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A CONTROLLED ENVIRONMENT CABINET

by

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This report describes an inexpensive and versatile controlled environment cabinet designed to regulate temperature, humidity, photoperiod and, to some extent, quality of light within the ranges usually required for insect rearing. Since 1964 ten cabinets have been operated continuously at a variety of temperature, humidity and photoperiod combinations to rear insects and to grow plants. The cabinets do not have cooling or dehumidifying equipment so it is not possible to operate them at lower than room temperature and humidity. To overcome this limitation, conditions of low temperature and low humidity are obtained in an air-conditioned room.

The general design of the cabinet (Fig. 1) is unusual in that it consists of three distinct units which are interchangeable between cabinets: an environmental chamber, a light unit above the chamber, and a control unit below. The outside dimensions of the complete cabinet are 52" by 26½" by 19¾". The environmental chamber is fitted with movable shelves and a large door. The light unit (Fig. 5) contains fluorescent and incandescent lamps which may be

1/ Dr. Haynes is now at Michigan State University, East Lansing. Mr. Morgan is now a student at the University of New Brunswick, Fredericton.

used separately or in combination on any selected photoperiod. The heat of the lamps is dissipated by a fan and controlled air circulation and does not affect the temperature of the chamber below. The control unit is a sliding drawer (Fig. 2) within a box (Fig. 3) and holds the control panel, the heating and humidifying equipment, and a fan which circulates air between the control unit and the environmental chamber.

Description of Cabinets

The Environmental Chamber

The chamber is constructed of $\frac{3}{4}$" plywood with outside dimensions 26$\frac{1}{2}$" wide by 19$\frac{3}{4}$" deep by 36" high (Fig. 7). The limited insulation provided by the plywood allows the cabinet to be operated within a few degrees above room temperature. The top of the chamber is of frosted plate glass supported by a wood sill. The chamber has two openings: a large door with a small central inspection port. Just inside the inspection port is a removable plexiglas plate (Fig. 4) which can be removed for minor adjustment of experimental material with minimal disturbance of the controlled environment. A corked hole below and to the right of the door is provided for introduction of a thermistor probe. Adjustable shelves of galvanized steel screen allow free air circulation.

The Light Unit

The light unit (Fig. 5) is constructed of $\frac{1}{2}$" plywood, 26$\frac{1}{2}$" by 19$\frac{3}{4}$" by 7" (Fig. 8), and fits on top of the environmental chamber. A hinged cover allows easy access to replace lamps. Receptacles for

four 15-watt fluorescent tubes and four 25-watt incandescent lamps are mounted on wooden bars along the sides. The ballasts for the fluorescent lamps are mounted outside and behind the unit and an interval timer is mounted on the front. The lights are wired to the ballasts and the interval timer through a 16-pole terminal block to permit easy replacement of components. A fan[2/] mounted in the cover of the unit operates while the lights are on and removes the heat generated by the lamps. The wiring is shown schematically in Fig. 11.

Air is drawn in through openings on the top of the unit, down channels along the sides, across the glass plate sealing the main chamber, up centrally between two glass baffle plates, outward over the lamps, around a wooden baffle plate attached to the cover, and out through the fan. This provides cooling, first to the glass which forms the top of the environmental chamber, then to the lamps, to minimize effect on temperature within the chamber. This system is so effective that when all lamps in the light unit are operated the environmental chamber loses heat. This effect is easily compensated by increased operation of the heater and suggests that much more light could be used.

The control unit

The control unit is constructed of plywood and consists of a control drawer (Fig. 2) housed in a front-opening box (Fig. 3) which supports the main chamber and light unit. The box (Fig. 10) has two ventilation slots cut in the top which match similar slots in the bottom of the environmental chamber. Air is drawn down from

2/ Pamotor Axil Model 1000 fan, Alpha Aracon, Toronto.

the chamber through the slot on one side, conditioned, and forced back into the chamber through the slot on the other side. Two tapered blocks are fitted at the rear of the support box so that the drawer is forced up against the top of the support box to make a tight seal.

The design of the control drawer is shown in Fig. 9. Air is drawn from the environmental chamber into the right end compartment (a, Fig. 2) where a fan[2/] (b) forces the air over a thermostat (c) and through the heater (d). The warmed air then passes along the tunnel to the left end compartment (f) where it recirculates to the environmental chamber. However, if the warm air is drier than required it is deflected through the twin humidifying compartments (e).

The wiring is shown schematically in Fig. 12. The heater consists of 30 ft. of chromel-A 28 gauge wire mounted in a rectangular form of 1/8" asbestos board. The heater is centre-tapped to give three different capacities: 120 watts over the whole heater, 240 watts on half the heater, or 480 watts from the two halves wired in parallel. In our model only the two lower capacities are used and a switch allows for selection of these. The fine-gauge wire used in the heater heats and cools very rapidly and retains little latent heat to raise the temperature of the cabinet beyond the temperature set on the regulator. A bimetal thermostat[3/] controls the heater and to prevent point chatter and eventual breakdown, a delay relay switch[4/]

2/ Pamotor Axil Model 1000 fan, Alpha Aracon, Toronto.
3/ Cenco bimetalic thermoregulator, Central Scientific Co., Toronto.
4/ Amperite 115N03 Relay, Alpha Aracon, Toronto.

was installed.

Cabinet temperatures in excess of 20°F above room temperature can be obtained by installing an uncontrolled fixed-resistance heater (not shown). This assists the controlled heater and makes possible controlled temperatures at a higher range. This is necessary only when hot, dry conditions are needed.

The humidifier has two water reservoirs, each with six glass evaporating plates of the type used in furnace humidifiers. When an increase in humidity is needed all of the circulating air is guided by rigid clear vinyl plastic baffles over both sides of each plate, a total of 648 sq. in. of evaporating surface. The water level is maintained by a small float and valve of the type installed in domestic furnaces so that the lower ½ inch of each evaporating plate is immersed. Both reservoir trays maintain the same water level by means of a small connecting pipe, and only one valve is necessary. The water supply is connected to the humidifier by means of plastic tubing with a pinch cock on the supply side of a plastic friction coupling. A small inspection port (A, Fig. 9) is provided to check the float operation and water level. The useful life of the evaporating plates is increased by using distilled water.

Air is directed into the humidifiers by plastic gates operated by a solenoid[5/]. When humidity is not called for the gates seal the openings to the humidity compartment; when the solenoid is

5/ Guardian 12 continuous 115V AC solenoid, Alpha Aracon, Toronto.

activated by the humidistat[6/] the gates are pulled into the tunnel. The action of the solenoid is cushioned by a compression spring in the gate linkage. Minor adjustments in the gate travel can be made by varying the tension of this spring. A tension spring closes the gates and resets the solenoid when the humidifying cycle is completed.

Most controls are on a panel which is accessible through the small right-hand door (B, Fig. 9) in the front of the unit. The panel is made of 16-gauge aluminum plate and supports the power, humidity, and heater switches, heat and humidity pilot lights, and the thermo-regulator control. A terminal strip mounted on the back of the panel allows the control panel to be completely wired before it is placed in the small compartment. The humidistat is located in the right end compartment (a, Fig. 2) and is adjusted from the control compartment by a knob which is linked to the humidistat through a shaft and friction coupling.

Discussion

The cabinet was designed to give a variety of rearing conditions but not extremely precise control of temperature and humidity. Control within two degrees Fahrenheit and 10 per cent relative humidity was considered satisfactory. The hygrothermograph records in Fig. 6 demonstrate that this aim has been achieved.

At present hygrothermographs are used to keep continuous records. They are bulky where space is limited and if there is

6/ Johnson type 500-1 thermostat, Johnson Service Co., Milwaukee

much experimental material in a cabinet the door may be open longer than desirable to service the hygrothermograph. Other recording methods have been used, but the advantages in having a continuous trace are usually greater than loss of shelf space or short interruptions in control.

The three interchangeable units ensure ease of servicing because defective units can be removed and replaced by others while being repaired. Ten cabinets are in use at this Laboratory with one extra control unit in case of breakdown.

This controlled environment cabinet is versatile, easy to operate and maintain, and is inexpensive. The unit cost of ten built at one time was about $700.00 exclusive of labour. The cabinet could easily be modified to give conditions other than those we have made possible. For example, existing devices could be coupled to the controls to give diurnal temperature fluctuations. the cabinet is small but much larger units could be built by the same method.

A battery of six cabinets operating in an air-conditioned room is shown in Fig. 13.

Figures 1 to 6

Fig. 1 General perspective view of the complete cabinet with the environmental chamber door open and the drawer of the control unit open. The cabinet is resting on a box-type stand (not described in text), and has a hygrothermograph on the shelf of the environmental chamber. 2 - control drawer. 3 - inspection port. 4 - box part of control unit. 5 - light unit.

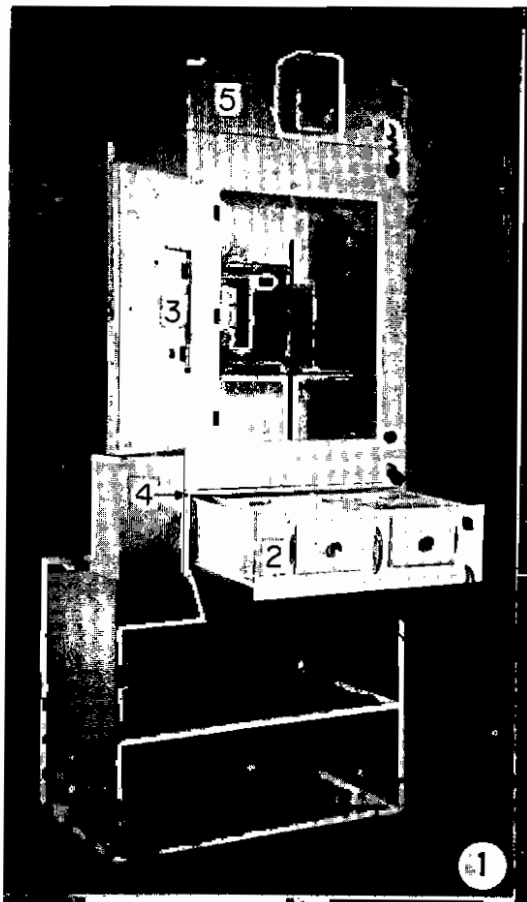
Fig. 2 Top view of the control drawer. a - right end compartment. b - fan. c - thermostat. d - heater. e - humidifying compartment. f - left end compartment.

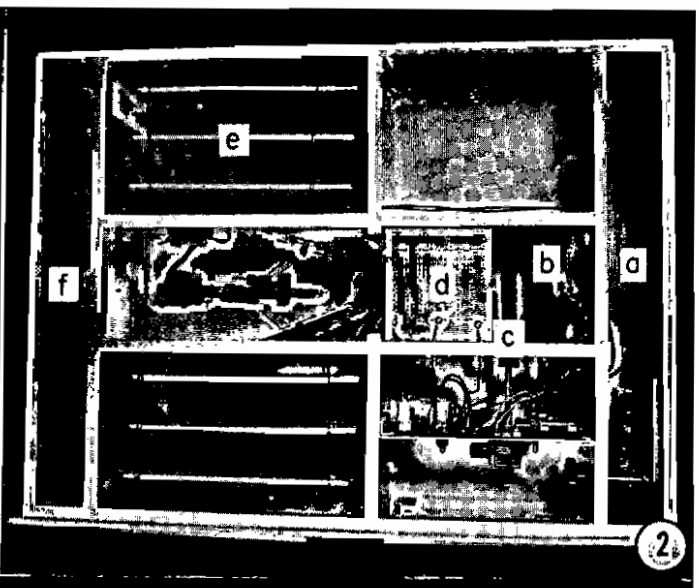
Fig. 3 Box for control drawer.

Fig. 4 Inspection port and plexiglas plate.

Fig. 5 Light unit with the top raised.

Fig. 6 Sample hygrothermograph trace.


5
3
4
2
1


e
f
d
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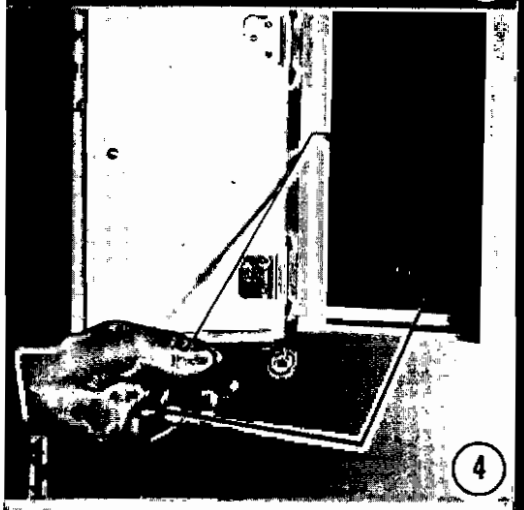
c
2


3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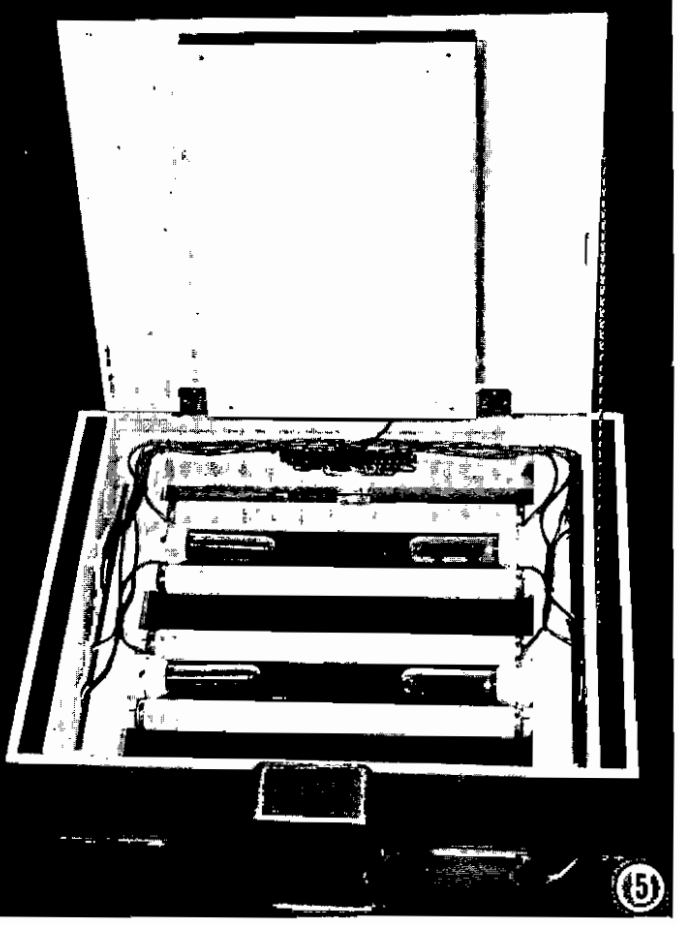
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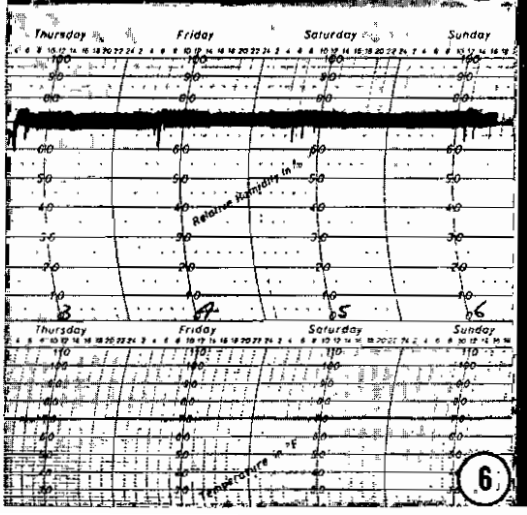
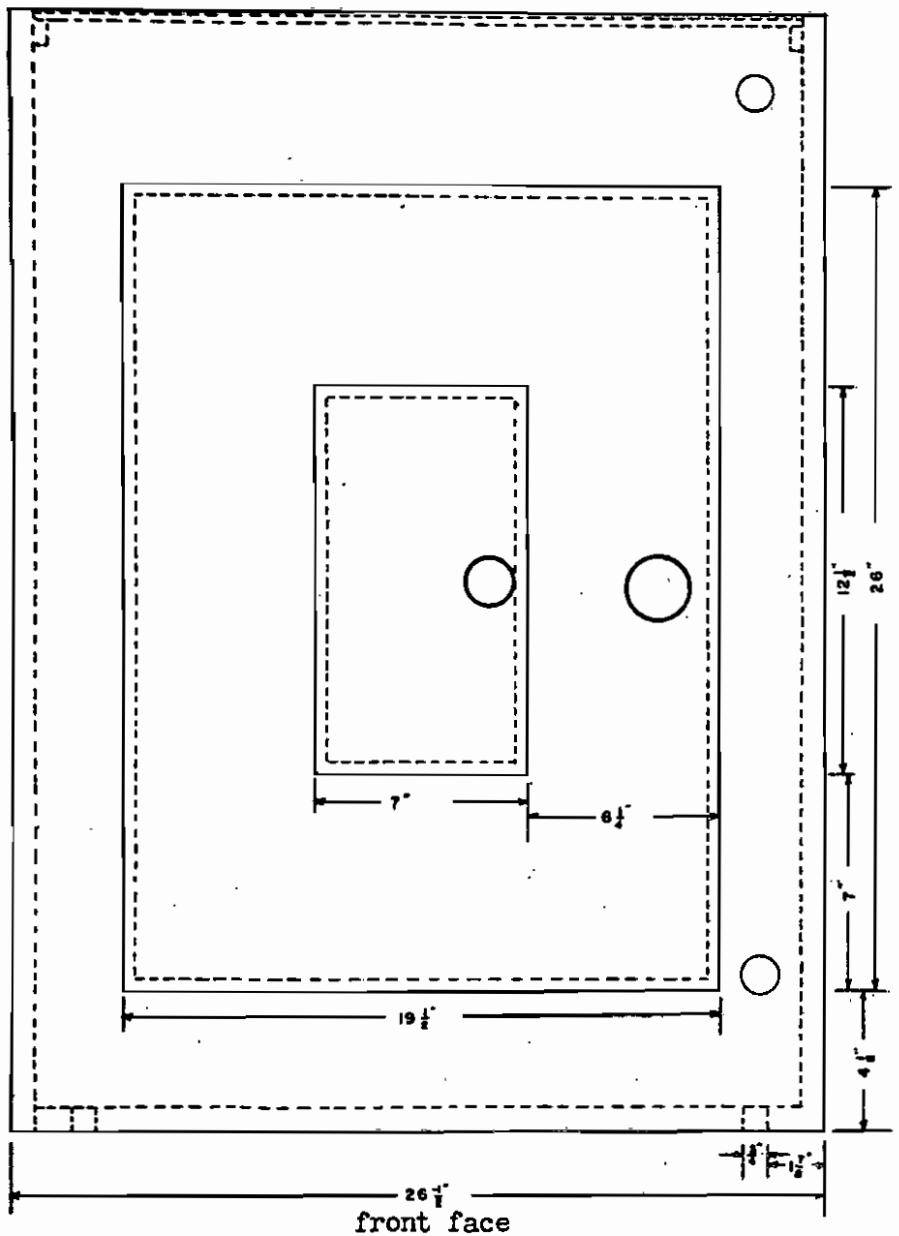

Thursday
Friday
Saturday
Sunday
Relative Humidity in %
Temperature in °F
6



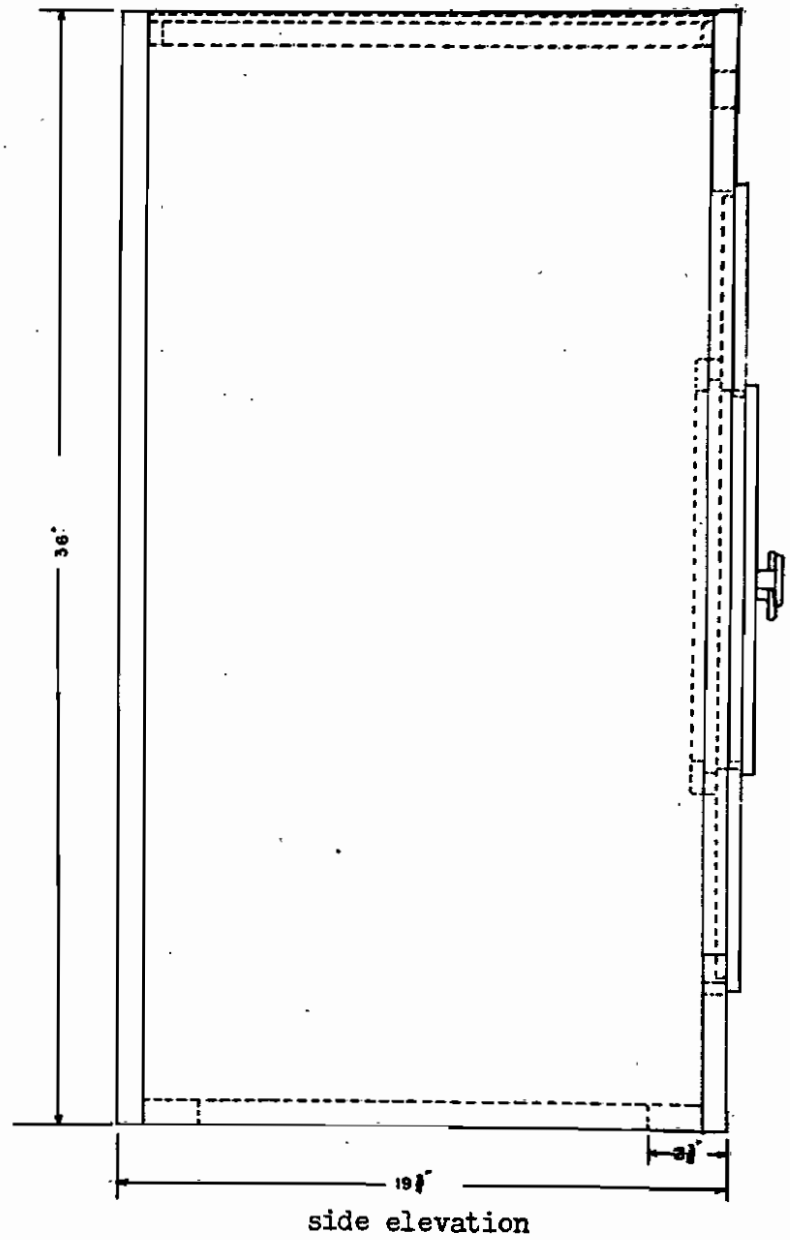
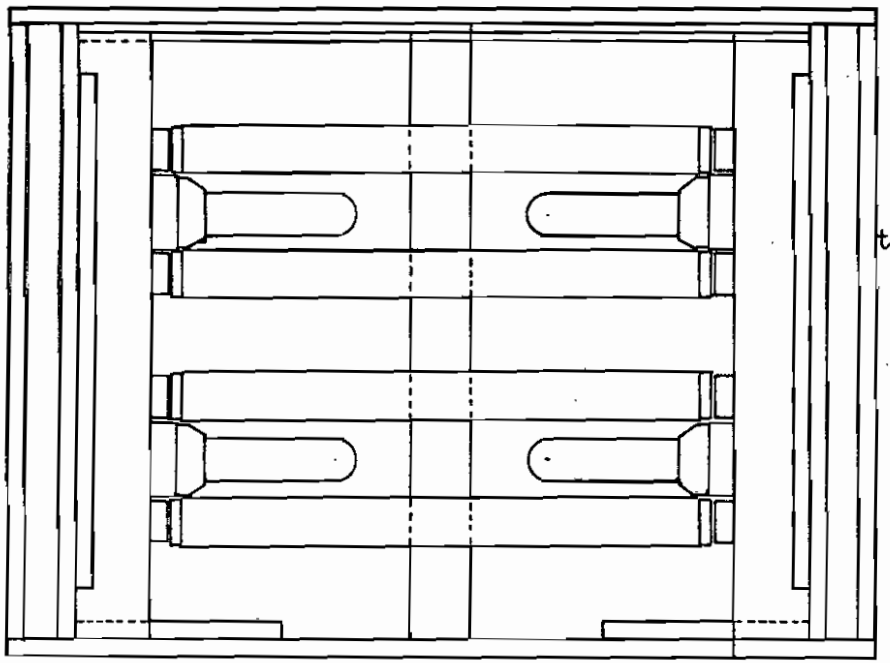
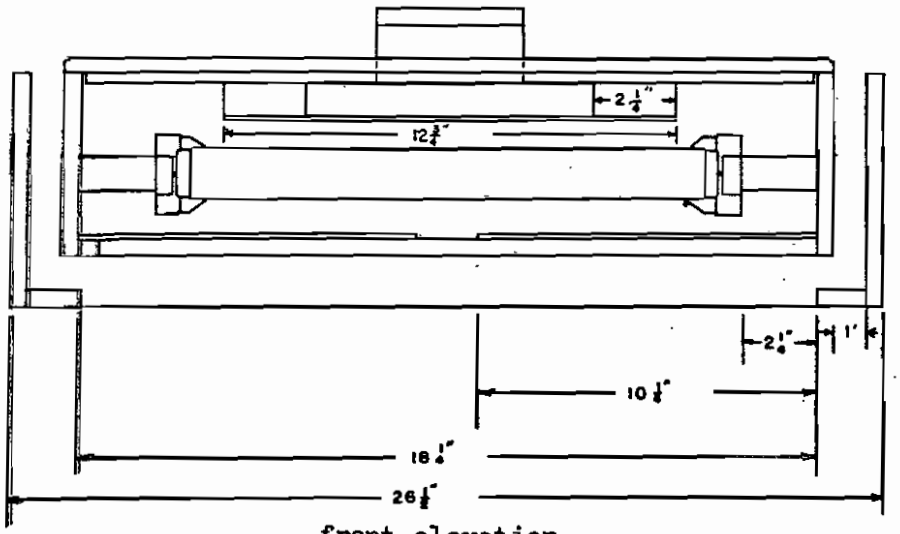


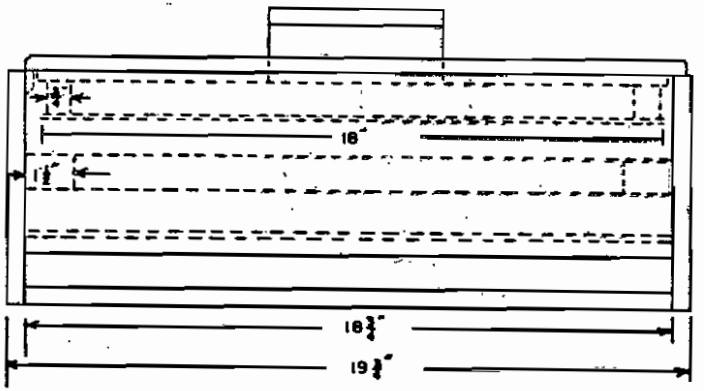
Fig. 7. Cabinet specifications for environmental chamber.



top sectional view

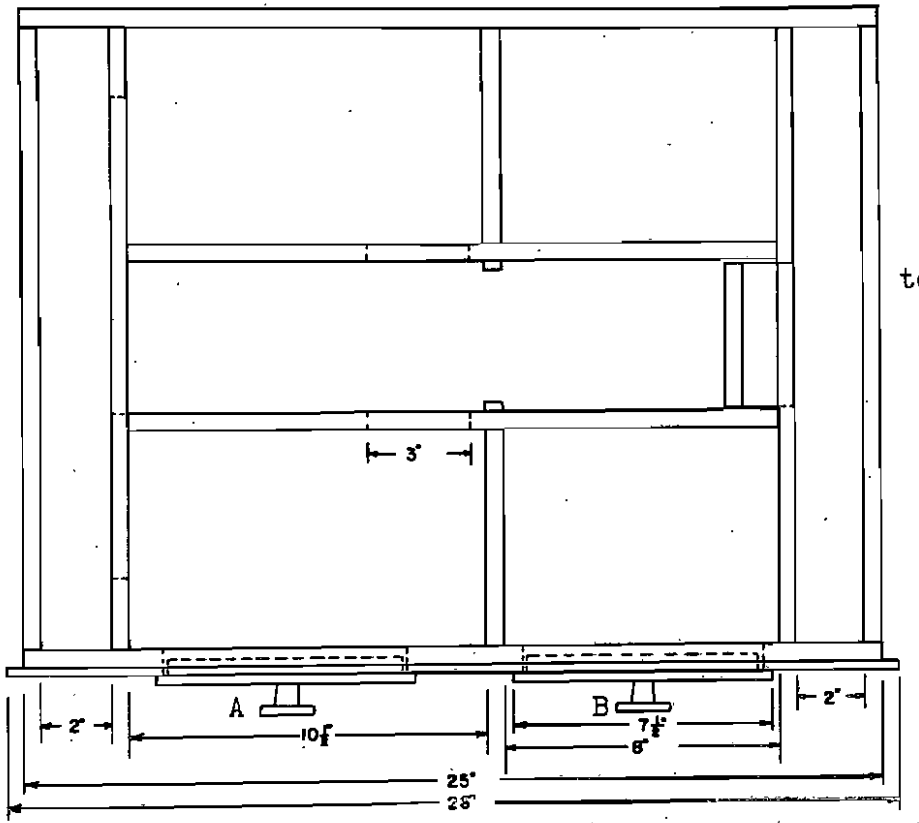


front elevation

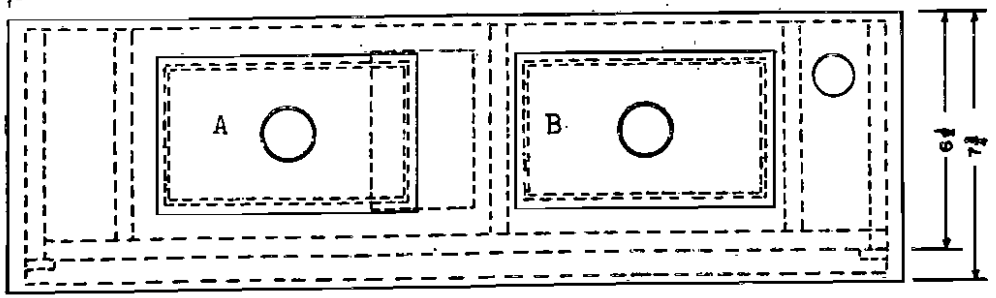


end elevation

Fig. 8. Cabinet specifications for light box.

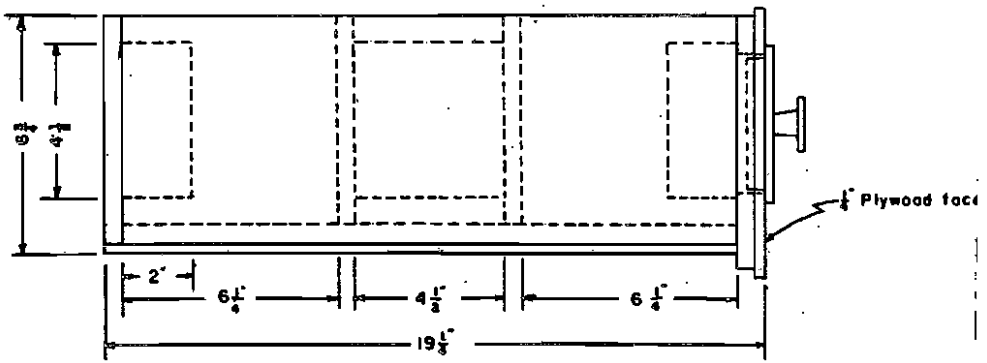


top view



front face

Fig. 9. Cabinet specifications for control drawer.



end elevation

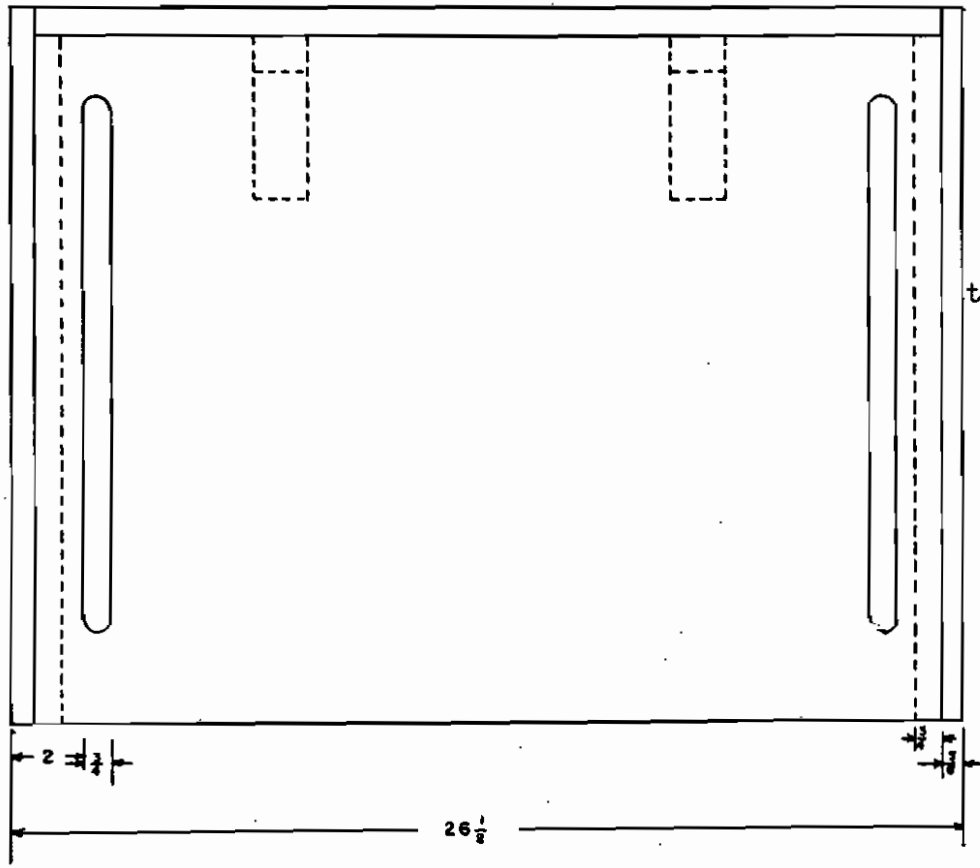
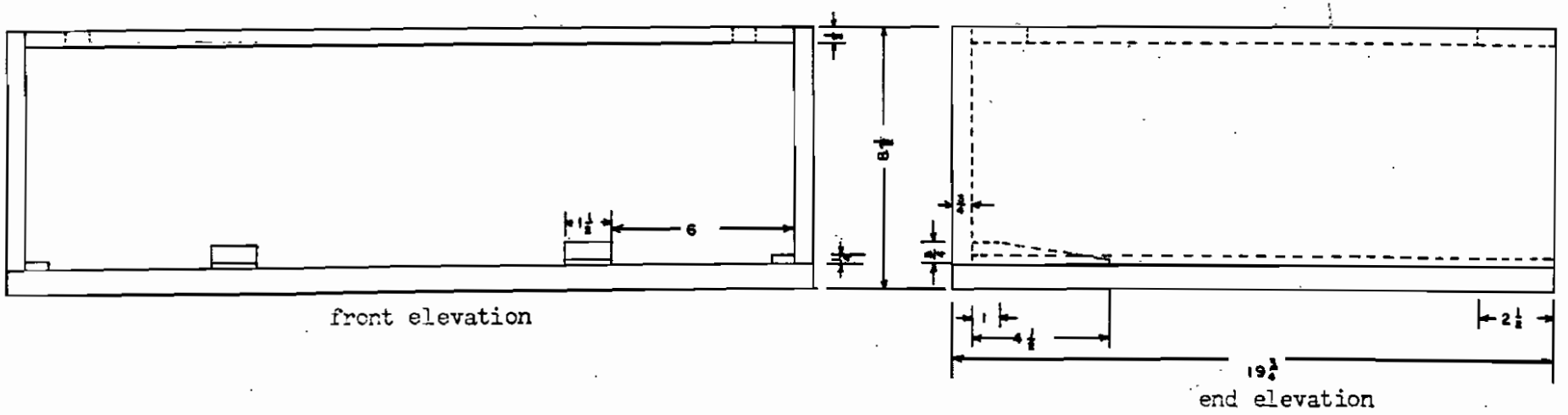


Fig. 10. Cabinet specifications for box part of control unit.



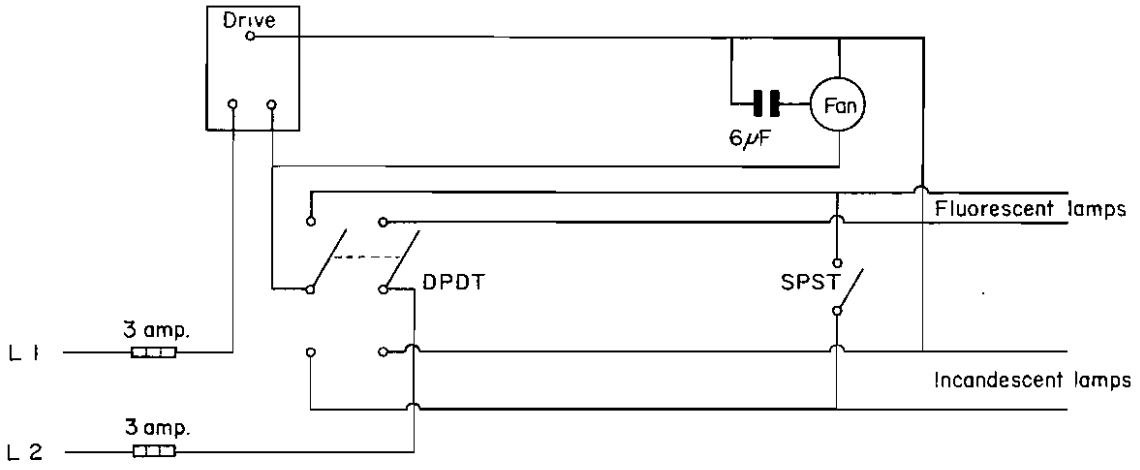


Fig. 11. Light box circuit diagram.

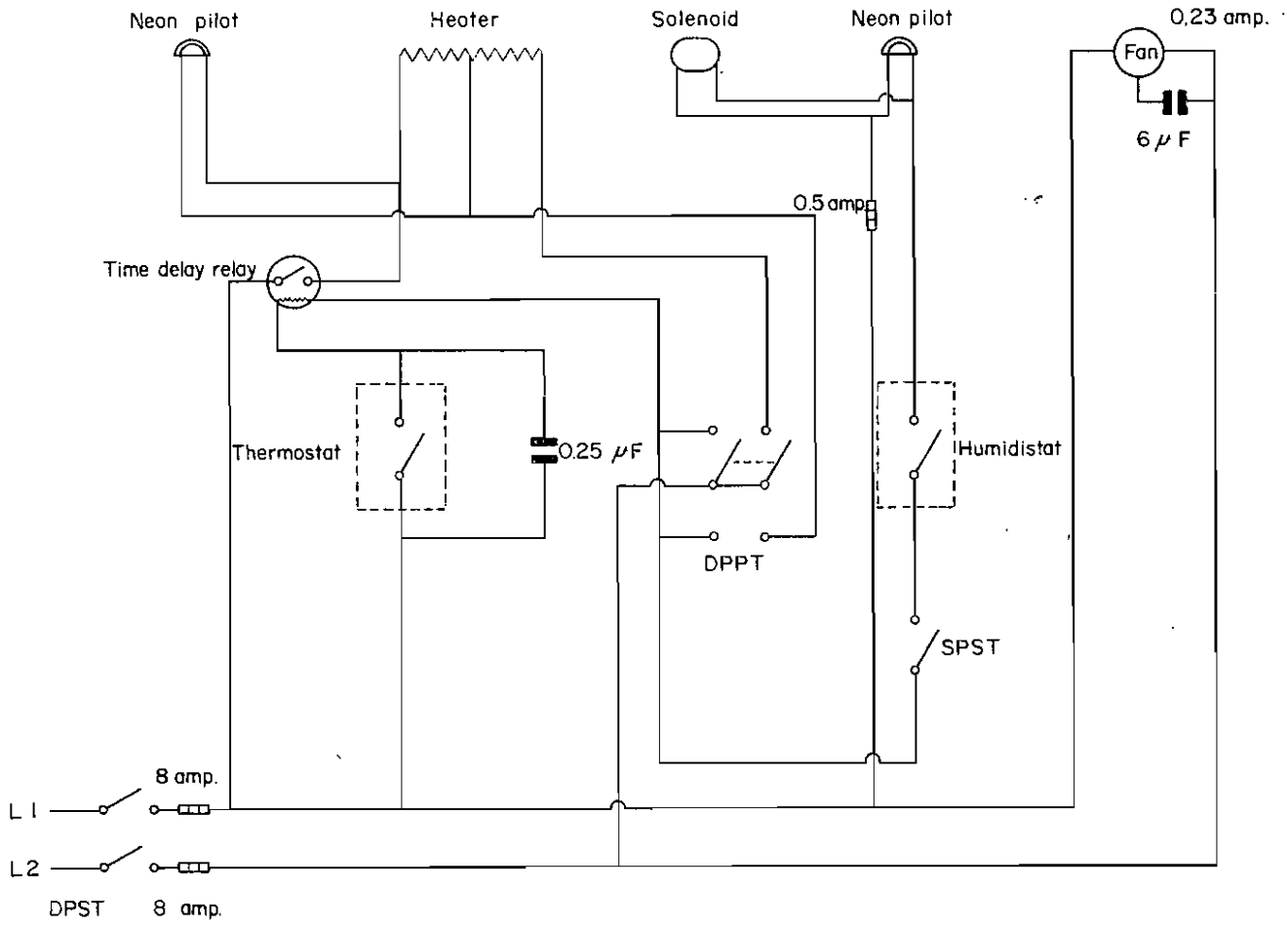


Fig. 12. Control unit circuit diagram.

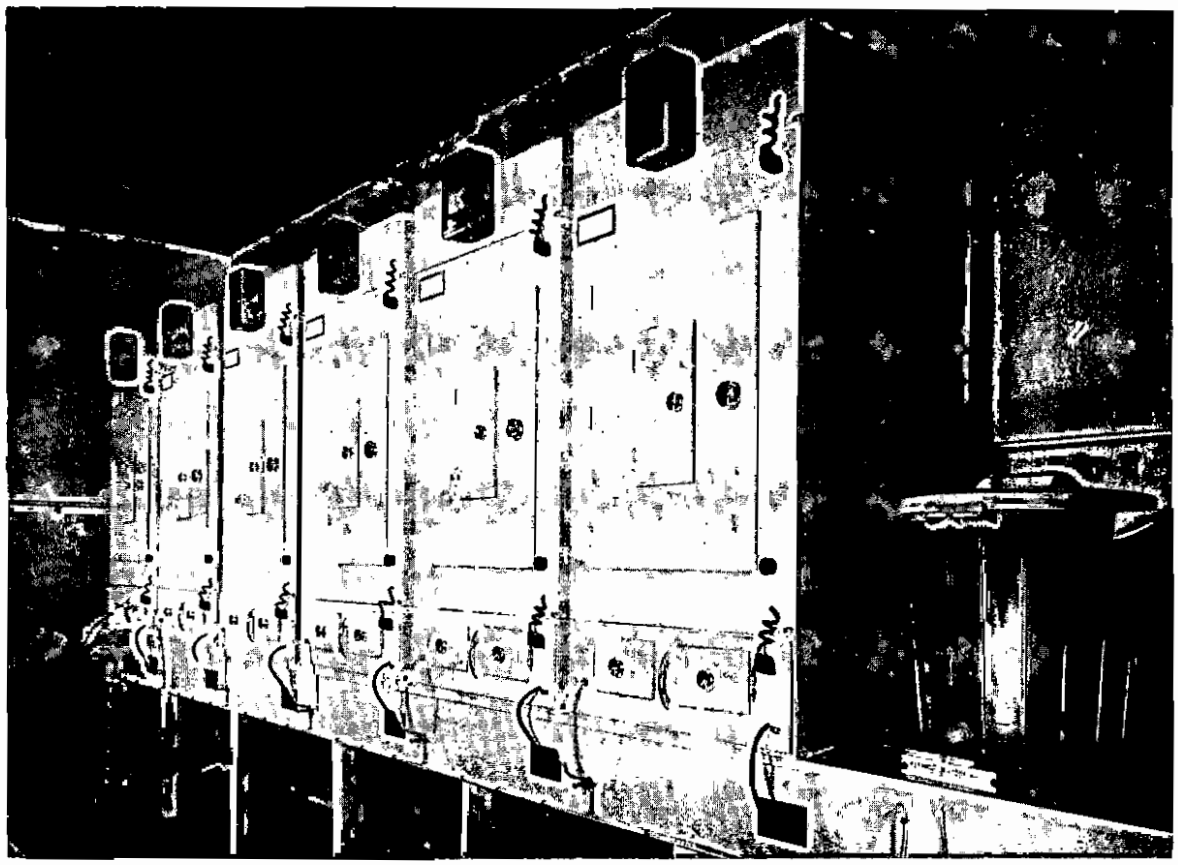


Fig. 13. A battery of cabinets operating in a low temperature room. Note common water reservoir, manner in which electrical supply passes through control unit to environmental chamber to light unit, stoppered hole for thermistor probe near lower right corner of door.