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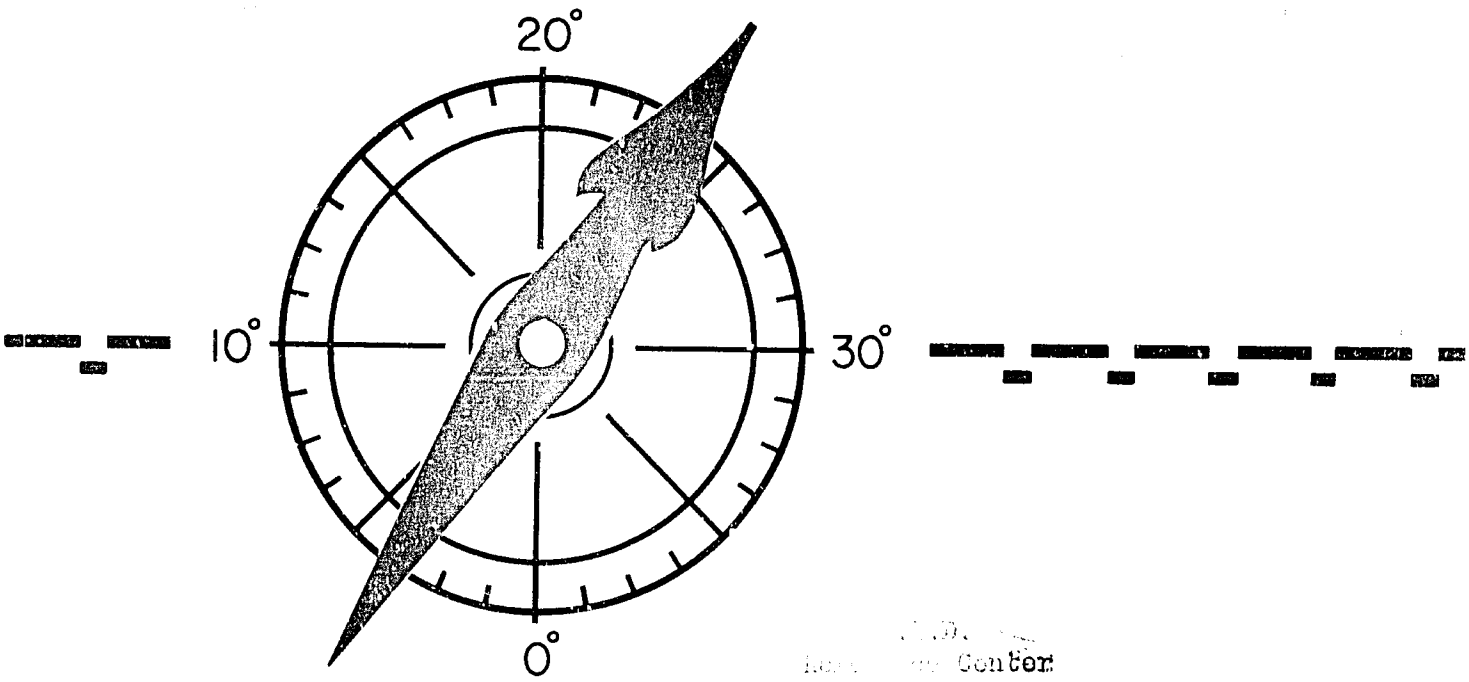

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SEED TECHNOLOGY LABORATORY
and
AGRICULTURAL and BIOLOGICAL ENGINEERING
MISSISSIPPI STATE UNIVERSITY

LOW COST TEMPERATURE CONTROLLED ROOMS

G. Burns Welch and James C. Delouche[1/]

Temperature controlled rooms or chambers are necessary facilities for seed testing laboratories and research programs on seed storage and packaging. Prefabricated chambers complete with a "package" of refrigeration and heating equipment and controls are available from many suppliers. Mechanical refrigeration, heating equipment, and control equipment are also available as separate items, and can be selected and installed by an air conditioning technician in existing or newly constructed rooms. In either case, the equipment needed and services of a specialist may not be readily available and the costs can be considerable.

For facilities in which temperatures lower than about 16° C. are required, use of heavy-duty refrigeration units is necessary and the costs are justified. There are many other situations, however, in which the temperatures required are in the range 16° to 40° C. It was with these situations in mind that the facilities described here were designed.

The temperature controlled rooms described below were designed and put into operation in the Seed Technology Laboratory about 2 years ago. During the first year of operation a few modifications in control devices were incorporated. Since then operations have been continuous and completely satisfactory.

The description that follows is based on the actual installation in the laboratory. Modifications that can be made to fit local conditions or materials without being detrimental to performance are suggested.

DESCRIPTION OF FACILITY

Rooms or Chambers

Two small rooms that had been previously constructed for other purposes within a much larger room were used (Figures 1 and 2). They are approximately 6.5 feet wide by 11 feet long by 8 feet high. The clearance between the top of the small rooms and the ceiling of the larger room is about 7 feet. The small rooms are of standard wood frame construction with blanket insulation between the double walls and ceiling. The floors are of double board construction and not insulated. The inner walls and ceilings of each room are covered with 1/4 inch mesh wire

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1/ Dr. Welch is Associate Agricultural Engineer, and Dr. Delouche is Agronomist, in Charge, Seed Technology Laboratory, Mississippi State University.

cloth (hardware cloth) for rodent control. The wire mesh in turn is covered with overlapping 30 pound asphalt building felt painted with two coats of aluminum paint.

Wood frame construction is not the most satisfactory type for rooms of this kind. If rooms are not available and one must start with their construction, an alternative and more satisfactory type of construction is as follows: Floor - reinforced concrete slab poured over 6 or 10 mil plastic sheeting for vapor barrier, with center drain in floor; Walls - concrete blocks or bricks plastered to a smooth surface on the inside and with 2 inches of rigid plastic foam insulation covering all interior surfaces; Ceiling - plaster or wood with 2 inches rigid insulation.

Many variations in type of construction are possible. The only essential feature is incorporation of some insulation in the construction.

Equipment and Operation

Temperature control in the rooms is accomplished by use of a standard 14,000 BTU room air conditioner and electric space heaters (with fan) controlled by thermostats and venting mechanisms.

The air conditioner is located on top of the rooms and is connected to a divided plenum chamber or tunnel at its discharge end. The plenum tunnel is divided vertically or horizontally depending on the arrangement or position of the discharge and intake vents of the air conditioner. The vertically divided type is illustrated in Figure 1 and the horizontal type in Figure 2. The important point is that one section of the plenum should be for discharge of air from the air conditioner and the other for intake of air. The plenum tunnel is wrapped with ducting type insulation.

The plenum tunnel is connected to each of the rooms with an air inlet duct and an air exhaust duct. The air inlet duct joins to the air discharge section of the plenum tunnel and the air exhaust duct joins to the intake section. The two ducts enter through the ceiling toward the rear of the rooms. They are made of sheet metal and are curved after they enter the room so that the open ends are parallel to the ceiling and about 6 inches below it. The air inlet duct is directed toward the front of the room, while the exhaust duct is directed toward the rear of the room. This arrangement provides for good air circulation in the room. Other arrangements are possible provided the duct openings are not so close together that the air flow is short-circuited and goes directly from the inlet duct to the exhaust duct without circulating in the room.

A damper is positioned in the straight section of each duct and is opened or closed by a small motor. The damper is made of plywood and pivoted on a 3/8 inch shaft. It does not form an air tight seal, but does satisfactorily control the flow of air into or out of the room.

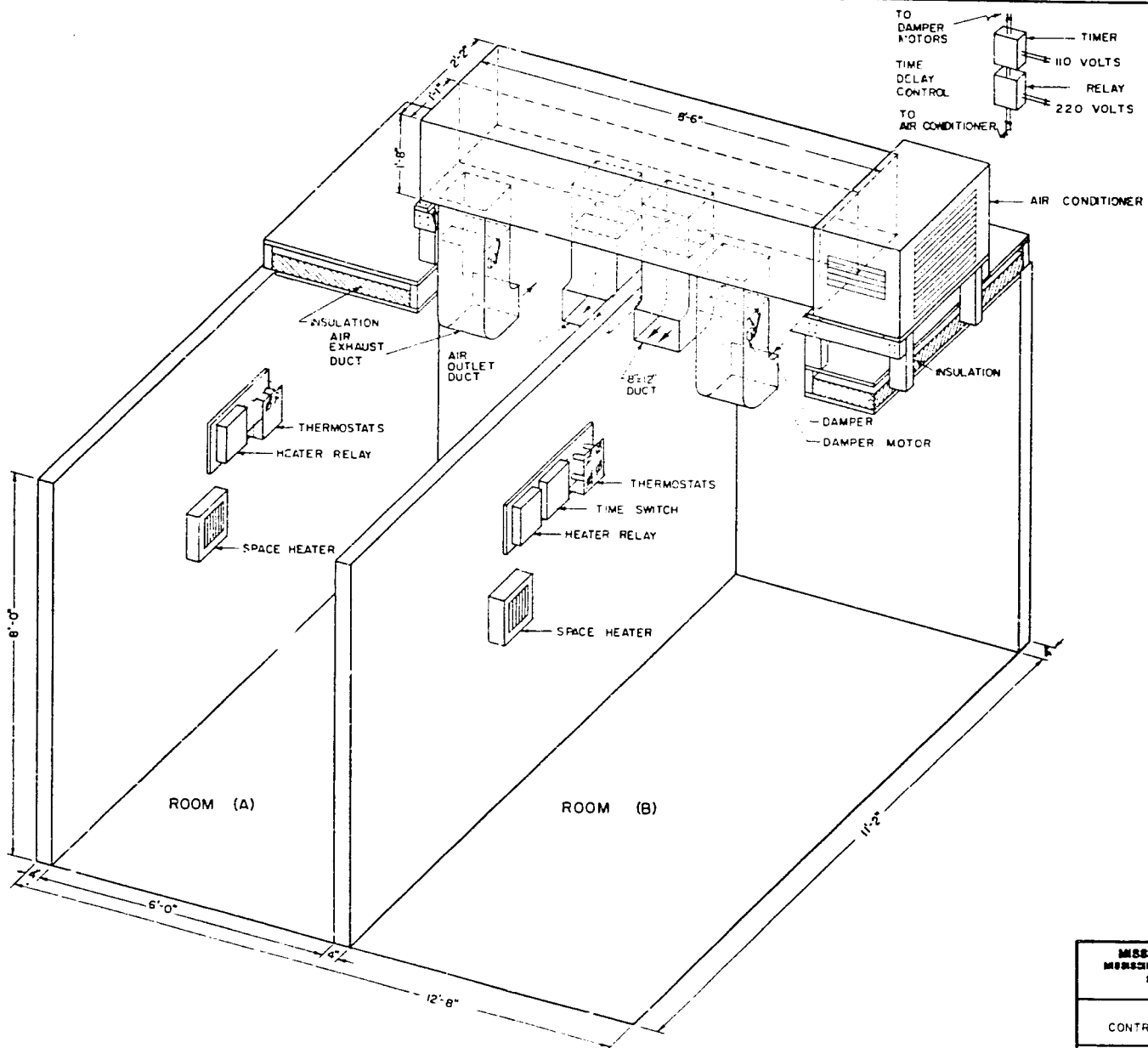

Figure 1. Isometric drawing of rooms with vertically divided plenum chamber.

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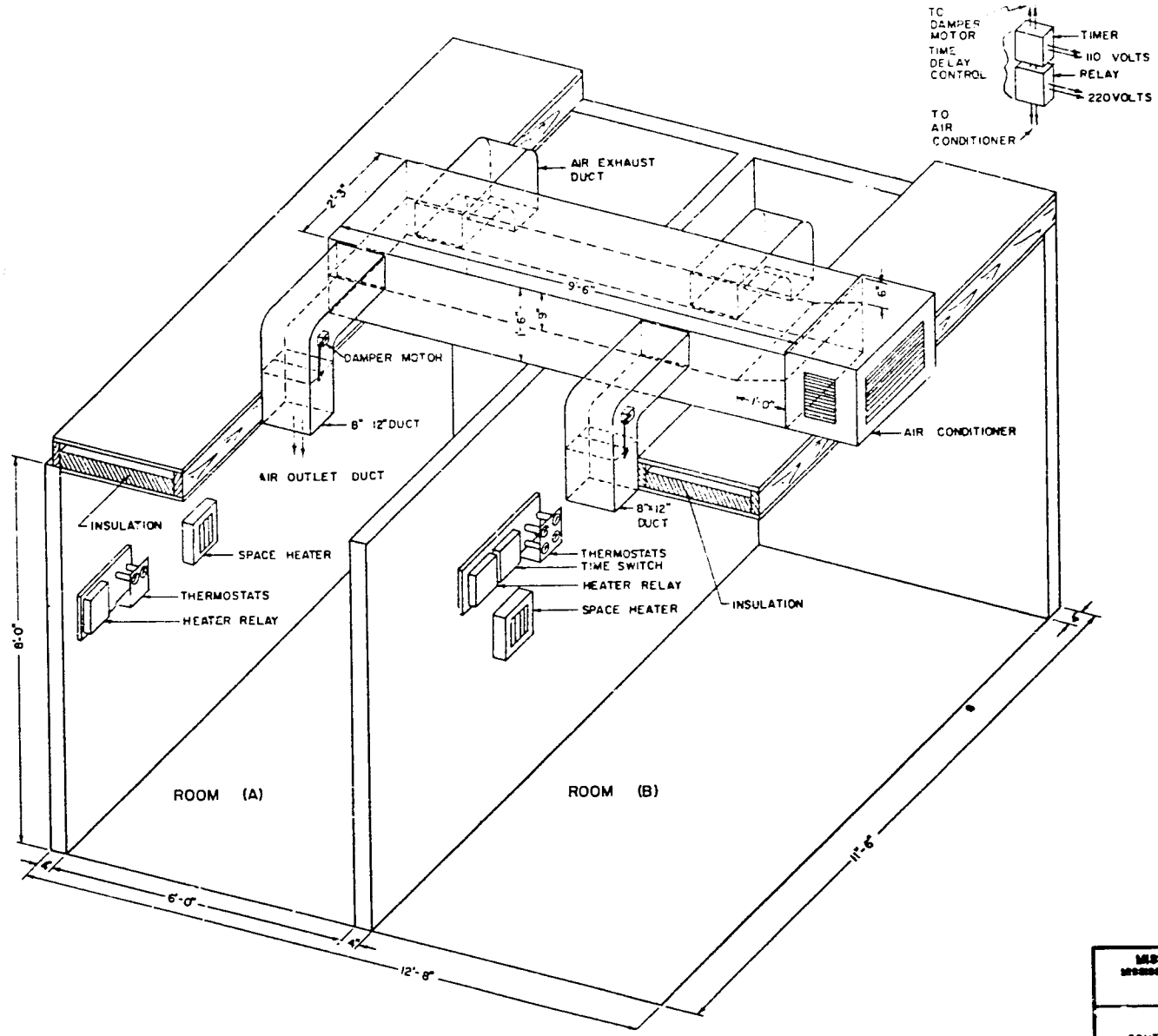
STATE COLLEGE, MISSISSIPPI

PLENUM DIVIDED VERTICALLY
CONTROLLED TEMPERATURE ROOMS

DESIGNED BY: GBW	DATE: DEC 1966	SHEET 2 OF 3
DRAWN BY: EAJ	FILE NO.	
APPROVED BY: JCB		



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SEED TECHNOLOGY LABORATORY
STATE COLLEGE, MISSISSIPPI

PLENUM DIVIDED HORIZONTALLY
CONTROLLED TEMPERATURE ROOMS

DRAWN BY: G.B.W.
DESIGN BY: E.A.J.
APPROVED BY: J.C.D.
DATE: DEC 1966
FILE NO.
SHEET 3 OF 3

Figure 2. Isometric drawing of rooms with horizontally divided plenum chamber.

Constant Temperature

Any constant temperature between 16° C. and 40° C. can be maintained in Room A (Figures 1 and 2). Two thermostats with a sensitivity of plus or minus 1° to 2° C. are used. One cooling type thermostat controls the air conditioner and is used for cooling the room when the temperature rises above that desired in the room (20° C. for example). The other thermostat is a heating type and turns on the electric space heater when room temperature drops below the desired level. The cooling and heating thermostats are adjusted to break contact slightly above and below the desired temperature level. This prevents overlapping of the thermostats and operation of both air conditioner and heater at the same time. An electrical schematic of the system is shown in Figure 3.

A constant temperature is achieved and maintained as follows using a 20° C. temperature setting for purposes of illustration.

(1) When the room temperature rises above the 20° setting, the contacts in the cooling thermostat close and activate small motors that open the dampers in the inlet and exhaust ducts connected to plenum chamber.

(2) When the motors open the dampers completely, an auxiliary switch is activated which turns on a time delay device set for 5 minutes. [2/]

(3) After 5 minutes the time delay switch activates a relay which turns on the air conditioner.

(4) When the temperature inside the room has been reduced to the 20° C. setting, the contacts in the cooling thermostat open, the motors close the dampers, and the auxiliary switch opens the relay that turns off the air conditioner. (There is no time delay on the off cycle of the air conditioner.)

(5) When the temperature drops below the level desired in the room, the heating thermostat becomes active. Its operation is very simple: the contacts close and activate

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2/ The time delay is necessary to keep the air conditioner from starting immediately after it has stopped. Rapid stops and starts will ruin compressors in a very short time. Some air conditioners and refrigeration units have "built in" time delay devices to keep the unit from starting for 2 or more minutes after stopping. Others have only a warning label stating that the unit should not be turned on for 2 or more minutes after stopping.

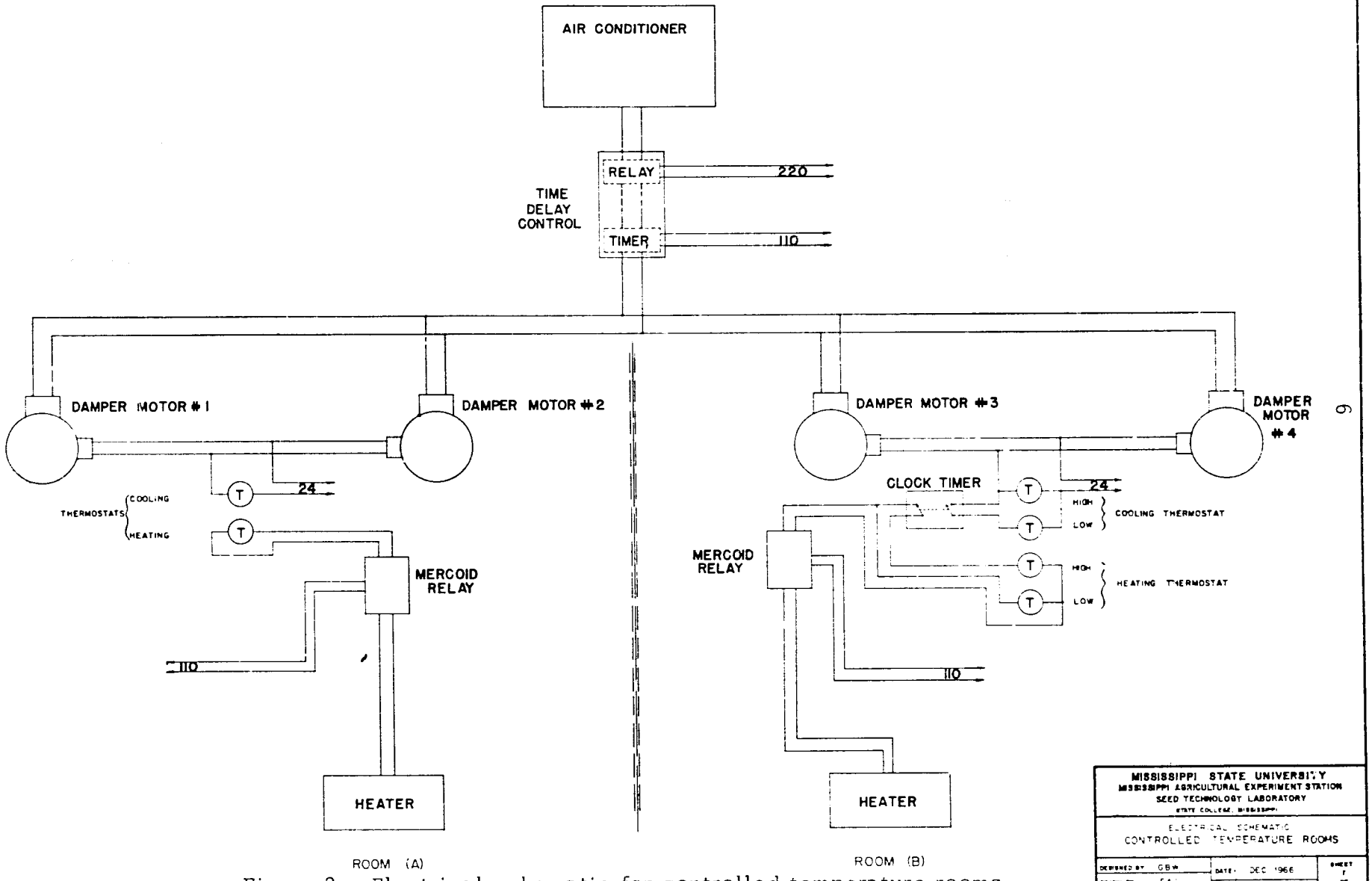

Figure 3. Electrical schematic for controlled temperature rooms.

a relay which turns on the heater. As the temperature rises to the desired level the contacts open and the relay turns off the heater.

Alternating Temperature

The controls is Room B are designed to automatically alternate the temperature in the room between a high and low level at desired time intervals (Figures 1 and 2).

Two pairs of cooling and heating thermostats are used - one pair controls the low temperature cycle of the alternation and the other pair controls the high temperature cycle. A time switch is used to alternate the controls between the high and low temperature cycles. To illustrate the controlling action of the thermostats and time switch, let us assume that the room is set at the 20° to 30° C. alternating temperature recommended for germination tests of many kinds of seed. This alternation normally consists of 30° from 0800 to 1600 hours and then 20° from 1600 to 0800 hours of the next morning.

(1) When the time switch rotates to 0800 hours, it opens the circuit of the low cycle cooling thermostat, which is set at 20° C., and closes the circuit of the high cycle heating thermostat, which is set at 30° C. (see wiring diagram in Figure 3).

(2) The high cycle heating thermostat turns on the heater as soon as it is switched into the circuit. When the temperature in the room reaches 30° C., the contacts of the high cycle thermostat open and the heater is turned off. Every time room temperature drops below the 30° setting, the thermostat turns on the heater and warms the room back to 30° C.

(3) In situations where the room temperature rises above the 30° C. setting because of a high outside temperature, the high cycle cooling thermostat, which is set at about 31° C., turns on the air conditioner to cool the room to the setting. This thermostat acts through the damper motor switch-time delay circuit previously described in the section on constant temperature.

(4) At 1600 hours, after the usual 8 hour high temperature period, the time switch opens the circuit of the high cycle heating thermostat and closes the circuit of the low cycle cooling thermostat, which is set at 20° C. The low cycle cooling thermostat turns on the air conditioner through the

damper switch-time delay circuit (5 minutes delay) and the room is cooled from 30° C. down to the 20° C. setting. Once the room is cooled to 20° C., the low cycle thermostat turns off the air conditioner. This thermostat will then activate the cooling system every time the temperature in the room rises above 20° C.

(5) In situations where room temperature drops below 20° C. because of a low outside temperature, the low cycle heating thermostat, which is set at about 19° C., turns on the heater and warms the room back to the setting.

(6) The low cycle temperature is usually maintained from 1600 hours to 0800 hours of the next morning. At that time, the time switch opens the circuit of the low cycle controls and closes the circuit of the high cycle controls. Temperature is then raised to the desired 30° C. as described in (1) above.

Although an alternating temperature of 20° - 30° C. was used here as an illustration, alternations between any two temperatures in the range 16° to 40° C. can be achieved. Also, the cycle of alternation can be set for any combination of hours that total to 24: 16 and 8 hours, 12 and 12 hours, 14 and 10 hours, etc.

One item not shown in the drawings is a small, low speed, continuously operating fan in each room. We have found that a fan is necessary to prevent temperature stratification when both the heater fan and air conditioner are not in operation.

Combination of Rooms

It should be pointed out that one alternating and one constant temperature room are described here for the purpose of illustrating both types. In practice, the two rooms can be both alternating, both constant, or a combination of the two types depending on the conditions needed.

Regardless of the combination of types of rooms used, both rooms are independently controlled even though they are both cooled by the same air conditioner (see wiring diagram in Figure 3). Each room, however, requires a separate heating source (electric space heater).

USES OF THE FACILITY

Temperature control in the rooms at constant or alternating levels is entirely satisfactory for their use in seed storage research or as walk-in type germinators. In either case, additional provisions must

be made because only temperature is controlled. Relative humidity is not controlled and tends to be quite low - particularly at high temperatures. It would be simple enough to install a humidifying device in the rooms, but special "wet room" construction, plenum chamber, air conditioner, and heater would have to be used. Those described here would deteriorate rapidly at humidities above 75 percent.

For storage research, we have constructed humidity chambers of plexi-glass or other rigid clear plastic material (Figure 4). In each chamber there is a shelf about 6 inches from the bottom. The chamber cover has a rubber gasket and thumb screws to force a vapor tight seal. The desired humidity is maintained in the chamber by placing a saturated aqueous solution of the appropriate salt in the bottom of the chamber. The seed research material are packaged in cloth bags or other packaging material and placed on the shelf in the chamber. We have also effectively used large steel drums with tight fitting covers as humidity chambers. In this case, the saturated salt solution should be placed in a plastic container in the bottom of the drum to minimize corrosion.

When the rooms are used as walk-in germinators the seed are planted in rolled towels or other paper media and then placed in plastic crisper boxes to minimize desiccation (Figure 5). Each box holds two complete germination tests (larger boxes can be used). Placing the boxes (and tests) in the slanting position illustrated permits geotropic responses of the germinating seeds and facilitates interpretation of the tests.

Shelving in the temperature controlled room is necessary to hold the humidity chambers and plastic boxes used for germination tests. We use wooden shelving supports and shelves (Figure 6). The shelves are of the "slip in" type and can be easily adjusted in height. In cases where light is required, fluorescent lights can be attached to the bottom of the shelves to illuminate the area directly below. The lights can be turned on and off manually or with a time clock similar to the one described for the alternating temperature room.

LIST OF EQUIPMENT

The cost of the mechanical and electrical equipment for the two-room facility was approximately $1,000. This included the cost of the air conditioner, plenum chamber, ducting, dampers, damper motors, variable transformer, thermostats, heaters, relays and time-switch devices, but not the cost of construction of the rooms and labor involved in installing the equipment.

The equipment listed below are those actually used in the facilities described in this publication. Equivalent equipment are also available from many other suppliers and manufacturers. For areas in which electrical power characteristics (voltage and cycles) are different from those described here, equipment specifications should reflect the

Figure 4. Plastic humidity chamber used in seed storage research.

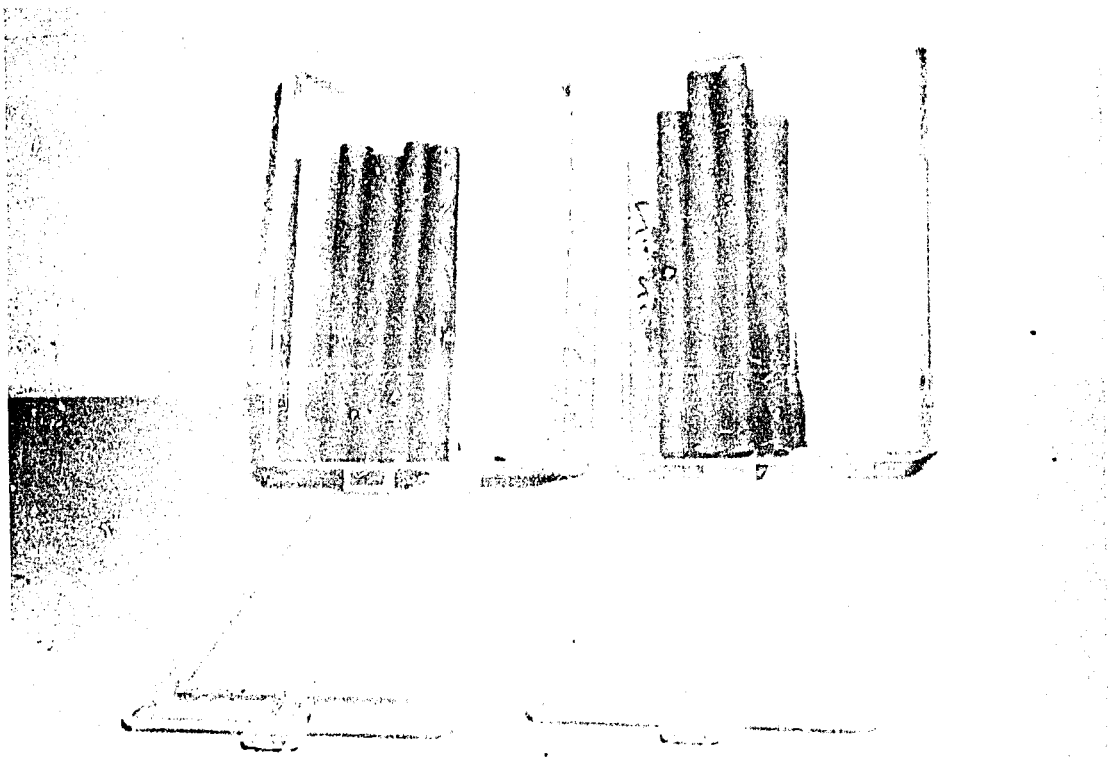

Figure 5. Plastic boxes used to prevent desiccation of germination tests.

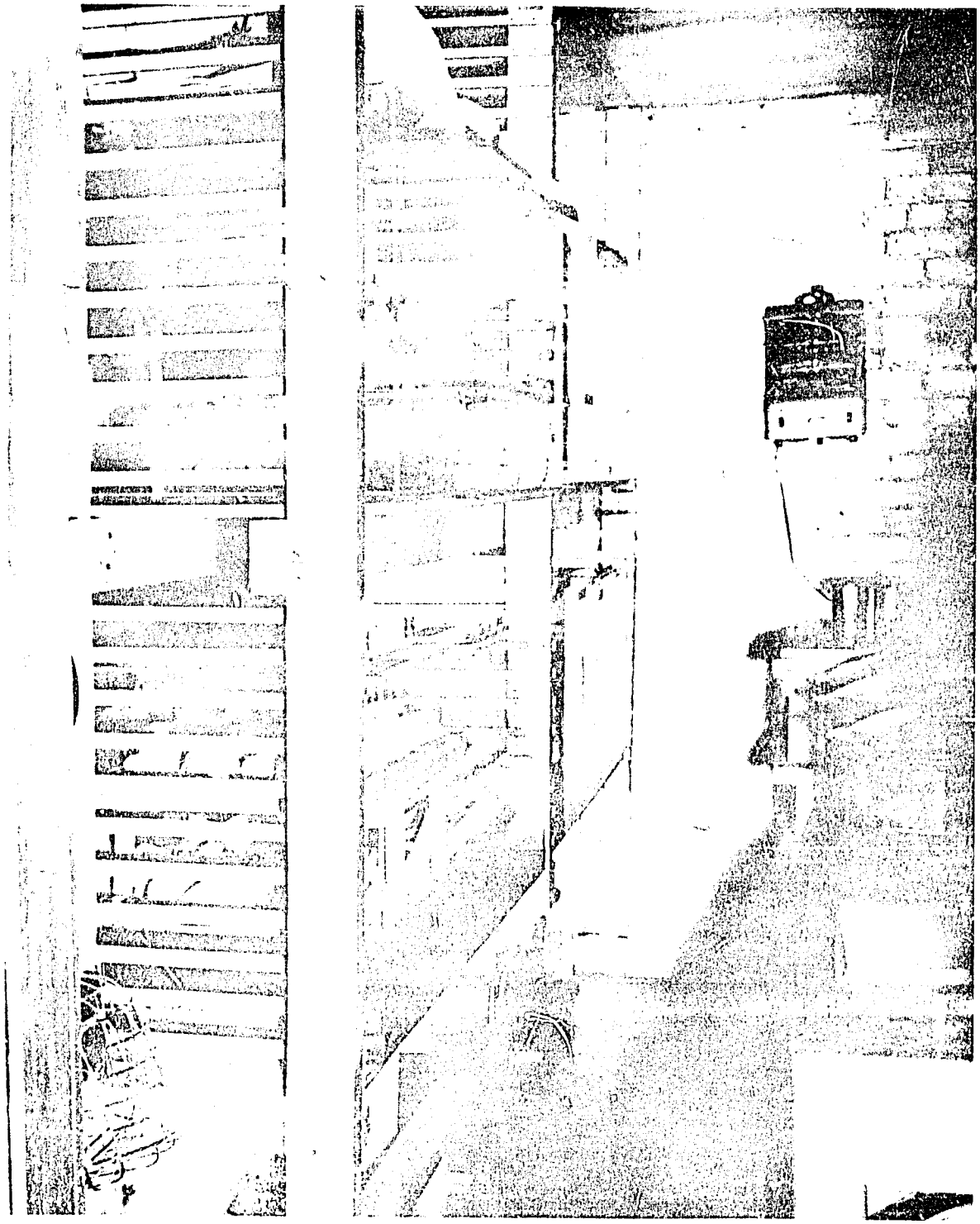

Figure 6. Interior view of room showing type of shelves used.

characteristics of the local power system.

1 - Air Conditioner, window type with 10,000 to 14,500 BTU rating.

1 - Honeywell Relay, R847A1903, 220 volts, 16 Amps, 60 cycle, internal transformer, low voltage control.

2 - Mercoid Relay, V3-113A, 110 volts, 20 Amps.

4 - Mercoid Damper Motor, Type 12-L, with built-in auxiliary switch, 24 volts AC.

1 - Intermatic Time Switch No. T105, SPDT.

1 - Industrial Timer, Time-Delay Control, 5 minutes delay, Model CSF.

3 - Fenwal Thermostat, No. 17300 - 0, contacts open on temperature rise, with 2 inch dial and knob.

3 - Fenwal Thermostat, No. 17321 - 0, contacts close on temperature rise, with 2 inch dial and knob.

1 - Superior "Powerstat" No. 116, 110 volts, 7.5 Amps. Variable transformer used for 24 volt AC power supply for damper motors.

2 - Portable Electric Heater, with circulating fan, 1650 watts. 115 volts, AC.

Further details on construction of rooms, mechanical and electrical equipment, and circuitry can be obtained by writing to Seed Technology Laboratory, Box 5267, State College, Mississippi 39762, USA.