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Progress Report

WATER VAPOR TRANSMISSION IN REFRIGERATED WAREHOUSES

April 1 to June 30, 1953

by

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Some alterations of parts of the 4x8 ft. panel apparatus were made, as a result of analysis of operational tests conducted during the last quarter. The desiccant box refrigerating equipment was changed to make its control independent of the cold box system; the water vapor generating capacity on the warm side was increased, and an extra blower installed on the cold side to increase the absorbing capacity of the desiccant system.

Three runs of several days' duration were made to determine the calibration coefficient of the differential thermocouple system which indicates heat exchange between the warm side box and the laboratory room. With this coefficient, and the values of the differential thermocouple reading and the measured heat input to the warm side, it is possible to compute the heat flow through a test panel during a regular test, and thus to observe changes in its insulating value if they occur. These tests were made with an aluminum-faced panel with 3-5/8 inches of glass fiber insulation, and were conducted with the warm side at temperatures equal to, 20 degrees F above, and 20 degrees F below,

room temperature. The cold side was held at about -23°F.

By simultaneous solution of pairs of the three equations representing the three test conditions, values were derived for the calibration coefficient of the warm side differential thermocouples. The three values thus obtained for the calibration coefficient were within 2% of the average value of 7.37 watts of heat exchange with the room per millivolt of emf of the differential thermocouple. The C-value of the test panel derived from these tests was about 30 percent higher than the value estimated on the basis of its construction and materials; this is in part at least due to heat leakage around the panel through the sealing compound and laterally along the box walls. An effort is being made to evaluate this heat leakage, although it should not be important so far as observation of changes in test panel insulating value is concerned.

In the course of these tests, observations on the cold side of air temperatures and evaporator coil temperatures indicated that with the flooded evaporator and the present air flow through the coil, their temperature difference did not exceed 5.3 degrees F, for a coil temperature of -28°F, even with a small amount of bucking heat introduced for temperature control. This is satisfactory for

preventing moisture accumulations on the coil for cold side relative humidities up to 72 percent.

An operational test of seven days' duration was made to observe and study the performance of the vapor generating equipment and controls on the warm side and of the vapor absorbing desiccant system and controls on the cold side. The test panel used for this purpose had an aluminum sheet on its warm side, with one inch of fiberglas duct insulation glued to its cold side and exposed to the cold side air. The frame of the panel was composed of 2x4 studs on 16-inch centers and 2x4 edges, and was exposed to the cold box air. Six 1/4-inch holes were drilled in the aluminum sheet in each of two horizontal lines 6 ft. apart vertically, the insulation being chamfered around the holes. Convective circulation of air between the warm and cold sides through these holes carried vapor from the warm side to the cold side at a steady rate depending on the temperature and humidity conditions.

Conclusions drawn from the test were:

(a) The cantilever weighing devices for determining vapor release and receipt rates on the two sides of the panel performed satisfactorily, as did the control systems for both sides.

(b) Vapor flow from the warm side through the holes of the panel was measured as equivalent to 3.3 grains per hour per square foot of panel. This is in agreement with the vapor flow that would be predicted on the basis of a coefficient of discharge for the holes of 0.78 for convective air flow, under the test conditions of 80°F and 51% R.H. on the warm side and 30°F and 66% R.H. on the cold side.

(c) The heating and refrigerating systems, and their controls, operated very satisfactorily for the entire test period.

(d) The rate of vapor receipt on the cold side was initially twice the rate of vapor release on the warm side, but tended to approach the latter as the test was continued. Calculation shows that the excess was probably due to moisture released from the exposed wood framing of the test panel.

The last conclusion indicates the importance of avoiding hygroscopic materials exposed to the air inside the apparatus. It suggests also the important role played by hygroscopic materials, such as wood members, in the vapor transmission or accumulation characteristics of refrigerated insulated structures.

The coefficient of discharge of 0.7[illegible] found for the 1/4-inch holes is not unreasonable for holes of this size made by a hand drill in soft aluminum sheet 1/16 inch thick. It is believed that reasonable reliance can be placed on the method of calculating such ventilation rates, which will be useful when panels are to be designed to investigate the value of cold side ventilation in tests to be made later in the project program.

It is believed, from the experience of these tests, that the next phase of the program--the determination of the performance of full-size panels of various designs--can be initiated at once. Material has been obtained for the first such panel to be tested, which will be a slab of homogeneous non-hygroscopic material (Styrofoam), of low thermal conductance and moderately low vapor permeance. The material was furnished without charge by the Dow Chemical Corporation.

After consultation with the representative of the Quartermaster Corps, it was decided to construct an apparatus for measuring the vapor permeance of samples, about

one foot square, of the materials used in the construction of the 4x8 ft. test panels, or in actual structures. An apparatus was devised, utilizing a hypodermic syringe, in which the feed of water necessary to maintain a steady vapor flow through a specimen is automatically introduced, metered and controlled, with relatively simple equipment. A working model of the moisture feeding and metering component has been made and tested. Plans are being worked out to build a complete permeance apparatus capable of operation at different temperatures and humidities on the two sides of the specimen. Features of the apparatus are that the results will have been obtained as soon as the specimen itself has come to an equilibrium with the imposed conditions, and that little or no attendance during a measurement should be necessary.

Ten photographs are attached showing views of the 4x8 ft. panel apparatus and parts, as follows:

Figure 1. General view with apparatus in horizontal position.
Figure 2. " " " " " vertical "
Figure 3. Apparatus separated.
Figure 4. Closeup of warm side.
Figure 5. " " cold side.

Figure 6. Closeup of desiccant box.

Figure 7. Refrigeration equipment and controls.

Figure 8. Instrument panel.

Figure 9. Warm side of test panel showing 1/4 inch holes and thermocouple stations (black patches).

Figure 10. Cold side of test panel.

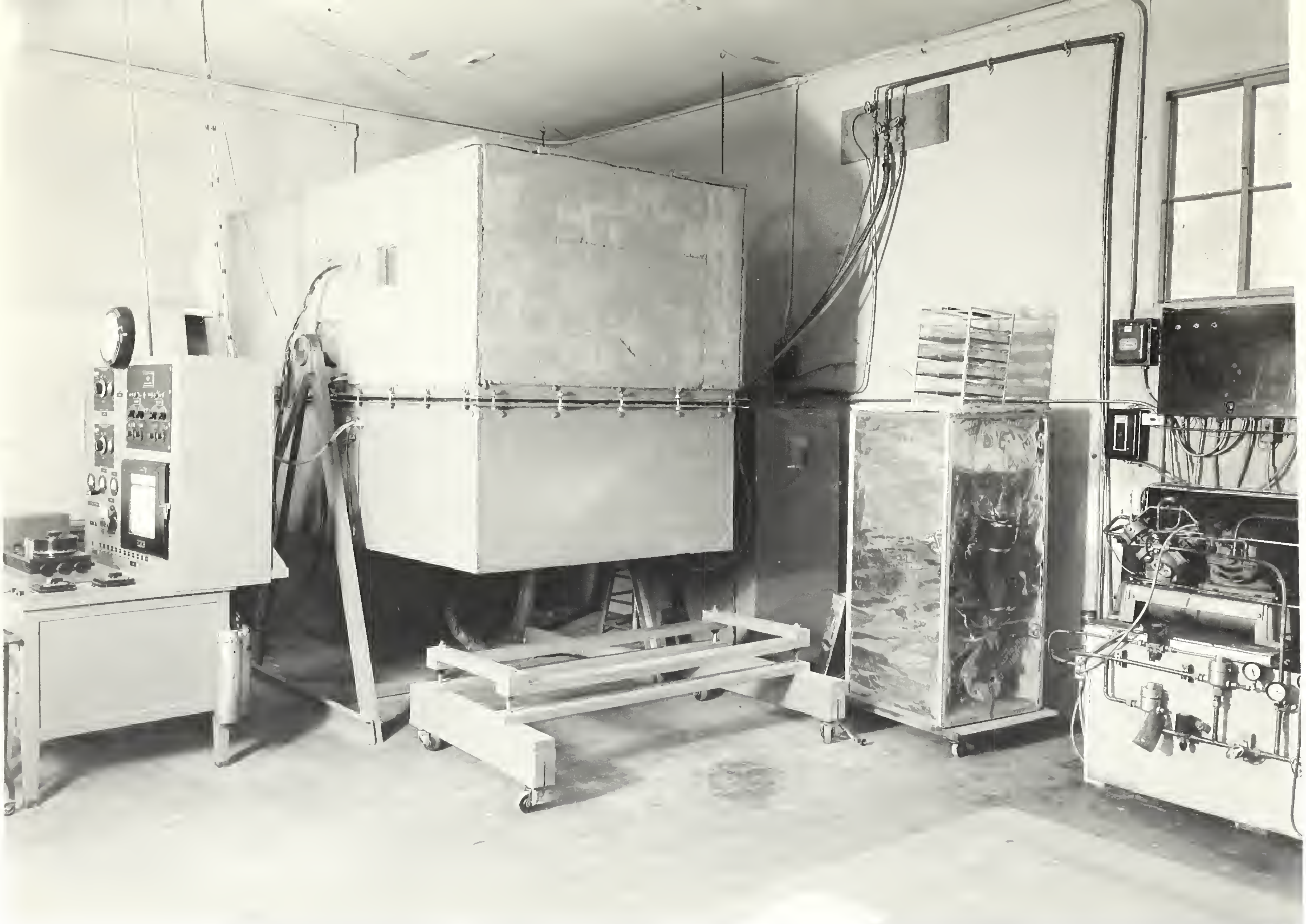

FIG. 1

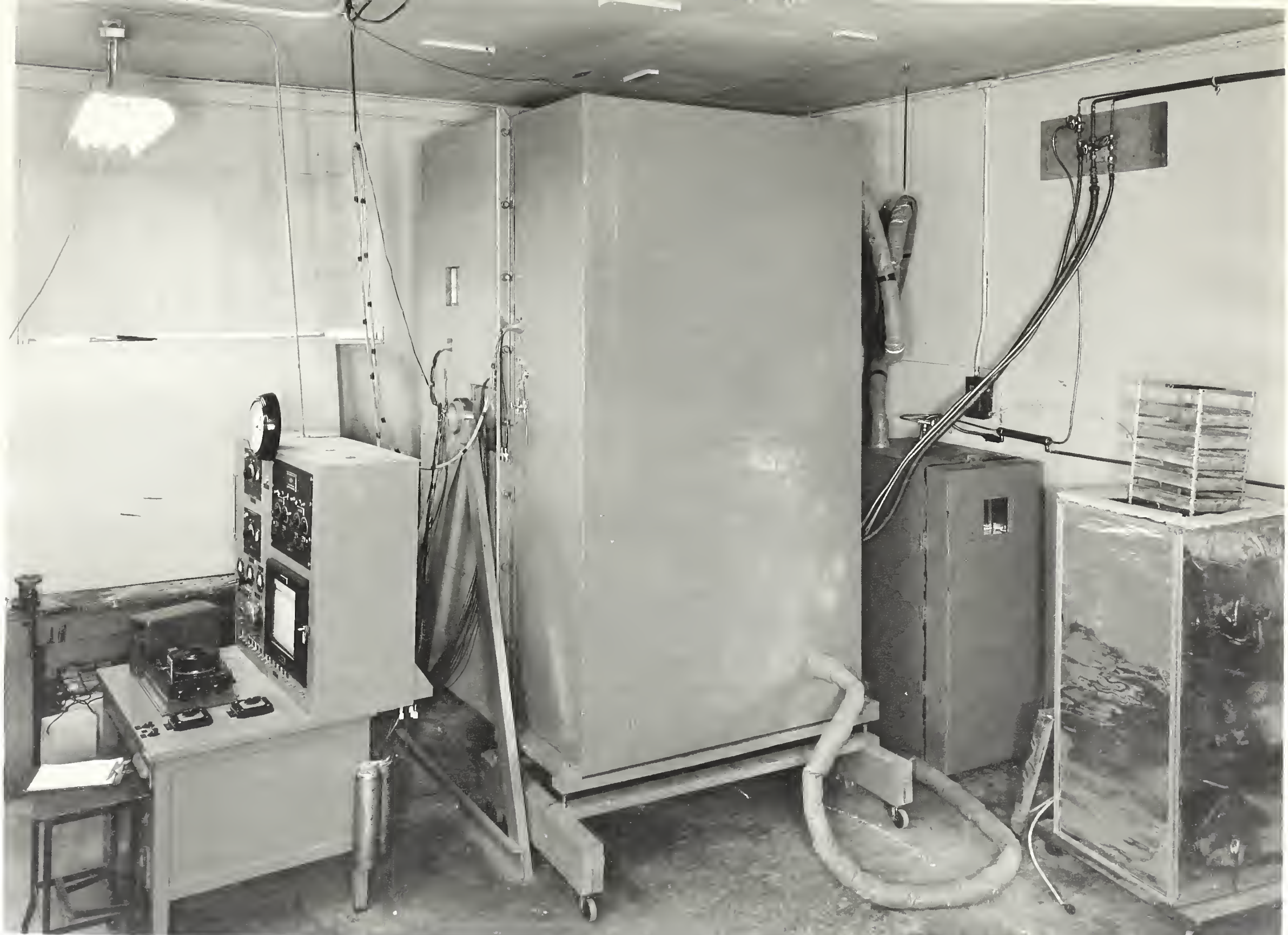

FIG. 2

FIG. 3

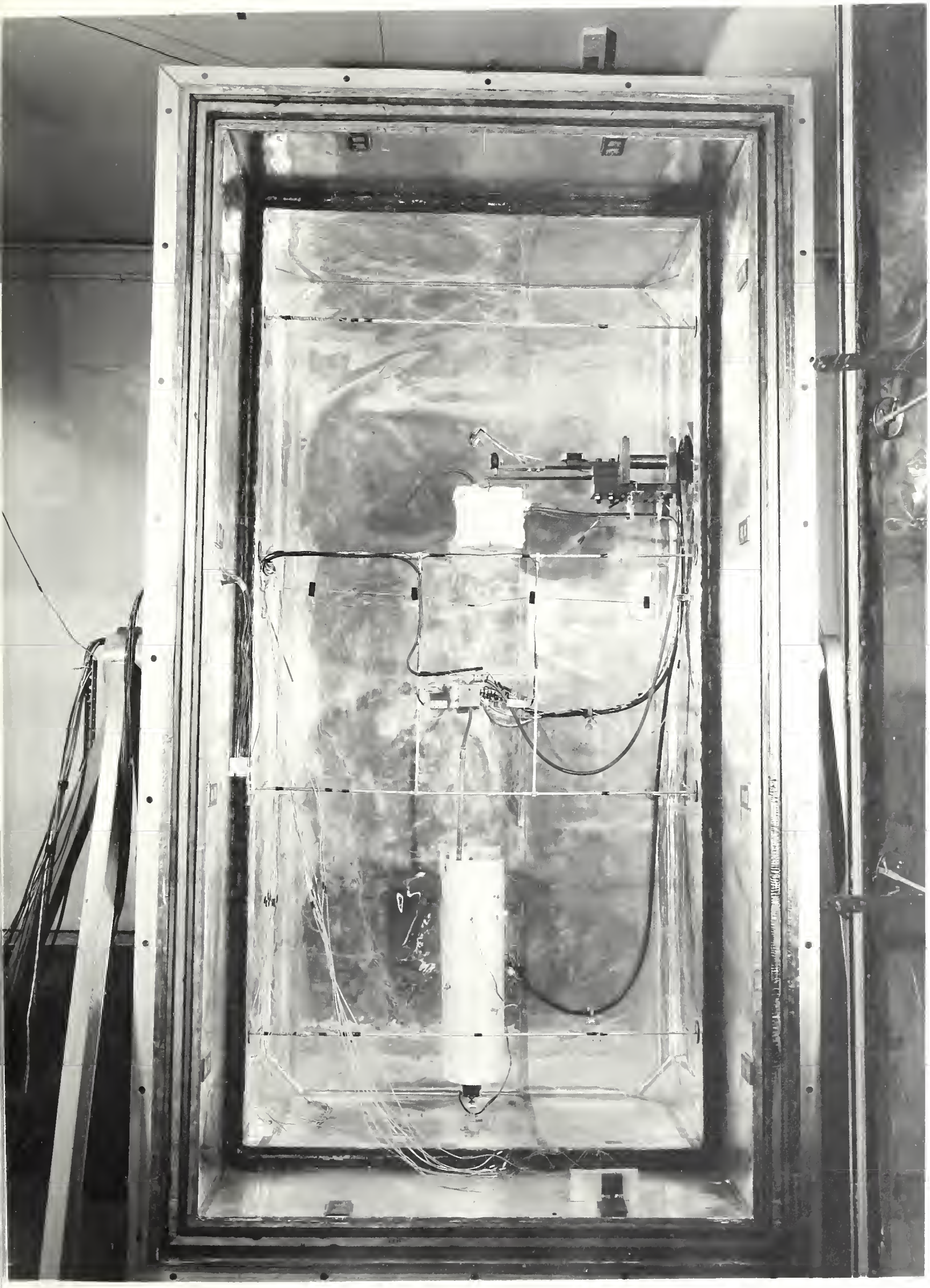

FIG. 4

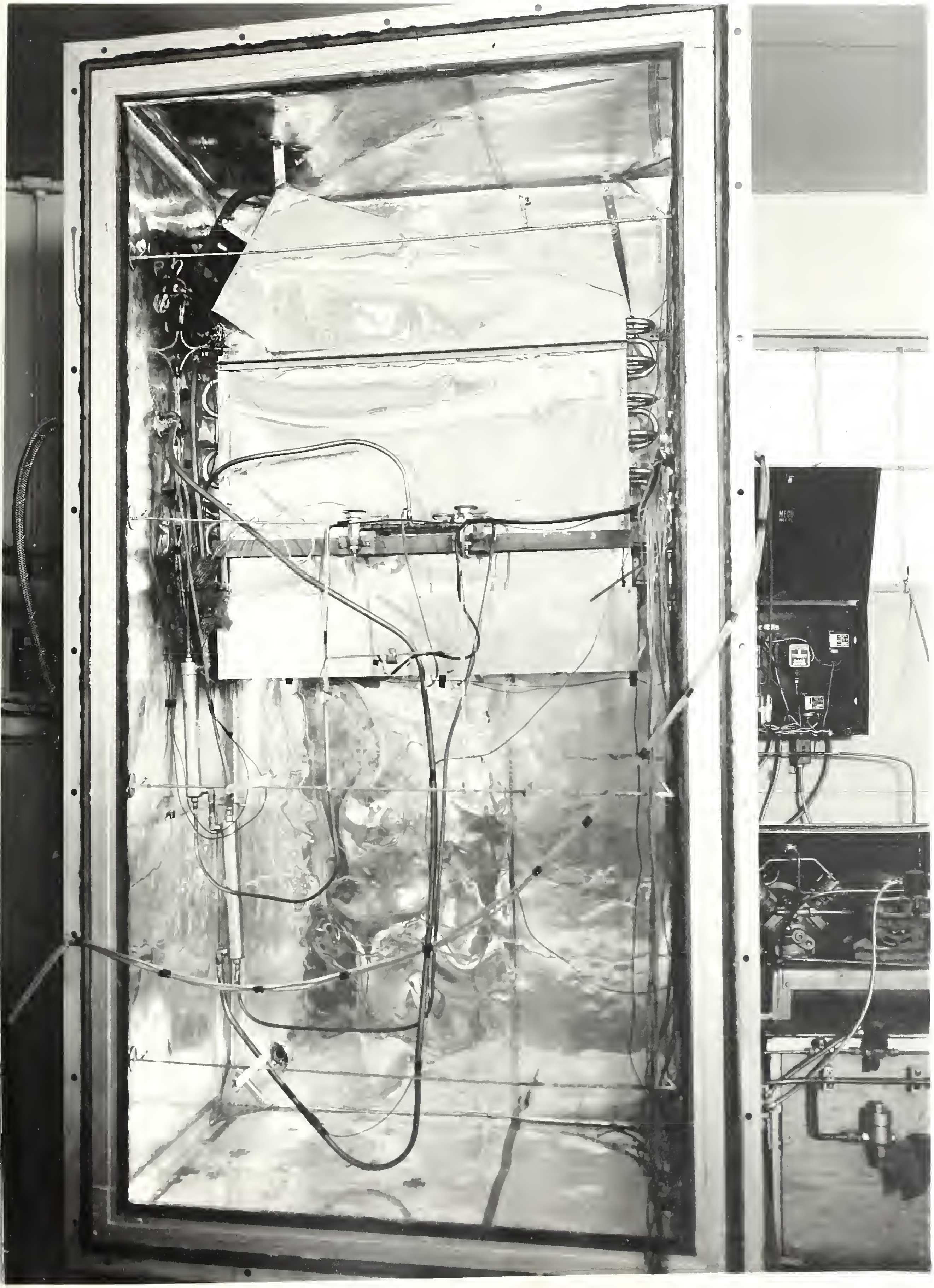

FIG. 5

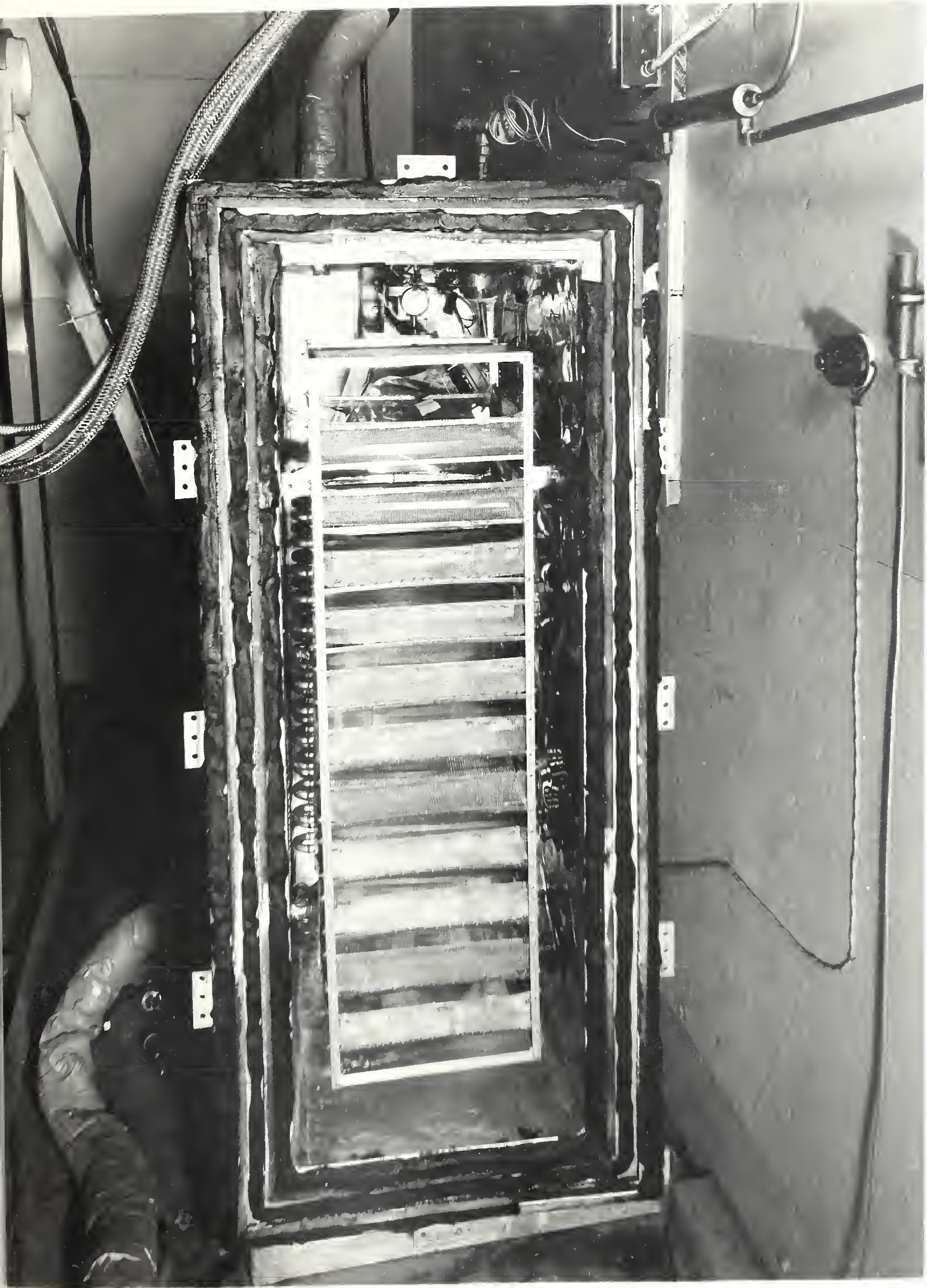

FIG. 6

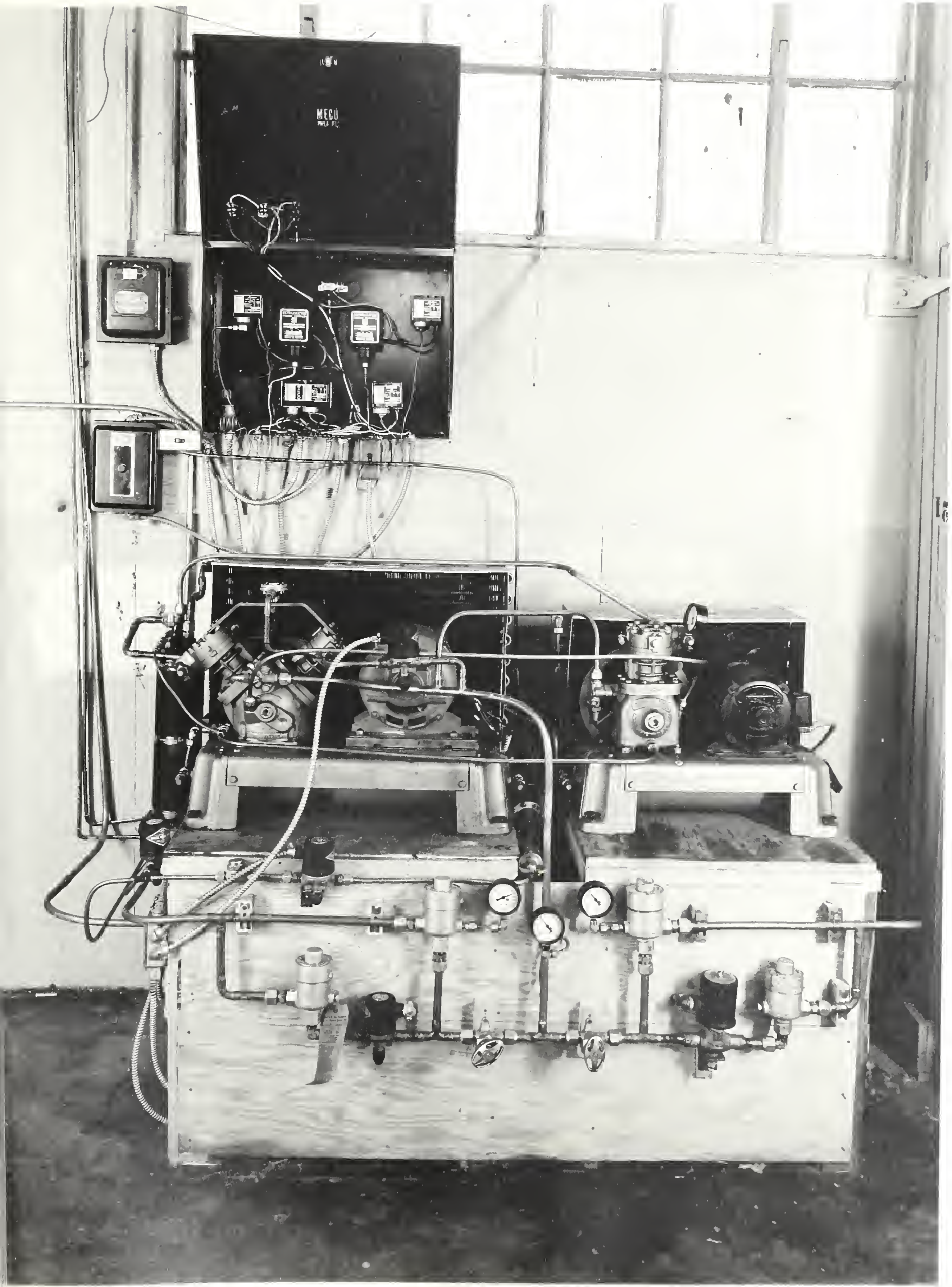

FIG. 7

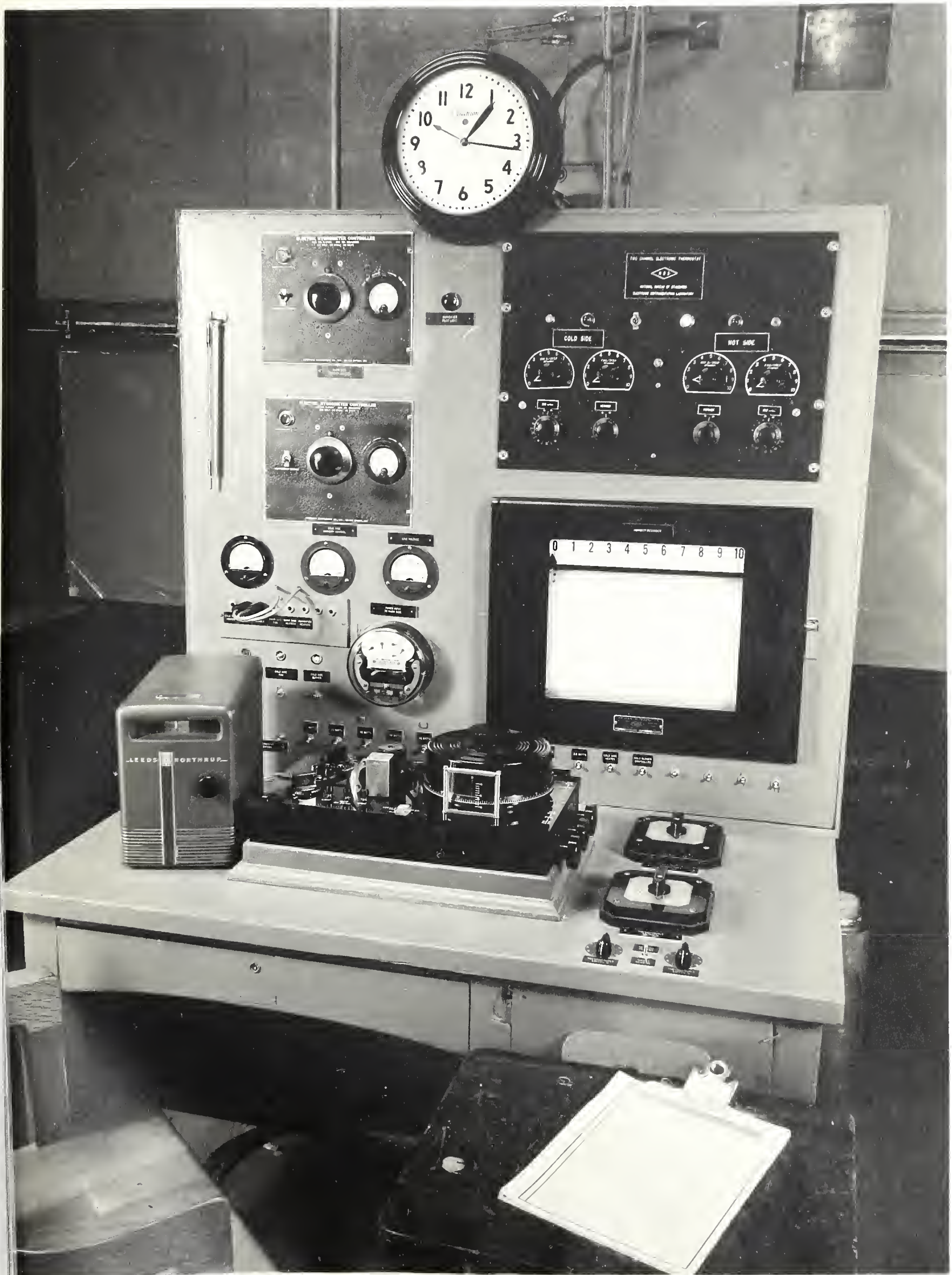

FIG. 8

FIG. 9

FIG. 10