

## THE DESIGN AND CONSTRUCTION OF A PILOT-SIZED HERMETIC CONTROLLED ATMOSPHERE COLD STORAGE CHAMBER

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THE APPLICATION of controlled atmosphere (CA) conditions for prolonging the storage life of fruit, although not new in principle, currently is receiving wide interest from growers and handlers. In a review article, West (1951) noted that research on CA storage started in England in 1919 and that the first commercial storage was constructed in 1929.

The development and utilization of CA storage for apples in the United States has been described by Smock (1949). Commercial storages in this country were first constructed in the late 1930's. At present, the storages are located primarily in the northeastern United States and have an estimated capacity of 812,000 bushels.

The need and desirability of CA facilities for farm storage of Michigan apples resulted in establishing a research project on CA storage. Comparisons of different types of storage structures on a laboratory scale demonstrated the need for a hermetic room as a control in establishing and maintaining the desired atmospheres.

Uncontrollable variables, such as changes in atmospheric pressure and temperature (Pflug and Dewey, 1955) which influence the rate of leakage are eliminated in a hermetic room. The utilization of oxygen and production of carbon dioxide by the fruit may then be accurately determined.

### DESIGN AND CONSTRUCTION

Dimensions of the hermetic room were dictated by the size of the other experimental chambers which have an inside width of 40 inches, height of 60 inches, and length of 80 inches. These rooms

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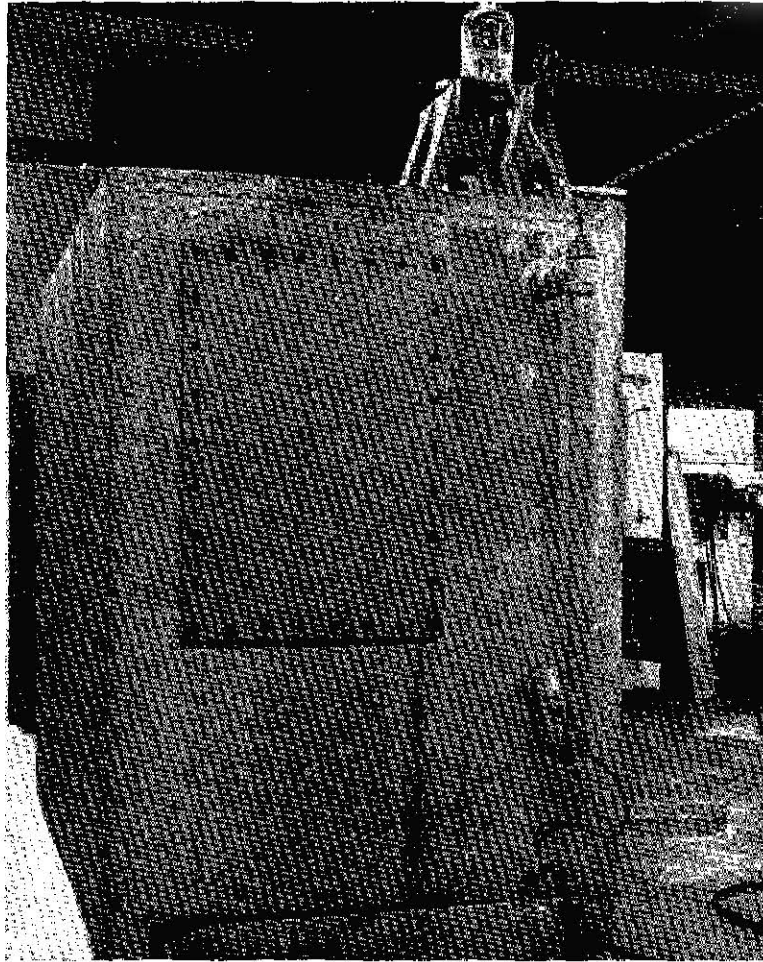


Fig. 1. Front view of hermetic storage chamber, showing scaled service door and attached carbon dioxide absorption unit.

have a capacity of 38 field crates of apples when a blower-type evaporator is used. The material selected for the hermetic room was 10 gauge (0.134 inch thick) steel plate.

The general method of construction was: (1) Make a metal tank 40 by 60 by 80 inches, thoroughly tested to insure a hermetic unit; (2) insulate the outside of the tank with 4 inches of board-form insulation; and (3) add the auxiliary facilities.

The loading door, 20 inches wide by 30 inches high, was made as small as practical in order to seal the door and yet allow space for

a man to enter and work in the room. The doorway was located near the upper left corner of the front of the room so the storage could be completely filled with fruit (Fig. 1).

Openings into the room for refrigeration lines, gas sampling, carbon dioxide absorption, temperature measurement, and air equalization were provided by locating two 2-inch pipe nipples in the front and two 2-inch pipe nipples in the rear of the storage.

The six sides of the room, doorframe and pipe nipples were electric-welded together. The sides, ceiling and floor were reinforced by welding 2-inch by  $\frac{3}{8}$ -inch flat strips at right angles to these surfaces (Fig. 2).

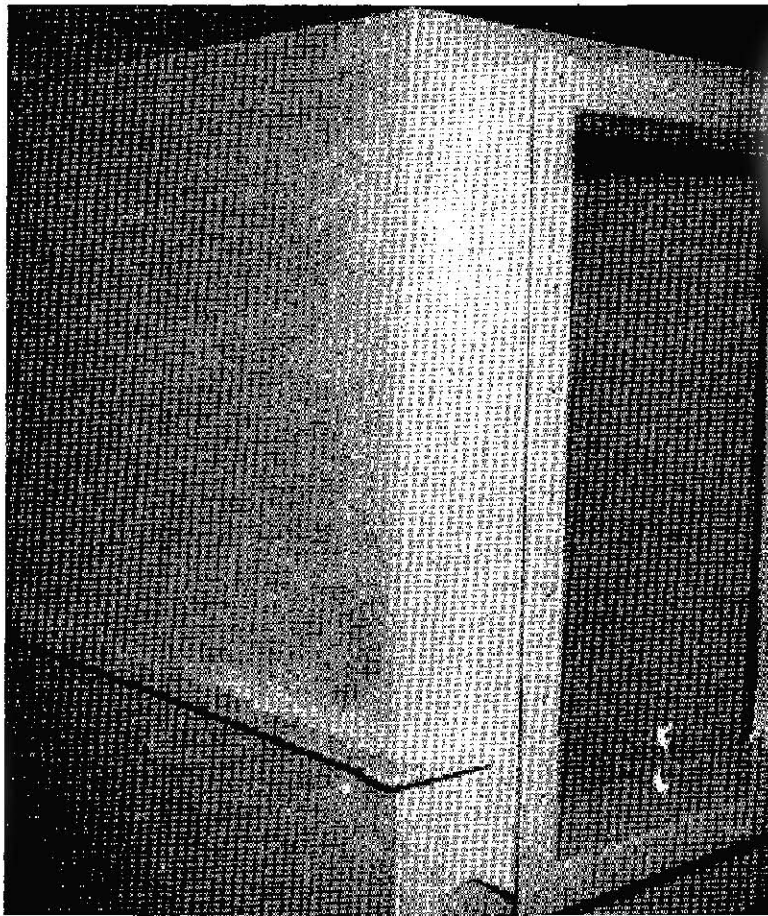


Fig. 2. Steel tank without insulation, showing door construction, side wall reinforcement and welded seams.

Following fabrication, all seams were checked for leakage and re-welded as necessary to make them gastight. Leaks were located by using a halide detector at the exterior surface after establishing a positive pressure (15 inches water gauge) of Freon 12 (dichlorodifluoromethane) and air within the closed chamber.

The metal surface of the hermetic chamber was then primed with red lead and covered with a wearing coat of aluminum paint. The chamber was mounted on a wood skid to facilitate moving (Fig. 3). The room was insulated on the outside with two layers of Styrofoam fastened to the chamber with metal clips and sealed with an asphalt emulsion.

A blower-type refrigeration evaporator was installed in the room;

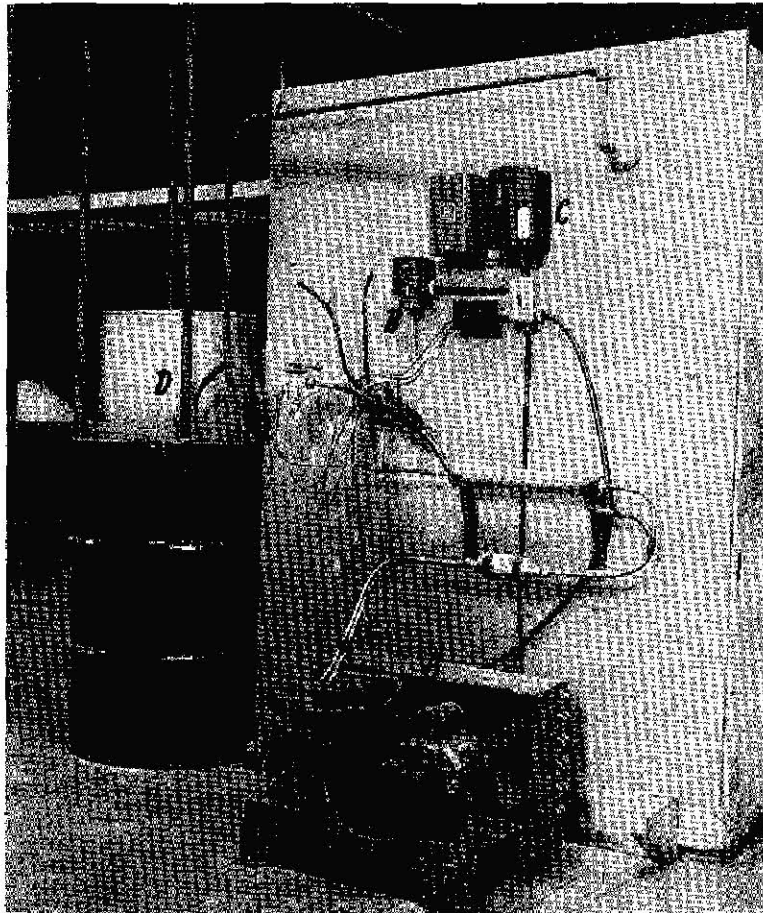


Fig. 3. Rear view of hermetic storage: (A) Condensing unit; (B) thermostat; (C) defrost time clock; (D) air-expansion unit.

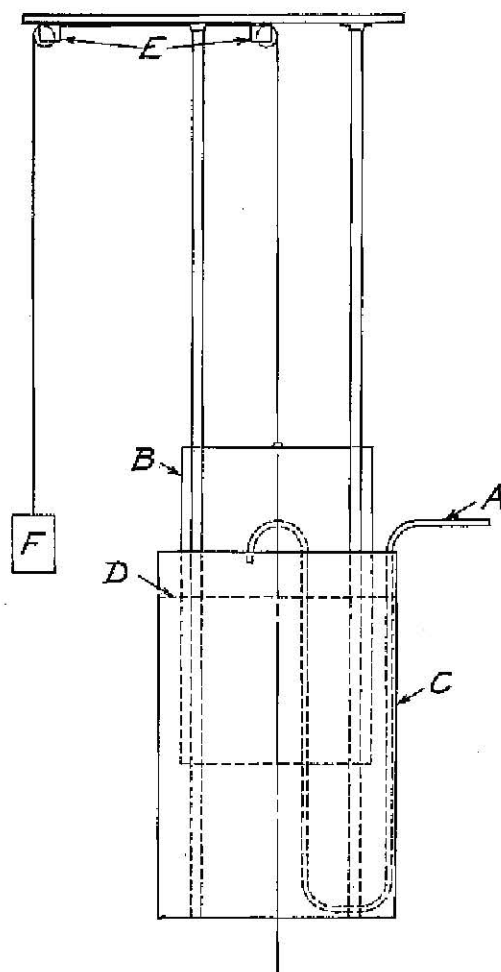


Fig. 4. Detail of air-expansion unit: (A) Air line to storage; (B) inverted galvanized metal tank counterbalanced by weight (F); (C) 55-gallon metal drum filled with water to level (D); (E) low friction pulleys.

the accompanying condensing unit was installed behind the room (Fig. 3). A plywood panel was attached to the rear of the storage for mounting the thermostat, heat exchanger, time clock and control switches (Fig. 3). A carbon-dioxide absorption unit was fabricated and connected to the appropriate nipples in the front of the storage (Fig. 1).

An air-expansion unit (illustrated in Fig. 3 and shown in detail in Fig. 4) was attached to compensate for changes in volume of the

storage room atmosphere due to temperature fluctuation, changing barometric pressure and absorption of carbon dioxide. A safety device was designed (Fig. 5) to guard against collapse or buckling of the chamber due to abnormal pressure differentials.

An oxygen-feeding device designed to maintain a constant oxygen level during respiration tests is illustrated in Fig. 6. Oxygen can be supplied to the storage chamber at a constant rate determined by the size of the sprockets used in the drive. Continuous oxygen addition in conjunction with continuous carbon dioxide absorption permits studies of the respiratory activity of the fruit under constant, controlled conditions.

The oxygen content of the atmosphere in the storage chamber is measured and recorded continuously by a Model F-3 Beckman oxygen-analyzer and strip chart recorder. A closed system air-circulating pump is used to supply the analyzer with a sample of the atmosphere from the chamber.

The carbon dioxide and oxygen level is manually determined daily by a Hayes orsat gas analyzer. Although this analysis is pri-

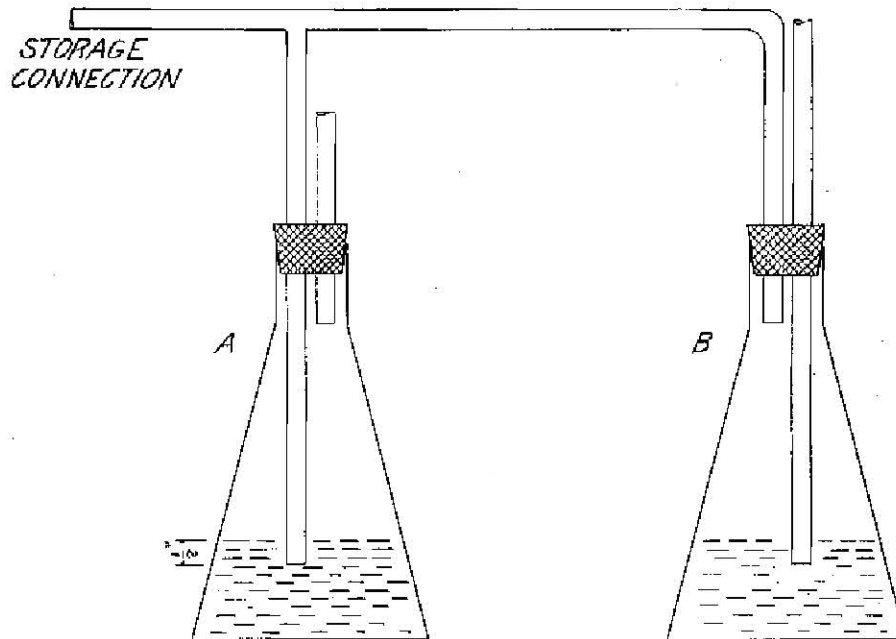


Fig. 5. Safety device to prevent excessive differential pressure. Bottle A allows atmosphere to escape from the room when differential pressure is greater than 0.5 inch of water; bottle B vents air into the room.



Fig. 6. This electrically-driven unit supplies oxygen from the reservoir tank to the storage chamber at a constant and adjustable rate.

marily to determine the carbon dioxide level, it serves as a check on the automatic oxygen-analyzing equipment.

The temperature of the air and fruit in the storage is measured by a temperature-recording potentiometer connected to three thermocouples in the storage. The thermocouples are located near the inlet and discharge sides of the evaporator and in an apple near the center of the chamber.

The storage chamber is equipped with an activated carbon air-purifier as an aid toward reducing off-odors and fruit scald during the storage period.



### SUMMARY

A hermetic storage chamber with a capacity of 38 bushels of fruit was designed and constructed for CA research. This storage facility is designed to provide operational conditions similar to those of a commercial room. The desired atmosphere is established by the natural respiration process of the stored fruit and is maintained by chemical absorption of carbon dioxide and mechanical addition of oxygen. Gas samples removed for analysis are of negligible size in respect to the volume of the chamber. Furthermore, accurate control of the gas levels is facilitated by the elimination of air leakage and its many associated problems. This chamber appears to have unlimited usefulness for storage and respiration studies under controlled conditions.

### ACKNOWLEDGMENT

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