Colorado Flower Growers Association Inc.

IN COOPERATION WITH COLORADO STATE UNIVERSITY

H. A. Lazier, Executive Secretary

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Air Movement and Temperature Control

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A marked improvement in the accuracy of temperature control may be obtained by 1) a positive flow of air over the thermostats and 2) proper location of the controls in their shelter.

Figure 1 shows one end of the 75-ft. temperature house at Colorado State University. The 4 compartments are undergoing constant improvement in temperature control as further temperature research is conducted. A progress report of the present study of day temperature effects on carnations was given in Bulletin 96.

Methods Heating and Cooling

A modulating heat control is used with trombone coils in conjunction with an "on-off" type cooling system in which the presence or absence of air movement directly determines the degree of cooling. While the dimensions of the compartments are small temperature control is accomplished in a manner similar to that used in most commercial ranges in Colorado.

Because the direction of air movement may change according to the demand of the cooling system (as does the velocity of air flow), the controls must be located in a position which will tend to represent air temperature under all conditions. Figure 1 (3) shows the present location of the thermostat shelter.

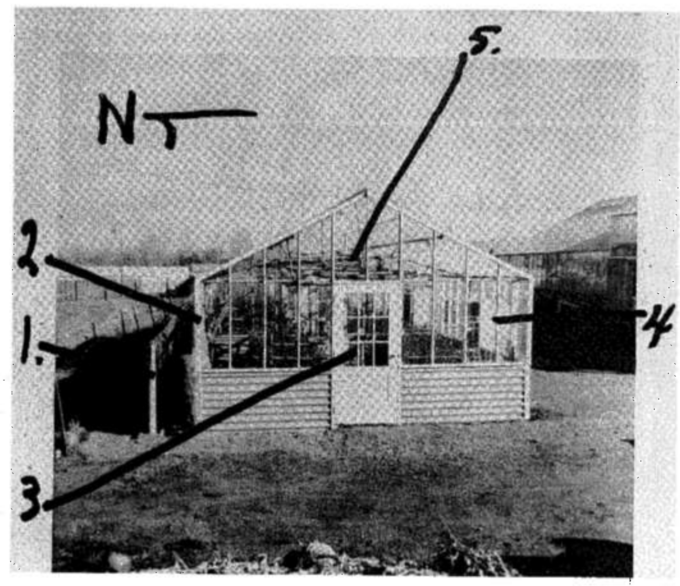

Fig. 1. View of the west gable end of CSU temperature research house: 1) Evaporative pad, 2) ventilator, 3) thermostat shelter, 4) cooling fan, 5) overhead circulating fan, Approximate dimensions for each of four compartments are 17' by 15' with a 7' eave.

Forced Air Over Theromstats

Regardless of how well shielded thermostats are from the sun, reflected radiation will enter the shelter and strike the controls. The mountings of the instruments will conduct heat to and from them depending upon external conditions. The control shelter will radiate heat to the interior when warmed by the sun. This heating by conduction and radiation causes the thermostats to sense higher or lower than true air temperatures and the desired air temperature will not be maintained.

By means of a positive flow of air over the controls, this undesirable heating and cooling of the thermostats can be almost eliminated. Without forced-air circulation, temperature differences as great as 3 degrees have been found to occur within the shelter. Positive air flow tends to equalize differences and increases the sensitivity of the thermostats to changes in actual air temperature. The use of the small fan shown in Figure 2 has reduced variation about the set point of the thermostat from 4 to 2 degrees. This is especially apparent at night.

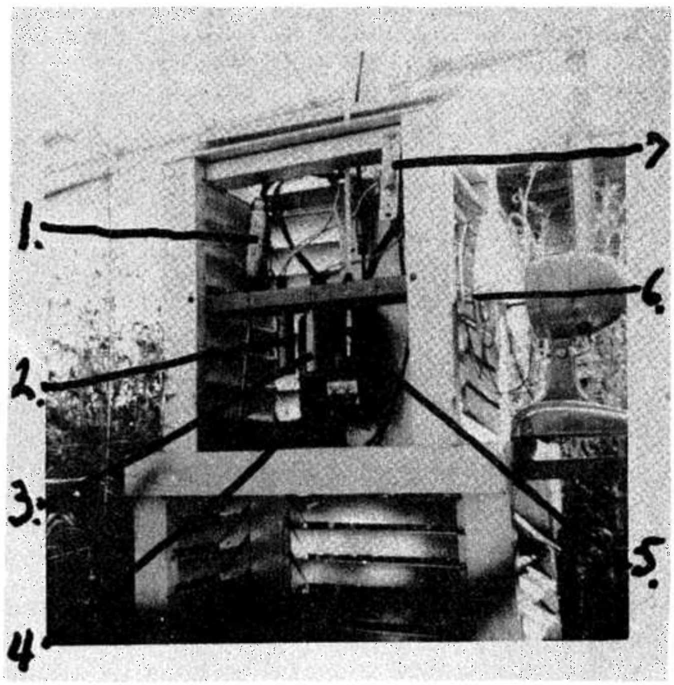

Fig. 2. Thermostat shelter in one of the compartments: 1) remote temperature recording lead, 2) day cooling thermostat, 3) night cooling thermostat, 4) modulating day-night heating thermostat, 5) mercury thermometer, 6) circulating fan, and 7) cooling thermostat day to night switch.

Theromostat Location and Mounting

The use of forced-air circulation to improve control will be partially defeated if the thermostats are placed too close to each other, close to the radiating surfaces of the shelter, or improperly shielded from the sun. While general location of the thermostat shelter in different greenhouses, and the method of mounting them, is a matter depending upon individual circumstances; the following might be kept in mind:

1. Both the shelter and thermostat mountings should be of a material that will conduct a minimum of heat. Wood is preferred over metal.
2. The shelter must be sufficiently open on all sides to allow air circulation in any direction.
3. The thermostats should be well spaced, allowing a minimum impediment of air flow around them.
4. The controls must be protected from vibration.
5. Sensitive mechanisms should be shielded from accumulation of dust.
6. Where close settings are desired on more than one thermostat within a shelter, they should be mounted on the same level. This facilitates setting as variations in temperature are likely to be greater in a vertical direction than in a horizontal plane.

The present set-up may be seen in Figure 2. It shows that the shelter was not originally intended to be used with a fan, and it could be redesigned to give better flow and easier thermostat setting. The mounting of the heating thermostat (4) is not ideal since its back is against a surface which may be warmed by the sun, nor is it fully protected from dust.

The result of the improvements in the shelter can be observed by looking at Figure 3 which shows a typical 24-hour temperature record.

Further Improvement of Control

In attempting to maintain more even temperature throughout the entire compartment, overhead circulating fans were installed. These are positioned so that air flow is directed into the ridge. For day operation, the sensitivity of the thermostats was increased with an improvement in control. More apparent is the increased heating capacity of the radiating pipe. Formerly, the 75°F compartment was the last unit to reach its operating point in the mornings despite more coils and heating surface in this compartment. With air circulation, this compartment now reaches 75° about the same time as 60° is reached in the 60° compartment, which has a smaller overhead fan. However, night operation of the heating thermostat is considerably more sensitive than day operation and the use of

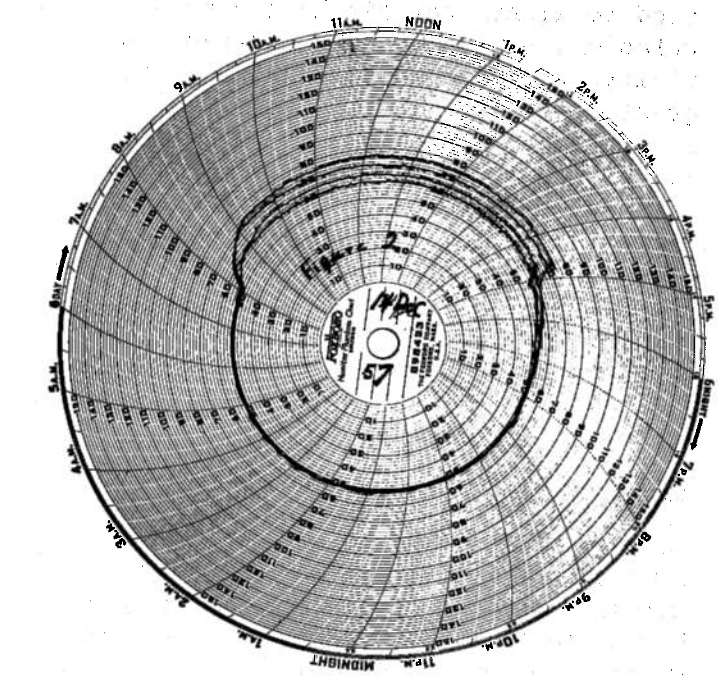

Fig. 3. A record of temperature in each compartment. This was made prior to installation of overhead circulating fans and automatic ventilators.

overhead fans, in addition to the small fans located at the shelter, is sufficient to throw the heating system into a "hunting" cycle. This increased variation at night so much that all overhead fans are now shut off during the night although the shelter fans operate continually. The reason for this will be discussed later.

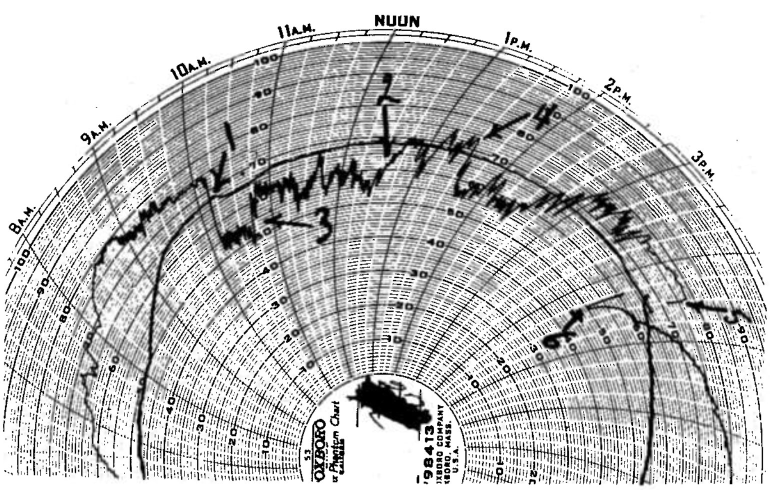

Fig. 4. Humidity record made in the 70° compartment before any circulating fans were installed. The instrument was located about 12 inches below the thermostats. Individual peaks and valleys are the "on-off" cycles of the cooling fan: 1) ventilators opened, 2) cloudy, 3) water circulated through evaporative pad, 4) clear sky, 5) water in pad turned off, and 6) ventilator closed.

The humidity record in Figure 4 gives an indication of the heavy demand that is placed on the cooling thermostats when precise control of temperature is desired. Instrument operation must be reliable. Prior to May 1957, the cooling thermostats were operated on 110 volts which resulted in sticking of the contacts. Since that date 25 volts has been used to actuate relays which in turn send the 110 volt current to the cooling fans. From May 1 to Feb. 15, these thermostats have given no signs of arcing or sticky points.

During January of this year a program of tightening up the individual compartments was completed. This is a time-consuming job, but has resulted in a lighter heating load with a corresponding increase of reliability in temperature control. From smoke studies of the air currents, it was found that vagrant air movement can disrupt normal currents in such a manner as to prevent the thermostats from maintaining the desired temperature. The tightening of the already "tight" houses promises to increase the efficiency of the cooling system next summer.

Future Studies and Improvement

Automatic ventilators for each compartment have just been installed. Operation of the ventilators is quite critical in temperature control. Reliable control cannot be maintained unless an operator who is familiar with the system is in constant attendence, or unless controls are completely automatic.

Also on schedule are plant temperature determinations and observations of temperature fluctuations in different parts of the compartments. It is expected that the air temperature will vary without good circulation and the plant temperature may vary more markedly than formerly considered possible under the present system of control.

Along with the improvement of temperature control through air movement, there remains the problem of carbon dioxide relationships. The question which needs to be answered is: Just how much of the improvement in yield and quality of summer cooled carnations is due to the lowering of the temperature and how much is due to the improved supply of CO_2 brought about by the greater movement of air past the plant? It is likely that prior to cooling CO_2 as well as high temperature may have been limiting factors in plant growth. This introduces the possibility that poor quality during the winter months may be partially due to a limited supply of CO_2 during bright days when the greenhouse is closed. Equipment is now being accumulated and construction will shortly be started on facilities for CO_2 research.

In summation, it is possible to improve temperature control by proper location of the thermostats in a ventilated shelter and by positive air circulation through the shelter.

In greenhouses which use long coils of radiating pipe, control may be improved, up to a point, by increased air circulation. Beyond this point, the basic limitations of the present method of heating prevent further increase in accuracy. A coil of pipe takes a certain period to heat up and longer to cool off. This time lag can be shortened to within certain limits by air circulation. But to attempt increased sensitivity, either by better instruments or greater air circulation, will be wasteful. If still better control is needed, an entirely different system of heating will have to be used. If a thermostat is too sensitive, either because of the control itself or because of too much air circulation, the system will be thrown into a "hunting" cycle and variation about the set-point will be greater than that obtained without any forced-air circulation.

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Error in Bulletin 97

Liquid feeding instructions page 2, col. 2---The nitrogen we use per 1000 gallons of irrigation water is 3 lbs. of ammonium nitrate or 6 lbs. of calcium nitrate. These two are roughly equivalent since ammonium nitrate is 33% nitrogen and calcium nitrate is 15½% nitrogen, about half as much per pound.

Your editor,
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