AN AUTOMATIC SIDEWALL SYSTEM FOR GREENHOUSE ENVIRONMENTAL CONTROL

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The use of plastics for greenhouse coverings was started in Kentucky by Dr. Emmert in the early 1960s. Utilizing this same basic idea, people throughout the world have used plastics as an inexpensive means to provide protection for the growth of a great variety of greenhouse plants. A major problem which became apparent soon after the development of plastic greenhouses was the difference in environmental conditions between these houses and those of glass. In particular, relative humidity builds to very high levels. The lack of small cracks and openings which exist in glass greenhouses is largely responsible for this. Under these conditions of high humidity, it is common to have a high incidence of leaf diseases. Diseases such as leaf mold and early and late blights of tomatoes are common.

In addition, many of the heating systems installed in the early plastic greenhouses were inadequate both in capacity and uniformity of heat distribution. As a result, they frequently were not capable of providing the uniform, positive temperatures necessary for successful plant growth.

Problems were also encountered in spring and summer with keeping the house from becoming excessively warm. The use of continuous metal ridge and side ventilators that can be manually operated, such as those in glass greenhouses, is not practical. Existing designs using manually operated ridge and side ventilators make ventilation of plastic greenhouses a time-consuming operation, and generally temperature control is inadequate.

As a result of these shortcomings, an air circulation, ventilation and heating system was designed which would automatically control the temperature throughout the cropping year and which could be put together as a single unit. The system maintains air circulation within the house at all times and automatically provides ventilation whenever the temperatures rise above the desired level. Heat is also provided automatically if the temperature drops. This design was the fore-runner of several such greenhouse automatic heating, ventilation and circulation systems.

DESCRIPTION OF THE SYSTEM

The heart of the system is a fan, or several fans, which run constantly and have the capacity to move one cubic foot of air per minute (CFM) against 1/8 inch static pressure for each cubic foot of space in the house (Figure 1). If the fans to be used are not rated against a static pressure, the required capacity should be increased by at least 30 percent. Performance tests on such fans have shown that they may lose from 30 to 50 percent of their rated capacity when required to operate against 1/8 inch pressure. During cold weather the fan pulls air from the house and blows it back into the house (100% recirculation). Since the fan has a large capacity, a high degree of turbulence and mixing exists within the house at all times.

A triangular-shaped baffle is placed immediately in front of the fan to direct the air upward along the underside of the roof of the greenhouse (Figure 2). By regulating the size and shape of the openings between the baffle and the ceiling, the distribution of the air can be adjusted to obtain uniform distribution and turbulence throughout the house. The slot area between the edge of the
Figure 1. The fan should be installed in the north sidewall of the greenhouse and should be wired to run continuously. The opening below the fan is the opening through which the fan pulls air from the house when it is recirculating air within the house.

The baffles and the greenhouse roof should be such that 1 square foot of area is provided for each 650 CFM of air moved by the ventilating fan. For effective and uniform air distribution within the greenhouse, the underside of the roof must be smooth. For wood frame houses, this normally means a polyethylene film liner must be attached to the bottom side of the rafters.

When the inside air temperature rises above the desired level, a damper motor (Figure 3), controlled by a modulating thermostat set approximately 5°F above the setting of the furnace thermostat, opens the vertical damper in the outer wall of the ventilating chamber and closes the horizontal damper a corresponding amount. This enables the fan to pick up cool outside air and blow it into the house. The hot air in the house is exhausted from the house through motorized anti-back-draft shutters (Figure 4). Since the damper motor and thermostat are of the modulating type, the vertical damper is fully open and the horizontal damper is fully closed only during periods of high temperature (100% ventilation).

During cool sunny winter days when heat build-up can become excessive, the dampers will be positioned so that a portion of the air being moved by the fan is cool air from outside the greenhouse and the remainder is warm air from inside the greenhouse. These two sources of air will be mixed by the fan, and the temperature of the mixed air will be sufficient to reduce the temperature in the house, but
not so cool that the plants will be affected. Since the baffle directs the air upward along the ceiling, additional mixing and tempering of the air will occur before the air reaches plant level. The dampers and shutters should have one square foot of area for each 700 to 1,000 CFM of air moved by the fan.

Added to the circulation ventilation system described (but not essential to its functioning) is a forced hot air furnace (Figure 1). The furnace, which is controlled by a day-night thermostat, provides heat whenever the temperature drops below the desired level. The use of a day-night thermostat permits the holding of one temperature during the day when plant growth is occurring and a lower, more economical temperature at night. The furnace, which has its own fan, pulls cool air from the greenhouse, heats it, and discharges the heated air into the chamber behind the ventilating fan. The ventilating fan then blows the heated air into the house and effectively distributes it. By using the one fan for circulating, ventilating, and distributing heat, obvious savings occur.

In place of the day-night thermostat, a time clock and two standard thermostats can be combined to provide the same flexibility in obtaining different day and night temperatures (Figures 5 and 6).

The furnace should have capacity adequate to maintain the desired temperature in the section of the house served by the ventilation fan. This is discussed in a separate publication of this series, AEN-8, "Estimating Greenhouse Heating Requirements and Fuel Costs".

With many greenhouses, especially those of commercial size, more than one fan system may be required per house. As a general rule the fans should be placed in the sidewall so that the distance air is forced laterally along the house is not more than the width of the house. This means that the distance between fans normally should not be greater than twice the width of the house. With wide houses it may be necessary to place the fans more closely together since there is a practical limit to the amount of air which can be moved by one fan. The use of multi-units has the advantage that in case of mechanical breakdown of one of the units the other units will normally prevent serious crop injury. This is particularly true when more than one furnace is used. The units are not adaptable to ridge and furrow type houses.

The fans, dampers and heating units are housed in a specially built enclosure along the side of the house (Figure 4). The enclosure should be adequate to house the equipment and to permit reasonable access for servicing. Since it is important to avoid shading of any kind, the greenhouse should run east and west, thus providing a north sidewall for the construction of the enclosure.

Additional details relative to the design and installation of a sidewall heating, ventilation and air circulation system are presented in blueprint plan numbers Ky. 11.811-1 and 11.811-2, available from the Agricultural Engineering Department, University of Kentucky.