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CONTROLLING GREENHOUSE TEMPERATURES

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One of the most difficult problems in greenhouse management is that of measuring and maintaining accurate temperatures during daylight hours. Every grower thinks he is maintaining his temperatures within one or two degrees of the optimum for his crop, but this may not be true. Morris and Winspear (3) stated, "Any thermometer indicates its own temperature, and not necessarily that of the surrounding medium." This statement also applies to thermostats that control heating and cooling.

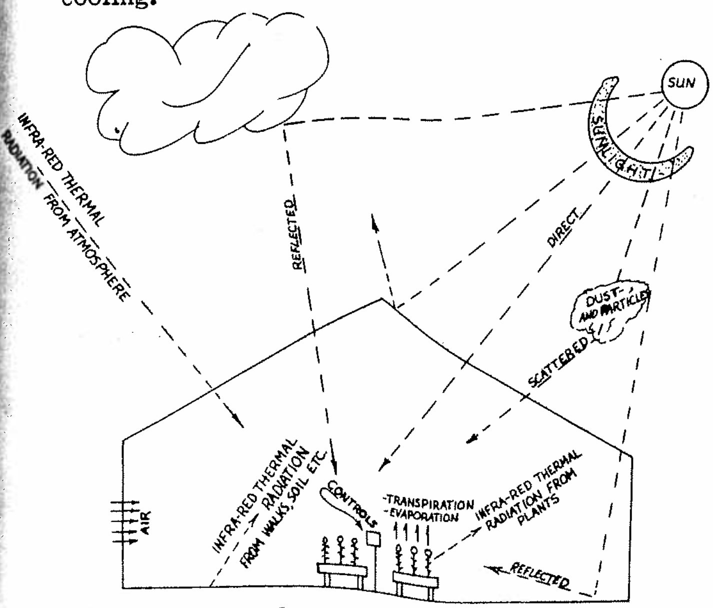

Fig. 1. Sources of radiation that can affect temperature and controlling equipment in a greenhouse.

Approximately 47 percent of the solar constant reaches a greenhouse in the form of direct and diffuse solar radiation. The other 53 percent is absorbed in the upper atmosphere, or reflected back into space from clouds, dust particles, and other bodies. It is the infrared portion of solar energy that warms the earth and greenhouses. Radiation is also received from objects other than the sun. Gates (1,2) indicated that all objects at a temperature above absolute zero (-459.7°F) radiate energy. Figure 1 shows how direct solar radiation and other forms of radiation can affect temperatures and temperature controlling equipment in a greenhouse.

Recent temperature studies in the Colorado State University Research Greenhouses have shown how radiation affects sensing elements and temperatures of moving air.

Methods

Temperature tests were conducted in the glass section of a 36 ft. by 82 ft. greenhouse. One-half of the house, on the pad end, was covered with corrugated fiberglass; the other half (fan end) was covered with glass. Two 42 inch fans, on separate stages, moved a total of 28,400 CFM when in operation.

Several types of thermostat and thermometer holders were built to compare their value for greenhouse use (Fig. 2). These holders were placed in the glass portion of the house, and thermocouples from a Bristol 24 point recorder were placed in or on the holders. Temperatures were recorded during periods of bright sunlight, haze, heavy clouds, and at night. Temperature measurements from aspirated holders (Fig. 2B and 2G) were compared with nonaspirated holders during the aforementioned atmospheric conditions.

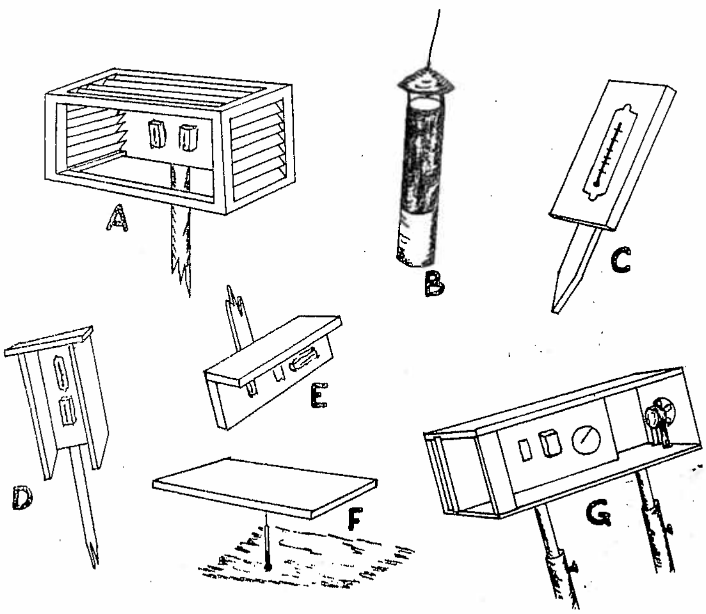

Fig. 2. Temperature control holders commonly found in greenhouses: A. slotted box; B. vertical pipe; C. plain board; D. shed box; E. hooded board; F. shaded; G. aspirated.

Types of Thermostat Holders

An aspirator box (Fig. 2G) was placed in the center of the glass portion of the house and compared to the other types of holders. Temperatures within thermostat holders such as slotted boxes, hoods, and shaded areas were 3 to 5 degrees F warmer during sunny weather than within the aspirated unit (Table 1). During periods of haze, there were small differences, and during periods of heavy clouds or at night, there were no temperature differences between any of the holders.

Table 1. Average temperatures in several holders on sunny days.

Aspirated box	Shed box	Slotted box	Pipe
68.8° F	72.3	73.1	73.6

Motorized pipe	Shaded	Outside
69.2	69.6	62.0

Air Flow across Thermostats

An aspirating box was placed in the center of the glass house and the fan speed controlled by a rheostat. When the air flow through the box was zero, temperatures in the box exceeded those of the greenhouse air by approximately 4 degrees F. As the air speed was increased in the box to 210 FPM, the difference in temperature between that measured in the box and that of the greenhouse air decreased to zero. In other words, the slower the air was pulled through the box, the more it warmed (Fig. 3). A pipe made by soldering three juice cans together was aspirated by placing a small d-c motor on the top and connecting it to a fan under the hood. When the air was moved through the unit at a rate of 130 to 150 FPM, a temperature within 1/2 degree of that in the aspirated box was measured.

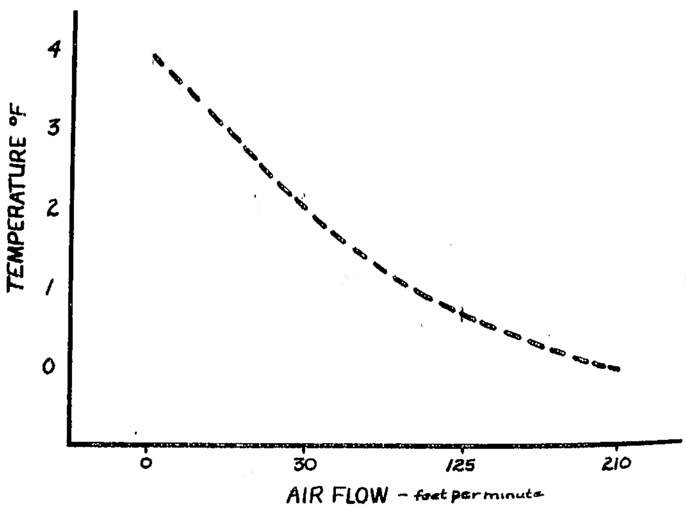

Fig. 3. Effect of air speed in an aspirated box on differences between temperature in the box and that of the greenhouse air (sunny day).

Placement of Thermostats

Temperatures of sensing elements 1 or 2 feet directly above the tops of recently watered plants were lowered 4 to 5 degrees for 2 or 3 hours after watering. The cooling effect was caused by the evaporation of excess moisture in the plant area. This cooling effect was measured in all types of thermostat holders.

Using a pulley system, aspirated and non-aspirated pipe temperatures were recorded at different distances above the walk in the center of a glass carnation house. Air temperatures in the aspirated pipe were similar between 2 and 6 feet (bud height) above the walk (Fig. 4). The temperatures increased slightly more than one degree per foot from 6 to 15 feet above the walk. Temperature readings in the nonaspirated pipe were higher at all levels up to the 15 foot height, where both pipes gave the same air temperature readings.

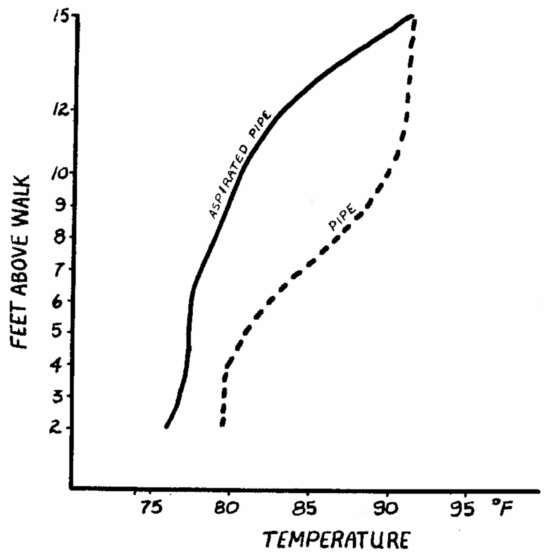

Fig. 4. Temperature measurements in aspirated and nonaspirated pipes at various distances above a greenhouse walk on a clear spring day.

Application of Results

When there is high solar radiation, temperatures within the shelter around thermometers and thermostats vary according to the type of structure, its location, and the air movement across these sensing elements. Structures may allow the sensing elements to be "preheated" due to heat transfer through the back board on which the element is connected; improper shielding of radiation from the sun, heating pipes or the surrounding area; and from lack of air movement within the shelter. Sensing elements under these conditions will cause the house to run cold. Temperature of the thermometer, or to which the thermostats are reacting, may be several degrees above that of the air in the greenhouses.

Sensing elements placed over frequently watered plant material, under mist nozzles, near pads or cold air inlet areas will be "precooled" and will cause the house to run warm.

Night conditions should also be cônsidered when placing sensing elements in the greenhouse. Controls placed directly over or beside heating pipes can also be "preheated" causing the rest of the house to run cool at night or when the heat is on. It is important to locate sensing elements near the plant material preferably just below the tops of plants. Elements too high or too low will cause temperatures to be controlled several degrees above or below those desired. The installation of air mixing devices in the plant area reduces the temperature variation both vertically and horizontally.

Shelters for Controls

Every greenhouse manager will encounter different problems relating to temperature control and the maintenance of temperatures. Several basic considerations should be kept in mind when making and installing control holders:

1. Use a holder which allows the air to enter from one inlet.
2. Insulate the holder with dead air space, moving air, or fiberglass.
3. Paint the outside white. Black or other dark colors absorb radiation.
4. Air should flow across controls at rates of 130 to 210 feet per minute. Faster speeds do not increase accuracy, and a slower speed allows the air to be warmed in sunny weather.
5. Attach holders to adjustable pipes installed in the ground. Vibrations from running fans can cause controls to chatter when connected to the building framework. The adjustable feature allows the shelter to be raised as the crop grows.
6. Face the intake any direction but south.
7. A small slot for observing thermometers and controls can be placed on the north exposure of the holder, but must be covered with plastic or glass.

Aspirator Box Plan

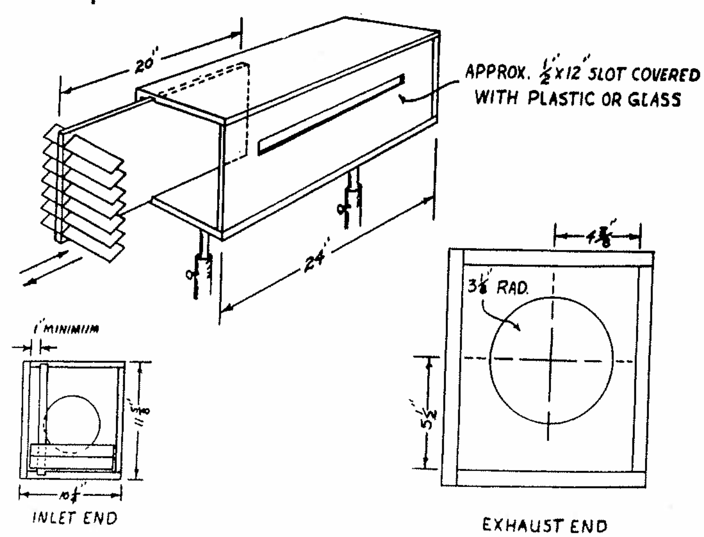

Fig. 5. Plan for aspirated box using a 1/70 hp, 1520 rpm motor with 6-inch blade.

A plan for an aspirator box styled after those used at CSU is shown in Figure 5. The basic construction consists of a 1 by 12 inch board for the back, 1 by 10 inch boards for the top and bottom, and used wooden venetian blind slats for the louvers. Air is moved by a 1/70 hp, 1520 rpm motor with a 6 inch blade.

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