QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES
DIVISION OF PLANT INDUSTRY BULLETIN No. 390

GLASSHOUSE TEMPERATURE MEASUREMENT AND SCREEN DESIGN

By N. A. CORNWALL, B.Sc.Agr., and R. F. BLACK, B.Sc., Ph.D.

SUMMARY

A modification of the Stevenson screen which provides increased sensitivity to temperature changes in glasshouse compartments is described.

Introduction

For recording ambient temperature, a Stevenson screen is the standard cabinet used for instrument housing and protection. This screen is defined as a louvred cabinet with a double roof, so constructed that it will permit a free flow of air past thermometer bulbs and, at the same time, shield them from heat radiated from the sun and the ground (Anon. 1954).

For temperature recording in the Pineapple Research Laboratory glasshouse at Nambour, a screen in each of the five compartments was required to house thermostats which should respond to air temperature at the plant level, and various thermometers and sensing elements.

Heating of the compartments is by electric cables embedded in the cement floor; cooling is by an evaporative forced-draught system. The air-flow within the compartments was calculated to be no more than 3 knots. Under these conditions, the double louvres of the Stevenson screen tend to impede the flow of air around the thermometer bulbs, resulting in inaccurate temperature recordings. The use of a metal tube and blower fan, to increase air-flow, was considered impractical from the points of view of size and cost. A modified screen, allowing greater air-flow and increased sensitivity to temperature changes, has been developed at the Pineapple Research Laboratory and has replaced the Stevenson screen in glasshouse compartments.

Details of P.R.L. Screen

This single-louvred screen (Figures 1-3), constructed on a 2 in. x 2 in. dressed pine frame, has internal dimensions of 18 in. x 18 in. x 13 in. high. The louvres are set at an angle of 45° and are 4½ in. in width. There are four louvres on each of the three sides, and the overhang of louvre to louvre is ¼ in. The gable roof, with overhang of 1½ in. at each end, is made in two separate units to allow effective air circulation and removal of the top "jack" section for ease of instrument placement and entry of leads. Louvres and roof are constructed with ¼-in. tempered wallboard ("Masonite"); flooring is slatted to improve air circulation. All interior and exterior surfaces are painted white.

A later addition was a door on the open side. This is constructed in two overlapping sections, hinged top and bottom so that the sections open outwards. Made on 1¼-in. frames, each section has three 2½-in. louvres spaced 1 in. apart.

Comparison Between Stevenson Screen and P.R.L. Screen

(a) Night Temperatures

Minima recorded in the Stevenson screen were up to 1°F higher than those of the P.R.L screen. Temperature patterns showed that there was a lag in temperature response in the double-louvred Stevenson screen in the still air of a glasshouse compartment.

For both screens, black bulb readings were lower than silvered elements. This difference was greater for the Stevenson screen—0·36°F compared with 0·06°F for mean data collected daily over a period of 5 weeks. These differences were not as great as the mean difference between screens (0·43°F). Because of the net radiation losses indicated,

$$Ts > Ts_1,$$

and

$$Tp > Tp_1,$$

where Ts is the true air temperature within the Stevenson screen, Ts_1 the silvered element reading, Tp the true air temperature within the P.R.L. screen, and Tp_1 the silvered element reading respectively.

Because of the greater net radiation loss within the Stevenson screen,

$$Ts - Ts_1 > Tp - Tp_1$$

As

$$Ts_1 > Tp_1 \text{(data)},$$

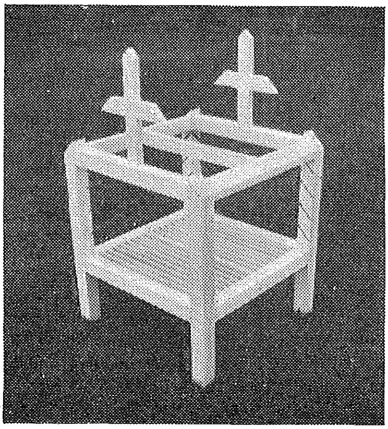
Therefore

$$Ts > Tp$$

As minimum trends were being followed, it is clear that Tp (or Tp_1) would be the best indicator of the glasshouse air temperature surrounding the plants at night.

(b) Day Temperatures

Temperature recordings within the P.R.L. screen showed marked fluctuations which coincided with the operation of the fans of the evaporative cooling system —falling while they were on and rising when they were off. In the Stevenson screen these fluctuations were not so sharply defined; in addition, there was a



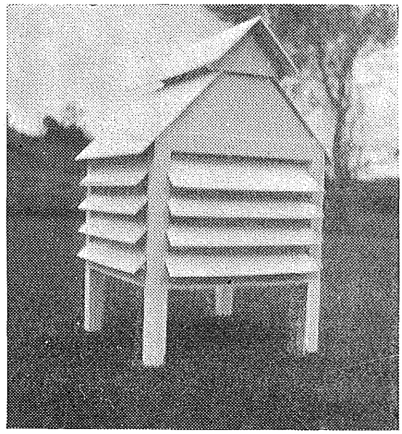


Fig. 1.—Frame and slatted floor of P.R.L. screen.

Fig. 2.—Rear view of P.R.L. screen.

distinct lag in temperature recording. The mean amplitude for a series of P.R.L. screen readings was 4·07°F, as against 1·96°F for the Stevenson screen, giving a ratio of 2·07:1. Ratios as high as 3·73:1 have been noted. These fluctuating patterns occurred on days of intermittent cloud cover, and also when ambient conditions were close to the conditions required in the glasshouse.

Accurate temperature control requires a system sensitive to temperature changes; the P.R.L. screen fulfilled these requirements more effectively than the Stevenson screen. This was confirmed by tests where the thermostat control was changed to the Stevenson screen; temperature fluctuations were wide and the general temperature control obtained was coarse.

Of further interest was the observation that higher readings were consistently recorded during the day in the P.R.L. screen. As a greater intensity of incoming radiation could contribute to these higher readings, a comparison was made between recorded maxima from the two screens, using both silvered and blackened elements (Table 1).

TABLE 1

Mean Maximum Temperatures (°F) for a 14-day Period

—	Silvered Element	Difference Between Elements	Blackened Element
P.R.L. screen	81·3	+0·4*	81·7
Difference between screens ..	1·6	0·9	2·5
Stevenson screen	79·7	−0·5*	79·2

* + indicates net incoming radiation

− indicates net back radiation

D

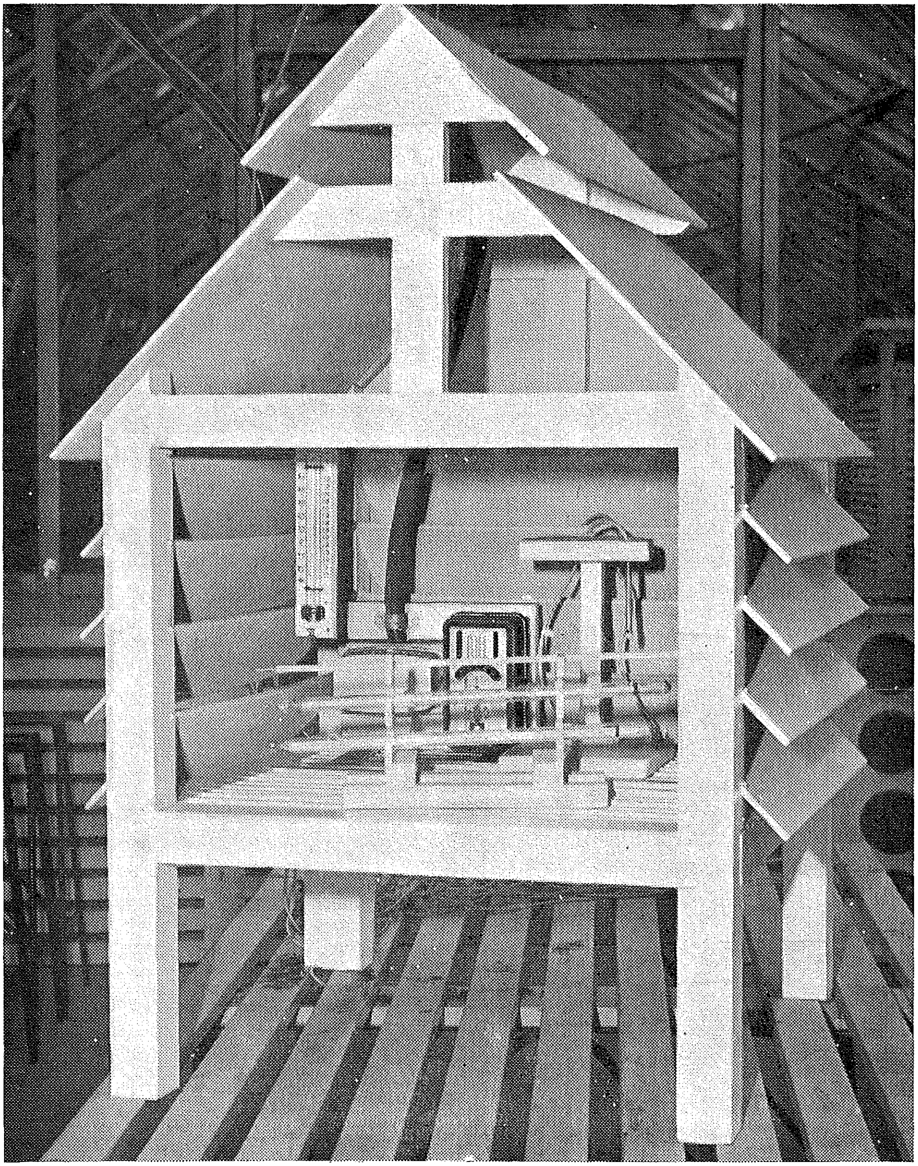


Fig. 3.—P.R.L. screen with front panel and door removed, showing interior and standard glasshouse equipment.

In the P.R.L. screen the blackened element was 0·4°F higher than the silvered element (Table 1). This difference, which is a measure of radiation effects in the P.R.L. screen, was only a quarter of the difference between silvered elements for both screens. The lowered reading for the blackened element in the Stevenson screen indicates back radiation. This difference between elements in the Stevenson screen was also smaller than the difference between screens. A small amount of radiation is entering the P.R.L. screen but the use of a silvered sensing element reduces this error.

To test the significance of the radiation effects in the two screen types, data were collated from the troughs which occur in the daylight temperature pattern when the fans switch off after cooling the compartment (Table 2). Here, because of increased sensitivity, the P.R.L. screen indicated lower air temperatures than the Stevenson screen.

In the P.R.L. screen, the net radiation gain (+ 1·7°F for blackened element) indicates that

$$Tp < Tp_1,$$

and for the Stevenson screen, where back radiation is indicated (—0·7°F for blackened element),

$$Ts > Ts_1 \qquad \text{(Table 2).}$$

The data (Table 2) show that

$$Ts_1 > Tp_1.$$

Therefore the relationship of true air temperatures within the screens is

$$Ts > Tp.$$

This relationship shows clearly the lag characteristic of the Stevenson screen under these conditions and that errors in the P.R.L. screen caused by incoming radiation are more than offset by its increased sensitivity.

Under the conditions of low air movement in glasshouses, where protection from the elements is not required, the Stevenson screen is not suitable for the measurement of air temperature. Further, the use of this screen to house thermostat control equipment causes increased fluctuations of the air temperature surrounding experimental plants.

TABLE 2

MEAN TEMPERATURES (°F) OF 10 TROUGHS OCCURRING OVER A 2-DAY PERIOD

—	Silvered Element	Difference Between Elements	Blackened Element
P.R.L. screen	78·5 (Tp_1)	+1·7*	80·2
Difference between screens ..	1·5	2·4	—0·9†
Stevenson screen	80·0 (Ts_1)	—0·7*	79·3

* + indicates net incoming radiation; — indicates net back radiation

† — indicates reversed trend between screens of blackened elements

General Temperature Measurement

In conjunction with the use of the P.R.L. screen, a system of general temperature recording has been developed. Degussa Hanau platinum resistance sensing elements have been embedded with 'Epistop' in 3-in. long copper tubes of ¼-in. diameter O.D. These elements, when silver-plated and mounted in pairs on a wooden stand within the screen (Figure 3), can be used for wet and dry bulb air temperatures.

Unsilvered elements have been inserted into fruit for recording temperatures during fruit development under different climatic regimes, and into soil, both in the field and under glasshouse conditions. The elements are connected to a 20-channel Leeds-Northrup Recorder calibrated from 0°C to 50°C.

This system is reliable, accurate and adaptable. Data are easily collected and collated. The installation costs of this temperature recording system are comparable to the cost of eight thermographs, without allowance being made for the greater capacity and adaptability of the new system.

Acknowledgement

This work was made possible by a research grant from the Pineapple Sectional Group Committee of the Committee of Direction of Fruit Marketing, Queensland.

REFERENCE

ANON. (1954).—"Australian Meteorological Observers' Handbook (1954)". (Government Printer: Melbourne.)

(Received for publication August 29, 1966)

The authors are officers of the Horticulture Branch, Division of Plant Industry, Department of Primary Industries, and are stationed at the Pineapple Research Laboratory, Nambour.