAL
30 A.
120 V AC
60 MINUTE REPEATING TIMER
WATERING SYSTEM
WITH TIME CLOCKS
NO SCALE
NOTE:
IF THIS UNIT IS INSTALLED IN A POORLY VENTILATED OR CLOSED ROOM IT WILL BE NECESSARY TO AIR CONDITION AS FOLLOWS,
4 FT. LAMP UNITS - 3/4 TON AIR CONDITIONER
6 AND 8 FT. LAMP UNITS - 1 TON AIR CONDITIONER
3'-2 1/2"
CONSTRUCT FRAME WITH 1/2" EXTERIOR PLYWOOD
FLEXIBLE PLASTIC TUBING, BLACK, 3/8" O.D. x 1/4" I.D.
3/4" PLYWOOD STRIPS
DISPOSABLE HYPODERMIC NEEDLES, 18 GA. x 1 1/2"
2 3/4" DIA. FOR 3" POT
2 3/8"
3 3/4"
2 3/4"
4 1/8"
PLAN
6"
3"
16"
SIDE ELEVATION
END ELEVATION
DETAILS OF POT HOLDER FRAME
NO SCALE
COOPERATIVE EXTENSION WORK IN AGRICULTURE AND HOME ECONOMICS
AND
UNITED STATES DEPARTMENT OF AGRICULTURE COOPERATING
PROPAGATION UNIT FOR PLANTS
USDA
'70
6101
SHEET 2 OF 3



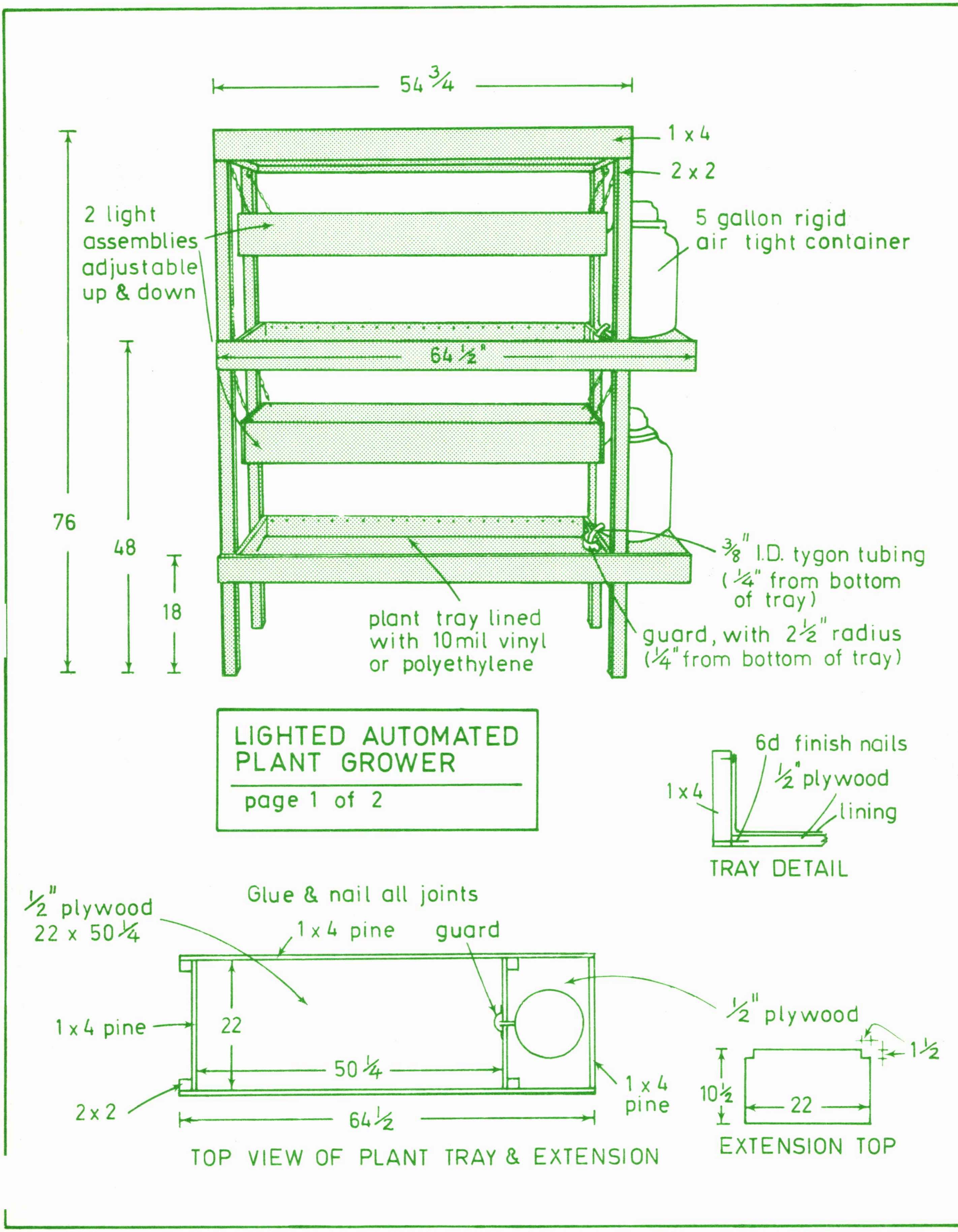
LAMP UNIT
SCALE: 1" = 1'-0"



WIRING SCHEMATIC
NO SCALE

NOTE: ALL WIRING MUST MEET THE LOCAL AND NATIONAL ELECTRICAL CODES

COOPERATIVE EXTENSION WORK IN AGRICULTURE AND HOME ECONOMICS AND UNITED STATES DEPARTMENT OF AGRICULTURE COOPERATING		
PROPAGATION UNIT FOR PLANTS		
USDA '70	6101	SHEET 3 OF 3


54 3/4
1 x 4
2 x 2
2 light assemblies adjustable up & down
5 gallon rigid air tight container
64 1/2"
76
48
18
3/8" I.D. tygon tubing (1/4" from bottom of tray)
plant tray lined with 10mil vinyl or polyethylene
guard, with 2 1/2" radius (1/4" from bottom of tray)
LIGHTED AUTOMATED PLANT GROWER
page 1 of 2
6d finish nails
1/2" plywood
1 x 4
lining
TRAY DETAIL
1/2" plywood 22 x 50 1/4
Glue & nail all joints
1 x 4 pine
guard
1/2" plywood
1 x 4 pine
22
50 1/4
1 x 4 pine
2 x 2
64 1/2
1 1/2
10 1/2
22
EXTENSION TOP
TOP VIEW OF PLANT TRAY & EXTENSION

MATERIALS

Lumber

Frame

No.	Item	Material
4	legs	2x2x76-inch lumber
4	sides	1x4x64 1/2-inch lumber
2	top sides	1x4x54 3/4-inch lumber
8	ends	1x4x22-inch lumber
2	tray bottoms	1/2x22x50 1/4-inch A-C exterior plywood

Lamps and Shields

No.	Item	Material
4	ends	1x4x20-inch lumber
4	sides	1/4x5 1/2x50 1/2-inch plywood
2	tops	1/8x19 1/2x50 1/2-inch pegboard or 1/4" plywood
	cleats	3/4x3/4-inch Pine, 25 lineal feet

Automated Waterers

- 2 — 5 gal polyethylene aspirator bottles or 5 gal round gas can (solder 3/8-inch OD copper tube at bottom)
- 1 ft — 3/8" ID tygon tubing
- 2 — tubing shut off clamps
- 2 pcs — 2 1/2x12-inch light aluminum or galvanized metal shield strip

Hardware and Miscellaneous

Frame

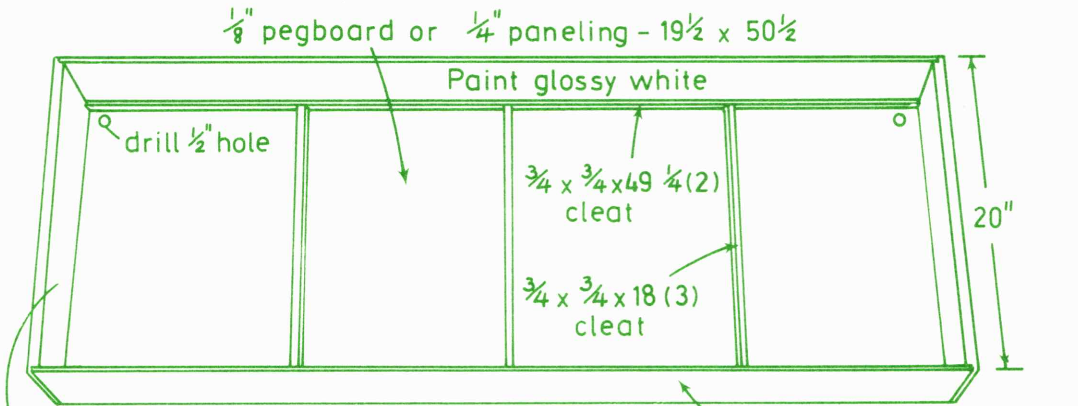
- 56 — #8x1 1/2" FH wood screws and glue to assemble main frame
- Glue and nails to assemble other parts
- 2 pcs 10 mil vinyl or polyethylene film, 30x59 in.
- 1 small box upholstery tacks

Lamps and Shields

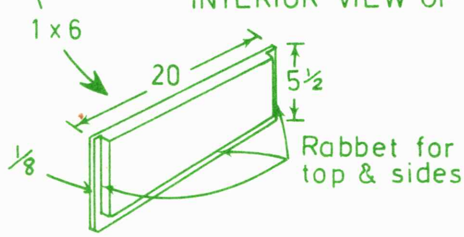
- Glue and nails to assemble shields
- 2 pcs 24x48-inch, 16 gauge, galvanized sheet metal for lamp assembly
- 12 ft light weight chain
- 8 — 3/8-inch IDx5/32-inch shank eye bolts to hang lamp assemblies
- 8 — 5/32-inch shank screw-in hooks to hang lamp assemblies

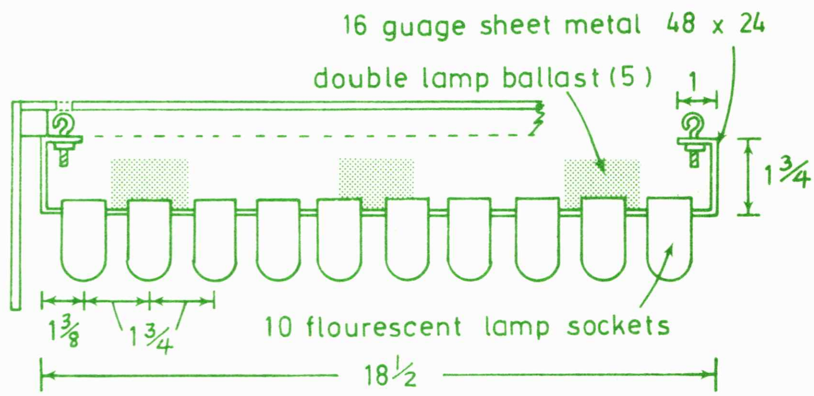
Electrical

- 10 — 40W fluorescent rapid start ballast kits, including lamp holders and wire
- 20 — 40W cool white fluorescent lamps
- 12 ft 16 gauge 2 wire with ground, flexible cord, and two plugs
- 1 — electrical timer, 15 amp
- 20 — electrical connectors



INTERIOR VIEW OF LAMP SHIELD





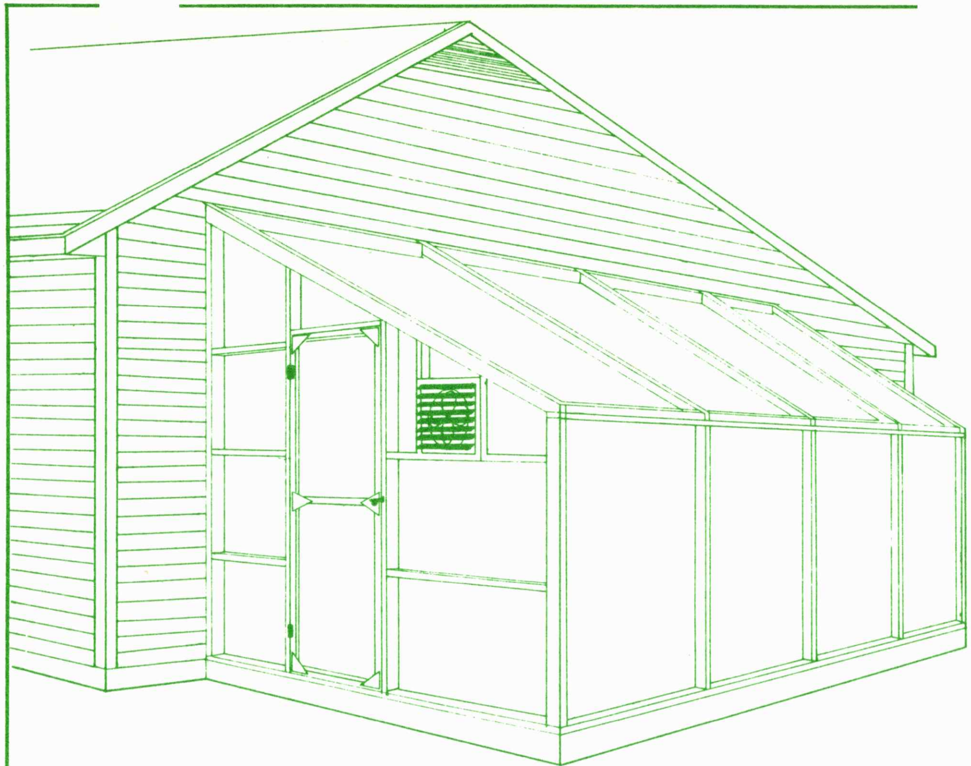
LAMP FIXTURE & SHIELD

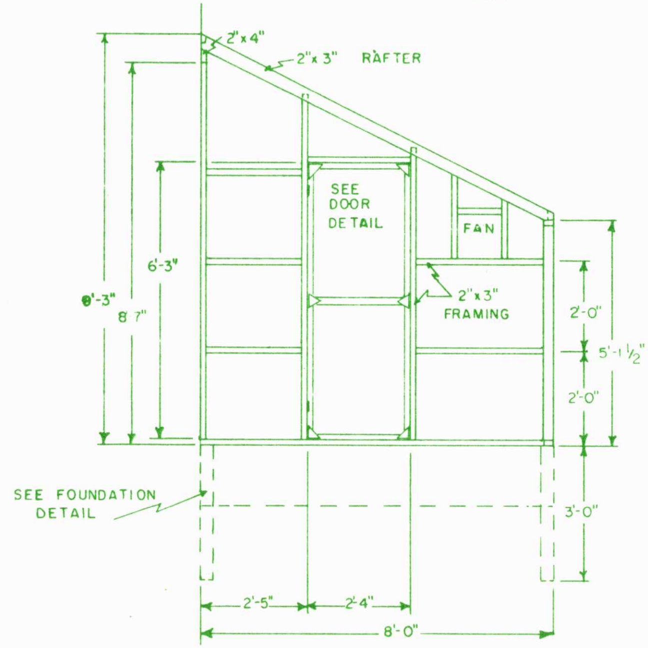
LIGHTED AUTOMATED PLANT GROWER

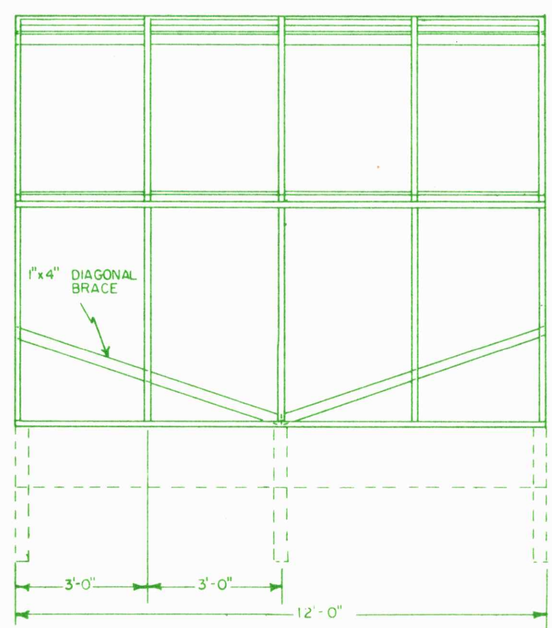
based on Grower Plan No.4 shown in Cornell University Information Bulletin 40

page 2 of 2

Dimensions in inches unless otherwise noted.







CONSTRUCTION NOTES

GENERAL

SELECT A LEVEL, WELL DRAINED SITE.
PREFERRED LOCATION: SOUTH OR SOUTHEAST, EAST, WEST.
PAINT POSTS, BENCHES AND LUMBER THAT IS NEAR THE GROUND WITH THREE COATS OF COPPER NAPTHENATE WOOD PRESERVATIVE.

FRAME

USE CONSTRUCTION GRADE FIR LUMBER.
PAINT FRAME WITH AN EXTERIOR WHITE PAINT.
DOOR CAN BE PLACED AT EITHER END.
USE FLASHING BETWEEN HOUSE WALL AND GREENHOUSE ROOF.
CAULK ALL CRACKS.

COVERING

ROUND AND SMOOTH ALL EDGES
FOR SPRING AND FALL USE,
USE SINGLE LAYER OF 6 MIL POLYETHYLENE PLASTIC HELD IN PLACE BY 1"x2" FIRRING STRIPS.
FOR YEAR AROUND USE 2 LAYERS OF POLYETHYLENE WITH UV INHIBITOR SEPARATED BY A 2"x2" SPACER.
PLASTIC SHOULD BE APPLIED IN SEPTEMBER OR OCTOBER.
5 OZ. CLEAR FIBERGLASS CAN BE USED AS A COVERING TO REDUCE MAINTENANCE.

WALKS

A CENTER WALK OF PEA STONE OR BRICKS LAID IN SAND CAN BE ADDED AFTER THE GREENHOUSE IS BUILT.

VENTILATION

A 10 INCH DIAMETER FAN WITH AUTOMATIC BLOWER AND THERMOSTAT SHOULD BE USED.
LOCATE A 10 OR 12 INCH INTAKE LOUVER ON OPPOSITE END WALL.
PLACE THERMOSTAT ALONG SIDE WALL NEAR PLANT LEVEL.

HEAT

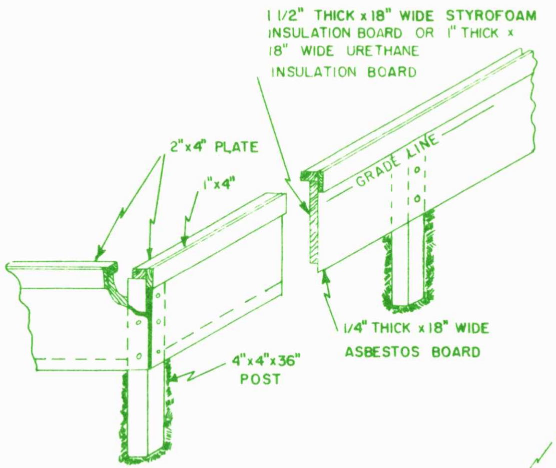
HEAT MAY BE SUPPLIED FROM THE HOME HEATING SYSTEM OR FROM A SEPARATE HEATER. OUTPUT REQUIRED CAN BE OBTAINED FROM THE FOLLOWING TABLE.

MINIMUM OUTSIDE TEMPERATURE °F	SINGLE LAYER PLASTIC OR FIBERGLASS BTU/HR			DOUBLE LAYER PLASTIC BTU/HR		
30°	8960	13780	17820	5940	9160	11900
20°	13780	17820	22360	9160	11900	15340
10°	17820	22360	26780	11900	15340	17800
0°	22360	26780	31200	15340	17800	20800
-10°	26780	31200	35750	17800	20800	23720
MINIMUM NIGHT TEMPERATURE	50°	60°	70°	50°	60°	70°

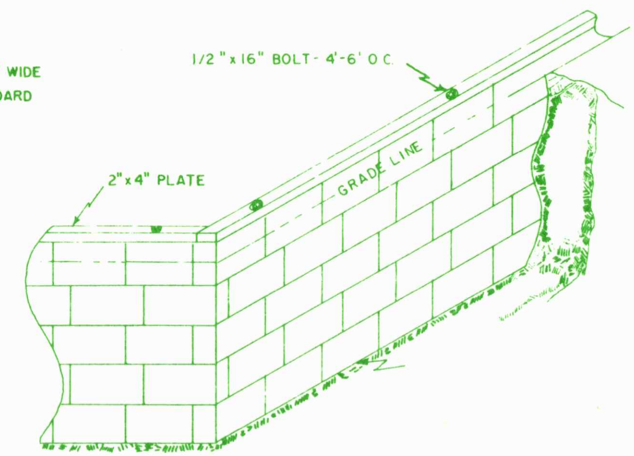
COOPERATIVE EXTENSION WORK IN
AGRICULTURE AND HOME ECONOMICS
AGRICULTURAL ENGINEERING DEPARTMENT
UNIVERSITY OF CONNECTICUT
STORRS, CONNECTICUT
AND
U. S. DEPARTMENT OF AGRICULTURE COOPERATING

8' x 12' LEAN-TO GREENHOUSE

DR. BY JWB	CK. BY	SHEET 1 OF 2
SCALE 1/2" = 1'-0	DATE 11-28-72	PLAN # 248



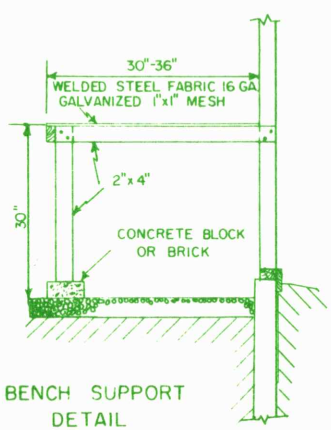
POST FOUNDATION DETAIL



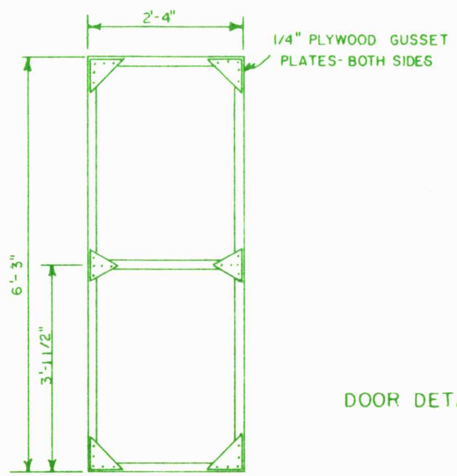
CEMENT BLOCK FOUNDATION
(ALTERNATE METHOD)

BILL OF MATERIALS

QUANTITY	ITEM	LOCATION
5 PCS	4"x 4" x 3'	POSTS
5 PCS	2"x3"x14'	RAFTER AND SIDEWALL
1 PC	2"x4"x12'	HOUSE WALL PLATE
3 PCS	2"x3"x12'	BASE
2 PCS	2"x3"x8'	BASE
10 PCS	2"x3"x10'	END WALLS
2 PCS	2"x2"x12'	DOOR
	1/4" EXTERIOR PLYWOOD SCRAPS	DOOR
1 PC	1"x 4"x14'	DIAGONAL BRACE
200 LIN. FT.	1"x 2" FIRRING STRIPS	BATTENS
1/2 GALLON	COPPER NAPTHENATE WOOD PRESERVATIVE	BASE
1 GALLON	WHITE EXTERIOR PAINT	ALL FRAMEWORK
1 PR	3" STEEL BUTT HINGES	DOOR
1	DOOR LATCH	DOOR
1 ROLL	10'x50' 6 MIL POLYETHYLENE PLASTIC	COVERING-SINGLE LAYER
3 LBS	10 D GALVANIZED COMMON NAILS	FRAME
2 LBS	6 D DUPLEX HEAD NAILS	BATTENS



BENCH SUPPORT DETAIL

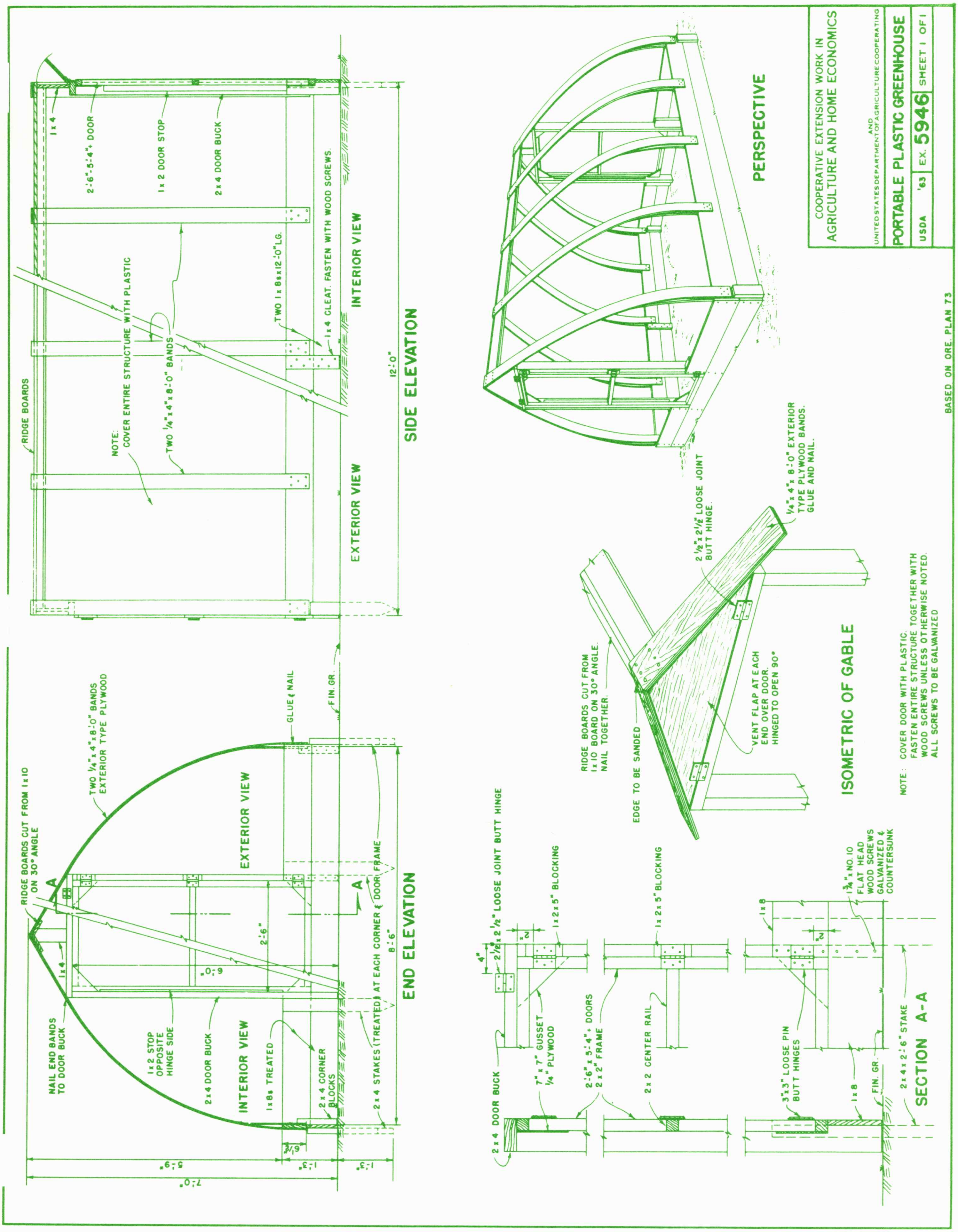


DOOR DETAIL

COOPERATIVE EXTENSION WORK IN
AGRICULTURE AND HOME ECONOMICS
AGRICULTURAL ENGINEERING DEPARTMENT
UNIVERSITY OF CONNECTICUT
STORRS, CONNECTICUT
AND
U. S. DEPARTMENT OF AGRICULTURE COOPERATING

8'x12' LEAN-TO GREENHOUSE

DR. BY JWS	CK. BY	SHEET 2 OF 2
SCALE 1/2"=1'0"	DATE 11-28-72	PLAN # 248


COOPERATIVE EXTENSION WORK IN AGRICULTURE AND HOME ECONOMICS
UNITED STATES DEPARTMENT OF AGRICULTURE COOPERATING
PORTABLE PLASTIC GREENHOUSE
USDA '63 EX. 5946 SHEET 1 OF 1
BASED ON ORE. PLAN 73
PERSPECTIVE
SIDE ELEVATION
INTERIOR VIEW
EXTERIOR VIEW
1 x 4
2'-6" - 5'-4" DOOR
1 x 2 DOOR STOP
2 x 4 DOOR BUCK
TWO 1 x 8 x 12'-0" LG.
1 x 4 CLEAT. FASTEN WITH WOOD SCREWS.
RIDGE BOARDS
NOTE: COVER ENTIRE STRUCTURE WITH PLASTIC
TWO 1/4" x 4" x 8'-0" BANDS
12'-0"
END ELEVATION
RIDGE BOARDS CUT FROM 1 x 10 ON 30° ANGLE
TWO 1/4" x 4" x 8'-0" BANDS EXTERIOR TYPE PLYWOOD
GLUE & NAIL
FIN. GR.
NAIL END BANDS TO DOOR BUCK
1 x 4
1 x 2 STOP OPPOSITE HINGE SIDE
2 x 4 DOOR BUCK
1 x 8s TREATED
2 x 4 CORNER BLOCKS
2 x 4 STAKES (TREATED) AT EACH CORNER & DOOR FRAME
2'-6"
6'-0"
8'-6"
5'-9"
1'-3"
1'-3"
7'-0"
6 1/2"
A
A
ISOMETRIC OF GABLE
2 1/2" x 2 1/2" LOOSE JOINT BUTT HINGE.
1/4" x 4" x 8'-0" EXTERIOR TYPE PLYWOOD BANDS. GLUE AND NAIL.
RIDGE BOARDS CUT FROM 1 x 10 BOARD ON 30° ANGLE. NAIL TOGETHER.
EDGE TO BE SANDED
VENT FLAP AT EACH END OVER DOOR. HINGED TO OPEN 90°
NOTE: COVER DOOR WITH PLASTIC. FASTEN ENTIRE STRUCTURE TOGETHER WITH WOOD SCREWS UNLESS OTHERWISE NOTED. ALL SCREWS TO BE GALVANIZED
SECTION A-A
4"
2 1/2" x 2 1/2" LOOSE JOINT BUTT HINGE
1 x 2 x 5" BLOCKING
2 x 4 DOOR BUCK
7" x 7" GUSSET 1/4" PLYWOOD
2'-6" x 5'-4" DOORS 2 x 2" FRAME
2 x 2 CENTER RAIL
1 x 2 x 5" BLOCKING
3" x 3" LOOSE PIN BUTT HINGES
1 x 8
1 3/4" x NO. 10 FLAT HEAD WOOD SCREWS GALVANIZED & COUNTERSUNK
FIN. GR.
2 x 4 x 2'-6" STAKE

CONSTRUCTION NOTES

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 AROUND USE, TWO LAYERS OF PLASTIC SHOULD BE USED.

FOR SPRING AND FALL USE, SINGLE LAYER IS SUFFICIENT.

TO REDUCE LABOR OF REPLACING PLASTIC, A 4-5 YEAR ULTRA-VIOLET 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.

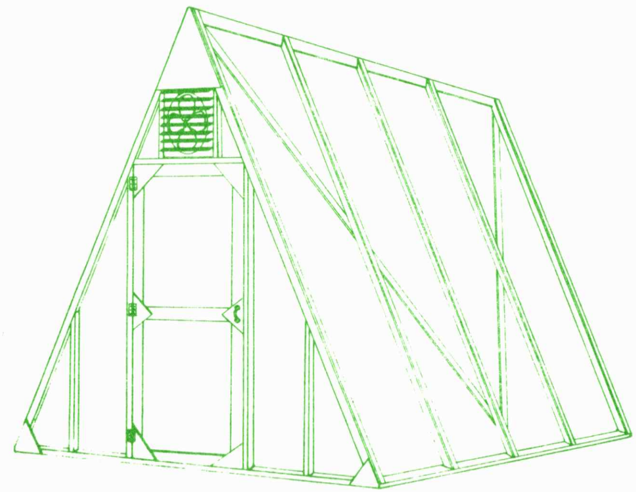
PLACE THERMOSTAT ALONG SIDEWALL NEAR PLANT LEVEL.

HEAT

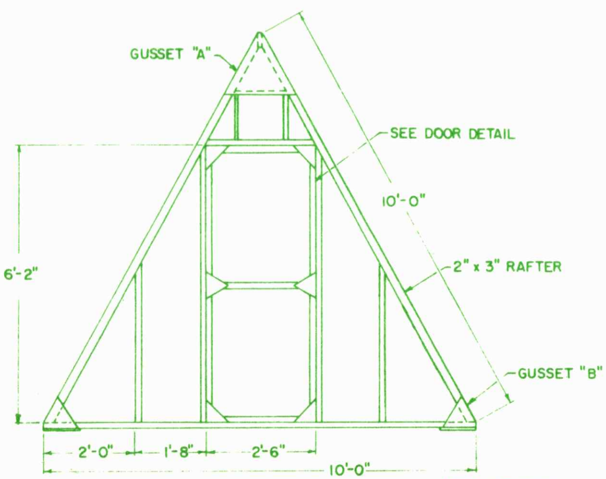
HEAT MAY BE SUPPLIED FROM THE HOME HEATING SYSTEM OR FROM A SEPARATE HEATER. OUTPUT REQUIRED CAN BE OBTAINED FROM THE FOLLOWING TABLE.

		SINGLE LAYER PLASTIC BTU/HR.			DOUBLE LAYER PLASTIC BTU/HR		
MINIMUM OUTSIDE TEMPERATURE	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



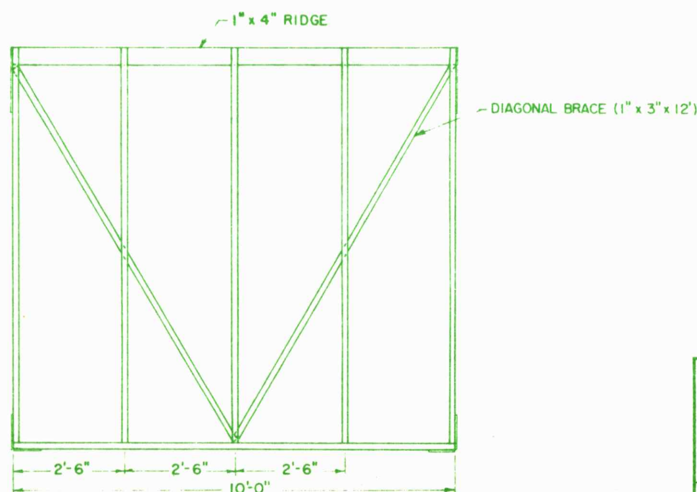
PERSPECTIVE



END VIEW

SCALE: 1/2" = 1'-0"

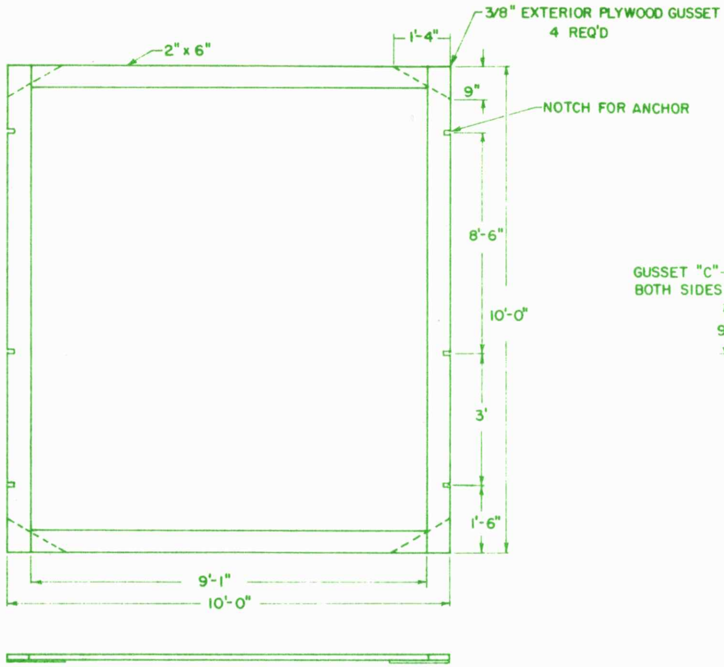
SEE BASE DETAIL



SIDE VIEW

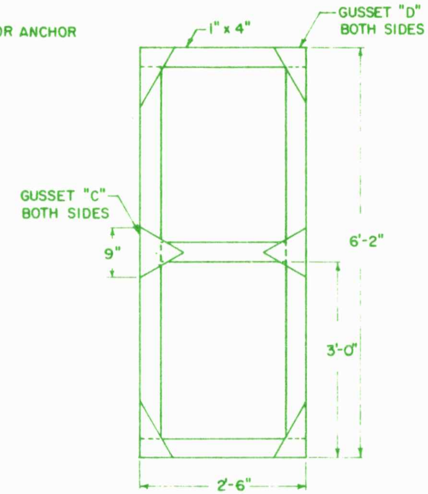
SCALE: 1/2" = 1'-0"

COOPERATIVE EXTENSION WORK IN AGRICULTURE AND HOME ECONOMICS AGRICULTURAL ENGINEERING DEPARTMENT UNIVERSITY OF CONNECTICUT STORRS, CONNECTICUT AND U. S. DEPARTMENT OF AGRICULTURE COOPERATING		
"A" FRAME HOME GREENHOUSE		
DR. BY JWB	CK. BY REP	SHEET 1 OF 2
SCALE SHOWN	DATE 7-3-	# 238



BASE DETAIL

SCALE: 1/2" = 1'-0"

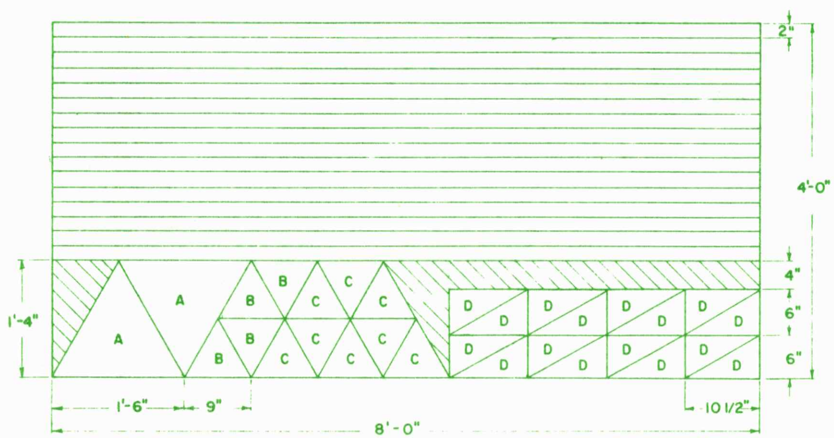


DOOR DETAIL

SCALE: 3/4" = 1'-0"

BILL OF MATERIALS

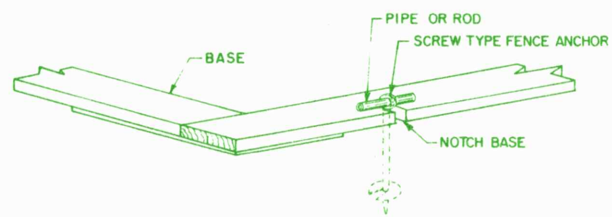
QUANTITY	ITEM	LOCATION
4 PCS.	2" x 6" x 10'	BASE
15 PCS.	2" x 3" x 10'	RAFTERS, END WALLS & DOOR FRAMES
7 PCS.	1" x 4" x 10'	RIDGE & DOORS
4 PCS.	1" x 3" x 12'	DIAGONAL BRACE
2 SHTS.	4' x 8' x 1/4" EXT. PLYWOOD	BATTEN STRIPS & GUSSETS
3 PR.	3" STEEL BUTT HINGES	DOOR
1/2 GAL.	COPPER NAPHTHENATE WOOD PRESERVATIVE	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/ULTRA-VIOLET INHIBITOR	OUTSIDE COVERING
1 PC.	10' x 35' x 4 MIL POLYETHYLENE	INSIDE COVERING
3 LBS.	4d COMMON NAILS	
1 LB.	8d COMMON NAILS	



PLYWOOD CUTTING DIAGRAM

SCALE: 1" = 1'-0"

NOTE: USE 1/4" EXTERIOR PLYWOOD
CUT ONE SHEET INTO 2" STRIPS & ONE AS SHOWN



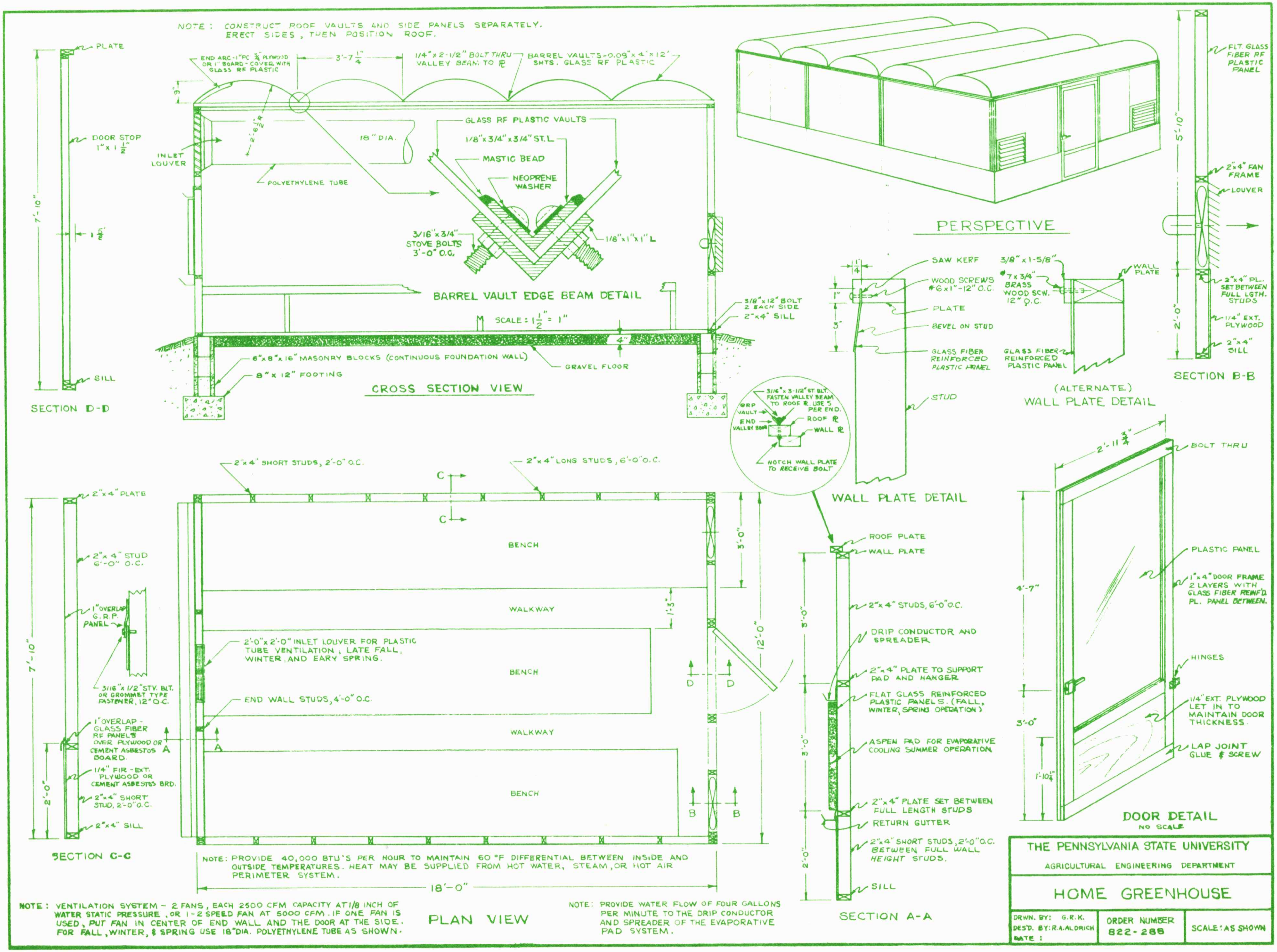
ANCHOR INSTALLATION

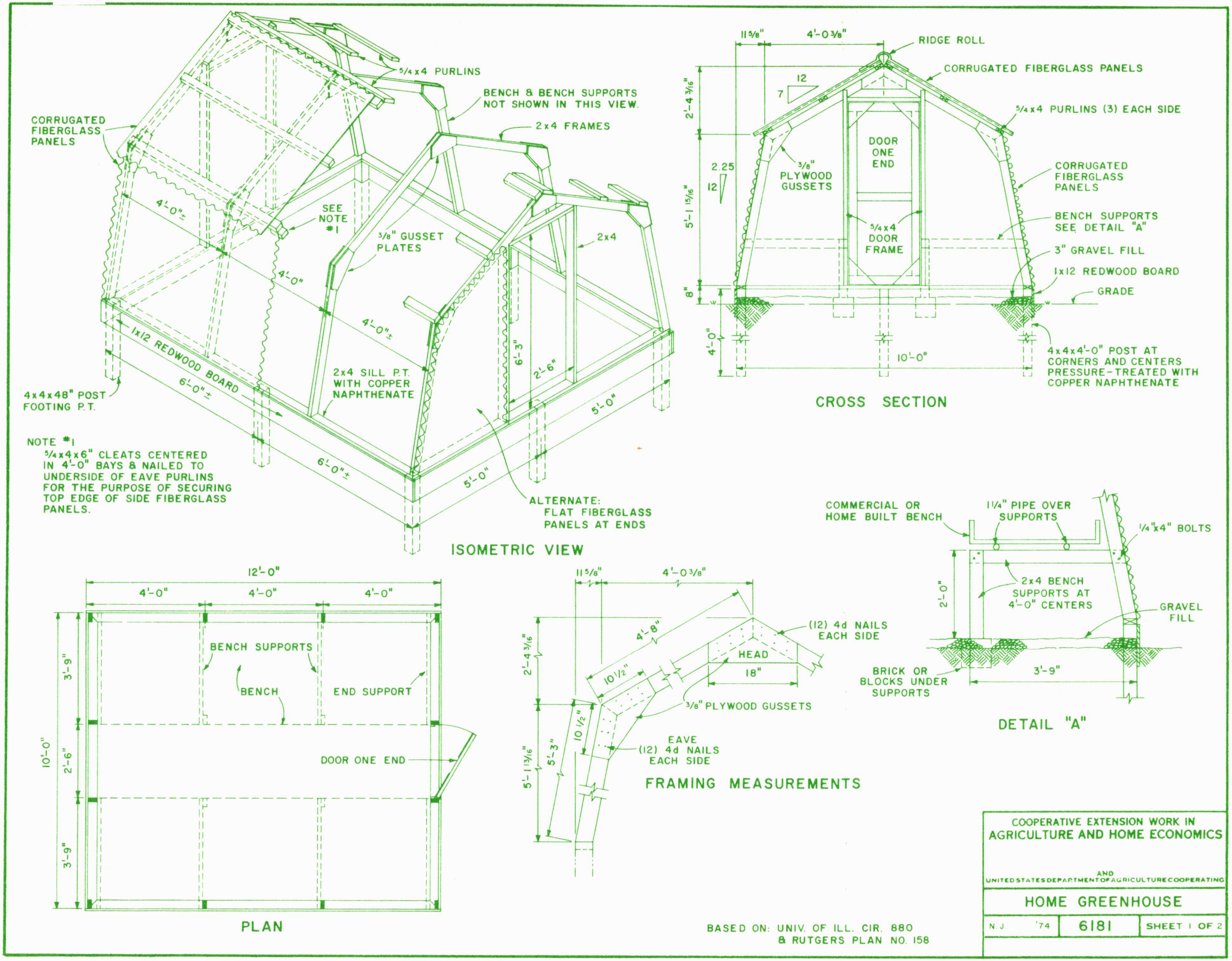
NO SCALE

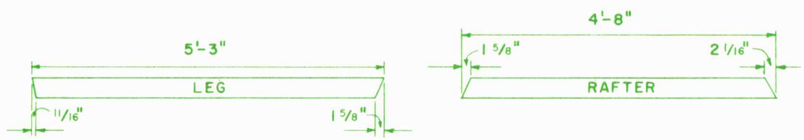
COOPERATIVE EXTENSION WORK IN
AGRICULTURE AND HOME ECONOMICS
AGRICULTURAL ENGINEERING DEPARTMENT
UNIVERSITY OF CONNECTICUT
STORRS, CONNECTICUT
AND
U. S. DEPARTMENT OF AGRICULTURE COOPERATING

"A" FRAME HOME GREENHOUSE

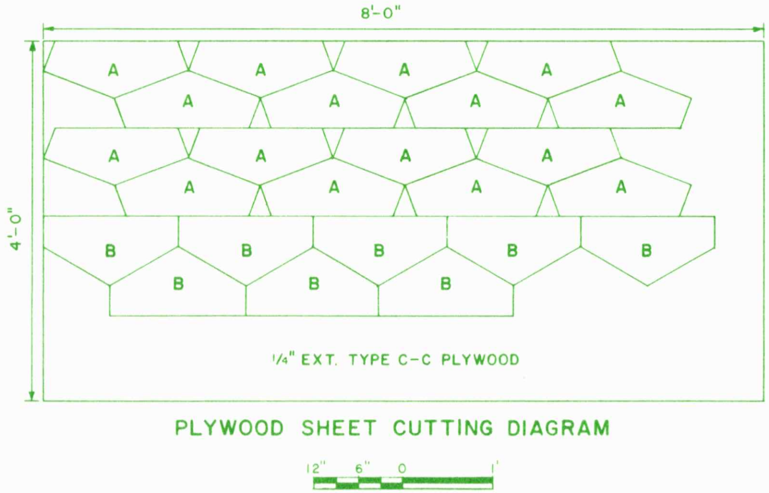
DR. BY JWB	CK. BY REP	SHEET 2 OF 2
SCALE SHOWN	DATE 7-3-67	PLAN # 238


NOTE: CONSTRUCT ROOF VAULTS AND SIDE PANELS SEPARATELY. ERECT SIDES, THEN POSITION ROOF.
PLATE
DOOR STOP 1" x 1 1/2"
7'-10"
1 1/2"
SILL
SECTION D-D
END ARC-1"PC 3/4" PLYWOOD OR 1" BOARD-COVER WITH GLASS RF PLASTIC
3'-7 1/4"
1/4" x 2-1/2" BOLT THRU VALLEY BEAM TO ℞
BARREL VAULTS-0.09" x 4' x 12' SHTS. GLASS RF PLASTIC
9"
2'-6" R
INLET LOUVER
18" DIA.
POLYETHYLENE TUBE
GLASS RF PLASTIC VAULTS
1/8" x 3/4" x 3/4" ST. L
MASTIC BEAD
NEOPRENE WASHER
3/16" x 3/4" STOVE BOLTS 3'-0" O.C.
1/8" x 1" x 1" L
BARREL VAULT EDGE BEAM DETAIL
SCALE: 1 1/2" = 1"
3/8" x 12" BOLT 2 EACH SIDE
2" x 4" SILL
4"
6" x 8" x 16" MASONRY BLOCKS (CONTINUOUS FOUNDATION WALL)
GRAVEL FLOOR
8" x 12" FOOTING
CROSS SECTION VIEW
PERSPECTIVE
FLT. GLASS FIBER RF PLASTIC PANEL
5'-10"
2" x 4" FAN FRAME
LOUVER
2" x 4" PL. SET BETWEEN FULL LGTH. STUDS
2'-0"
1/4" EXT. PLYWOOD
2" x 4" SILL
SECTION B-B
SAW KERF
WOOD SCREWS #6 x 1" - 12" O.C.
PLATE
BEVEL ON STUD
GLASS FIBER REINFORCED PLASTIC PANEL
STUD
1/4
1"
3"
3/8" x 1-5/8"
#7 x 3/4" BRASS WOOD SCW. 12" O.C.
WALL PLATE
GLASS FIBER REINFORCED PLASTIC PANEL
(ALTERNATE) WALL PLATE DETAIL
3/16" x 3-1/2" ST. BLT. FASTEN VALLEY BEAM TO ROOF ℞. USE 5 PER END.
GRP VAULT
END VALLEY BEAM
ROOF ℞
WALL ℞
NOTCH WALL PLATE TO RECEIVE BOLT
WALL PLATE DETAIL
2" x 4" SHORT STUDS, 2'-0" O.C.
2" x 4" LONG STUDS, 6'-0" O.C.
C
C
BENCH
WALKWAY
BENCH
WALKWAY
BENCH
3'-0"
1'-3"
12'-0"
2'-0" x 2'-0" INLET LOUVER FOR PLASTIC TUBE VENTILATION, LATE FALL, WINTER, AND EARY SPRING.
END WALL STUDS, 4'-0" O.C.
A
A
D
D
B
B
NOTE: PROVIDE 40,000 BTU'S PER HOUR TO MAINTAIN 60 °F DIFFERENTIAL BETWEEN INSIDE AND OUTSIDE TEMPERATURES. HEAT MAY BE SUPPLIED FROM HOT WATER, STEAM, OR HOT AIR PERIMETER SYSTEM.
18'-0"
PLAN VIEW
2" x 4" PLATE
2" x 4" STUD 6'-0" O.C.
1" OVERLAP G.R.P. PANEL
3/16" x 1/2" STV. BLT. OR GROMMET TYPE FASTENER, 12" O.C.
1" OVERLAP - GLASS FIBER RF PANELS OVER PLYWOOD OR CEMENT ASBESTOS BOARD.
1/4" FIR - EXT. PLYWOOD OR CEMENT ASBESTOS BRD.
2" x 4" SHORT STUD, 2'-0" O.C.
2" x 4" SILL
7'-10"
2'-0"
SECTION C-C
NOTE: VENTILATION SYSTEM - 2 FANS, EACH 2500 CFM CAPACITY AT 1/8 INCH OF WATER STATIC PRESSURE, OR 1-2 SPEED FAN AT 5000 CFM. IF ONE FAN IS USED, PUT FAN IN CENTER OF END WALL AND THE DOOR AT THE SIDE. FOR FALL, WINTER, & SPRING USE 18" DIA. POLYETHYLENE TUBE AS SHOWN.
NOTE: PROVIDE WATER FLOW OF FOUR GALLONS PER MINUTE TO THE DRIP CONDUCTOR AND SPREADER OF THE EVAPORATIVE PAD SYSTEM.
ROOF PLATE
WALL PLATE
2" x 4" STUDS, 6'-0" O.C.
DRIP CONDUCTOR AND SPREADER
2" x 4" PLATE TO SUPPORT PAD AND HANGER
FLAT GLASS REINFORCED PLASTIC PANELS. (FALL, WINTER, SPRING OPERATION)
ASPEN PAD FOR EVAPORATIVE COOLING SUMMER OPERATION
2" x 4" PLATE SET BETWEEN FULL LENGTH STUDS
RETURN GUTTER
2" x 4" SHORT STUDS, 2'-0" O.C. BETWEEN FULL WALL HEIGHT STUDS.
SILL
5'-0"
3'-0"
2'-0"
SECTION A-A
2'-11 3/4"
BOLT THRU
PLASTIC PANEL
1" x 4" DOOR FRAME 2 LAYERS WITH GLASS FIBER REINF'D. PL. PANEL BETWEEN.
4'-7"
HINGES
3'-0"
1/4" EXT. PLYWOOD LET IN TO MAINTAIN DOOR THICKNESS.
1'-10 1/4"
LAP JOINT GLUE & SCREW
DOOR DETAIL
NO SCALE
THE PENNSYLVANIA STATE UNIVERSITY
AGRICULTURAL ENGINEERING DEPARTMENT
HOME GREENHOUSE
DRWN. BY: G.R.K.
DES'D. BY: R.A. ALDRICH
DATE:
ORDER NUMBER 822-288
SCALE: AS SHOWN

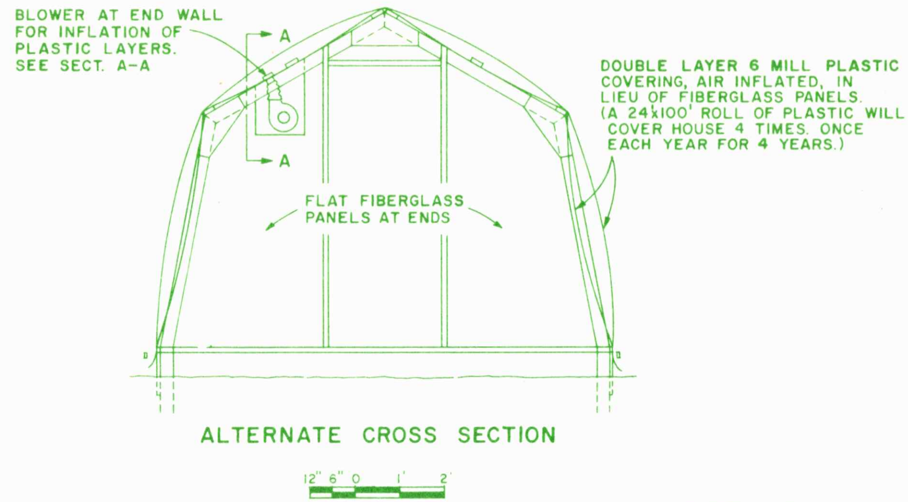

5/4 x 4 PURLINS
BENCH & BENCH SUPPORTS NOT SHOWN IN THIS VIEW.
2 x 4 FRAMES
CORRUGATED FIBERGLASS PANELS
SEE NOTE #1
3/8" GUSSET PLATES
2x4
4'-0"±
4'-0"
4'-0"±
6'-3"
2'-6"
1x12 REDWOOD BOARD
6'-0"±
2x4 SILL P.T. WITH COPPER NAPHTHENATE
5'-0"
4x4x48" POST FOOTING P.T.
6'-0"±
5'-0"
NOTE #1
5/4x4x6" CLEATS CENTERED IN 4'-0" BAYS & NAILED TO UNDERSIDE OF EAVE PURLINS FOR THE PURPOSE OF SECURING TOP EDGE OF SIDE FIBERGLASS PANELS.
ALTERNATE: FLAT FIBERGLASS PANELS AT ENDS
ISOMETRIC VIEW
11 5/8"
4'-0 3/8"
RIDGE ROLL
CORRUGATED FIBERGLASS PANELS
12
7
5/4x4 PURLINS (3) EACH SIDE
2'-4 3/16"
DOOR ONE END
2.25
12
3/8" PLYWOOD GUSSETS
5'-1 15/16"
CORRUGATED FIBERGLASS PANELS
BENCH SUPPORTS SEE DETAIL "A"
5/4x4 DOOR FRAME
3" GRAVEL FILL
1x12 REDWOOD BOARD
8"
GRADE
4'-0"
10'-0"
4x4x4'-0" POST AT CORNERS AND CENTERS PRESSURE-TREATED WITH COPPER NAPHTHENATE
CROSS SECTION
COMMERCIAL OR HOME BUILT BENCH
1 1/4" PIPE OVER SUPPORTS
1/4"x4" BOLTS
2'-0"
2x4 BENCH SUPPORTS AT 4'-0" CENTERS
GRAVEL FILL
BRICK OR BLOCKS UNDER SUPPORTS
3'-9"
DETAIL "A"
12'-0"
4'-0"
4'-0"
4'-0"
BENCH SUPPORTS
BENCH
END SUPPORT
DOOR ONE END
10'-0"
3'-9"
2'-6"
3'-9"
PLAN
11 5/8"
4'-0 3/8"
4'-8"
(12) 4d NAILS EACH SIDE
HEAD
18"
2'-4 3/16"
10 1/2"
10 1/2"
3/8" PLYWOOD GUSSETS
5'-1 13/16"
5'-3"
EAVE (12) 4d NAILS EACH SIDE
FRAMING MEASUREMENTS
BASED ON: UNIV. OF ILL. CIR. 880 & RUTGERS PLAN NO. 158
COOPERATIVE EXTENSION WORK IN AGRICULTURE AND HOME ECONOMICS
AND
UNITED STATES DEPARTMENT OF AGRICULTURE COOPERATING
HOME GREENHOUSE
N.J '74 6181 SHEET 1 OF 2



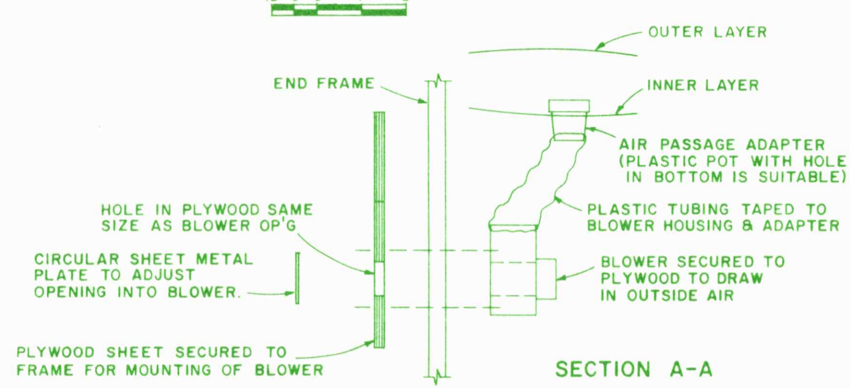
FRAME CUTTING LAYOUT (CUT FROM (8) 2x4x10')



PLYWOOD SHEET CUTTING DIAGRAM



ALTERNATE CROSS SECTION



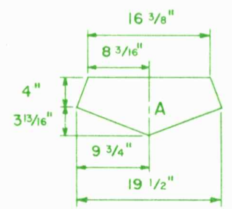
SECTION A-A

BILL OF MATERIALS

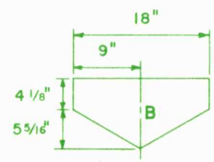
CORRUGATED FIBERGLASS REINFORCED PANELS (F.R.P.) *
5 OZ. COATING:

ROOF PANELS (6) 2'x10' CUT IN HALF
SIDE PANELS (5) 2'x12', 2 SHEETS EACH SIDE
5 TH SHEET CUT LENGTHWISE
END PANELS (9) 2'x8' OF WHICH 5 ARE LOCATED AT END WITH NO DOOR
RIDGE ROLL (1) 12' LENGTH

LUMBER:
(8) 2x4x10' TO MAKE FRAMES
(2) 2x4x10' SILL AT ENDS (P.T. COPPER NAPHTHENATE)
(2) 2x4x12' SILL AT SIDES (P.T. COPPER NAPHTHENATE)
(2) 2x4x16' END FRAMING
BENCH SUPPORTS NOT INCLUDED
(8) 5/4x4x12' FOR PURLINS & DOOR
(2) 4x4x16' P.T. POST FOR FOOTINGS
(2) 1x12x12' & (2) 1x12x10' REDWOOD BOARDS
(1) 4'x8'x1/4" 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



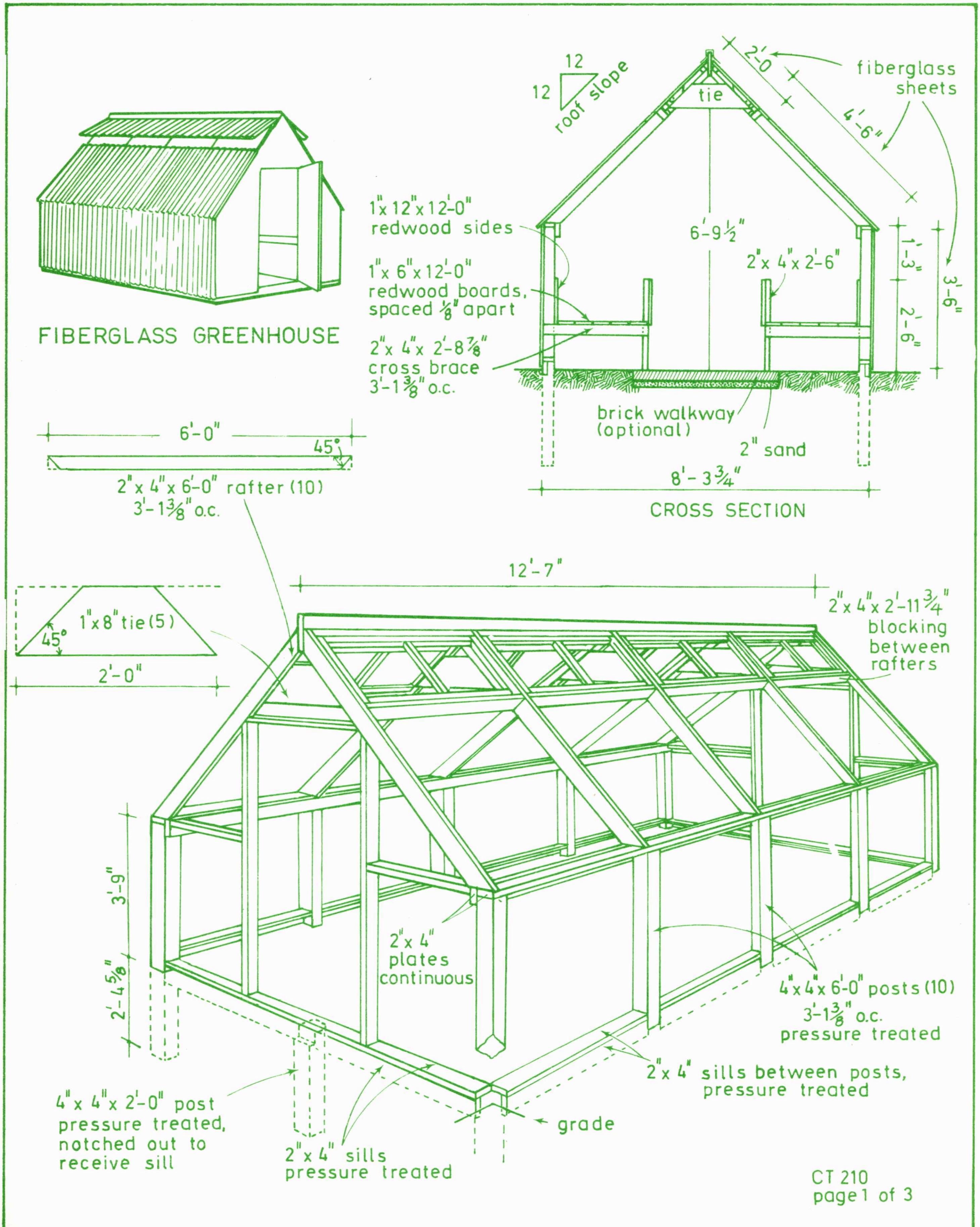
HEAD GUSSETS
8 REQ'D

ENVIRONMENTAL CONTROL

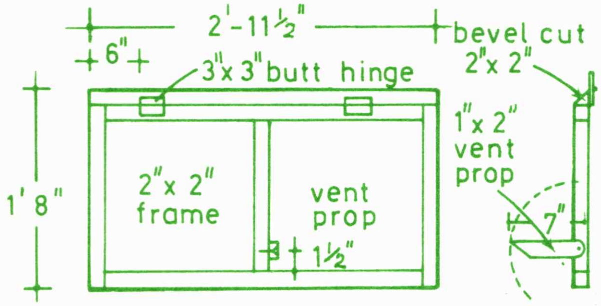
HEATING:
TO MAINTAIN A TEMPERATURE DIFFERENCE OF 60° BETWEEN INSIDE & OUTSIDE
30,000 BTU/HR. SINGLE COVERING
20,000 BTU/HR. DOUBLE COVERING
CONNECTION TO HOME HEATING SYSTEM IS MOST DESIRABLE. IF NOT POSSIBLE, USE GAS OR OIL HEATER VENTED TO THE OUTSIDE. ELECTRIC HEATERS ARE EASY TO INSTALL, CLEAN, BUT 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 AIR INLET IN THE OTHER. BOTH SHOULD BE CONTROLLED BY A THERMOSTAT.
FOR MORE INFORMATION SEE USDA BULLETIN NUMBER 357 "BUILDING HOBBY GREENHOUSES."

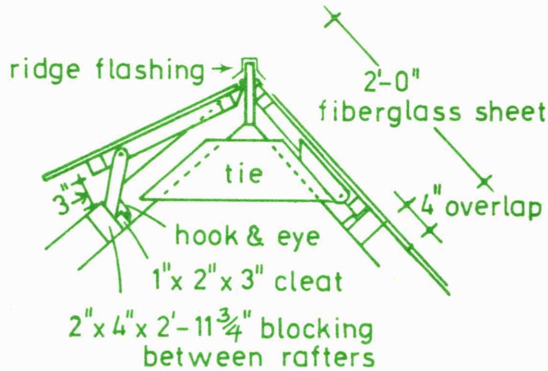
COOPERATIVE EXTENSION WORK IN AGRICULTURE AND HOME ECONOMICS AND UNITED STATES DEPARTMENT OF AGRICULTURE COOPERATING		
HOME GREENHOUSE		
N.J. '74	6181	SHEET 2 OF 2

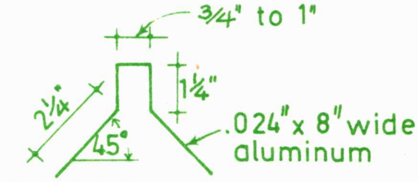


FIBERGLASS GREENHOUSE
12
12
roof slope
tie
2'-0"
4'-6"
fiberglass sheets
1" x 12" x 12'-0" redwood sides
1" x 6" x 12'-0" redwood boards, spaced 1/8" apart
2" x 4" x 2'-8 7/8" cross brace 3'-1 3/8" o.c.
6'-9 1/2"
2" x 4" x 2'-6"
1'-3"
2'-6"
3'-6"
brick walkway (optional)
2" sand
8'-3 3/4"
CROSS SECTION
6'-0"
45°
2" x 4" x 6'-0" rafter (10) 3'-1 3/8" o.c.
1" x 8" tie (5)
45°
2'-0"
12'-7"
2" x 4" x 2'-11 3/4" blocking between rafters
3'-9"
2'-4 5/8"
2" x 4" plates continuous
4" x 4" x 6'-0" posts (10) 3'-1 3/8" o.c. pressure treated
2" x 4" sills between posts, pressure treated
4" x 4" x 2'-0" post pressure treated, notched out to receive sill
2" x 4" sills pressure treated
grade
CT 210
page 1 of 3

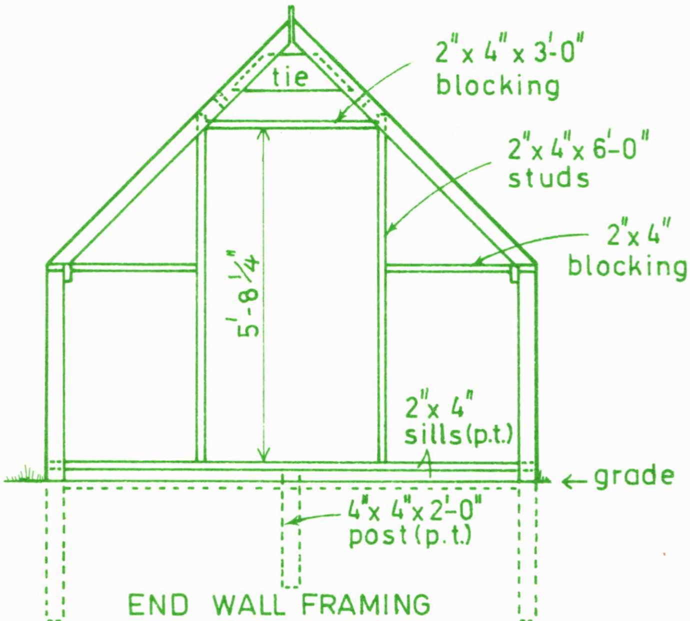


VENT DETAILS

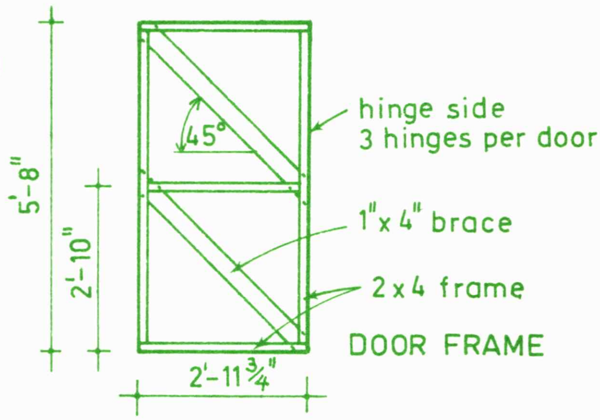




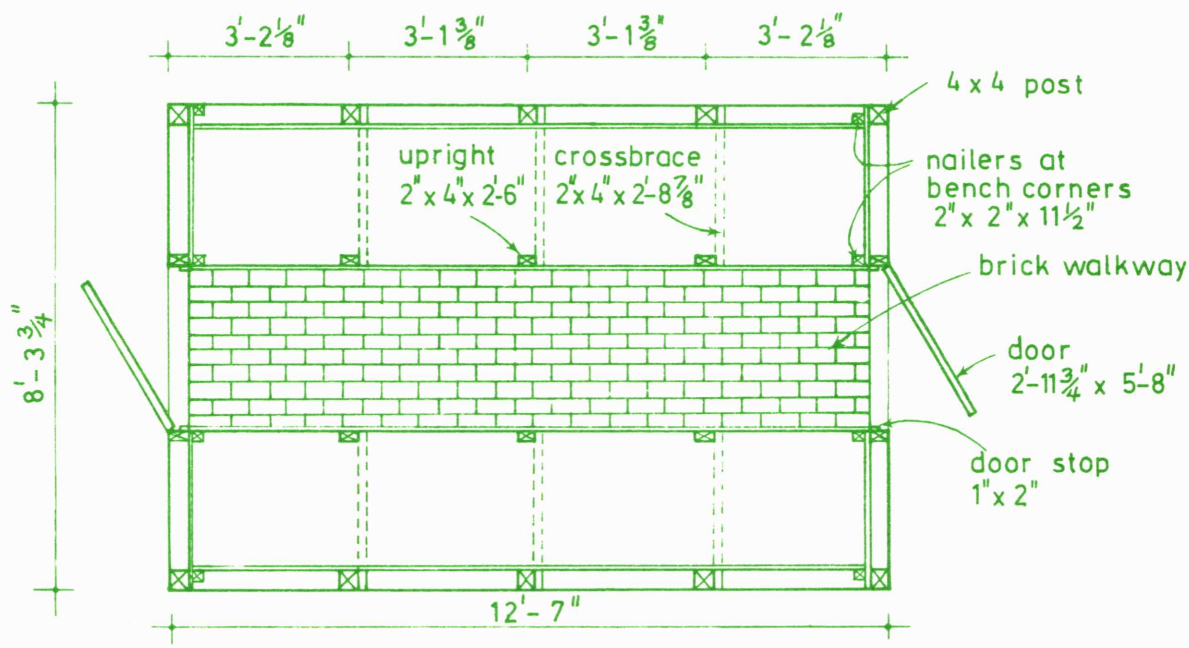
RIDGE FLASHING



END WALL FRAMING



DOOR FRAME



PLAN

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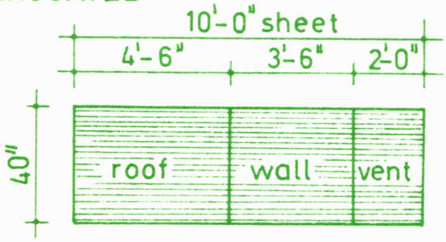
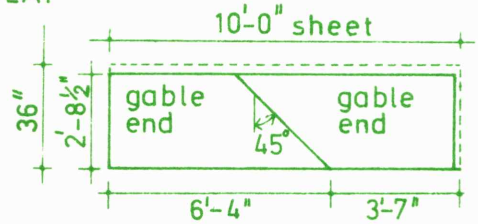
FRP SHEET CUTTING DIAGRAMS

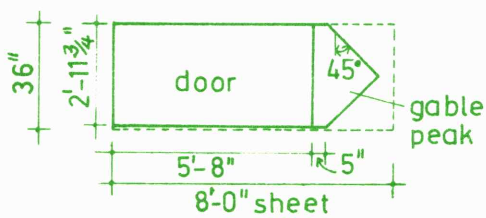
CORRUGATED



FLAT



FLAT



MATERIALS

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

	Size	Quantity
<u>Fiberglass Sheets</u>		
corrugated	2 1/2"x40"x10'-0"	8
flat	36"x10'-0"	2
flat	36"x8'-0"	2
<u>Hardware</u>		
Hinges (door & vent)	3" butt type	11 pair
flashing (aluminum)	.024"x8"wide	13 lineal ft.
nails (aluminum)	1 3/4" screw shank	550
nails (framing)		
<u>Miscellaneous</u>		
corrugated filler 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
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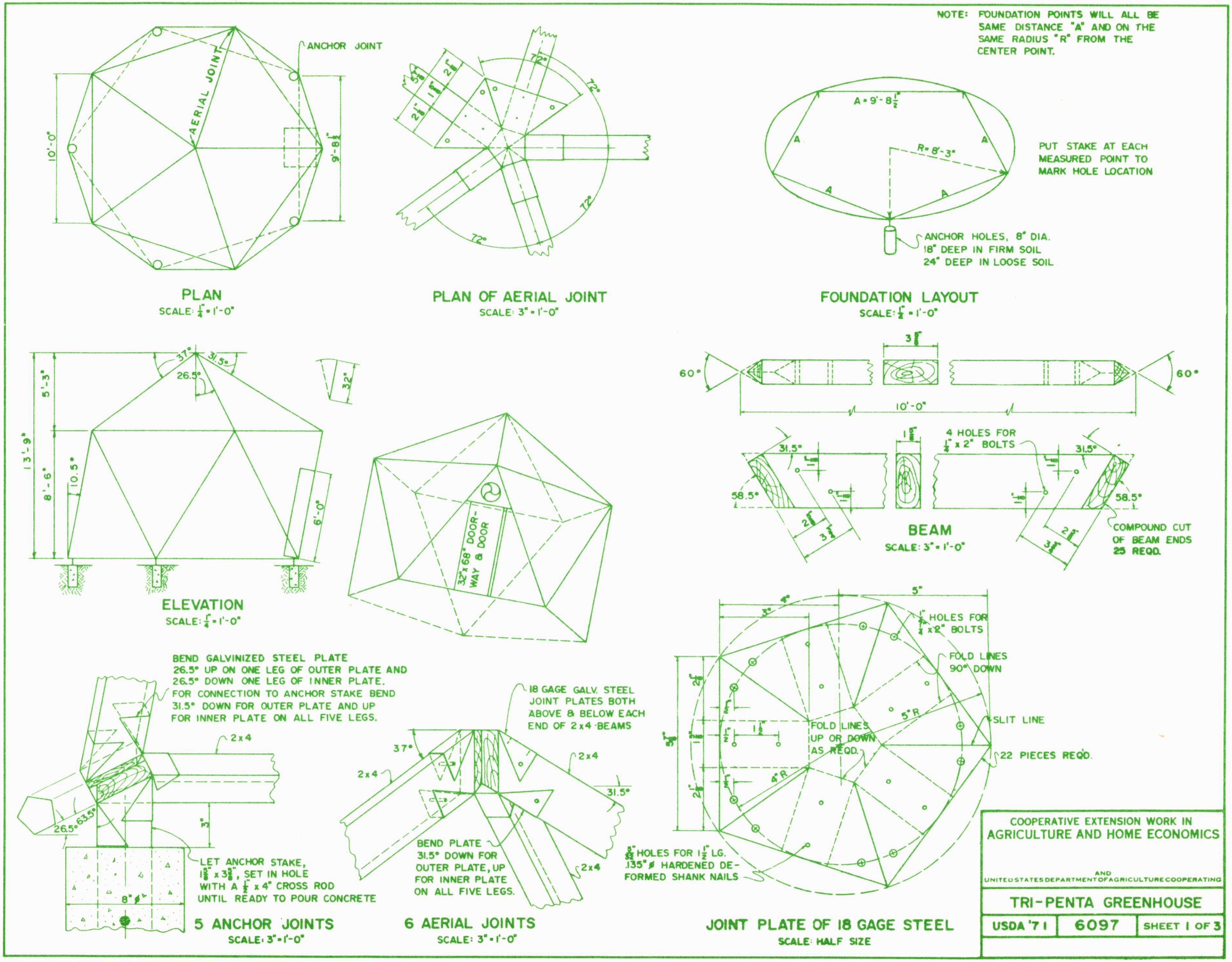
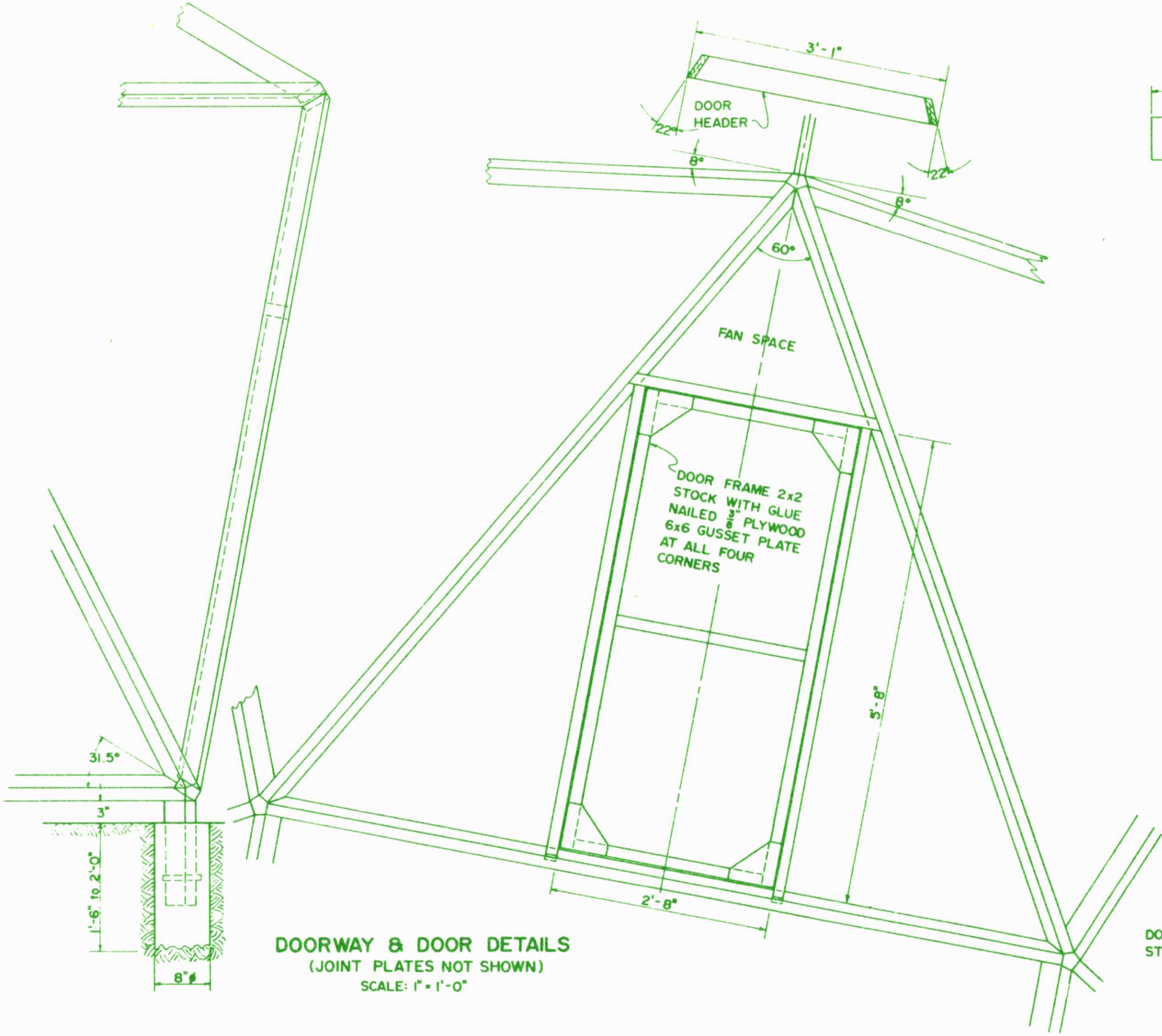
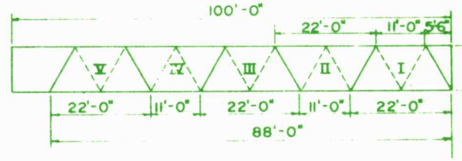

NOTE: FOUNDATION POINTS WILL ALL BE SAME DISTANCE "A" AND ON THE SAME RADIUS "R" FROM THE CENTER POINT.
ANCHOR JOINT
AERIAL JOINT
10'-0"
9'-8½"
PLAN
SCALE: ¼"=1'-0"
72°
PLAN OF AERIAL JOINT
SCALE: 3"=1'-0"
A=9'-8½"
R=8'-3"
A
PUT STAKE AT EACH MEASURED POINT TO MARK HOLE LOCATION
ANCHOR HOLES, 8" DIA. 18" DEEP IN FIRM SOIL 24" DEEP IN LOOSE SOIL
FOUNDATION LAYOUT
SCALE: ⅛"=1'-0"
37°
31.5°
26.5°
32°
5'-3"
13'-9"
8'-6"
10.5°
6'-0"
ELEVATION
SCALE: ¼"=1'-0"
32"x68" DOOR-WAY & DOOR
60°
10'-0"
4 HOLES FOR ¼" x 2" BOLTS
31.5°
58.5°
BEAM
SCALE: 3"=1'-0"
COMPOUND CUT OF BEAM ENDS 25 REQD.
5"
HOLES FOR ¼" x 2" BOLTS
FOLD LINES 90° DOWN
5"R
SLIT LINE
FOLD LINES UP OR DOWN AS REQD.
22 PIECES REQD.
4"R
HOLES FOR 1½" LG. .135" ⌀ HARDENED DE-FORMED SHANK NAILS
JOINT PLATE OF 18 GAGE STEEL
SCALE: HALF SIZE
BEND GALVINIZED STEEL PLATE 26.5° UP ON ONE LEG OF OUTER PLATE AND 26.5° DOWN ONE LEG OF INNER PLATE. FOR CONNECTION TO ANCHOR STAKE BEND 31.5° DOWN FOR OUTER PLATE AND UP FOR INNER PLATE ON ALL FIVE LEGS.
2x4
26.5°
63.5°
3"
LET ANCHOR STAKE, 1⅝" x 3⅝", SET IN HOLE WITH A ½" x 4" CROSS ROD UNTIL READY TO POUR CONCRETE
8" ⌀
5 ANCHOR JOINTS
SCALE: 3"=1'-0"
18 GAGE GALV. STEEL JOINT PLATES BOTH ABOVE & BELOW EACH END OF 2x4 BEAMS
BEND PLATE 31.5° DOWN FOR OUTER PLATE, UP FOR INNER PLATE ON ALL FIVE LEGS.
6 AERIAL JOINTS
SCALE: 3"=1'-0"
COOPERATIVE EXTENSION WORK IN AGRICULTURE AND HOME ECONOMICS
AND
UNITED STATES DEPARTMENT OF AGRICULTURE COOPERATING
TRI-PENTA GREENHOUSE
USDA '71
6097
SHEET 1 OF 3



DOORWAY & DOOR DETAILS

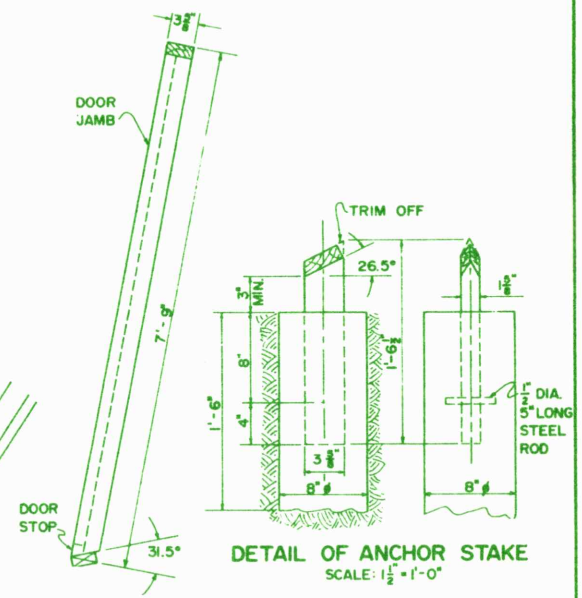
(JOINT PLATES NOT SHOWN)

SCALE: 1" = 1'-0"



LAYOUT PLAN FOR FILM SECTIONS

SCALE: 1/2" = 10'-0"

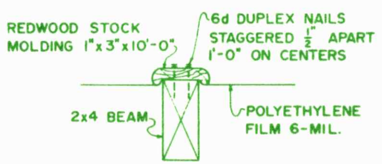


DETAIL OF ANCHOR STAKE

SCALE: 1 1/2" = 1'-0"

COVERING PROCEDURES

1. 6 MIL. POLY FILM SHOULD BE ORDERED IN 100'-0" ROLL, 10'-0" WIDE.
2. THIS SECTION WILL COVER 3 TRIANGULAR SURFACES; ONE CROWN AND TWO SIDE SURFACES.



NAILING DETAIL

SCALE: 3" = 1'-0"

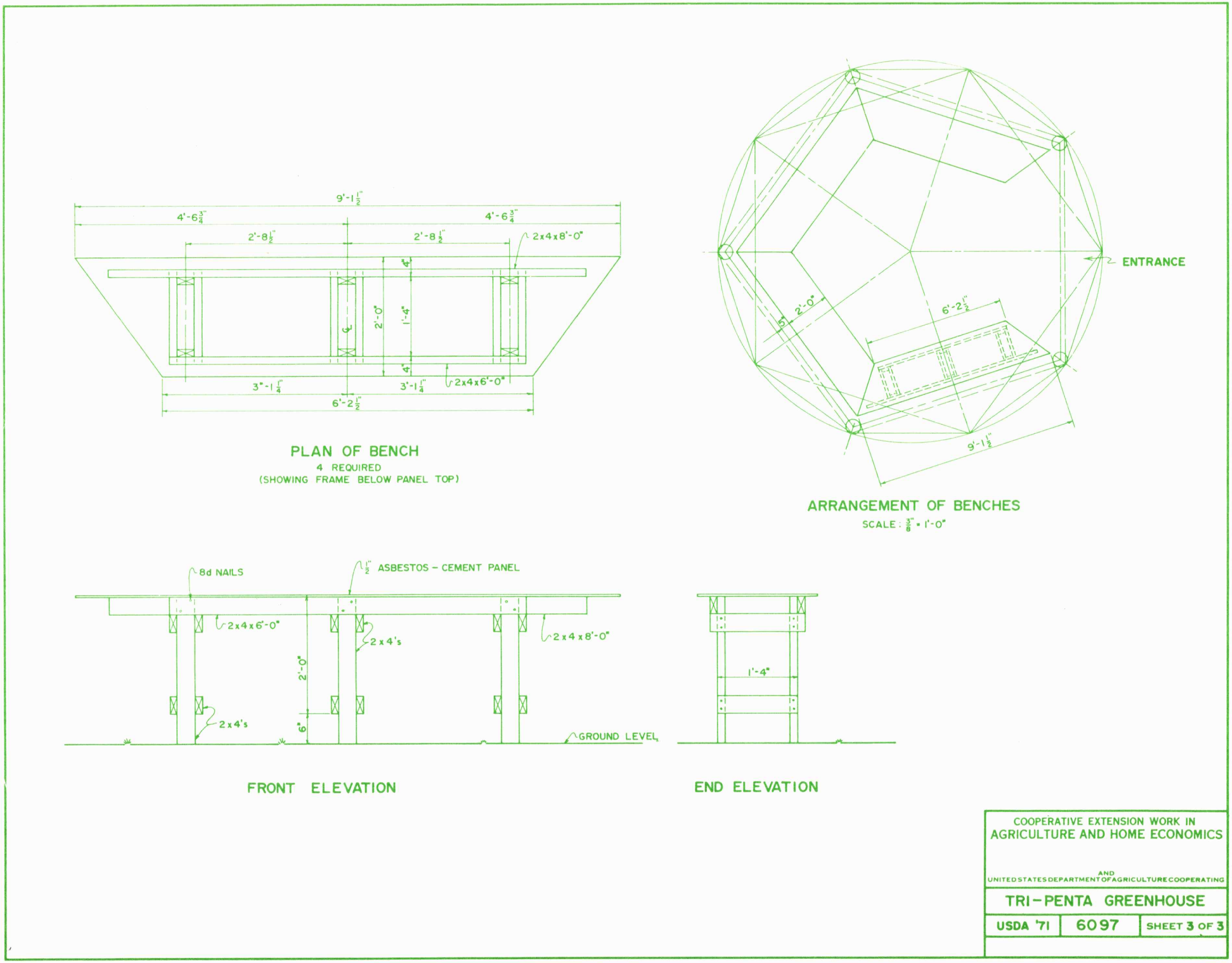
COOPERATIVE EXTENSION WORK IN AGRICULTURE AND HOME ECONOMICS

AND

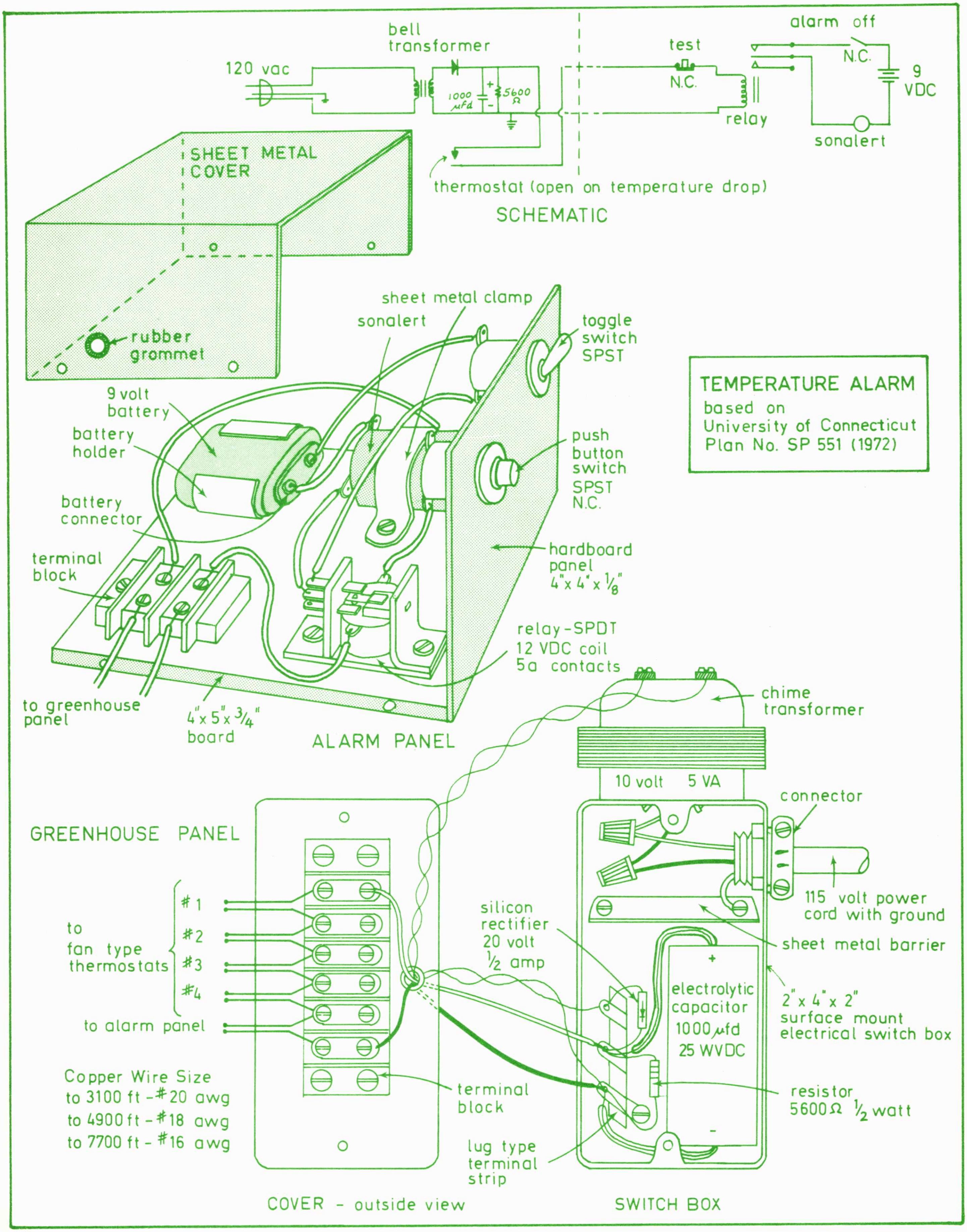
UNITED STATES DEPARTMENT OF AGRICULTURE COOPERATING

TRI-PENTA GREENHOUSE

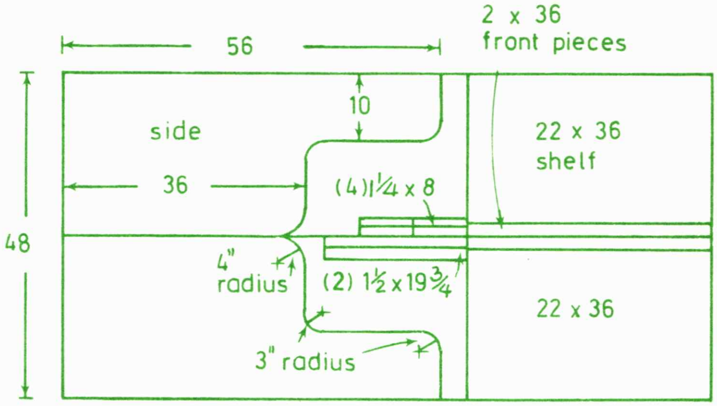
USDA '71	6097	SHEET 2 OF 3



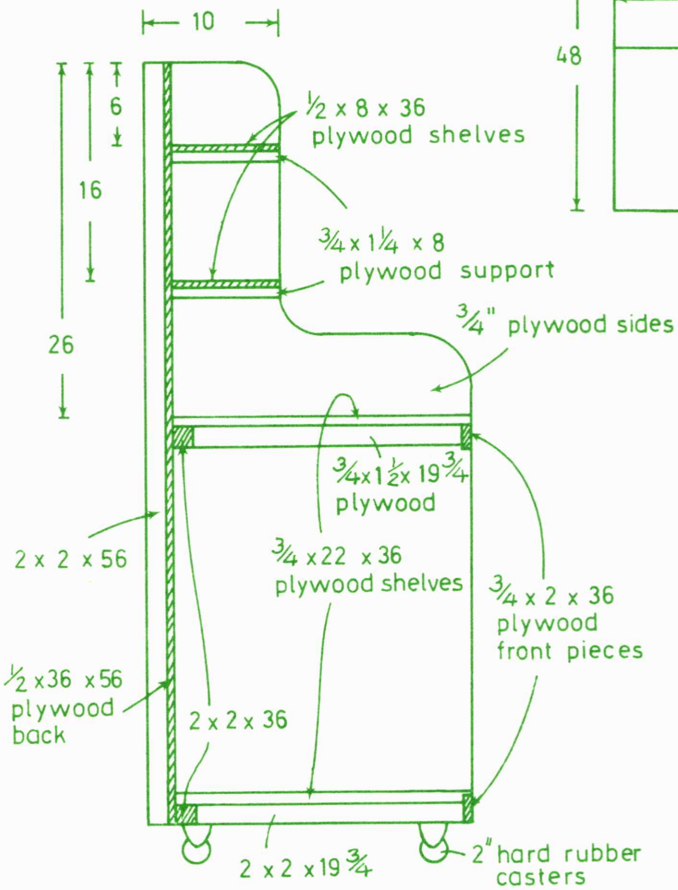
9'-1 1/2"
4'-6 3/4"
4'-6 3/4"
2'-8 1/2"
2'-8 1/2"
2x4x8'-0"
4"
2'-0"
1'-4"
4"
3'-1 1/4"
3'-1 1/4"
2x4x6'-0"
6'-2 1/2"
PLAN OF BENCH
4 REQUIRED
(SHOWING FRAME BELOW PANEL TOP)
ENTRANCE
2'-0"
5"
6'-2 1/2"
9'-1 1/2"
ARRANGEMENT OF BENCHES
SCALE: 3/8" = 1'-0"
8d NAILS
1/2" ASBESTOS - CEMENT PANEL
2x4x6'-0"
2x4's
2x4x8'-0"
2'-0"
6"
2x4's
GROUND LEVEL
1'-4"
FRONT ELEVATION
END ELEVATION
COOPERATIVE EXTENSION WORK IN
AGRICULTURE AND HOME ECONOMICS
AND
UNITED STATES DEPARTMENT OF AGRICULTURE COOPERATING
TRI-PENTA GREENHOUSE
USDA '71
6097
SHEET 3 OF 3



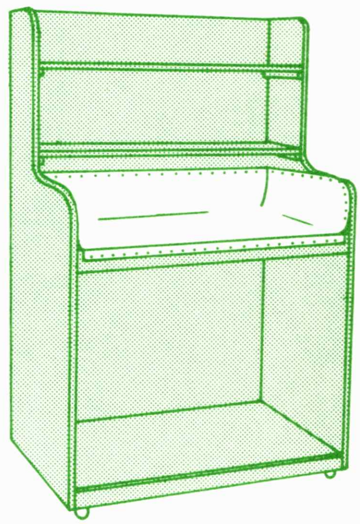
TEMPERATURE ALARM
based on
University of Connecticut
Plan No. SP 551 (1972)
bell transformer
120 vac
1000 µfd
5600 Ω
test
N.C.
relay
alarm off
N.C.
9 VDC
sonalert
thermostat (open on temperature drop)
SCHEMATIC
SHEET METAL COVER
rubber grommet
sheet metal clamp
sonalert
toggle switch SPST
9 volt battery
battery holder
battery connector
push button switch SPST N.C.
terminal block
hardboard panel 4"x 4"x 1/8"
relay-SPDT 12 VDC coil 5a contacts
to greenhouse panel
4"x 5"x 3/4" board
ALARM PANEL
chime transformer
10 volt 5 VA
connector
GREENHOUSE PANEL
#1
#2
#3
#4
to fan type thermostats
to alarm panel
115 volt power cord with ground
sheet metal barrier
silicon rectifier 20 volt 1/2 amp
electrolytic capacitor 1000 µfd 25 WVDC
2"x 4"x 2" surface mount electrical switch box
Copper Wire Size
to 3100 ft - #20 awg
to 4900 ft - #18 awg
to 7700 ft - #16 awg
terminal block
resistor 5600Ω 1/2 watt
lug type terminal strip
COVER - outside view
SWITCH BOX



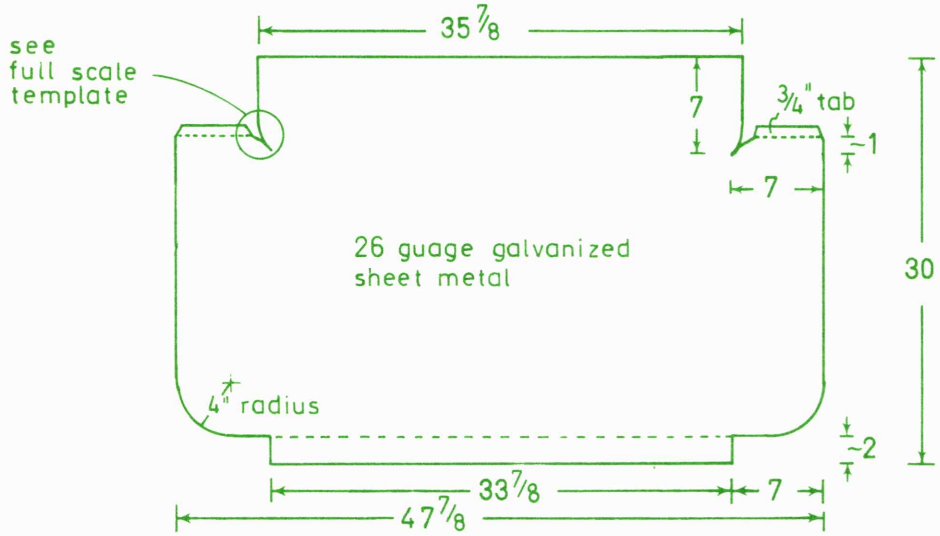
CUTTING DIAGRAM ¾ x 48 x 96 plywood



POTTING BENCH



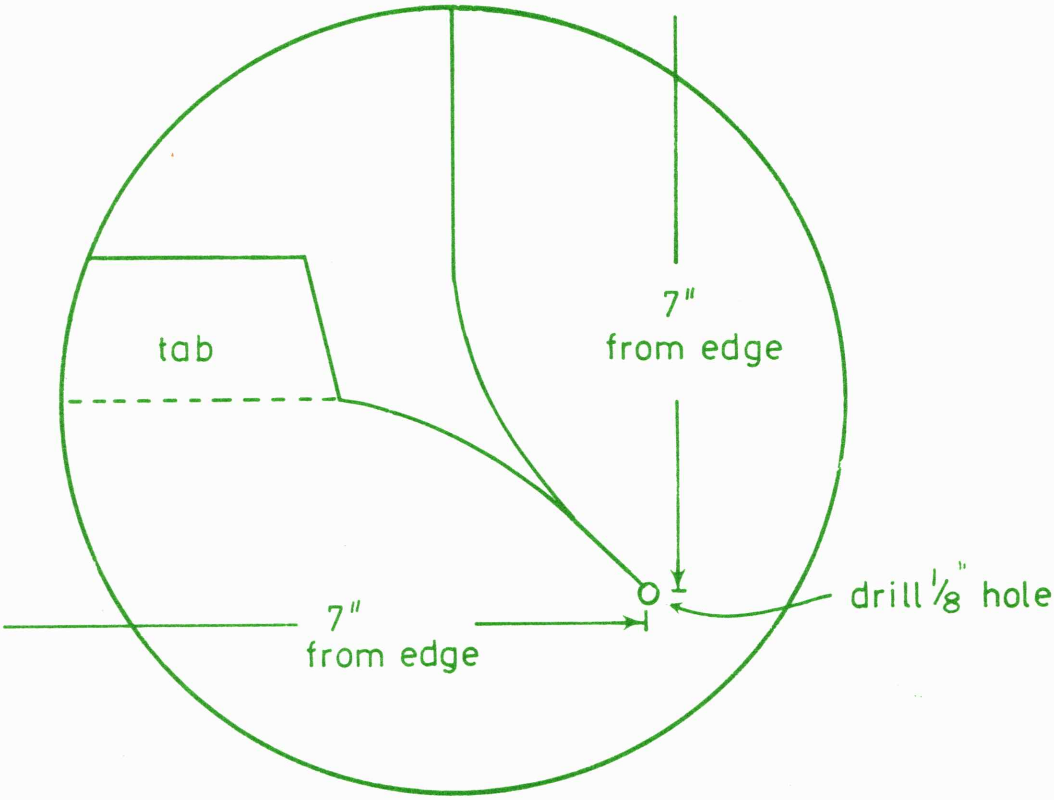
SHEET METAL CUTTING DIAGRAM



Bend on dotted lines with sheet metal brake
or clamp in 2x4s & bend over with block of wood & hammer

POTTING BENCH
adapted from
Cornell University
IB 40

page 1 of 2



FULL SCALE CUTTING TEMPLATE FOR BACK CORNERS OF SHEET METAL TOP

MATERIALS

Lumber

2 pieces 2x2 Fir or Pine 8' long
1 sheet 3/4" A-C exterior plywood
1 sheet 1/2" A-C exterior plywood

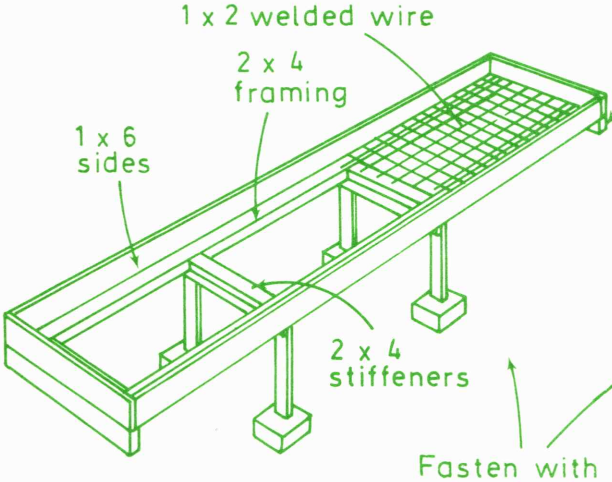
Hardware

1/4 lb 6d nails
1/4 lb 4d nails
5/8"x16 gauge wire nails
Resorcinol glue (waterproof)

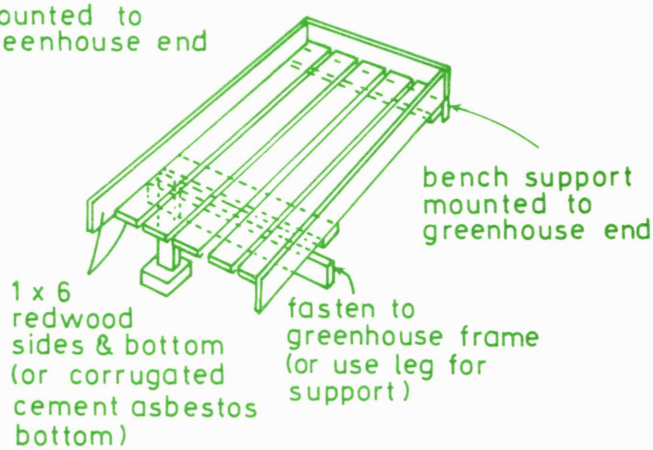
Miscellaneous

1 piece 26 gauge galvanized sheet metal 30x48 in.
Solder
4 2" dia x 3/4" wide wheel casters
16 No. 10 x 1" RH wood screws to fasten casters

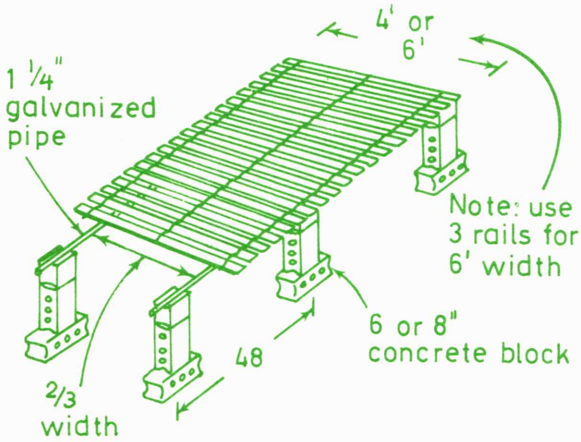
POTTING BENCH
adapted from
Cornell University
IB 40



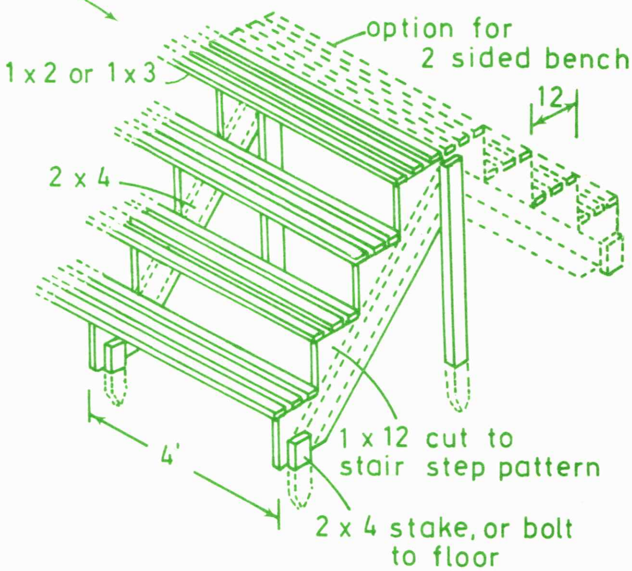
WELDED WIRE BENCH



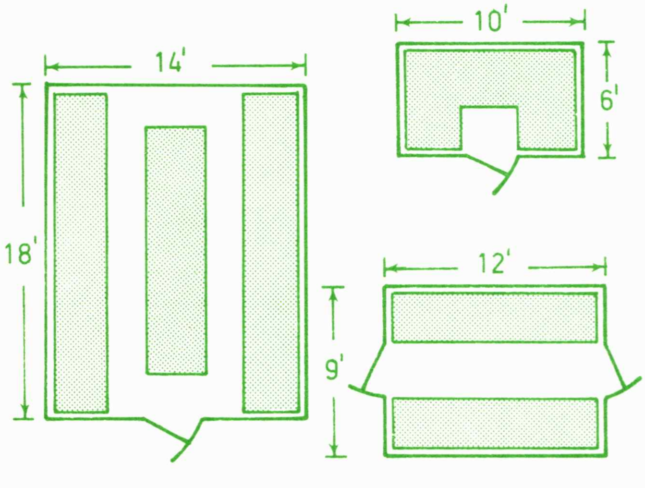
REDWOOD BENCH



ECONOMY LATH FENCE BENCH
(for a large greenhouse)



WOODEN STEP BENCH



BENCH LAYOUTS

GREENHOUSE BENCHES

Lath fence bench and Wooden step bench based on U.S.D.A. Plan No. 6133

Welded wire bench and Redwood bench based on Rutgers University plans.

References

Home gardening

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