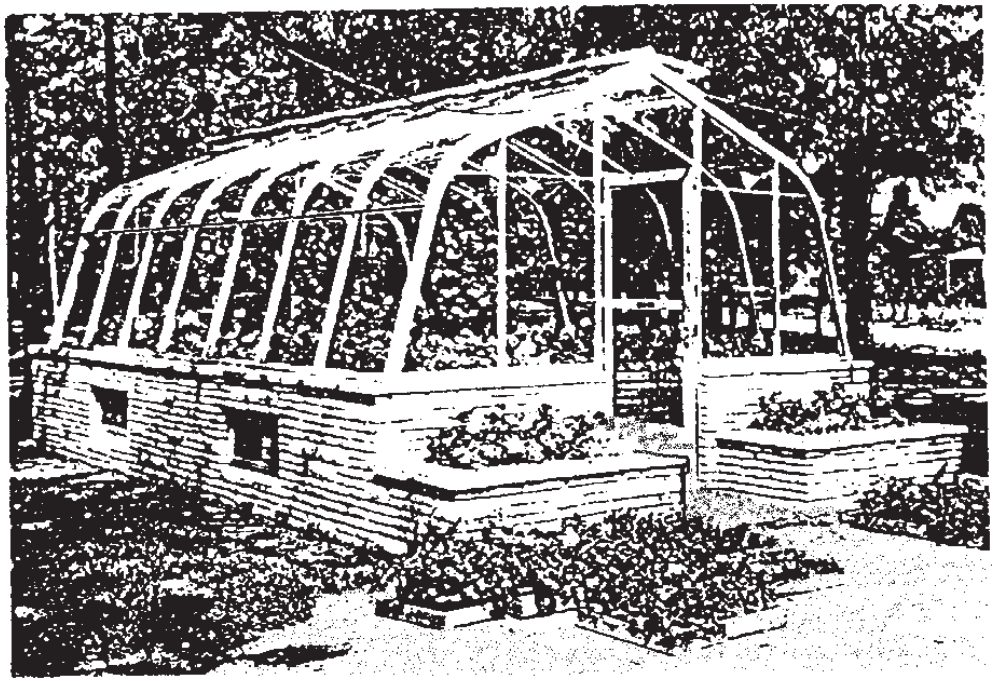
Building Hobby Greenhouses



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Building Hobby Greenhouses

So you've finally decided to get that hobby greenhouse you've always wanted. The first thing you have to do is make a couple of decisions: How much money do you want to spend? How much work do you want to do?

A hobby greenhouse can range from a simple polyethylene covered framework that you can put together in an afternoon for less than $125 to a $6000 fully automated conservatory.

No matter which greenhouse you choose, consider how much time you'll have to spend in it after it's built. Don't be overly enthusiastic; some new greenhouse owners find they don't have as much time as they thought for gardening.

On the other hand, there is a misconception that greenhouses require constant attention. By combining automatic controls and easy-care plants, maintenance can be kept low. Automatic controls are ideal for providing proper growing temperature, artificial light, watering, humidity and ventilation. Or if you have time, you can save a lot of money by not using automatic controls.

You can get the most greenhouse for your money by doing some of the construction work yourself. How much work you do depends on how handy you are with tools. Be honest with yourself; don't take on a job that's too big to handle.

If you are good with tools, you can put up any plastic covered greenhouse and almost any prefabricated glass greenhouse. You may have to hire a qualified electrician and plumber.

Types of Greenhouses

There are two basic types of greenhouses: attached and free standing. An attached greenhouse may be even-span, lean-to or window-mounted. A free-standing greenhouse is usually even-span (symmetrical roof).

Attached Lean-to

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

Space heaters can maintain a minimum of 60 degrees F in the greenhouse. Higher temperatures on plant benches can be provided with soil-warming equipment.

Remember that heat is lost from a greenhouse by radiation, conduction and convection through glass; walls and other non-glass parts of the structure; floor or soil; ventilation, door openings and cracks.

Control Units

Automatic controls are important in greenhouses. Without them, switching lights, fans, pumps, heaters and misters on and off at a prescribed time would be a complicated and laborious task.

Many time clocks, photocells, thermostats and other controls are available commercially. When used individually or in combination they will provide any time interval or control desired.

Before Building Your Greenhouse

Almost every gardener eventually reaches a point of wanting a greenhouse. Before buying or building one, you should--

•Give careful thought to the size, style and kind of control desired.

•Contact your county agricultural agent to help you locate and visit a few of your neighbors who have garden greenhouses. Learn about their problems so you can choose the best greenhouse for you.

•Check local building codes and zoning laws before you start construction.

Information for this publication was furnished by William A. Bailey, Robert C. Liu and Herschel H. Klueter, agricultural engineers, Northeastern Region, Agricultural Research Service.

single units or in tandem arrangements for large windows. Only simple tools are needed to remove the regular window from the frame and fasten the prefabricated window greenhouse in its place.

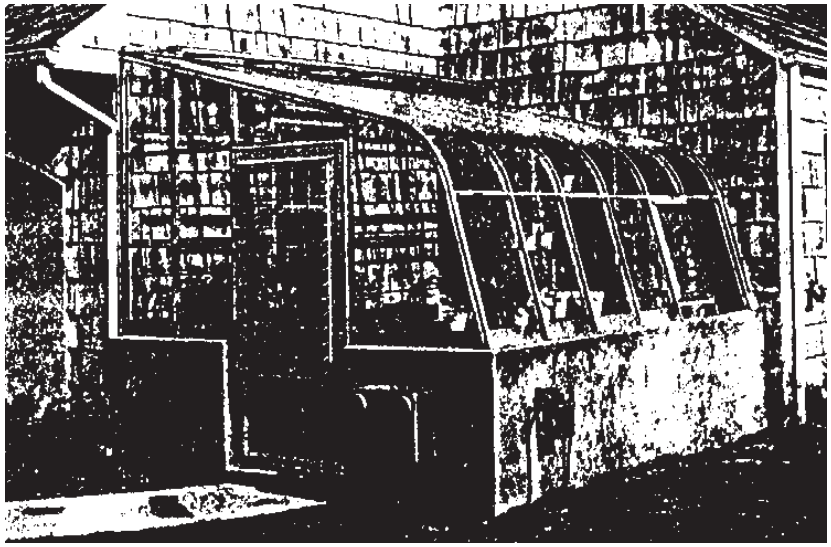
Free-standing

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

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

Cost

The lowest cost per square foot of growing space is available in the even-span greenhouse 17 to 18 feet wide. It will house two side benches, two walks and a wide center bench. The lowest total cost greenhouse is the lean-to house 7 to 12 feet wide with double-row benches and a central walk.



This 10-foot-wide lean-to has ample room for two 36-inch-wide benches along each wall. Glass shelves and hanging baskets may also be installed.

directly to each plant through hollow plastic tubes, which are permanently attached. One tube can be used for each small pot and two or more for larger pots. Water tubes are weighted at the outlet end; each tube is approximately 5 feet long, and can be cut to shorter length if necessary.

CO_2 and Light Control

Carbon dioxide (CO_2) and light are needed for plant growth. Closed greenhouses often have too little carbon dioxide during the day to use available light effectively. Therefore, plants grow poorly when air vents are closed. By enriching the atmosphere with CO_2, you can accelerate plant growth.

Because light and carbon dioxide complement each other in plant growth, additional electric lights in greenhouses combined with good carbon dioxide control will increase yields of lettuce, tomatoes, orchids, chrysanthemums, carnations, snapdragons, geraniums and other crops.

CO_2 equipment using red sensors are available for greenhouse owners who want to benefit from carbon dioxide enrichment with supplementary lighting. The equipment will measure and control CO_2 levels from 0 to 2,000 parts per million which will satisfy most of the production needs of greenhouse owners. This equipment is fairly expensive and requires frequent calibration.

Inexpensive color metric kits are also available for determining the CO_2 levels in your greenhouse.

Forms of CO_2

Forms of CO_2 for enriching greenhouse atmospheres follow:

•Bottled CO_2, which has been liquified from a burning process. This liquid CO_2 is kept under pressure and is controlled by a solenoid or metering device.

•Dry ice, which may be placed in a greenhouse or growth chamber in block form or placed in a converter (a pressure bottle) and stored until needed.

•Burned sulfur-free gaseous fuels such as natural gas, LP gas or a liquid carbon fuel such as kerosene.

Lighting, Temperature and Control Units

Plants respond to the relative lengths of light and dark periods as well as to the intensity and quality of light. Artificial light has been used extensively to control plant growth processes under various conditions.

Plants differ in the need for light; some thrive on sunshine, others grow best in the shade. Most plants will grow in natural or artificial light.

Artificial light in greenhouses can be used:

If you have an L-shaped house, you can save the cost of two greenhouse walls by building the greenhouse in the "L."

Whether your greenhouse runs north and south or east and west is not as important as wind protection. Protect your greenhouse from winds by locating it so existing buildings will shield it, or by providing it with a windbreak hedge or fence.

Location

An ideal site for your greenhouse is well drained, nearly level and has full exposure to sunlight. It slopes slightly to the south and has a windbreak on the side of the prevailing wind.

Designing Your Greenhouse

Determine the exact dimensions for your greenhouse before you start to build. Width is the most important dimension; it will not be changed during the life of the greenhouse. Length can be increased if more space is desired.

Greenhouse Width

Determine the width of your greenhouse by adding the widths of the plant benches and the walks. Allow about 6 inches for walls at either side and 2 inches for an air-circulation space between the side walls and the benches.

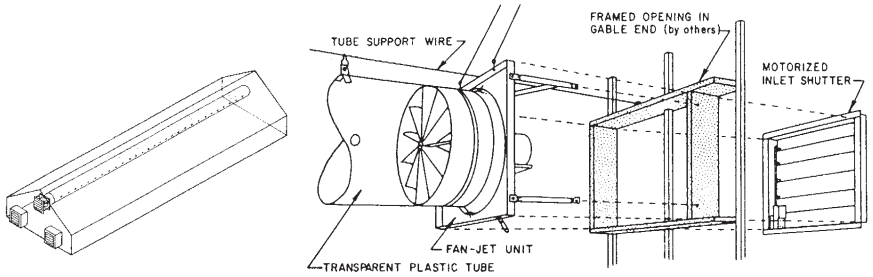
Side benches are serviced from only one side and should be no wider than you can reach across. For some people this will be 2 feet, for others as much as 3 feet.

Center benches are serviced from both sides and can be as wide as 6 feet. They should be no wider than to permit you to work comfortably.

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

Greenhouse Length

Determine the length of your greenhouse by multiplying the number of plants you can grow across the benches by the number of plants you want to grow. Then round off the measurement so that no glass will need to be cut to fill odd sash bar spacings. (A sash bar is a shaped wooden or metal bar used in the construction of a sash or frame and designed to hold and support the glass secure to it).



Fan and tube ventilation give positive air flow while polyethylene ducts distribute the incoming air evenly throughout the greenhouse. The plastic ducts are suspended by wires or straps from the roof of the greenhouse.

endwalls. This will exhaust the hottest, most humid air, and prevent a direct draft on the plants near the intake.

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

Shading Your Greenhouse

When protection from the sun is needed, use roll-up screens of wood or aluminum, vinyl plastic shading or paint-on materials.

Roll-up screens are available with pulleys and rot-resistant nylon ropes. These screens can be easily adjustable from outside as weather and sunlight vary.

Vinyl plastic shading is made of a flexible film that reduces light from 55 percent to 65 percent. The material comes in rolls and installs easily against the glass inside your greenhouse. To apply, just wash the glass with a wet sponge, then smooth the plastic onto the wet glass. When smoothed into position, it adheres to the glass. It can be pulled off and used again.

Shading compound can also be applied on the outside of glass greenhouses. It can be thinned with paint solvents. It usually comes in white or green. Shading compound which mixes with water can also be used.

Evaporative Cooling

An evaporative cooler (or fan and pad system) eliminates excessive heat and adds beneficial humidity. With an evaporative cooler, moist cool air is circulated throughout the greenhouse. Warm

For amateur gardeners, small prefabricated glass greenhouses are available for do-it-yourself installation. They are sold in different models, to fit available space and to fit your pocketbook.

The disadvantages of glass are that it is easily broken, expensive and requires a much better type of construction than fiberglass and plastic.

Fiberglass Greenhouses

Fiberglass is lightweight, strong and practically hailproof. Corrugated panels 8- to 12-feet long and flat fiberglass in rolls are available in 24- to 48-inch widths. Thicknesses range from 3/64 to 3/32 of an inch. Poor grades of fiberglass will discolor, and the discoloring reduces light penetration. Using a good grade, on the other hand, may make your fiberglass greenhouse as expensive to build as a glass one. If you select fiberglass, choose the clearest grade. Do not use colored fiberglass.

Plastic Greenhouses

Plastic greenhouses are increasing in popularity. The reasons are:

•Construction cost per square foot is generally one-sixth to one-tenth the cost of glass greenhouses. Plastic greenhouses can be heated as satisfactorily as glass greenhouses. Crops grown under plastic are of equal quality to those grown under glass.

•Plastic greenhouses are considered temporary structures and usually carry a low assessment rate for tax purposes, or may not be taxed at all.

•Plastic greenhouses can be made of polyethylene (PE), polyvinyl chloride (PVC), copolymers of these materials and other readily available clear films. Polyethylene must be replaced each year; it deteriorates rapidly in the strong sunlight of summer. Other films such as PVC or copolymers with ultraviolet (UV) inhibitors last longer. Descriptions of plastics available are provided.

Polyethylene

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

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

Ultraviolet-inhibited polyethylene lasts longer than regular polyethylene. It has an inhibitor that prevents the rapid breakdown caused by ultraviolet light. UV-inhibited polyethylene is available

Heating

Many types of heaters and heating systems are satisfactory for greenhouses. You must decide which heating system best suits your greenhouse operation. Consider the initial cost, economy of operation and available fuel. You can heat a greenhouse efficiently with coal, electricity, gas and oil.

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

The capacity of your heating system will depend on the size of your greenhouse, whether it is covered with a single layer or a double layer of plastic or glass, and the maximum difference between inside and outside temperatures.

Heating systems are rated in British thermal units (Btu) per hour. The firm from which you buy your greenhouse can tell you what size of heater you will need; or you can estimate the size as follows:

•First, find the temperature difference. This is the difference in degrees Fahrenheit between the lowest outside temperature and the temperature you want to maintain inside your greenhouse. For instance, if you want to maintain a minimum inside temperature of 60 degrees and the lowest night temperature you expect is -10 degrees, your temperature difference is 70 degrees.

•Next, find the number of square feet of exposed glass or plastic in your greenhouse. Don't forget to add the areas of the sides and ends to the area of the roof.

•Multiply the temperature difference by the number of square feet. For example, suppose you have a 20 by 100 foot greenhouse with a total of 3,400 square feet of exposed plastic. You would multiply 3,400 by 70 (the temperature difference). This would give you 238,000.

•Now, if your greenhouse is covered with two layers of plastic or glass, multiply the 238,000 by 0.8. If it is covered with only one layer, multiply by 1.2. This will give you the required Btu per hour capacity of your heater.

In the example, a two-layer greenhouse would be: 238,000 x 0.8 - 190,400 Btu per hour.

The one-layer greenhouse would be: 238,000 x 1.2 = 285,600 Btu per hour.

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

•**Space heaters.** For low-cost heating for small greenhouses, use one or more ordinary space heaters. WARNING: If you use a gas, oil or coal heater, be sure to have a fresh air supply to avoid carbon monoxide buildup caused

A-frame

In building an A-frame structure, consider the placement of cross rafters (supporting members). Cross rafters should be placed at least one-third of the distance down from the ridge on the outer rafters. Otherwise, it will be difficult to work around the cross rafters in applying an insulating layer of plastic.

When the cross-rafter support is high in the peak of the greenhouse, especially in narrow greenhouses, an essentially clear-span type of structure permits easy application of an inner layer of plastic. The inner layer can be applied under the cross-rafter supports, leaving a small triangular air space in the peak of the house.

Diagonal bracing wires provide added strength to an A-frame structure. This type of greenhouse is among the easiest to build.

Rigid Frame

Rigid-frame structures have been designed in widths up to 40 feet. This clear span structure has no columns to hold up the roof section. The best available rigid-frame greenhouse has a 6-foot sidewall and is designed for 30, 36, or 40 foot widths.

Prefabricated greenhouses are commercially available. They have very low sidewalls (low head room), and to grow tall plants the structure must be raised higher on the foundation sidewalls.

Panel Frame

Panel-frame greenhouses are a modification of the sash house (a small plastic greenhouse used for growing plants for later transplanting). This structure requires accurate carpentry, and construction costs are higher than for other frames because of the added lumber and labor needed to build the panels.

Advantages of panels are that they can be quickly installed and taken down and stored during the summer; this will increase the life of the plastic panels. Panel greenhouses can be easily ventilated.

Quonset

Quonset greenhouses have the same general shape as the quonset huts of World War II. Some have been constructed of wood, but usually the frames are metal. The half-circle frames are covered with one piece of wide plastic, and the houses are up to 20 feet wide. The advantage of this house is the ease of construction and covering. Ventilation is by exhaust fans at the ends of the houses.

Pipe Frame

A pipe structure can be used to frame an air inflated greenhouse. Air is introduced into a chamber formed by two layers of 4- or 6-mil film. The effect of the air under slight pressure is to force the inner layer of film over the circular greenhouse pipe frames. The outer layer assumes a circular shape over the frame and rides on a cushion of air. The outer layer lifts 3 to 4 inches from the frame at the top and 1 to 2 inches from the frame at the foundation sill. Air enters the chamber through 6-inch plastic tubing.

A manometer is used to measure static air pressure between the two layers of film.

Beds for Growing Small Plants

Coldframes

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

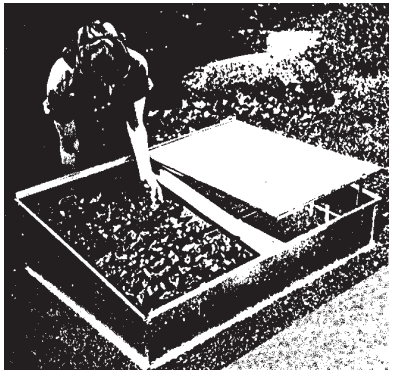
Coldframes use the sun's heat. The soil inside the box is heated during the day and gives off its heat at night to keep the plants warm. The frame may be banked with straw or strawy manure to insulate it from the outside air and to retain heat.

With a coldframe, you can do many of the same things you do in a greenhouse. You can sow summer flowers and vegetables weeks before outdoor planting. Often, you will gain sufficient time to grow an extra crop. You can start vegetables, annual flowers for fall and winter, and perennials for next year's bloom.

Plants are protected from harsh weather and will grow to transplant size quickly. You can root cuttings of deciduous and evergreen shrubs and trees. Softwood cuttings of chrysanthemums, geraniums and fuchsia, leaf cuttings of rex begonias, African violets, and succulent and foliage plants take root faster in a coldframe, particularly during warmer months.

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

Portable coldframes can be built in your workshop from surplus materials you may have on hand.



An aluminum coldframe glazed with corrugated fiberglass panels. Lightweight sash covers lift or slide for ventilation control.

Coldframes are constructed from sections of 3- by 4-foot or 3- by 6-foot millwork sash or plastic covered panels. Most coldframes can be converted to hotbeds for use in all seasons by installing electric heat and automatic clock controlled misting or watering.

Hotbeds

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

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

Between 10 and 15 watts of electric heat should be provided for every square foot of growing area in a hotbed. Soil-heating tape or cable is available in several lengths, which give a choice of wattages.

If the bed is in a sunny, well-sheltered location, and the climate not too severe, 10 watts per square foot should be adequate. Lining the side walls with moistureproof insulation is desirable. For localities with severe winters, a higher heat capacity is needed. Fifteen watts per square foot is recommended.

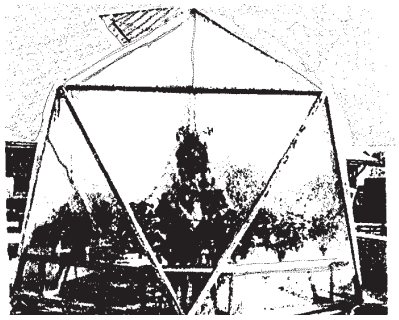
Tape or wire screening, 1/4- or 1/2-inch mesh, should be placed over the heating tape or cable to prevent possible damage by cultivating tools.

Do not place hotbed cables of any type directly in peat. When peat dries out, it acts as an insulator and may cause the cable to overheat. Use a thermostat to control temperature automatically and make more efficient use of electricity.

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

Weatherproof Wire

Use weatherproof wire for all outside wiring. Wire size depends on the distance to be covered and the number of hotbeds to a circuit. Use approved terminal equipment, and follow safe wiring practices. All wiring must conform to local wiring codes. by oxygen supply.



Greenhouses come in many types, styles and sizes. A plastic tri-penta greenhouse can provide do-it-yourself satisfaction. USDA Plan. No. 6097, "Tri-Penta Greenhouse," is available from your Extension Service.

in 2- and 6-mil thicknesses up to 40 feet wide and 100 feet long.

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

Polyvinyl chloride (PVC or Vinyl)

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

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

Plans and Drawings

Plans and drawings for plastic greenhouses and propagating frames are available free from your state agricultural experiment station, county agricultural agent, extension agricultural engineer at your state university or are for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. If you do not know the location of your state university, send your request to Agricultural Engineer, Louisiana Cooperative Extension Service, P. O. Box 25100, Baton Rouge, Louisiana 70803-5100.

Types of Frames

Plastic greenhouse structures range from crude wooden frameworks to air-supported houses. If you plan to build a plastic greenhouse, carefully consider economy of size and future expansion.

Because plastic is available in large widths and is lighter in weight, greenhouse rafters and supporting members can be widely spaced to permit maximum light penetration. Common types of greenhouse frames follow.

Fans are also needed to improve circulation. Use high grade (low sulfur) kerosene to avoid sulfur dioxide damage; the need for high ignition temperature to avoid carbon monoxide and ethylene buildup is important.

•Forced-air heater. The best system for heating a small greenhouse is a forced air furnace with a duct or plastic tube system to distribute heat. You can use a thermostat to control the temperature in the greenhouse.

•Hot-water or steam heater. A hot-water system with circulator or a steam system linked with automatic ventilation will give adequate temperature control. In some areas, coal or natural gas is readily available at low cost. This fuel is ideal for hot-water or a central steam system. Steam has an advantage; it can be used to sterilize growing beds and potting soils.

•Electric heaters. Overhead infrared heating equipment combined with soil cable heat provides a localized plant environment, which allows plants to thrive even though the surrounding air is at a lower than normal temperature. Electric resistance heaters are used as space heaters or in a forced air system.

Ventilation

Even during cold weather, a greenhouse can get too warm on bright, sunny days. So ventilation equipment should be built into your greenhouse to control temperatures in all seasons. If you use hand-operated roof vents, they will require frequent temperature checks. As outdoor weather changes, sashes must be opened and closed manually to keep plants from getting too hot or cold.

Automatic ventilation eliminates the manual work and is the best way to cool a greenhouse.

As an example, if your greenhouse has roof vents, a special electric motor and thermostat will open and close the vents. Fresh outside air is brought in through the roof vents. Warm air flows out through escape vents. Besides cooling the greenhouse, the change of air improves growing conditions.

Responding to this air transfer, the thermostat will turn off and on to keep temperatures right for plants. Fans provide good ventilation and are needed in both large and small greenhouses.

Exhaust fans should be large enough to change the air in the greenhouse once very minute. To accomplish this, the capacity of the fan in cubic feet per minute at 1/8-inch static pressure should equal the volume of the greenhouse. The volume can be calculated by multiplying the floor area by 7.

If the greenhouse is high enough, place the exhaust fan and the motorized intake louvers above the doors at opposite air

Standard glass sizes are 16 by 24, 18 by 20, and 20 by 20 inches. (Larger glass sizes mean few sash bars and less shadow inside the greenhouse.) Most plastics are available in 100-foot lengths.

When you figure the length of a glass greenhouse, allow for the width of the projecting part of each sash bar plus a fraction of an inch clearance. For plastic, allow an extra 24 inches to fasten the plastic properly.

Greenhouse Height

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

The pitch of the roof should be 6 in 12 (about 27 degrees). The eave height, the distance from the side wall to the center of the greenhouse and the roof pitch will determine the height of your greenhouse at the center.

The height of the greenhouse should be equal to the eave height plus one-fourth the width of the greenhouse. For instance, in an even-span greenhouse 18 feet wide, the distance from the side wall to the center of the greenhouse is 9 feet. The difference in height between the center of the greenhouse and the eave will be one-half of 9 feet, or 4 1/2 feet. If the eave is 5 feet high, the greenhouse should be 9 1/2 feet at the center.

Types of Construction

Whether you build a glass, fiberglass or plastic greenhouse, it will pay you to shop around for ideas.

Greenhouses have supporting framework made of wood, plastic pipe, aluminum, iron or galvanized pipe. Some have curved eaves; others have flat eaves. Some are glass or plastic from the ground up. All types have advantages and disadvantages.

If you build your own greenhouse, have the plumbing and electrical work done by professionals in accordance with local codes. Most local governments require a building permit to erect a greenhouse.

Glass Greenhouse

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

Aluminum frame and glass construction has pleasing lines and will provide a large growing area as well as being maintenance-free. It assures you of a weather-tight structure, which minimizes heat costs and retains humidity.

flows out through roof vents or exhaust fans. Temperature is lowered, humidity is increased and watering needs are reduced.

You can select a cooler of the right size as follows:

•First, calculate the cubic feet of your greenhouse by multiplying the length by the width by the average height.

•Next, add 50 percent to the total cubic space, then select a cooler which has at least this CFM (cubic feet per minute) air capacity rating.

The cooler must be installed outside the greenhouse. If it is inside, it can only humidify and cannot cool. A properly sized cooler will reduce the greenhouse temperature about 80 percent of the difference between the outside wet-bulb and dry-bulb thermometer readings.

In hot, dry areas this system can reduce the temperature from 30 to 40 degrees. In wet, humid areas the cooling will be less. It is most effective during the hottest part of the day.

Mist Propagation Controls

Mist sprays are used to keep the atmosphere humid. There are two types of mist propagation controls. The most popular is time clocks. The other system controls the cycles by evaporation from a mechanical or electronic leaf or screen.

Time Clock System

This system of automatic watering includes -

•A dual-time clock consisting of a 24-hour clock and a 6-minute clock.

•An electric water valve with strainer.

•Hose bibbs.

•A toggle switch to give you a choice of manual or automatic operations.

Evaporation System

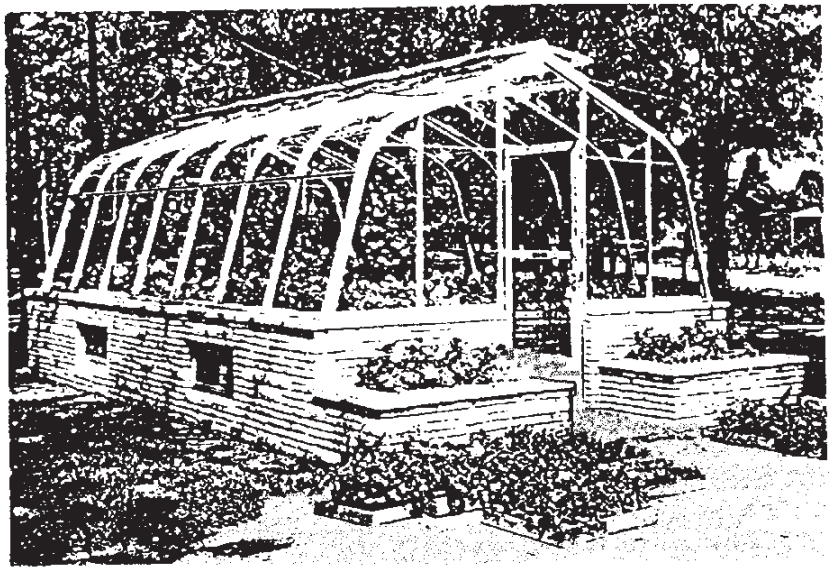
This system provides a special unit that operates within the mist spray from the nozzles. When the stainless steel or ceramic screen and the plants become saturated, the screen tilts downward, which switches off the water.

The water evaporates both on the mesh screen and on the cuttings. When the screen loses weight, the screen raises and actuates the switch. This opens the solenoid valve and starts the misting cycle again, according to the needs of the cuttings.

Because this control is activated by the weight of the water, it is fully automated and operates continuously day and night.

Watering Kits for Pot Plants

Watering kits for pot plants can also be used. Water is supplied



A free-standing greenhouse is set apart from other buildings, with a door at one end (or a door in both ends for long units).

Locating Your Greenhouse

After you decide which kind of greenhouse you want, you need to determine where to put it.

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

You can place your greenhouse where it will be partly shaded during the summer when light reduction is not serious and may be desirable. Be sure to take into account the possibility of falling limbs that can damage the greenhouse.

Some plants will grow in a greenhouse in any location. African violets and orchids, for example, will grow with northern exposure, but heating costs will be high. You'll limit the types of plants you can grow if you don't put your greenhouse in the best possible location.

Sometimes you can place a greenhouse against a door, window or basement entrance of your house. This will let you use heat from your house to grow plants, make your greenhouse more accessible and save on construction costs. Your home heating bill, however, will increase significantly.

•To provide high intensity light when increased plant growth is desired.

•To extend the hours of natural daylight or to provide a night interruption to maintain the plants on long-day conditions.

Proper lighting not only extends the gardening day by enabling the gardener to work in the greenhouse during the dark evenings of winter and early spring, but it aids plant growth.

Three basic types of lamps are used in greenhouse lighting. They are: **Fluorescent lamps**, which have the advantage of higher light efficiency with low heat. This type of lamp is the most widely used for supplemental light. It comes in a variety of colors but cool-white lamps are the most commonly used. High intensity (1500 ma) fluorescent tubes that require higher wattage are also commonly used to reach 2000 foot candles.

Incandescent lamps, which vary in size from 60 watts to 500 watts. They are used to extend day length in greenhouses. The grower can vary footcandle levels by adjusting the spacing and mounting height above the plants.

High-intensity discharge (HID) lamps, which have a long life (5000 hours or more). With improvements made possible by the addition of sodium and metal halides the lamp has a high emission of light in the regions used by plants.

Light Meters

Inexpensive light meters are available for measuring the light intensity in greenhouses. The most common light meters are calibrated in foot candles or lux (10.76 foot candles).

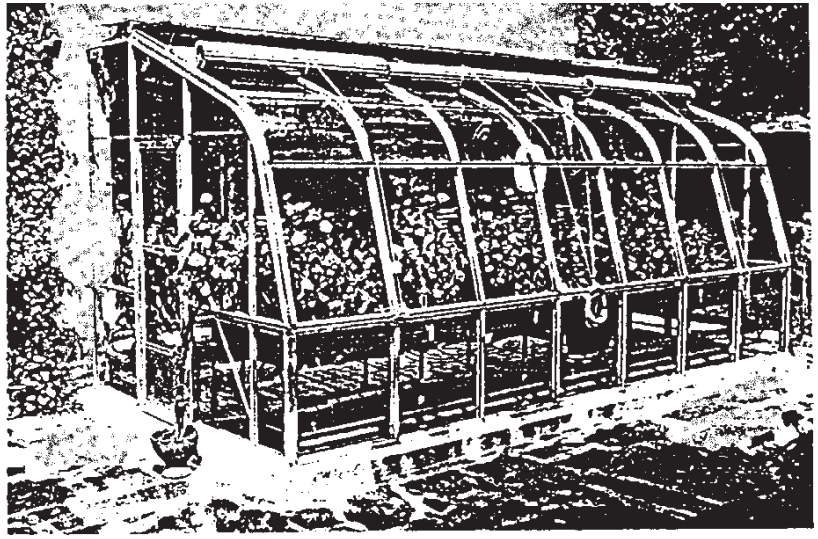
Temperature

As a gardener you will be concerned with two temperatures -- the air temperature required in the greenhouse and the minimum outside temperature that your heating equipment must overcome.

For most plants, a night temperature of 60-65 degrees F in the greenhouse is adequate. The general rule is not to have a higher temperature than is necessary.

If you grow some plants that require a higher temperature than is provided in the greenhouse, use a propagating case or a warmed bench with thermostatically controlled warming cables to warm the air surrounding the plants. This can be done at a fraction of the cost that would be necessary to heat the whole greenhouse to provide the same temperature.

If you want a temperature of 60 degrees F, install heaters that will provide that temperature. If you want no more than frost protection, set the thermostat at 40 degrees F.



The glass-to-ground even span can be built free-standing or attached to your home. This "all glass" greenhouse can accommodate 3 full-sized benches plus shelves.

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

The lean-to has these disadvantages:

Limited space.
Limited light.
Limited ventilation and temperature control.

Attached Even-span

The even-span greenhouse is the standard type -- the one people generally visualize when they think about a greenhouse. The even-span greenhouse is similar to a free-standing structure except that it is attached to a house at one gable end. It can accommodate two or three rows of plant benches.

An even-span greenhouse costs more than a lean-to, but it has greater flexibility in design and provides for more plants. Because of its size and greater amount of exposed glass area, the even-span greenhouse will cost more to heat.

Attached Window-mounted

A window-mounted greenhouse will allow space to grow a few plants at relatively low cost for heating and cooling. This reach-in greenhouse is available in many standard sizes, either in