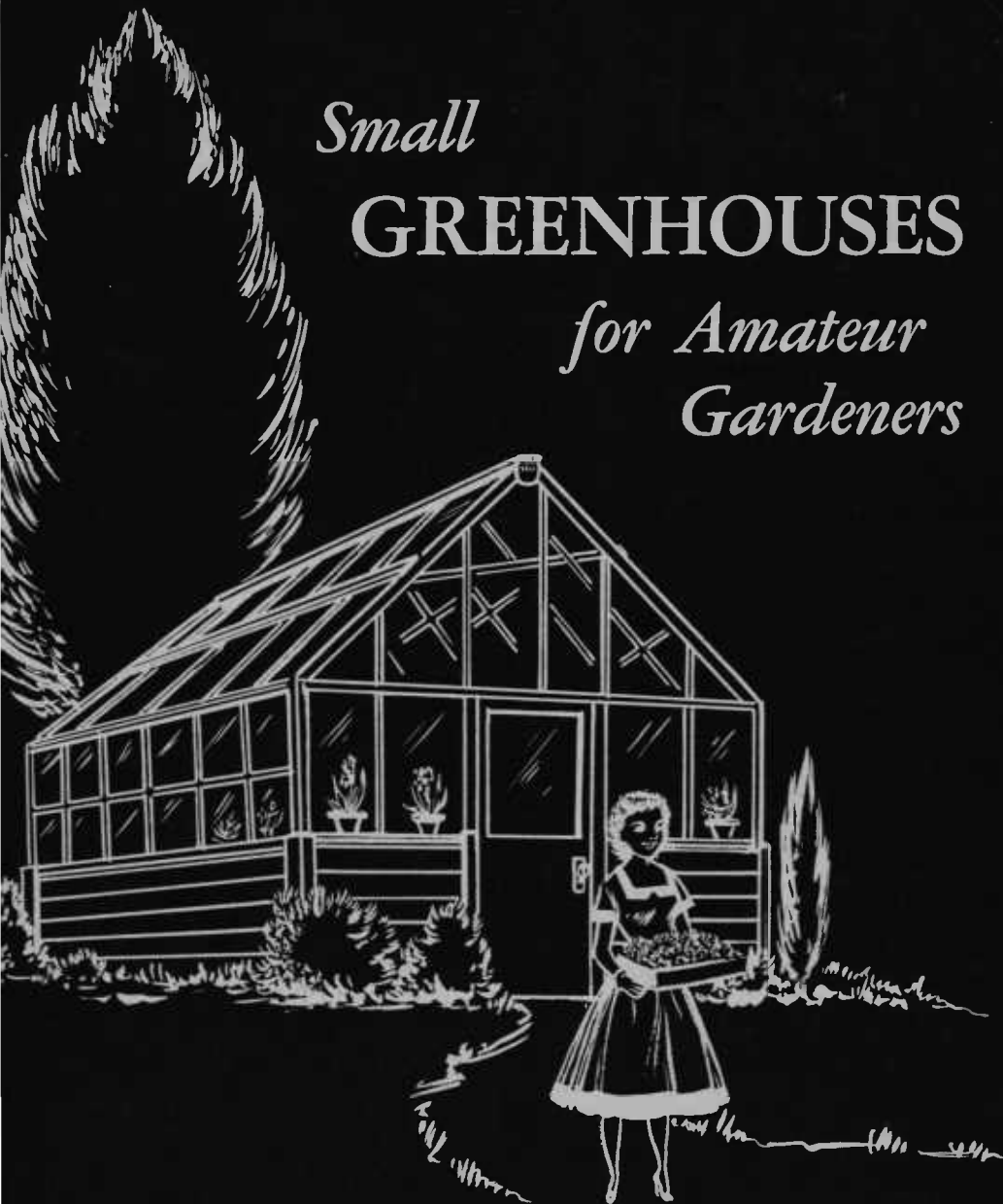


Small

GREENHOUSES

*for Amateur
Gardeners*



PNW Bulletin 32

April 1959

Small Greenhouses

FOR AMATEUR GARDENERS*

This publication has been prepared in reply to frequent requests by home gardeners for information on construction of small glass and plastic greenhouses. The subject is developed briefly with the hope that those interested may see the possible variations in construction and materials. Prefabricated greenhouses are readily available and actually may be cheaper in the long run than homemade ones.

Permanent structures for growing plants are built with durable

materials such as metal, glass, concrete, and a minimum of wood. Temporary types may be built with wood and plastic.

Many combinations of materials are possible to give varying length of life. A durable frame can be covered with short-lived plastic or the same frame can be glazed with one of the more durable plastics or glass. A wooden frame can be glazed with glass, making it quite long lived if it is taken care of properly.

Types of Greenhouses

These structures, whether permanent or temporary, are of two forms, the lean-to, and even-span.

The lean-to house takes advantage of an existing building for one side of the structure, making it more economical to build. Usually it is attached to the home but may be built against a garage or other building. The lean-to should be placed on the south side of the house for highest light efficiency. If this is not feasible an eastern exposure is preferable to a western exposure. A lean-to on the north side of a building is limited to the culture of foliage plants, shade loving plants, and general propagation. Having the greenhouse adja-

cent to the home allows the owner to tend it often and enjoy its contents frequently. The lean-to has the following disadvantages: (1) limited space; (2) limited light because of the solid back wall; (3) limited ventilation and control of temperature; (4) limited use of sprays, dusts, and fumigants for the control of insects and diseases.

The lean-to house is usually, but not necessarily, limited to 1 or 2 benches with a total width of 5 to 10 feet. The length is determined by the building to which it is attached.

The even-span is the standard greenhouse form. It, too, may be attached to the house at one gable

*This circular was prepared by M. G. Huber, Extension Agricultural Engineering Specialist, and Stanley E. Wadsworth, Associate Professor of Floriculture, Oregon State College. It was re-

viewed and approved for cooperative publication by agricultural engineering and horticulture specialists at Washington State University and the University of Idaho.

end but is better located at a slight distance from any building to allow maximum light, free use of materials for disease and insect control, better ventilation, and room for expansion.

The even-span house may be oriented north and south or east and west. It may be protected from high winds by existing buildings or windbreaks, provided little or no shade is cast on the greenhouse.

Workroom

A workroom is almost an essential part of the greenhouse layout. It is necessary to provide room for: (1) the heating unit; (2) storage for soil, sand, peat, leaf mold, pots, flats, and other general supplies; (3) operations such as soil mixing, seeding, transplanting, potting, etc.; (4) storage of all garden and lawn tools and maintenance equipment, unless the house and garage have more than usual space. The workroom should be north of the greenhouse to avoid casting a

shadow on the crop growing area.

A coldframe area should be included as a part of a complete greenhouse layout. The coldframe serves to harden plants before planting them in the garden, and may release space in the greenhouse, in effect increasing its usefulness.

Plans should be made before building so the layout may, in the end, be a well related, efficient setup and not something that has "grown up like Topsy."

Dimensions

An important part of the planning is to determine the exact dimensions of the greenhouse.

The decision on the width of the house is perhaps the most important, as this dimension will not be changed during the life of the greenhouse. Length may be increased if more space is desired.

The width of the house is determined by adding the widths of the various benches and walks and allowing approximately 6 inches for walls at either side, plus a 2-inch space for air circulation between side wall and bench. Side benches that can be serviced from only one side should be no wider than can be reached across conveniently. For some this will be 2 feet, for others $2\frac{1}{2}$ to perhaps as much as

3 feet. Center benches vary from 4 to 6 feet. The gardener should be comfortable while working. Walks may be varied in width, also depending on how they are to be used. If they will be used only as a place to stand while servicing the benches an 18- or 19-inch width is sufficient, but if a wheelbarrow or other equipment will be brought in, the width must be greater. Also, wider walks will allow easy passage for visitors and prevent brushing of clothing against the bench sides or plants. Walks of 2 to $2\frac{1}{2}$ feet are common. The lowest cost per square foot for actual growing space is in the even-span type house 17 to 18 feet wide, including 2 side benches, 2 walks, and a wide center bench. The lowest cost of

useable space is in the lean-to type house 8 to 9 feet wide, including two benches and a central walk.

The decision on the length of the house is not as important as the decision on width. The house may be extended by moving the gable end. The length should be figured so that no glass need be cut to fill odd sash bar spacings. (See glass sizes under glazing.) Allowance must be made for the width of the projecting portion of the sash bar and a fraction of an inch clearance. The gable end bars have a unique

shape and dimension.

The height of the greenhouse is determined by the desired height to the eave. An eave height of 5 feet may be possible with side benches and low growing crops. If taller plants are desired, a 6- or 7-foot eave height should be planned. The 7-foot eave height allows the use of a bracket supported shelf that will hold materials grown in flats or hanging plants grown in pots.

The pitch of the roof should be approximately 30°.

General Construction

Construction of Sides

The small pipe-frame greenhouse is supported by pipe side posts rather than the more apparent wall. The pipe size varies with the width of the house. Most greenhouses for hobbyists are narrow, allowing the use of 1¼- or 1½-inch pipe for side posts. The side posts should be set in concrete piers that extend at least 3 feet into the ground and are at least 1 foot in diameter. If the house is located on a deep fill, the piers must extend into undisturbed soil. The success or failure of the structure depends on the stability of these posts. Sinking of any of them will rack the house and cause glass breakage. No set spacing is compulsory but it is advisable to set them the width of 5 or 6 panes of glass apart.

The side wall which appears to support the greenhouse is merely a curtain wall to keep out the elements. It may be constructed in various ways. Often it is of poured

concrete about 6 inches thick. It should extend approximately 6 inches below grade and up to the sill level 32 to 34 inches above grade. Sometimes the footing, from 6 inches below grade to 6 inches above, is made of building blocks (concrete or pumice), brick, or building tile to extend the wall to the sill. Fitting the blocks around the posts is rather difficult. Wood siding also can be used above the footing. It is advisable to sheath the wall both inside and out. Weather resistant asbestos board also may be used for the curtain wall, and with this material no concrete footing is needed as moist soil has no effect on it.

The sill may be wooden, but angle iron is more permanent.

The eave plate may be wooden or, better, an angle iron positioned so that one side of the angle follows the line of the roof. This necessitates a special bracket that may

be purchased from greenhouse builders; otherwise, a very careful welding job is necessary at the top of the side post. The space between the sill and eave plate is closed by using glazing bars and glass or a combination of fixed glazing and a ventilator sash. The latter is preferable, as even small greenhouses need side ventilation in warm and hot weather.

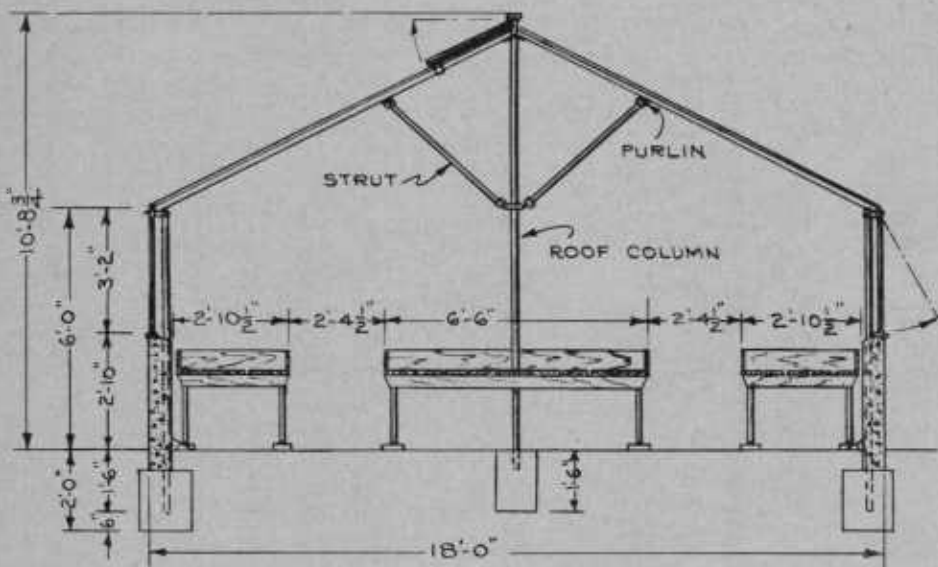
Some hobbyists prefer glazing that extends from just above the ground line to the eave. This gives extra growing space under the benches. The space is not easy to tend nor will it be satisfactory for any plants except those that grow with reduced light intensity. But it is useable to some extent and the additional space adds nothing to the cost.

Roof Construction

The roof of sash bars and glass is supported by roof columns and strengthened by purlins, struts, and tie rods. The ventilator sash makes up a small but essential part of the roof.

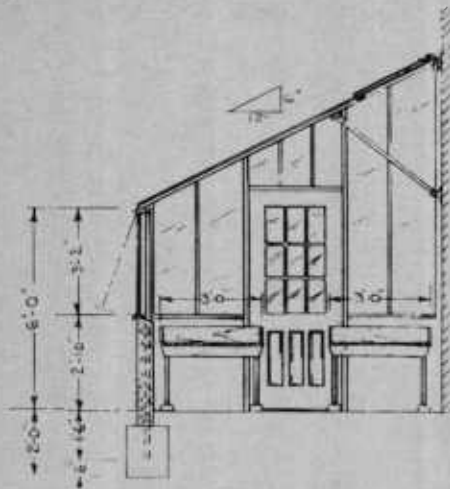
Sash bars (see Figure 3) are comparable to rafters in building construction. They may be homemade but it is better to purchase them

from greenhouse construction companies. It is very important they be made of well aged, straight grained wood to avoid warping, cracking, and splitting which cause glass breakage. Milling is not difficult but such high quality wood usually is not available at lumber yards. The bars have a drip groove toward the base which carries off water



SECTION OF EVEN-SPAN GREENHOUSE

Figure 1.



SECTION OF LEAN-TO GREENHOUSE

Figure 2.

that condenses on the glass and would otherwise drip on the plants. The sash bars in a pipe-frame house run from the eave plate to the ridge pole.

The *ridge pole*, usually 2- by 6-inch lumber, is supported by the roof column in houses from 12 to 20 feet wide. In wider houses the pole is supported by a truss.

The *ridge cap*, usually of a 2- by 4-inch board, set on its side on top of the ridge pole, prevents rain from leaking between the ridge pole and ventilator sash. Vents may be hinged to the ridge cap.

The *roof columns* are vertical pipes set in piers of concrete of the same specifications as the side posts and have the same spacing.

Struts extend at an angle from a point about level with the eave plate to the purlin serving as a sup-

port for the sash bars. Pipe of $\frac{3}{4}$ - to 1-inch size has adequate strength for this purpose. Special brackets are available for fastening the strut to the roof column, or the struts may be welded in place.

Purlins are roof supports running lengthwise the interior of the greenhouse. Purlins may be made of 1-inch pipe or angle iron of equal strength. Each sash bar is held firmly to the purlin by a pipe strap or clamp. Angle iron purlins may be drilled and the sash bars held in place with one screw. It is very important to check the spacing of the sash bars at this point to see that they are exactly parallel so there will be no difficulty in glazing.

Tie rods, cable, or heavy-wire ties are used in narrow houses with no need for roof columns, or in wider houses where two rows of roof columns are necessary. They prevent spreading of the house at the eave plate level in the narrow houses and at the top of the roof columns in wide houses.

Sway braces are rods fitted with tighteners (turn buckles) located just under the sash bars, running diagonally in the roof construction to keep the greenhouse in proper alignment.

Ventilators of some kind are essential for the control of temperature, humidity, and supply of fresh air. A run of sash part way or the full length of the greenhouse usually provides ventilation. The number of runs of sash will vary according to the type of house and the desired efficiency in ventilation.

The lean-to house must have a vent at the ridge, and for even fair

ventilation in warm weather must have a side vent hinged at the eaves.

The even-span house may be equipped with one ridge ventilator on the side away from the prevailing winds so that air is drawn out of the house rather than blowing into the vent. Ventilators on both sides of the ridge improve ventilation. The addition of side ventilators on both sides of the house just under the eave will make the house much more useable during hot weather.

Many of the greenhouses now being built for hobbyists are equipped with automatic ventilation controlled by thermostats. One such system uses a thermostatically controlled exhaust fan located at one side or end of the house with louvers at the opposite side or end to admit fresh air.

Glazing of a greenhouse roof is started at the eave and proceeds to the ridge. The rabbet or groove in the sash bar is filled with putty or glazing compound and the glass pressed firmly in place shingle fashion with one-fourth of an inch

overlap. The glass is held in place by standard square glazing nails set as shown in Figure 3. The greenhouse should be made as tight as possible to avoid unnecessary heat loss. The trend is toward larger glass sizes such as 16 by 24 inches, 18 by 20 inches, 20 by 20 inches. Larger glass means fewer sash bars and less shadow. The larger panes of glass actually have greater flexibility than small panes, and thus there is less breakage in hail and high winds. In areas with high wind or heavy snow, it is advisable to use double strength glass. Grade B glass is suggested for greenhouse use. It is less expensive but is free of bubbles and ripples that might cause burning of foliage and flowers.

End construction consists of sash bars and glass with a door from the work room if attached at one end. A door in each gable end increases the price somewhat but will greatly increase the efficiency of operating the greenhouse. The sash bars used in side and end construction need not have the condensate groove.

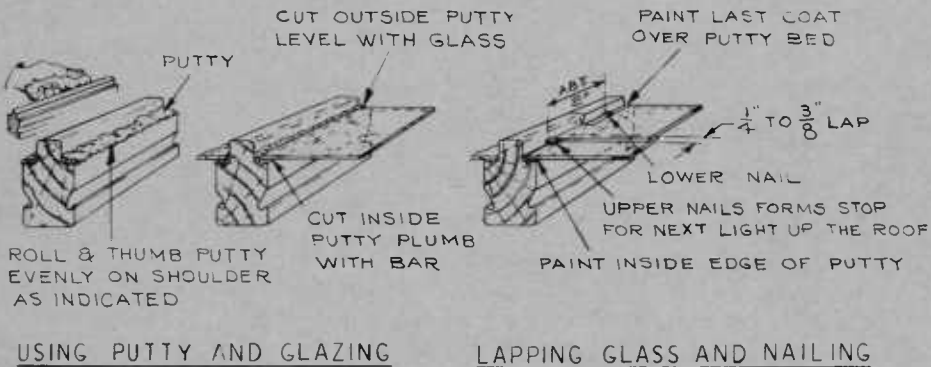


Figure 3.

Materials and Their Preservation

All wooden members of the greenhouse frame should be cut from long-lived woods such as cypress, redwood, or cedar. Cedar is a weak second choice, but is available at somewhat lower cost than the others mentioned.

All parts, metal or wood, should be given protective coats of paint *before assembly*. Care should be taken not to use a preservative containing creosote as its fumes are very toxic to plants. Extra care and extra coats of paint should be given

to joints, especially where sash bars join the eave plate—a point where decay damage starts.

Iron and steel parts within the greenhouse are constantly exposed to water and a moist atmosphere so should be coated with a rust inhibitor and well protected by paint.

The final coat of paint should be white or aluminum to produce a surface that will reflect a maximum of light. High light efficiency during winter is especially important for flowering crops.

Wooden Construction

A greenhouse may be completely built with hammer and saw. It will be less attractive and less efficient for light than some others, but can be satisfactory for the hobbyist.

Side posts are of 4- by 4-inch lumber spaced approximately 4 feet apart.

Sill plate is of 2- by 4-inch lumber.

Siding is any of a number of patterns, inside and out.

Eave plate is a 2- by 4-inch board, set on edge and tapered at

the top to match the slope of the roof.

Sash bars are toenailed to the eave plate and ridge pole (2 by 6 inches).

Roof columns also of 4- by 4-inch lumber.

Purlins are of 2- by 4-inch lumber supported by roof columns or struts of 1- by 4-inch or 2- by 4-inch lumber.

Ventilator sash may be a series of small windows hinged to the ridgepole and eave plate.

Sash Greenhouse

A simpler form of wooden construction makes use of standard 3- by 6-foot coldframe sash placed on a relatively simple frame. The lean-to form is approximately 5 feet wide inside; the even span about 10 feet. The length is any multiple of 3 feet. The sides and ends of the greenhouse may be made by laying the sash to give 3 feet of glazed

space; or a double growing surface may be obtained by standing the sash on end, making a 6-foot glazed wall. Window sash may also be used as side glazing. The gable itself will have to be glazed with sash bars and glass, or plastic.

The frame for the sash house consists of 4- by 4-inch side posts, a 2- by 4-inch eave plate (rest for

sash), 2- by 3-inch or 2- by 4-inch rafters spaced 3 feet apart and a ridgepole (2 by 6 inches) supported by the rafters and crossties to prevent spreading. Alternate lengths of sash are nailed or fastened with screws to the rafters, eave plate, and ridgepole to give rigidity to the structure. This leaves every other sash to be hinged

to the ridgepole or ridge cap to supply ventilation. These may be raised individually by hand or connected to a standard greenhouse ventilation mechanism. During hot weather when side ventilation is needed some of the sash may be removed, stored, and replaced when roof ventilation will properly control temperatures.

Bench Construction

Although many crops could be grown in the original soil covered by the greenhouse most gardeners want benches for all except tall growing crops such as tomatoes, cucumbers, and sweet peas (supported on stakes, wire, etc.) and perhaps chrysanthemums, roses, and carnations.

Benches may be built in a number of ways. Legs may be of wood, concrete blocks, angle iron, or pipe.

The moist conditions in the greenhouse tend to make wooden legs short lived. Raising the legs off the soil by placing them on bricks extends their life.

If benches are constructed with concrete blocks or pipe as legs and pipe as cross pieces, bench maintenance is reduced to a matter of replacing side and bottom boards only.

More than a flat-topped bench

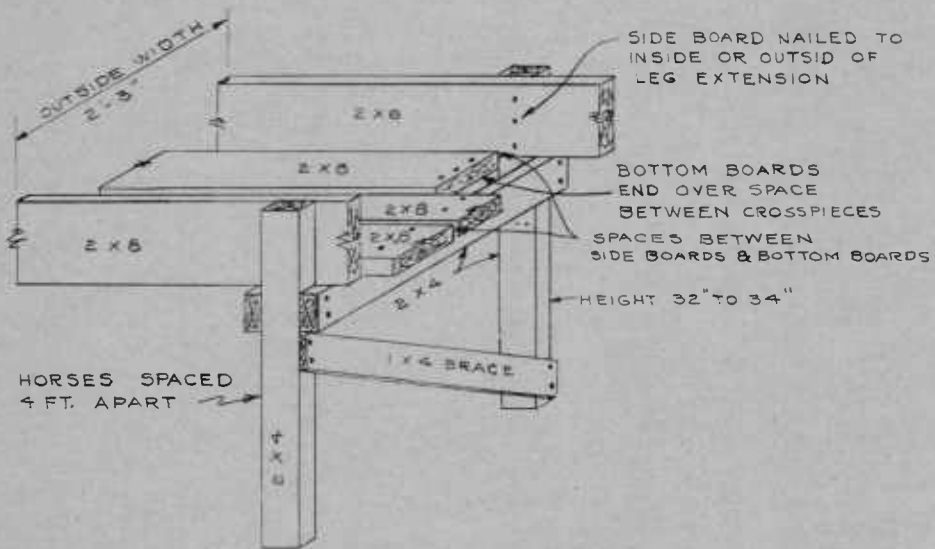


Figure 4.

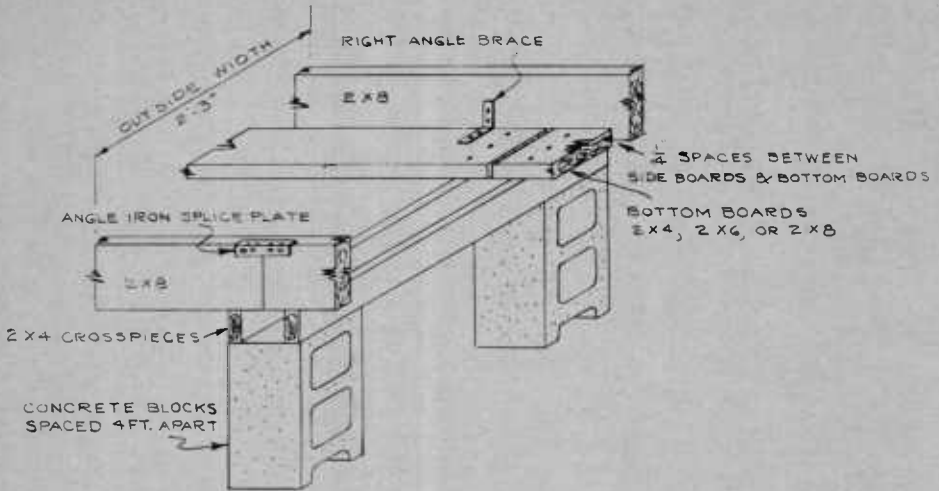


Figure 5.

surface is needed for pot plant crops. A one- to two-inch lip should be built on the edge, and small gravel or crushed rock spread on the bench before placing the pots. This material catches moisture and gives it off slowly increasing humidity of the greenhouse air.

Benches for cut flower crops and vegetables should have sides to hold 4 to 8 inches of soil, depending on the crop being grown.

Right-angle iron braces placed inside the bench will keep the side

boards in position, and pieces of strap iron or angle iron put over the top edges of the sides where the end of one board meets another will insure alignment.

Bench lumber, including the legs, may be treated with copper naphthenate base preservatives, or when very dry given a heavy application of old crankcase oil to retard decay. Crankcase oil usually can be obtained at no cost. Preservatives containing creosote should not be used.

Heating the Small Greenhouse

Heating requirements of a small greenhouse are based on three factors: (1) the lowest temperature during the winter, (2) the temperature to be maintained in the greenhouse during that period, (3) the area of glass and other materials.

The lowest temperature experienced in an area during the past several years can be obtained from weather station reports.

The temperature to be maintained is a matter for the grower to decide. Most plants have a rather

wide tolerance to temperature. In a hobby greenhouse where many different crops are likely to be grown together the selection of temperature range is bound to be arbitrary. Each crop has temperatures at which it will respond best. These are given in terms of night temperature. The day temperature is allowed to rise from 5 to 15 degrees above this stated night temperature, depending on the amount of sunlight.

The selection of a heating system depends on several factors: (1) cost of equipment and installation, (2) cost and availability of fuel, (3) size of the greenhouse to be heated, (4) how accurately temperature is to be controlled, (5) whether the grower wants automatic controls.

A very small greenhouse can be heated with a small stove. Temperature control is difficult and varies from place to place in the house. Better control is possible by placing the stove in the workroom and running stovepipe for radiating surface overhead the length of house to a flue or stack at the far end. By using what is called a salamander heater (gas) or by setting the stove in a pit, the stovepipe radiating surface may be located under the benches in a complete circuit of the house.

An electric space heater with a fan can be used. The fan may operate continuously with the heating element controlled by thermostat. This is quite satisfactory but a standby stove should be available if a power failure occurs during cold weather.

In a few cases it may be possible to heat the greenhouse from the

home heating unit if it has extra capacity. A greenhouse loses heat roughly 5 times as fast as a room in the home of the same size and it is unlikely that most heating systems would have that much surplus capacity.

A separate hot water system with the heater in the workroom and coils of pipe for radiation under the benches or along the side wall is the best system. For small houses 1½-inch pipe will circulate the hot water satisfactorily. In larger houses it will be necessary to use 1½-inch and sometimes 2-inch pipe. Finned radiation requires much less pipe but concentrates the heat to some extent.

A hot water system with circulator or a steam system linked with automatic ventilation will give quite adequate, accurate and worry-free temperature control.

No one wants to find his prized plants frozen because of equipment failure. It is wise to have a battery operated warning bell in the gardener's bedroom. It will ring when temperatures are approaching the danger point, and may help prevent a "freeze-out."

An electric cable may be used to supply extra soil heat for rooting of cuttings, germination of seed, etc., but this method will not heat the entire greenhouse.

It is advisable to consult a heating expert rather than plan a heating system on a costly trial-and-error basis.

Fumes from kerosene and oil burners, storage tanks, and fuel lines may be injurious to some plants. This should be considered in planning a heating system.

Plastic Greenhouses

Popularity of plastic greenhouses is increasing. The reasons are: (1) the initial construction cost per square foot is generally one-sixth to one-tenth the cost of more permanent glazed greenhouses; (2) plastic greenhouses may be considered temporary structures and therefore may carry a low assessment rate for tax purposes, or may not be taxed at all; (3) they can be depreciated in a few years, while glass houses usually carry a 15-year period for depreciation; (4) plastic houses can be heated as satisfactorily as glass houses and can be used to force crops that normally need higher temperature. Heat can be conserved by applying two layers of plastic, one on the outside and one on the inside of the framing; (5) because of the low initial investment, plastic houses can remain idle during certain periods of the year if this is necessary; (6) crops grown under plastic are of equal quality to those grown under glass.

Usually polyethylene plastic is used. Some of the other plastics cost more but may give longer service. Vinyl plastic, however, has not given any better results than polyethylene. Vinyl plastic should not be used where prolonged freezing weather occurs. It does not readily withstand cold and becomes brittle. Polyethylene and some other clear plastics deteriorate from light. Although heavier-weight plastics no doubt will outlast light-weight plastics, no figures are available as to the relative life expectancy of the various weights.

Polyethylene is available in many widths. It is advisable to check on

widths available before starting to build. Polyethylene is also available in various thicknesses, .002 inch, .004 inch, and .006 inch, often referred to as 2, 4, or 6 mil. plastic. If a plastic is to be used through winter months in a heated greenhouse, heavier plastic is recommended for the outside and lighter plastic for the inside. A plastic cover can be expected to last a year if applied in the fall and no unusual condition, such as hail, occurs. Hail will puncture plastic.

A number of other new plastics are on the market. Some are almost as rigid as glass and are used in much the same manner as glass. The cost is more, but the life may be sufficient to justify the expense.

A number of designs for plastic greenhouses are available from commercial companies and other states. The design shown in this publication uses 2- by 4-inch lumber. In most areas it is possible to buy low grade 2- by 4-inch lumber at a lower cost than high grade 2- by 2-inch pieces. The 2 by 4's, even though of a low grade, provide a larger nailing area and more strength than 2 by 2's.

If one sheet of plastic will not cover an entire wall or roof, joints should be made at the rafters or studs, with the two pieces overlapping. For example, if 42-inch width strips of plastic are used, studs and rafters may be placed at 20-inch centers to allow overlap.

If a gable-type plastic house is used the year round, ventilation should be provided on both sides of the ridge and under the eaves. The same type of ventilator is used

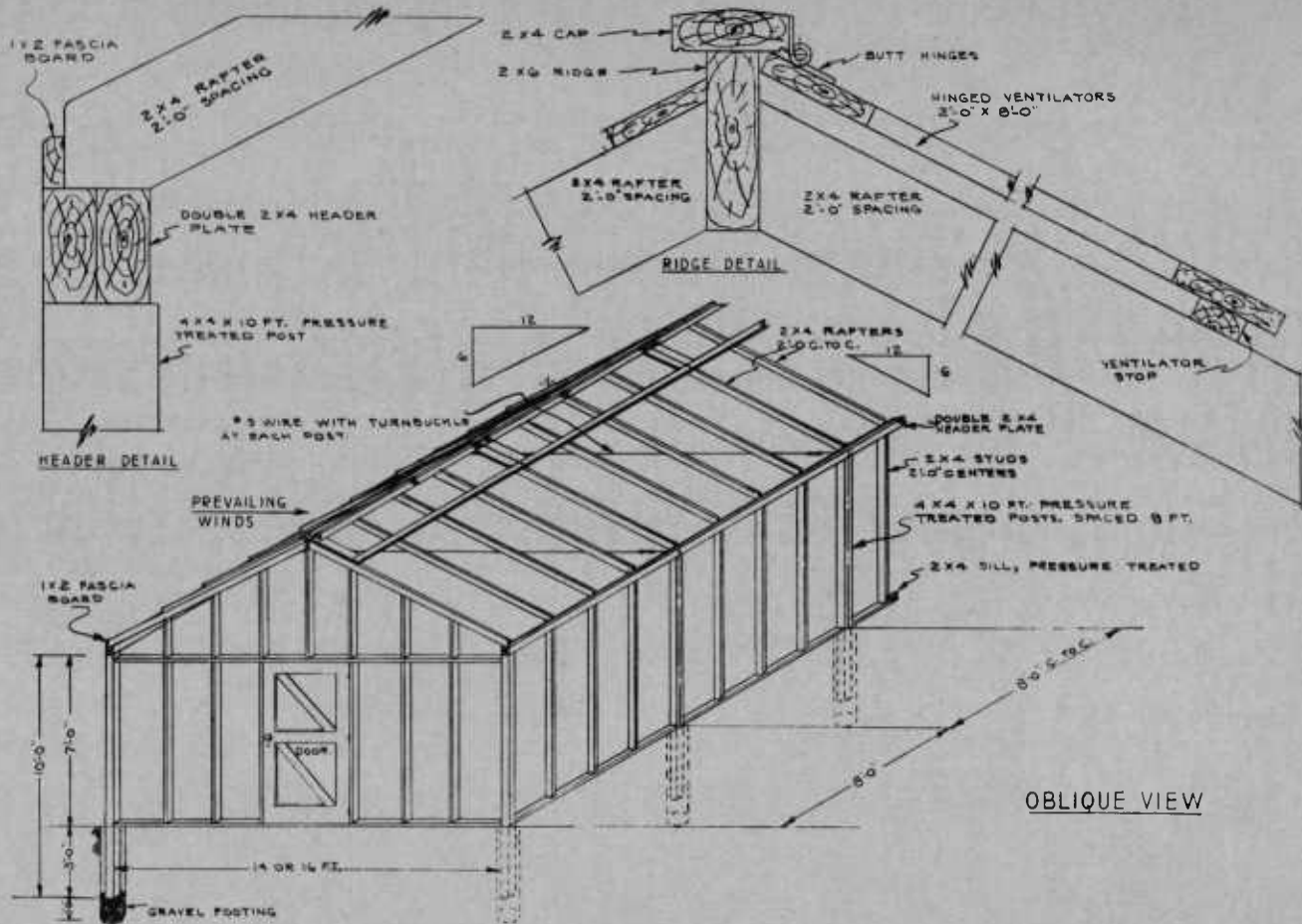


Figure 6.

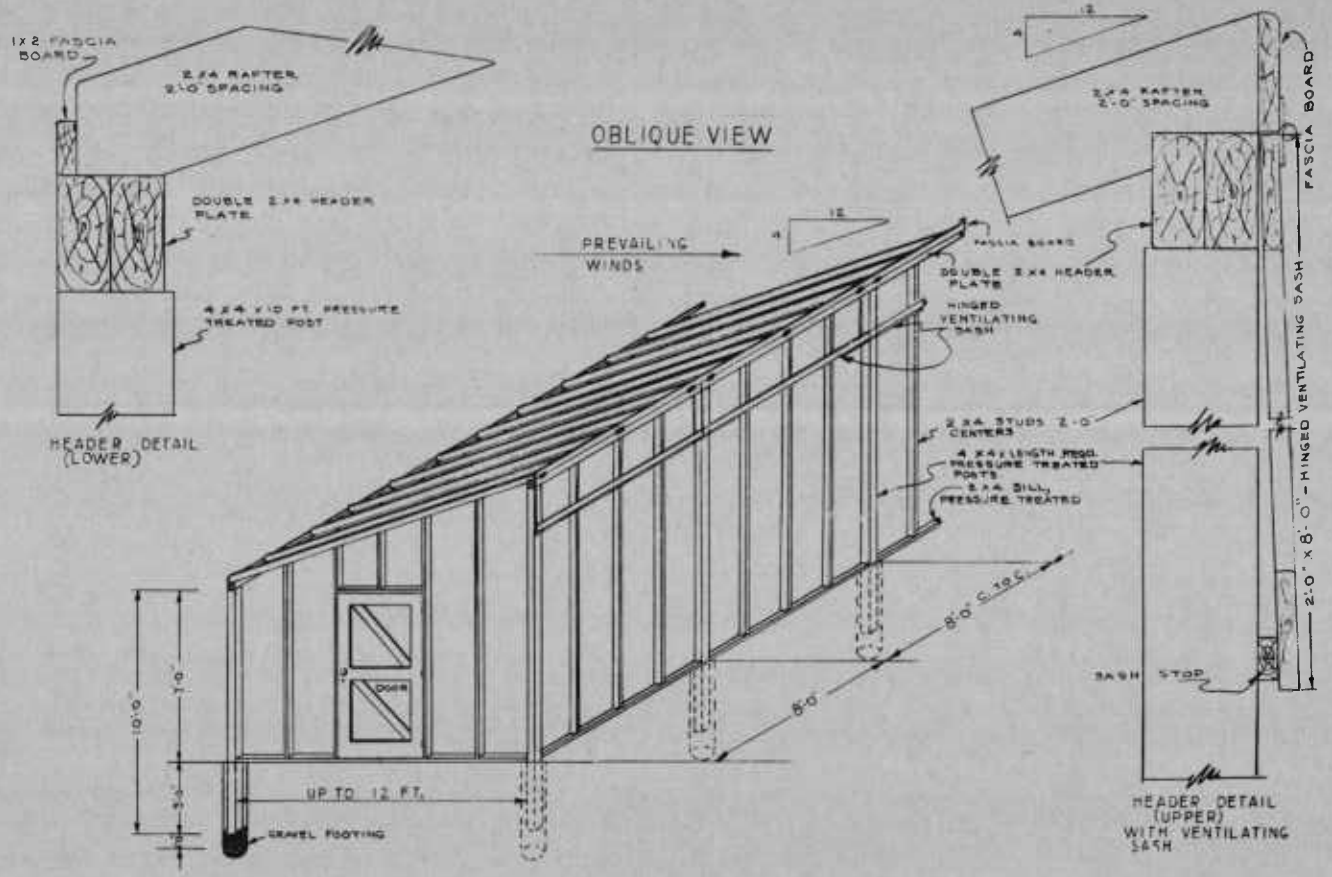


Figure 7.

under the eaves as on the shed-type roof. Hot weather use will require this ventilation on both sides of the house.

Management of a plastic greenhouse is essentially the same as any other greenhouse. The same kinds of heating systems can be used.

Applying Polyethylene Plastic to Greenhouses

Be sure to select a calm day to work with plastic. To unroll plastic put the roll on a pipe supported at each end. This may be set at the end of the house running from the ridge to the eave if the plastic is to be applied the long way of the house. If the plastic comes folded, this method will not work. Perhaps a better method is to locate the roll and its support at one side of the structure and pull the plastic over the ridge to the bottom of the opposite side. When the ridge and eave ventilation are used, it will be necessary to measure lengths of plastic carefully, allowing extra for fastening. Before being nailed to the ventilator stop, the plastic should be wrapped around a lath reduced in width to slightly less than the thickness of the ventilator stop. The ventilator stop should be set back under the ventilator far enough so that when this strip is nailed in place the rain water will drain onto the roof plastic.

The lumber should be smooth and all edges should be slightly rounded so there are no sharp or rough spots on the rafters or studs. Rough lumber will rapidly abrade the plastic. Since most laths are rough, a strip of corrugated cardboard should be placed between the plastic and the lath. The plastic should not be stretched and the nails must be firmly set so the plastic cannot slip. Form nails (double headed) facilitate removal of plastic.

Another method for applying plastic is to sandwich it between layers of welded wire. The welded wire can be 2- by 2-inch mesh or slightly larger. With this method fewer rafters are needed. A layer of welded wire is laid over the rafters, then the plastic is placed over the wire, and finally another layer of welded wire is put over the plastic. The top layer of wire should be omitted in areas where it might hold snow.

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