SMALL DEMOUNTABLE-TYPE LUMBER DRY KILN FOR EXPERIMENTAL DRYING

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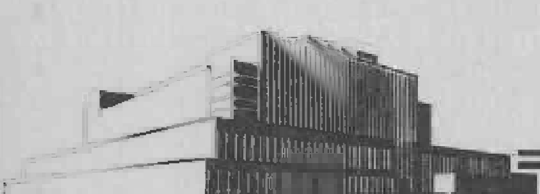

FOREST PRODUCTS LABORATORY
MADISON 5, WISCONSIN

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
In Cooperation with the University of Wisconsin

SMALL DEMOUNTABLE-TYPE LUMBER DRY KILN

FOR EXPERIMENTAL DRYING[1]

Forest Products Laboratory,[2] Forest Service
U. S. Department of Agriculture

As an aid in a study directed towards the development of new and improved kiln schedules, a small demountable type of lumber dry kiln was designed at the U. S. Forest Products Laboratory, principally for use in the field. To date, three such units have been constructed by Laboratory personnel. Each has automatic control equipment and a maximum capacity of about 1,000 board feet of 1-inch lumber. One is now located at a cooperating plant in Tennessee, another in Maine, and the third is being used to illustrate general design and operating principles in conducting courses in kiln drying.

The interest aroused by the operation of these kilns has led to many requests for plans and specifications as to their construction. This report has been prepared in response to these requests to illustrate and explain the important features of the kiln design and construction. It should be understood, however, that these features are not particularly new or novel and that similar units have been and still are available from some commercial dry-kiln companies and engineers.[3] The particular equipment and arrangements used are unimportant so long as they provide good control of temperature and relative humidity, and a brisk rate of air velocity through the load. The proper designing of a lumber dry kiln for a specific purpose is a real engineering problem and should be attempted only by qualified individuals. It is not the purpose of this publication, therefore, to attempt to give sufficient informational details for the construction of a kiln by persons inexperienced in this field.

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[1] The kiln described in this report was designed by O. W. Torgeson, former engineer at the Forest Products Laboratory. The original report, written by Mr. Torgeson, is dated April 1947.

[2] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[3] List of dry-kiln manufacturers and dry kiln engineers in the United States given in Report No. 1031, U. S. Forest Products Laboratory, Madison 5, Wis.

Structure

The structure consists of 13 prefabricated panels (fig. 1), whose overlapping edges are fastened together by means of screws. The frames are made from 1-1/2-inch-thick cypress and are covered on the inside by 1/4-inch asbestos-cement boards. These inside boards are fastened to the frame by flat-headed stove bolts instead of screws because screws often become loose due to charring of the wood caused by rapid heat conduction from metal to wood. The outside cover boards can be either the 1/4-inch asbestos-cement board or, preferably, 1/4-inch resin-bonded plywood, which is considerably lighter and less subject to fractures. If the kiln is located indoors, all outside cover boards can be omitted if desired. In that case, the insulation would have to be protected and held in place by some such means as strips or screening. An angle-iron frame would be more durable than wood. For a permanently located installation, consideration should be given to the use of hard-burned brick or tile walls, and also to the use of a thicker insulated wall to reduce heat losses.

To reduce weight, glass-wool insulation was used, but, except for the weight factor, rock-wool or other types of insulating material would be equally as good for this purpose.

The asbestos-cement boards on the drying-room side of the panels were cemented to the frame by applying a uniform ribbon of asphaltic mastic[4] to the frame before the boards were bolted on. An asphaltic coating was then applied to the entire face next to the frame before the insulation was laid in place to prevent the vapor from penetrating the insulation. No treatment of this kind was given the outside covering because that would only increase the difficulty for any moisture to escape that might penetrate the insulated space.

In erection, the panels were fastened together by screws on the outside only, which appeared to supply sufficient rigidity. After assembly, all inside joints were filled and sealed with the asphaltic mastic coating. As iron bolts were used to hold the asbestos-cement boards to the inside of the frame, their counter-sunk heads were coated to reduce corrosion. Except for the cost factor, brass bolts would be preferable.

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[4] A kiln coating obtainable from the following companies: Tropical Paint and Oil Co., Cleveland, Ohio; Black Cat Corp., Hattiesburg, Miss.; Ohmlac Paint and Refining Co., 6550 South Central Avenue, Chicago 38, Ill.; and Moore Dry Kiln Co., Jacksonville, Fla., or North Portland, Oreg.

The kiln, as used in the field, sets on a wood sill foundation with a sand fill for a floor. Cross members are provided to give support to a wooden-pile foundation frame. At the Laboratory a wood sill is placed on a concrete floor. In such case, a floor drain is desirable because a relatively cool floor will cause considerable condensation under certain operating conditions.

For outdoor use, a shelter and operating room was provided by attaching two additional side panels with corresponding roof panels and front panels, one of which contained a door in line with the door leading into the drying room. The panels were constructed with a 1/4-inch resin-bonded plywood outside covering, but with no insulation and no inside covering.

Steam Heating Coils and Spray Line

The general design and assembled arrangement of the kiln are shown in figure 2.

The heating coils consist of 30 runs of 1-inch pipe extending lengthwise of the kiln. They are divided into three units individually equipped with a hand valve on the outside of the kiln (fig. 3) because closest control of temperature and best distribution of heat are obtained when the amount of radiation in operation is not greatly in excess of that needed to maintain the desired temperature. The amount of radiation per 1,000 board feet of lumber is greatly in excess of that needed in commercial dry kilns, but in experimental drying it is desirable, occasionally, to use rather extreme conditions and to establish them as quickly as possible. One air-operated diaphragm motor and valve operate all open coils.

The steam-spray line consists of one run of 1/2-inch pipe perforated with 1/8-inch holes spaced about 1 foot apart. This is also operated by an air-operated diaphragm motor and valve.

A reducing valve is provided to regulate the steam pressure, but a secondary valve is often desirable to provide lower-pressure steam for the steam-spray line. Either a recording or an indicating steam pressure gage is used to check steam pressures (fig. 3).

Temperature Measuring and Controlling Equipment

A two-bulb recorder-controller instrument records both dry-bulb and wet-bulb temperatures on a circular chart (fig. 3) and, through an auxiliary air supply, controls the dry-bulb temperature. It can also control the wet-bulb temperature and, thus, the relative humidity, but a wood-element hygrostat[5] is preferred for experimental work. This hygrostat is connected through the auxiliary air-supply tube to the diaphragm motor and valve on the steam-spray line. The hygrostat on one of the kilns (the unit shown in figs. 3 and 4) is equipped with a second air-leakage port and air valve that connect with a diaphragm motor on the vent dampers. The relative positions of the two leakage ports can be adjusted so that the vent dampers will close before the steam sprays come on and open only after the sprays have been shut off. It is, however, entirely satisfactory to set the vent dampers by hand to give slightly excessive venting and then depend upon the automatically operated steam sprays to provide the humidification necessary.

A hygrometer, consisting of a wet-bulb and a dry-bulb thermometer (precision type), hangs directly inside of a window made from two clear-glass tile blocks. The wicks on the recorder-controller and thermometer bulbs hang into a trough in which the water is maintained at a constant level by means of an inverted water bottle mounted outside of the drying chamber (fig. 3). The hygrometer readings are helpful in checking the recorder and in obtaining more accurate and more instantaneous readings than can be obtained from the chart. In fact, the recorder-controller could be dispensed with if, instead, a single nonrecording thermostat were used to control the steam to the heating coils and the thermometers were used as a guide in obtaining the exact setting. The wood-element hygrostat could be used to control the steam to the steam-spray line. Automatic recorder controllers, however, give excellent control and also a very desirable continuous record of drying conditions.

All indicating and control elements are located on the inside of the kiln opposite the fans and motors where the recirculating air enters the lumber pile.

The use of air-operated valves requires an air supply at 15 to 20 pounds pressure. Where air is not already on hand, a small air compressor would be needed. A small air-reducing valve is used to maintain uniform pressure.

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[5] Described in Forest Products Laboratory Report No. 1602, A Wood-Element Hygrostat.

If desired, electrically operated control equipment can be used in place of the auxiliary air-control system. This would eliminate the need for an air supply.

Vents

A single 12-inch inlet vent (fig. 4) is located in the upper center of the side wall that supports the fan motors. A short Y-pipe extension is used on the inside in an attempt to obtain greater suction action from the fans.

Three 7-inch outlet vents (fig. 3) are located near the bottom of the wall on the opposite side.

All vent pipes are of copper and are supplied with lids that are set by hand or by a lever type of air-operated diaphragm motor. Air, at 15 to 20 pounds pressure, is supplied through the action of the wood-element hygrostat or the wet-bulb mechanism of the recorder-controller.

Fans

Air circulation through the lumber pile is provided by two motor-fan units of the extension-shaft type, the motors of which are located outside (fig. 4) the drying compartment and the fans sufficiently inside to provide an adequate space between them and the wall. The fans are of the propeller type and are 20 inches in diameter. Each fan is run by an individual 1/2-horsepower motor at 1,150 revolutions per minute and delivers about 5,000 cubic feet of air per minute at free delivery.

Direct-connected motor-fan units of the short-shaft type located entirely within the kiln are also satisfactory for kiln use provided special glass-wound motors are used as a protection against high temperatures and relative humidities. In small drying chambers, however, the heat from the motor will increase somewhat the minimum kiln temperature that might otherwise be maintained by mounting the motor on the outside. This, however, is of no importance in commercial drying and is only of occasional importance in experimental drying.

Another possible arrangement is to provide outside motors connected to the fan shafts by means of belts and sheaves. If desired, a single motor can be used for both fans. Multiple-disk fans can be used in place of the propeller type, but they are usually run at a lower speed, and, consequently, should be a little larger in size or more in number in order to provide the same air delivery.

Reversible circulation has not been provided because of the relatively short air travel through the load. It is, however, desirable in commercial-size kilns where, fairly commonly, the air passes through two 7- or 8-foot-wide loads.

The fans are set in a longitudinal baffle (fig. 2), which, together with a false ceiling below the fans and a baffle from that to the top of the load, prevents short circuiting and forces the air to pass through the load.

Costs

As some of the materials used came from miscellaneous supplies on hand at the Laboratory and as some of the work was done in conjunction with other Laboratory work, only approximate cost figures can be given. In fact, no particular attempt was made to keep accurate costs because these kiln units were merely equipment needed to conduct research studies in the drying of wood and were important only as to the work done with them.

The record kept indicated a total cost of about $1,500 for each unit, of which $1,000 was for material and equipment and $500 for labor, with some allowance for overhead. These costs do not include the cost of supplying air, steam, and electrical service connections to the kiln site. Other equipment and other types of construction would result in big differences in costs and, therefore, these figures should be used only as a guide in estimating the cost of similar drying units when built under different conditions.

The cost per thousand-board-foot capacity would decrease greatly with increase in size.

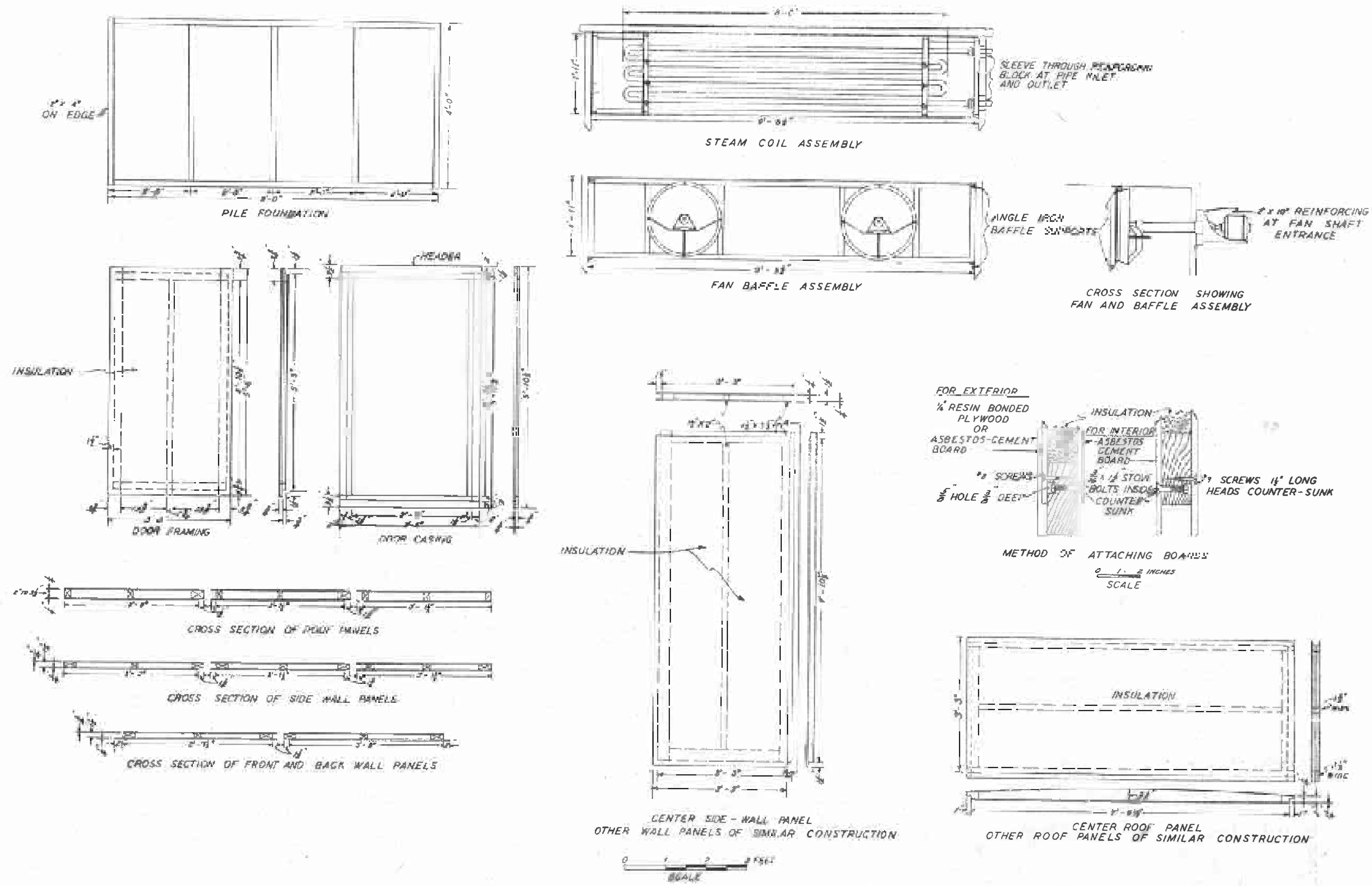

Figure 1.--Details of panel construction of small demountable-type kiln.

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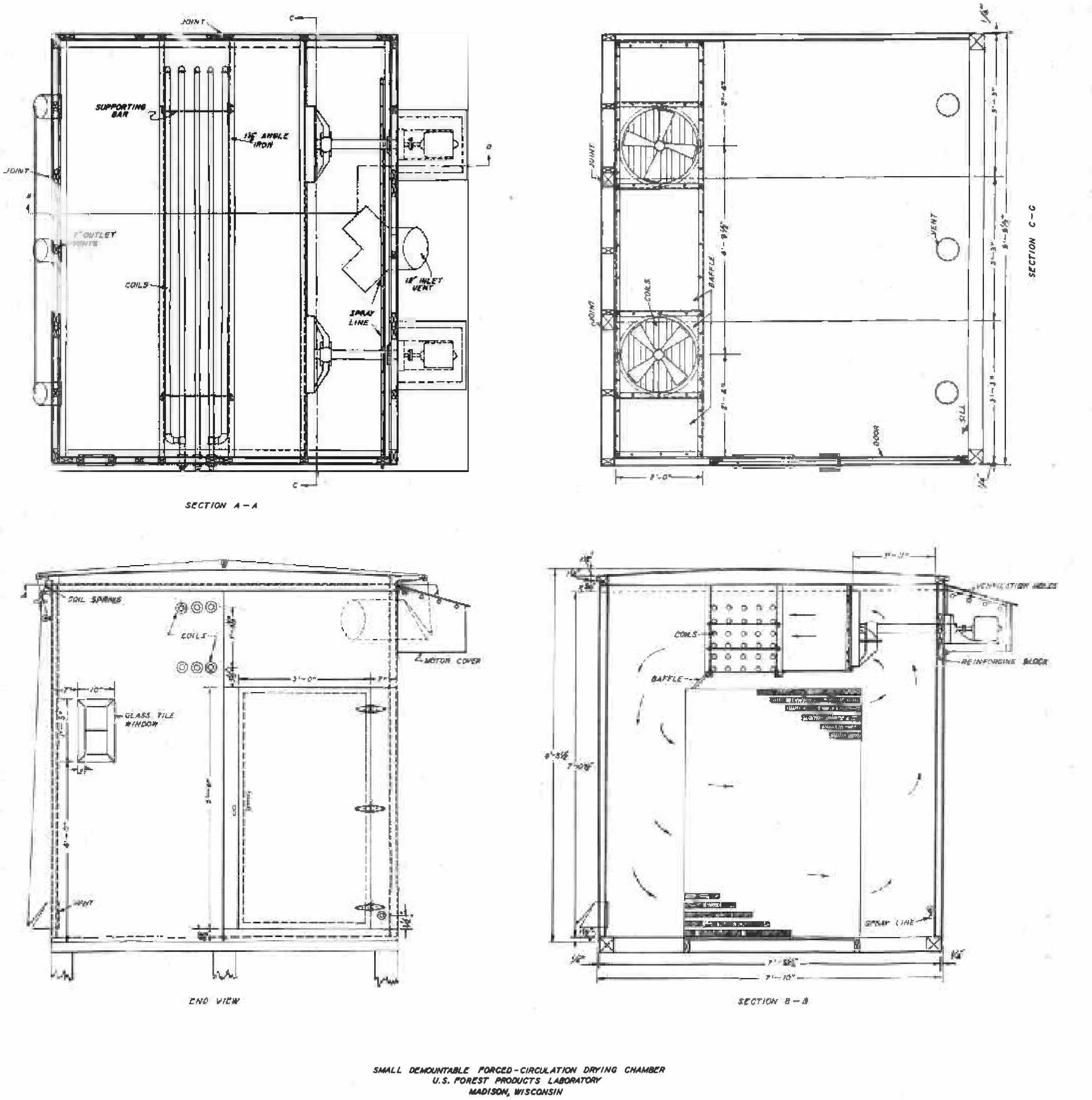

Figure 2.--General design and assembled arrangement of prefabricated panels of small demountable-type kiln.

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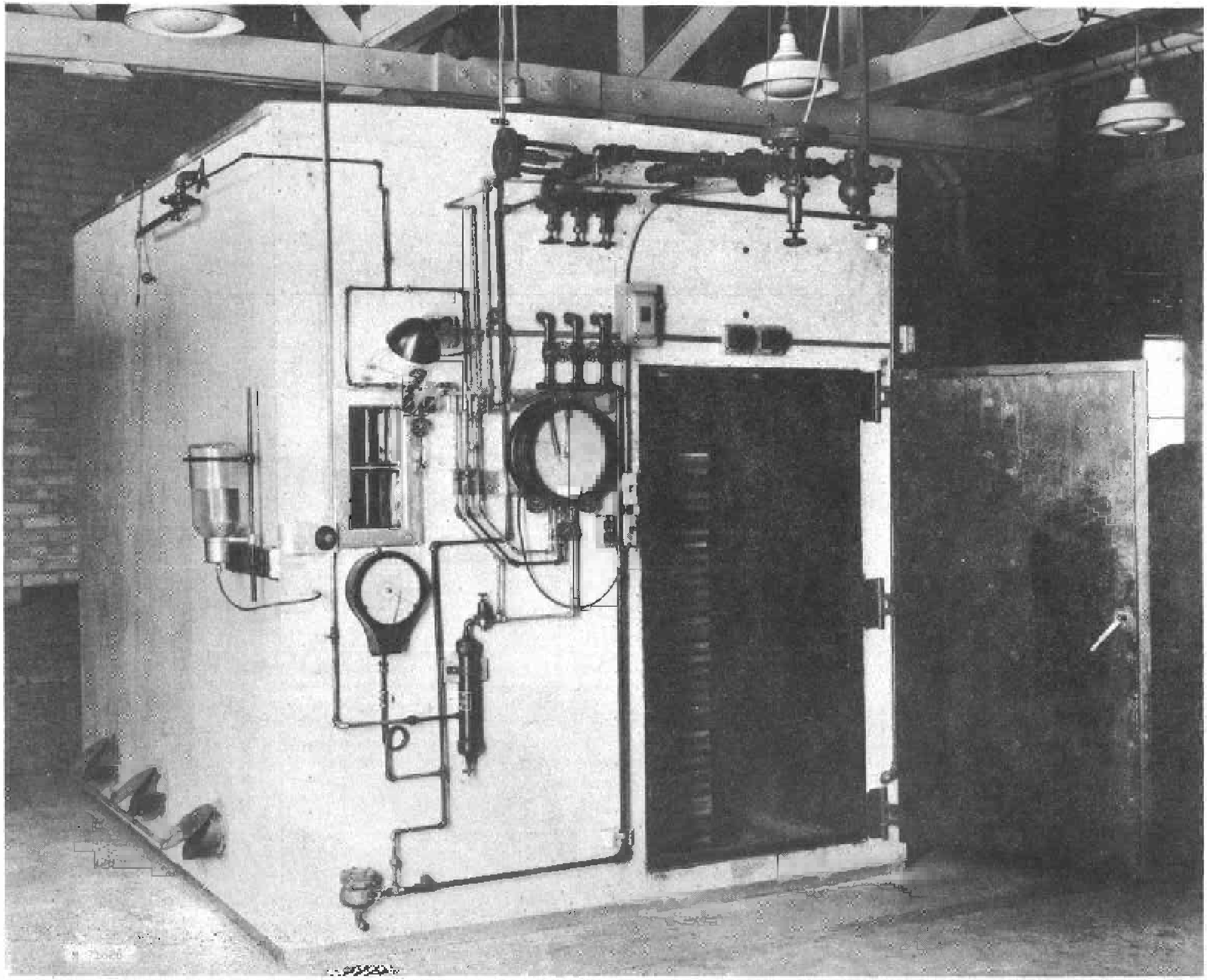

Figure 3.--Front view of small demountable-type kiln, showing service and control equipment, and outlet vents.

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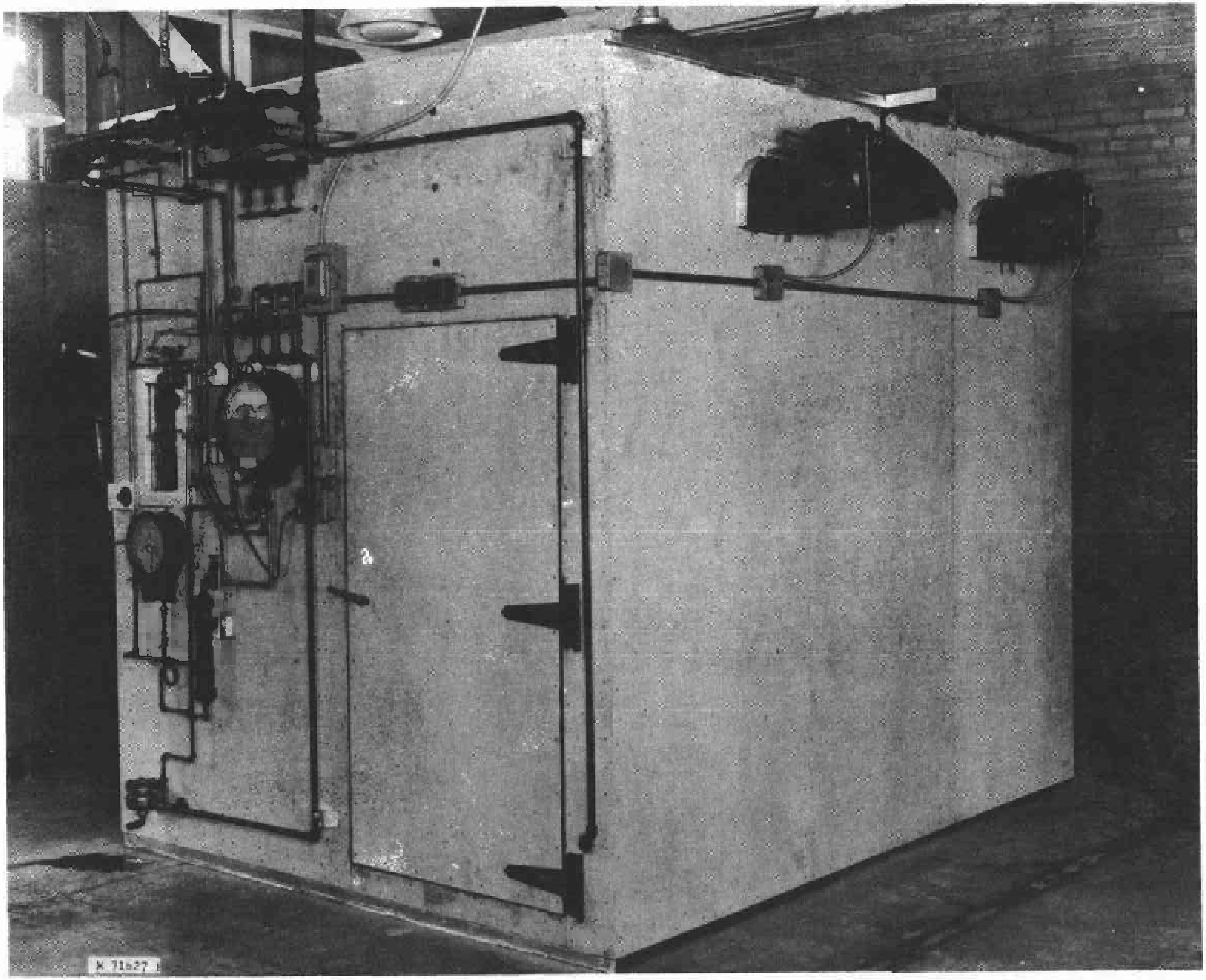

Figure 4.--Side view of small demountable-type kiln, showing fan motors and inlet vent.

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U.S. Forest Products Laboratory.
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6 p., illus. (F.P.L. rpt. no. 1671)

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