AUXILIARY KILN EQUIPMENT

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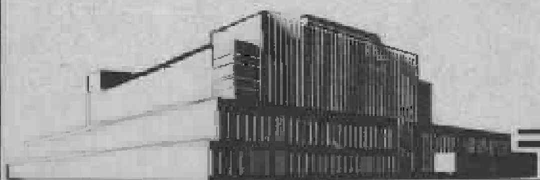

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UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
In Cooperation with the University of Wisconsin

AUXILIARY KILN EQUIPMENT[1]

Information on Equipment Used by the
Dry-Kiln Operator to Improve Drying Results

By

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

To operate a dry kiln in the most economical manner and to obtain good drying results requires the use of auxiliary equipment. Drying schedules based upon the moisture content of the stock being dried can not be successfully applied unless the moisture content is known. Therefore, equipment for determining moisture content should be available. For fast and uniform drying, drying conditions within the kiln should be as uniform as possible. These can be determined through the use of temperature- and air-measuring equipment.

Equipment for Determining Moisture Content

To determine the moisture content of wood, certain equipment must be available This equipment includes items such as balances, scales, drying ovens, saws, and electric moisture meters. The moisture content of some species of wood containing a high percentage of oil is more accurately determined with distillation equipment.

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[1]This chapter of a Dry-Kiln Operators' Manual was prepared by Edmund F. Rasmussen of the Division of Timber Physics, Forest Products Laboratory. The information and illustrations were obtained from various sources. The cooperation of the following companies is acknowledged: Central Scientific Co., Torsion Balance Co., Moore Dry Kiln Co., Howe Scale Co., Toledo Scale Co., Crescent Machine Co., Precision Scientific Co., Moisture Register Co., Delmhorst Instrument Co., Taylor Instrument Companies, Powers Regulator Co., Thwing-Albert Instrument Co., Brown Instrument Co., Keufel & Esser Co., Hastings Instrument Co., Illinois Testing Laboratories, Inc., and Northern Lumber Co.

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

Balances and Scales

There are many types of balances and scales that can be and are used for determining the moisture content of wood. Most of these, if properly used, will give fast and sufficiently accurate weights by which the moisture content can be determined.

Triple-beam balance.--One of the most commonly used types of balances is the triple-beam balance shown in figure 1. This balance has a central beam and poise with a 100-gram capacity, a rear beam of 10-gram capacity, and a front beam of 1-gram capacity. Auxiliary weights on the end of the central beam increase the weighing capacity of the balance. The maximum capacity of the balance shown is 1,111 grams. The weighing accuracy, when properly balanced, is within ± 0.01 gram. This balance is used for the weighing of small moisture sections.

Pan-type balance.--A pan-type balance, commonly called a torsion balance, also used to weigh small moisture sections, is shown in figure 2. This balance also has a weighing accuracy, when properly adjusted, of ± 0.01 gram. A set of auxiliary weights, as shown, increases the weighing capacity of this balance. This balance, because of the added manipulation of the loose weights, is slower to use than one of the triple-beam type.

Self-calculating balance.--To calculate moisture content it is necessary to know the original and ovendry weights of the wood specimens. The calculation involves dividing the loss in weight by the ovendry weight and is made either in longhand or by a slide rule or a calculating machine. To speed up these calculations or eliminate them entirely, self-calculating balances have been developed similar to the one shown in figure 3, A. Balances of this type are particularly useful where calculating machines are not available or the kiln operators are not accustomed to using slide rules. As shown in figure 3, B, the moisture readings can be estimated to about 0.5 percent when the values are less than 10 percent, and to about 1.0 percent when the values are more than 10 percent. The balance shown in figure 3 is operated as follows:

1. The balance is placed on a sturdy table, out of drafts and away from any vibration. The balance is leveled by using the leveling screws and bubble indicator. The revolving indicator on the moisture-content scale is set on zero, and the movable weights on the three beams are set at zero. The swing of the beam is adjusted to show a similar movement above and below the zero point on the swing indicator by moving the balancing nuts in or out.

2. The freshly cut wood specimen is placed on the pan with the revolving indicator set at zero. Then the beam is balanced with the movable weights on the right-hand beams. The positions of the three weights are marked on the specimen. The specimen is then ovendried.

3. After ovendrying, the specimen is placed on the pan with the movable weights in the positions corresponding to the first weighing.

4. The revolving indicator is then moved away from the zero position until the beam is balanced. The moisture-content value is read directly on the moisture-content scale.

Scales.--There are many types of scales suitable for the weighing of kiln samples. Scales of the platform type (fig. 4) are commonly used. For the weighing of kiln samples they should have a capacity of about 35 to 40 pounds. They should be calibrated to 0.01 pound rather than in ounces. This will simplify moisture-content calculations. When a considerable number of kiln samples are being weighed daily, an automatic indicating type of scale shown in figure 5 is very satisfactory. The scale may be used to determine weight either in pounds or in grams. The automatic scale is easily used, since the indicator reads directly to the nearest graduation and no manipulation of a sliding weight is necessary. It is, however, heavy and not easily moved about.

Moisture indicator or guide.--Another type of scale used to determine the daily or current moisture content of kiln samples is the moisture indicator or guide (fig. 6). Such indicators give satisfactory results if properly used. They are built with a movable weight on the long arm of the lever. This arm is graduated with a scale so that the sliding weight may be set in the same location at each weighing. The short arm of the lever has a plate attached below it that is graduated so that it can be read in terms of percentage of moisture content.

If moisture indicators for kiln samples are to be used with reasonable accuracy, certain procedures must be followed. The usual method requires that the long-arm scale setting shall be determined after the moisture-content value has been determined by drying the moisture-content sections from the ends of the sample. By this procedure, the loss in weight of the sample between the time the moisture-content sections are cut from the sample and the time the zero setting is determined is disregarded. This will result in errors in all subsequent moisture-content values determined by the use of the indicator. An improvement in the procedure, which consists essentially of a means of compensating for such moisture loss, may be accomplished by the following steps:

1. Immediately after the moisture-content specimens have been cut from the kiln sample and weighed, hang the kiln sample on the short arm, with the short-arm indicator on zero, and determine the setting on the long-arm scale that will bring the guide to balance. Mark this number on the kiln sample, which can then be placed in the kiln-truckload of lumber in the kiln.

2. Ovendry the moisture-content sections and calculate their moisture-content value.

3. Hang the kiln sample on the scale with the short-arm indicator set at zero and with the long-arm scale setting the same as determined in step 1. Then attach small metal weights, such as washers or lead slugs, to the kiln sample until balance is obtained.

4. Set the short-arm indicator to the value determined in step 2, and move the slide on the long-arm scale until balance is again obtained. This setting on the long-arm scale is the correct setting to use for all subsequent moisture

determinations with the moisture guide. Erase or cross out the previous recording of this number on the kiln sample and record the new and correct one. Remove washers from the sample as soon as the correct long-arm setting has been obtained. Rebalance by moving the short-arm indicator and read the moisture content on the scale before returning the kiln sample to the kiln. When the original moisture-content value of the green wood is greater than 50 percent, it is advisable to recheck the long-arm setting for the kiln sample by cutting new moisture-content sections from the sample. This should be done when the kiln sample indicates a moisture content of 40 percent or less. The original kiln sample cut from green lumber should be long enough and should be coated with a good end coating so that the second moisture analysis can be made without serious error.

Saws

Handsaws are not recommended for the cutting of moisture sections. Handsawing is slow and allows errors to develop through the loss or gain of moisture from the test sections before they can be weighed. Table saws, swing saws, and bandsaws are generally used in cutting moisture-content sections and preparing kiln samples. From the safety standpoint, however, table saws and swing saws should not be used for the slotting and slicing of the small moisture sections for making case-hardening tests. Portable power saws are often used to cut specimens in the yard or elsewhere, and these are subsequently prepared as kiln samples.

A bandsaw (fig. 7) of suitable size can be used for cutting moisture sections and kiln samples, and also for slotting and slicing the small sections for making moisture-distribution tests and case-hardening tests. Small bandsaws are extensively used by dry-kiln operators. They should always be kept in good working condition. For best results, sharp, properly set saws should be used at all times, and they should be provided with suitable safety guides.

Drying Ovens

Several kinds of drying ovens are used for the drying of moisture sections. Overloading an oven will extend the drying time considerably and delay the determination of moisture content. Therefore, all ovens should be large enough so that open spaces between the sections of wood being dried will be provided. The ovens should also be equipped with thermostats or other controls that will not permit the temperature to rise above the desired setting. Excessive temperature will char the sections and may also start fires. Temperatures within a drying oven should be maintained between 212° and 220° F. (100° to 105° C.). Ventilators on the top or sides and bottom should be kept open to allow the moisture being evaporated to escape.

Electrically heated ovens.--Most of the ovens commonly used in kiln-drying work are electrically heated (fig. 8). The contact points of the thermostat on all electrically heated ovens should be cleaned from time to time to prevent them from sticking. Most ovens of this type have a hole in the top through which a thermometer, used for setting the thermostat at the correct temperature, can be inserted. The thermostat setting should be checked at frequent intervals. Some of these ovens, in the higher price range, contain fans to circulate the air and speed up drying (fig. 9). Ovens of this type are recommended if a large number of moisture sections are being dried continuously.

Steam-heated ovens.--Steam-heated drying ovens are satisfactory if a suitable supply of steam is continuously available. Ovens of this type are usually home-made and may be equipped for either natural or forced air circulation. The heating coils can be made of pipe 1-1/4 inches or less in diameter. The temperature in the oven is usually regulated or controlled by means of a reducing valve on the steam feed line. Provisions should be made for inserting a thermometer through the top of the oven so that the reducing valve can be properly adjusted to maintain the desired temperature. Ventilators should be provided in larger ovens. Shelves for the moisture sections should be made of perforated metal or large heavy mesh wire.

Electric Moisture Meters

Electric moisture meters, if properly used, provide a rapid, convenient, and for most purposes, a sufficiently accurate means of determining the moisture content of wood. They are frequently used to segregate wet from dry boards preliminary to kiln-drying and to determine the final moisture content of kiln-dried stock. Their use, however, is not generally recommended for determining the current moisture content of kiln samples. Resistance-type meters are usually calibrated at temperatures between 70° and 80° F., and readings obtained on wood that is at a temperature above or below the calibration temperature must be corrected. Manufacturers of electrical moisture meters usually provide these temperature corrections in tabular form. They also provide correction values for species, as the resistance varies between species. Additional information on electric moisture meters will be found in another Laboratory report.[3]

Power-loss-type moisture meters.--A moisture meter of the power-loss type is shown in figure 10. The electrodes are the surface-contact type varying in design according to the material for which they are to be used. The instrument shown in figure 10 has eight spring-cushioned contact points equally spaced on the circumference of a circle. The range of these meters is from 0 to about 25 percent moisture content.

Resistance-type moisture meters.--The electrodes of resistance-type moisture meters consist of needles or contact pins that are driven into the wood to be tested; most generally two needles or contact pins, but sometimes one, inserted into a retaining bar serve for each contact. The retaining bars are about 1-1/4-inches apart. The standard contact length is about 5/16 inch. The range of most meters of this type is between 7 and 25 percent moisture content, although

[3] Dunlap, M. E., and Bell, E. R. Electrical Moisture Meters for Wood, Forest Products Laboratory Rept. No. 1660, Oct. 1951.

some instruments are calibrated to read above the fiber-saturation point. They are not, however, too accurate above this point. A meter of this type is shown in figure 11. Special electrodes have been developed to be used with resistance-type meters for measuring the moisture content of veneer and thick planks or poles. A two-pin electrode used to measure the moisture gradient in thick lumber timbers, and poles is shown in figure 12. It is provided with an electrode depth-indicating scale. To determine the average moisture content of thick planks having a normal drying gradient, the pins are driven to a depth that is about one-fifth, or 20 percent, of the thickness of the item. To get an estimate of the average moisture content of a pole, the electrodes are driven to about 15 percent of the pole diameter at the location of the test.

Distillation Equipment

Some woods contain a high percentage of volatile compounds or have been impregnated with volatile chemicals. These volatiles will be driven off in the oven-drying process, and an incorrect moisture-content value will result, as these volatiles are considered as being water. Therefore, the distillation method of determining moisture content should be used when woods containing considerable volatile materials are being tested. An apparatus suitable for this test is shown in figure 13.

The apparatus consists of an Erlenmeyer flask, a combination delivery tube and trap, and a water-cooled condenser, all tightly connected. An inflammable liquid, toluene, is generally used for making the extraction. The liquid condensed from the wood, usually in the form of very small chips that are weighed before the test, runs into the trap, and the water settles at the bottom. The trap is graduated in cubic centimeters, and, since a cubic centimeter of water weighs 1 gram, the total weight of water in the extracted wood can be determined. This weight being known, together with the original weight of the wood chips, the moisture content of the test sample can be calculated. The apparatus should be carefully cleaned and thoroughly dried after each test.

Equipment for Determining Temperatures

It frequently becomes necessary to check temperatures in a dry kiln in order to determine the causes for nonuniform drying and to determine the variation in temperature at the location of the control bulbs and other parts of the kiln. These temperature measurements are usually made on the entering-air side of the loads, although at times leaving-air temperatures are simultaneously obtained so that the temperature drop across the load can be determined. The equipment used for making these temperature tests are etched-stem glass thermometers, hygrometers, pressure-spring thermometers, resistance thermometers, and thermoelectric thermometers.

Etched-Stem Thermometers

Mercury-in-glass thermometers with the temperature scale etched on the glass stem are frequently used in well-operated lumber dry kilns. They should be calibrated to 1° F. and accurate to ± 1° F. These thermometers should be placed in the kiln at the locations to be checked, and a short time later should be read without moving them. Obviously, it is necessary for the kiln operator to go into the kiln to make these temperature readings. If the wet-bulb temperature is above 125° F., protective clothing and a face mask to provide cooled air should be worn. The temperature survey of the kiln can be quickly made if a number of thermometers are available and are placed at the different zones in the kiln where temperature checks are desired. The possibility of breaking these glass thermometers is reduced by placing them in metal sheaths that can be purchased with the thermometer. The sheath is suitable for making dry-bulb measurements, but if wet-bulb temperatures are also being measured, the sheath must be removed so that the wick can be applied directly over the mercury well or bulb of the thermometer. Sometimes dry-kiln operators make hygrometers out of etched-stem thermometers by mounting them on a metal plate, frame, or other suitable material. A water cistern is also attached, and the hygrometer is placed in the kiln where it is desired to check temperatures. Such a combination is shown in figure 14.

Maximum thermometers are often used for testing purposes when the kiln temperatures are excessively high. In kilns that have the heating coils located below the tracks and roof vents located directly over the plenum chamber between the kiln walls and the loads of lumber, thermometers can be lowered through the vents into the plenum chambers. Maximum thermometers should be used for this purpose, with the mercury being shaken down after each reading. By mounting two maximum thermometers on a frame and supplying one with wick from a water cistern (fig. 15), both the maximum wet- and dry-bulb readings can be determined. If the wick dries out before the hygrometer is removed from the kiln, both thermometers will read the maximum dry-bulb temperature that existed at the location tested for the period of placement.

Hygrometers

Hygrometers of the type shown in figure 16 are often found around dry kilns. These instruments are cheaper than etched-stem thermometers; but, though they serve a very useful purpose when they read correctly, there is always the possibility that the thermometer may slip up or down on the metal graduated base, in which case the temperature reading will be in error. These hygrometers are more suited to determine storage and plant conditions where some errors in readings can be tolerated. Their use in dry kilns to check temperatures and calibrate control instruments should be avoided.

Another useful thermometer for checking dry- and wet-bulb temperatures in dry-kiln storage areas and elsewhere around wood-working plants is the sling psychrometer. This instrument, shown in figure 17, is a dry- and wet-bulb hygrometer using etched-stem thermometers. One of the thermometers is provided with wick covering the mercury well. The instrument is provided with a means of whirling the thermometers. This is done to get adequate circulation, especially around the wet bulb. The readings are taken quickly after the whirling is stopped, the wet-bulb temperature first. The wick on the wet bulb is saturated with water before each reading is made with the instrument. Its use in dry kilns is limited to areas where adequate room is available to whirl the instrument.

Pressure-Spring Thermometers

These instruments are used to indicate or record kiln temperatures at a station outside of the kiln. An indicating pressure-spring thermometer is shown in figure 18. They are sometimes called dial thermometers. Pressure-spring thermometers ordinarily embody a tube system consisting of a bulb, a flexible capillary connecting tube, and a pressure spring that moves the pointer. Thermometers of this type used for dry-kiln work are usually of the vapor-pressure type, which means that the recorded temperature at the bulb is not seriously influenced by changes in temperature along the capillary tube or at the instrument case. Indicating thermometers of this type are primarily used in connection with manually operated dry kilns. The valves on the steam lines are manually adjusted so as to produce the desired temperature in the location of the indicating-thermometer bulb. The advantage of the recording thermometer over the indicating type is that a continuous record is made of the temperature conditions at the location of the temperature-sensitive bulb in the kiln. By combining two temperature-sensitive bulbs, one a wet bulb, and pressure springs in a single case, a recording dry- and wet-bulb thermometer is obtained. The record obtained from the daily variations in these temperatures is a definite aid in operating the kiln. Sometimes the recording pressure-spring thermometer is used to check dry-kiln controls or to record the temperatures in parts of the dry kiln or duct systems other than where the control-instrument temperature-sensitive bulbs are located. The indicating or recording pressure-spring thermometers can be purchased with capillary tubing of various lengths. The only precaution to be taken in using them is to check them for calibration occasionally when there is a considerable difference in elevation between the level of the bulbs and the instrument case.

Resistance Thermometers

The resistance thermometer is an electrical instrument that indicates or records the temperature response of a resistance bulb. The bulb is actually a resistance coil made of pure nickel or copper. As its temperature changes, the change in resistance of the coil is measured and indicated or recorded in terms of temperature. The advantage of this type of temperature-indicating or recording instrument, as compared with the pressure-spring thermometer, is that the bulb or resistance coil may be disconnected from the indicator or recorder. Therefore, a number of resistance coils or bulbs placed in widely separated locations may be successfully connected to one electrical measuring instrument that serves as the temperature indicator or recorder. By using resistance coils or bulbs that are resistant to corrosion, wet-bulb temperatures can be obtained by applying a wick over the bulb and providing a source of water to this wick. The bulbs are connected to the indicator or recorder with wires, usually of the compensating type, so that changes in temperature of the wires do not influence the instrument readings. The resistance thermometers are not generally used in dry kilns.

Thermoelectric Thermometers

If copper and copper-constantan wires are soldered together to make a closed circuit, and if one of the junctions is heated, an electromotive force is developed that depends only on the temperature difference between the two junctions. If one junction is maintained at a constant and known temperature, the temperature of the other junction can be determined by measuring the small voltage generated in the circuit. This voltage can be measured with a millivoltmeter or a potentiometer. The latter method is most generally used for lumber-dry-kiln work, as the millivoltmeter has certain disadvantages that are overcome when the potentiometer is used.

The thermoelectric thermometer used for measuring kiln temperatures consists of a thermocouple, lead wires, and the potentiometer. The thermocouple is usually made from copper and copper-constantan wires that are soldered or fused together to make the junction. Both of these wires act as lead wires back to the potentiometer. If a number of thermocouples are placed in the kiln, the wires are run back to a switch box that is connected to the potentiometer by two connecting wires, one copper and the other copper-constantan. In order to wire a kiln with thermocouples as rapidly and easily as possible, a thermocouple cable is suggested. A method of making a 50-foot cable with a pair of thermocouples spaced at 10-foot intervals is shown in figure 19, A and B. The wire size best suited for dry-kiln work seems to be about 20 gage. The ends of the wires leading from each thermocouple can be attached directly to the potentiometer, if desired, but faster readings can be taken when the ends are connected to a dial switch or jack box (fig. 20).

The potentiometer can be either portable or stationary. Portable types are only indicating. An instrument of this type is shown in figure 21. The cold junction is in the instrument and any change in the cold-junction temperature is compensated automatically so that the temperature calibration is always correct. Recording-controlling potentiometers are also used in dry-kiln work. These are permanently mounted on a panel board (fig. 22). Control of temperature can be switched to any thermocouple at any time by means of a control switch.

One of the advantages of the thermoelectric thermometer is that the thermocouples can be located almost anywhere in the dry kiln, either permanently or temporarily. The only precaution that needs to be considered is that the thermocouple be shielded from sources of direct radiation. Shielding also applies to other methods of temperature measurement. Figure 23 illustrates a method of shielding a thermocouple.

Equipment for Determining Air Movement

Much trouble in kiln-drying is caused by nonuniform air circulation in the kiln. Some of the causes for improper air circulation are poor stacking of the lumber, improper loading of the kiln charge, improper location or maintenance of load and fan baffles, defective fans or blowers, and improperly designed air ducts or plenum chambers. Sometimes the cause for improper air circulation can be found by a quick examination of the kiln and kiln charge. Usually, however, the cause cannot be found without first determining the rate and direction of air flow in all parts of the kiln. These can be found in some cases by smoke tests. In fast-circulation kilns, however, smoke tests are not reliable, and anemometers or velometers should be used.

Smoke

Tobacco, punk sticks, rope , or cloth may be used to provide smoke to test the general air movement within a dry kiln. These materials, however, produce only a small quantity of smoke and embody some fire hazard. Also, the smoke is hot, and the true direction of the circulation may not be known until the smoke has cooled to the temperature of the surrounding air.

A special form of a chemical smoke generator has been devised for use in the dry kiln (fig. 24). It consists essentially of two small bottles and few pieces of rubber tubing, one of which connects the two bottles. One bottle is filled with concentrated hydrochloric acid and another with strong ammonia water. When air is blown through the bottles, the fumes of the two chemicals mix and produce a dense smoke that will drift with the air current. Titanium tetrachloride also provides a good source of fireless smoke. Exposure of this chemical to air results in the formation of a smoke due to reaction of the chemical with the moisture in the air. Care should be used in handling any of the chemicals used to produce a fireless smoke to avoid injury to the skin and damage to clothing.

Anemometers

Anemometers are frequently used in dry kilns to determine the air velocity. There are several types of these instruments available. One type (fig. 25) consists essentially of a disk fan mounted on pivot bearings and provided with a revolution counter. The counter is usually in the form of a dial and pointer, with one revoltuion of the pointer representing an air movement of 100 feet. The rate at which the counter moves is timed with a watch. It is customary to let the fan run for a few minutes and then to divide the number of feet recorded by the number of minutes. The air-velocity measurement then is in terms of feet per minute. If the speed of the fan is not directly proportional to the air velocity over the entire range of the instrument, a correction factor is usually provided by the manufacturer. Errors may result if the fan is not set directly perpendicular to the direction of air flow, and the reading may be less than it should be.

Hot-wire air meters (fig. 26) are also used to determine air velocities. Such instruments depend upon the cooling of a hot wire by a stream of air. The wire is heated with electricity. A watch need not be used in conjunction with this instrument, since velocities are indicated directly on a scale calibrated in feet per minute. Readings are usually taken on the leaving-air side of the loads.

Velometers

Two types of velometers are used to determine air velocities. In one type the air enters the instrument through a shutter, in the other through a tube and jet or a port (fig. 27). In both types of velometers the air leaves through a port on the other side of the meter. A pointer and scale provide direct readings in feet per minute. Readings are usually taken on the leaving-air side of the loads.

Equipment for Stacking and Unstacking Lumber

The stacking and unstacking of lumber can be speeded up through the use of special equipment that can be purchased from manufacturers or that can be made at the plant. The larger the operation, the greater the need for such equipment.

Stackers and Unstackers

Mechanical stackers and unstackers are becoming more common, particularly at the larger producing and wood-using plants. This equipment employs conveyors, hydraulic lifts, or both. Some operate automatically, others are manually operated. Such equipment, properly designed, will speed up stacking and unstacking of the kiln loads of lumber. Furthermore, warping will be minimized by assuring proper support to the various layers of lumber through good sticker alinement.

Sticker Guides

Good alinement of stickers when stacking lumber for drying will restrain lumber from warping. Therefore, some type of sticker guide should be used if at all possible. Mechanical stackers, particularly those of the automatic type, are usually equipped with sticker guides. There are, however, many home-made guides that work very well, particularly when the kiln loads are being stacked by hand. Some of these are relatively low in cost.

A sticker guide may be composed of a frame or a bumper board that extends the full length of one or both sides of the truckload or package of lumber (figs. 28 and 29). Vertical slots or channels, slightly wider than the sticker being used, are located along the frame or the bumper board at the desired sticker spacing. The ends of the stickers are held in place by these slots or channels to assure vertical alinement as the load or package is built up layer by layer. The frame or the bumper board may extend to the full height of the load or package, or it may be only a foot or so high. In the latter case it is elevated from time to time as the load increases in height. Many plants use sticker guides on only one side of the load. For best results, however, they should be used on both sides if it is at all possible to do so. These guides or bumper boards will also eliminate ragged sides on the loads if the outside boards of each course are pushed out to the frame or bumper board. Ragged sides on loads of lumber may result in nonuniform air circulation through the loads in some types of dry kilns.

Sticker Racks

Careless handling of stickers at many plants results in heavy losses through breakage. Furthermore, stickers laying across rails and on the ground may cause derailment of truckloads of lumber or injury to workmen. Stickers should be carefully handled and stored in sticker racks conveniently located in the stacking and unstacking areas. Many operations have the sticker racks attached to the stacking equipment. Sticker racks can be built on kiln trucks and shuttled between the stacking and unstacking stores. At some plants sticker racks are built on skids and are transported from one place to another with fork-lift trucks.

Portable Power Saws

Occasionally, boards longer than the load of lumber being stacked are encountered. If these are stacked, the overhanging ends will result in large voids between the ends of the loads when placed in the kiln, which allow the air to short-circuit. Instead of having these long boards thrown out by the stackers, it is better to trim off one end. This can be done with a portable power saw. Frequently, these saws are hung directly on the stacking equipment where they are easily accessible. The ends trimmed off should be picked up and thrown into small bins as soon as possible to eliminate an accident hazard.

Kiln Trucks

Kiln trucks are used in most plants to facilitate the loading of lumber into and out of the dry kiln. They can be obtained in many sizes. Frequently, however, to reduce equipment costs, too few kiln trucks are used under the loads of lumber. This may result in an overload on the kiln trucks used, thereby reducing their life. Furthermore, too great a span between the trucks may permit the unsupported lumber to sag and become permanently deformed. Enough kiln trucks should be used under the loads of lumber to insure maximum truck life and also straight lumber.

Fork-Lift and Straddle Trucks

Fork-lift and straddle trucks are now being used at many plants to facilitate the handling of lumber in unit packages to and from the stacking and unstacking areas when loading and unloading kiln trucks, and when loading and unloading trackless kilns. Frequently, careless handling of this equipment, rough yard surfaces, or both will result in excessive jarring or shaking that dislodges stickers and also boards from the units being moved. When this occurs in moving the stickered packages from the yard or mill to the kiln trucks or into the kilns, warping and nonuniform drying may result. To obtain maximum benefit from this type of equipment, surfaces over which they travel should be smooth and durable. Furthermore, they should be operated at speeds that will hold the jarring and shaking of the units being moved to a minimum.

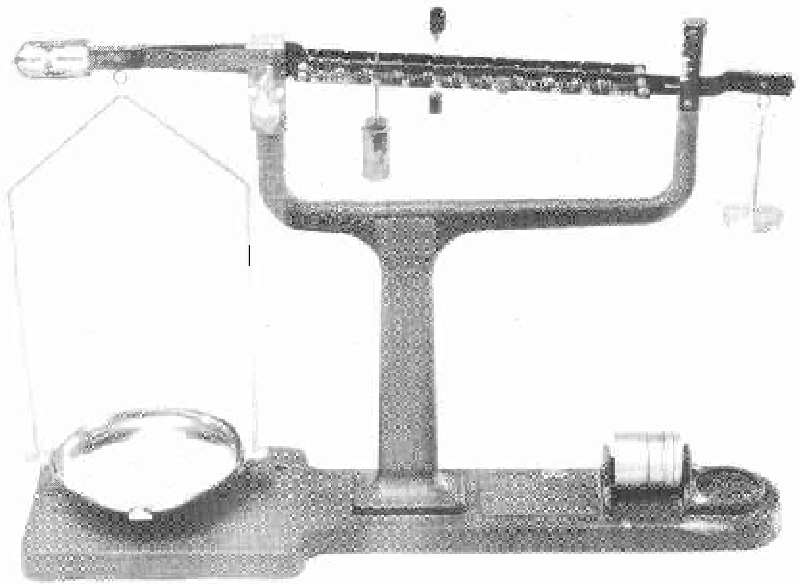

Figure 1.--Triple-beam balance with auxilliary weights.

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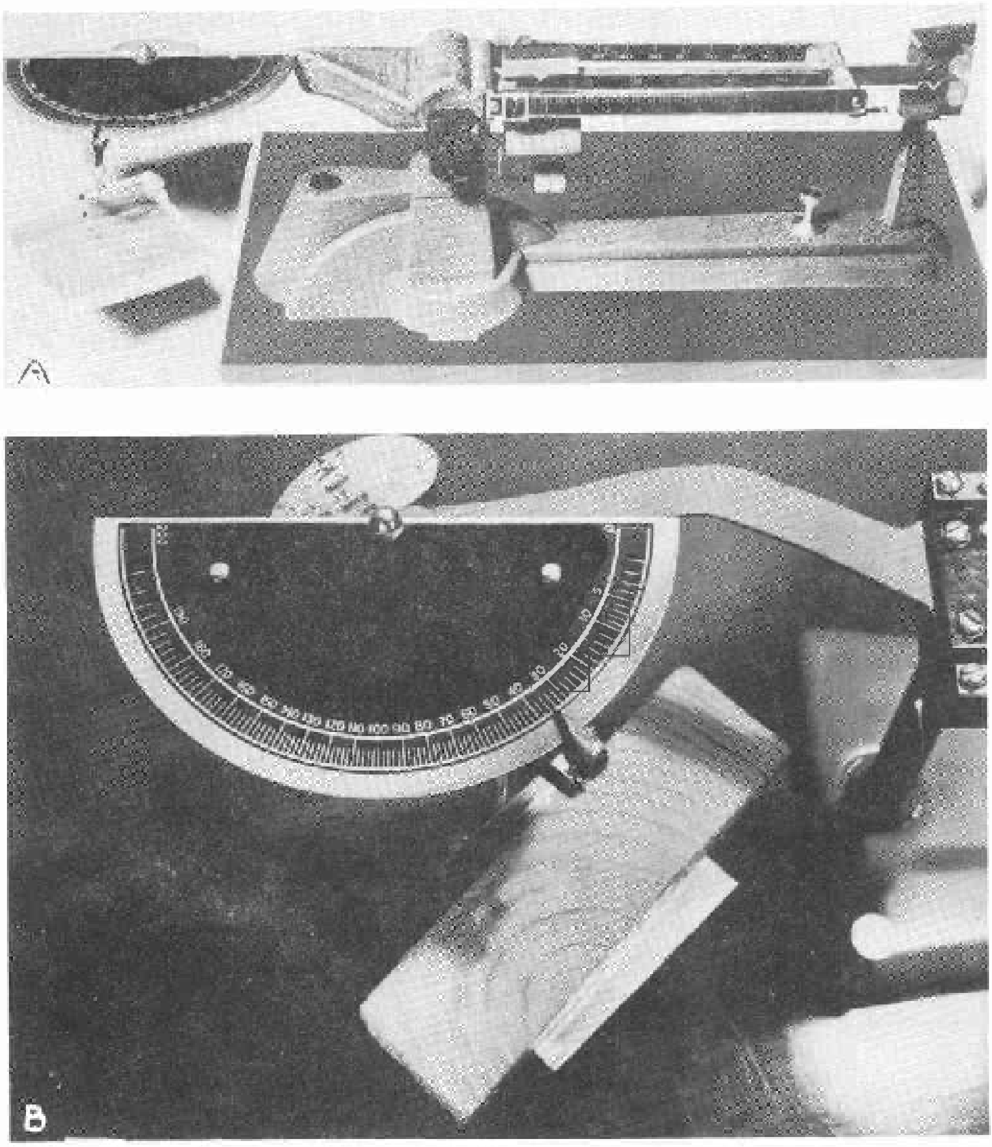

Figure 3.--Self-calculating moisture-content balance. A, Triple-beam balance with special scale on specimen pan used to calculate moisture content after oven-drying; B, specimen pan is carried on revolving indicator that, when properly used, reads moisture content directly on scale.

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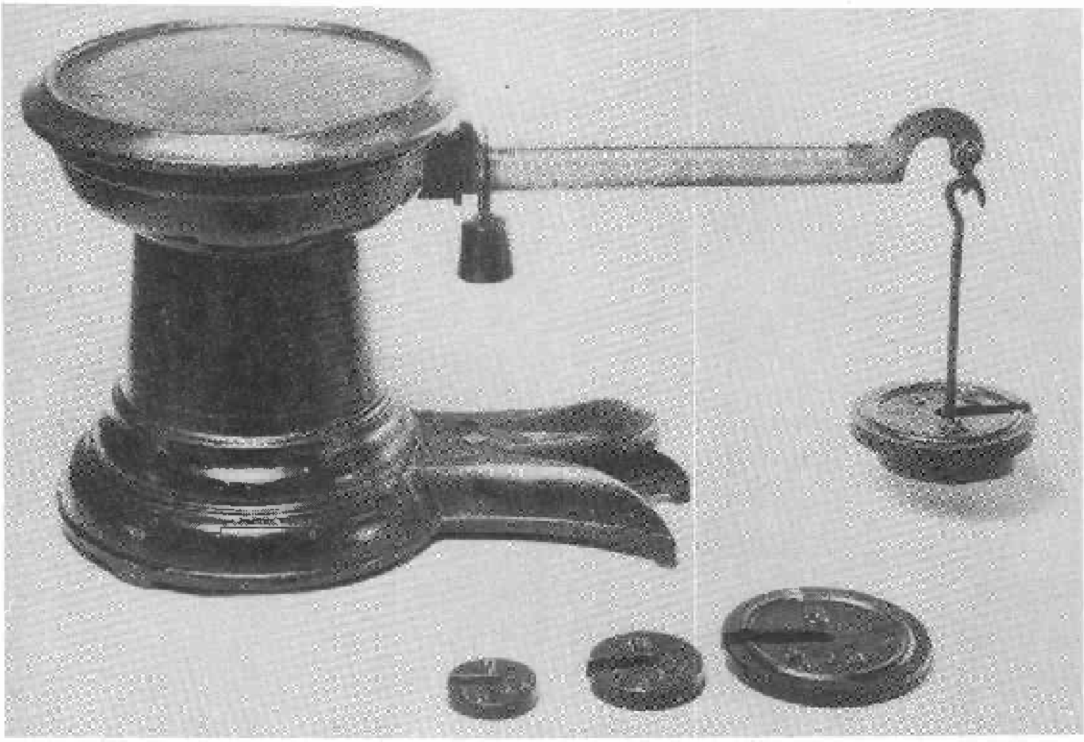

Figure 4.--Platform scale with capacity of 36 pounds and accuracy of 0.01 pound.
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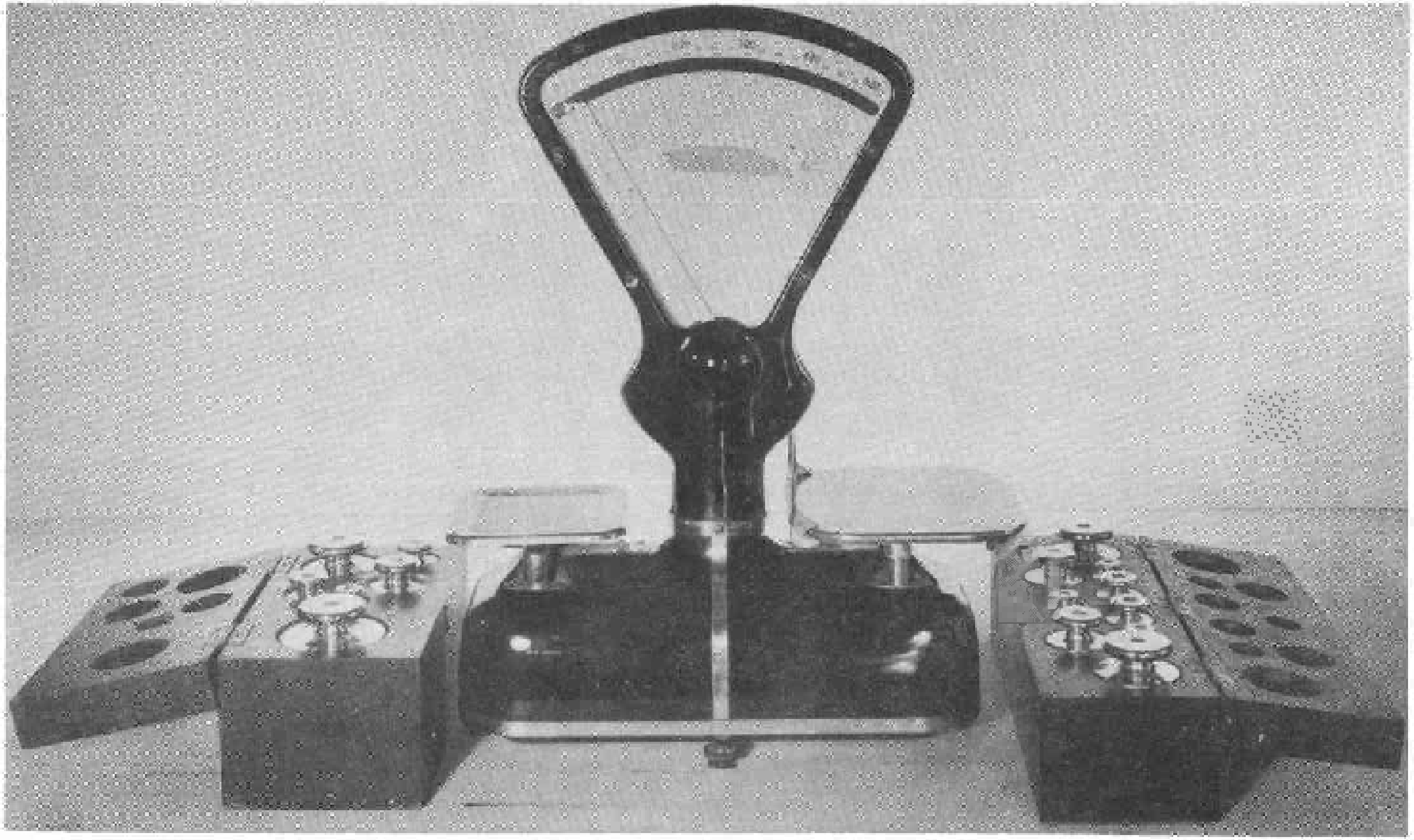


Z M 60557 F

Figure 5.--Automatic indicating scale.

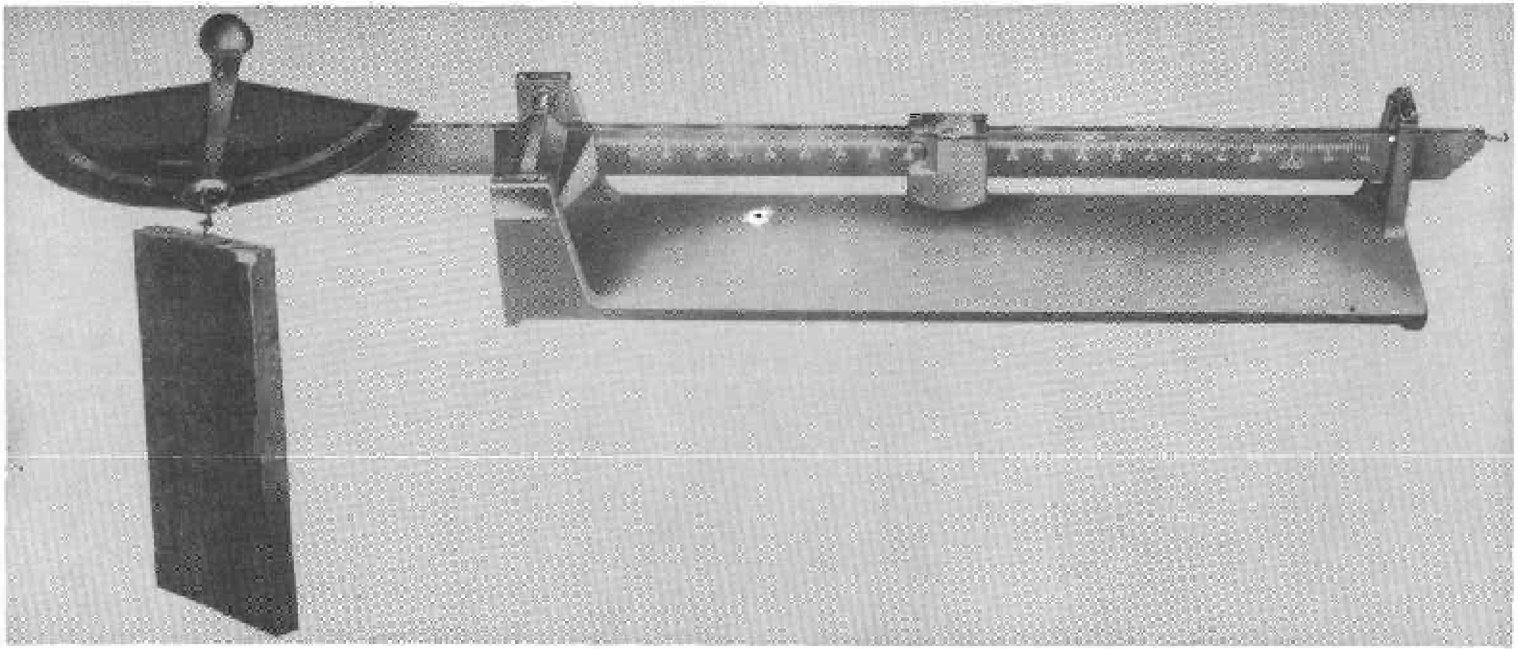


Figure 6.--Moisture indicator or guide for determining moisture content of kiln samples.

Z M 89780 F

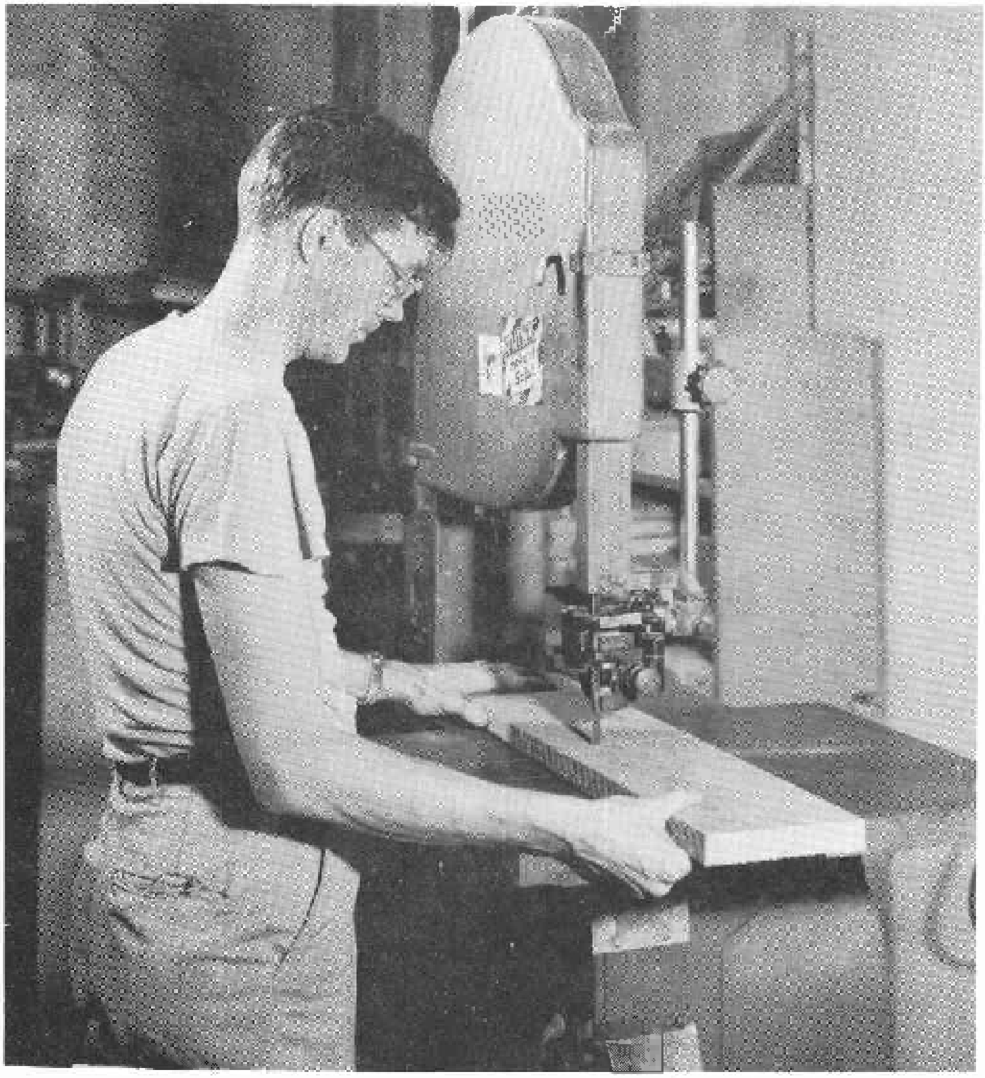


Figure 7.--Band saw being used to prepare kiln sample. A saw of this type is best suited for cutting case-hardening test specimens.

Z M 90101 F

Figure 8.--Natural-circulation electric oven for drying moisture sections.

Z M 8911 F

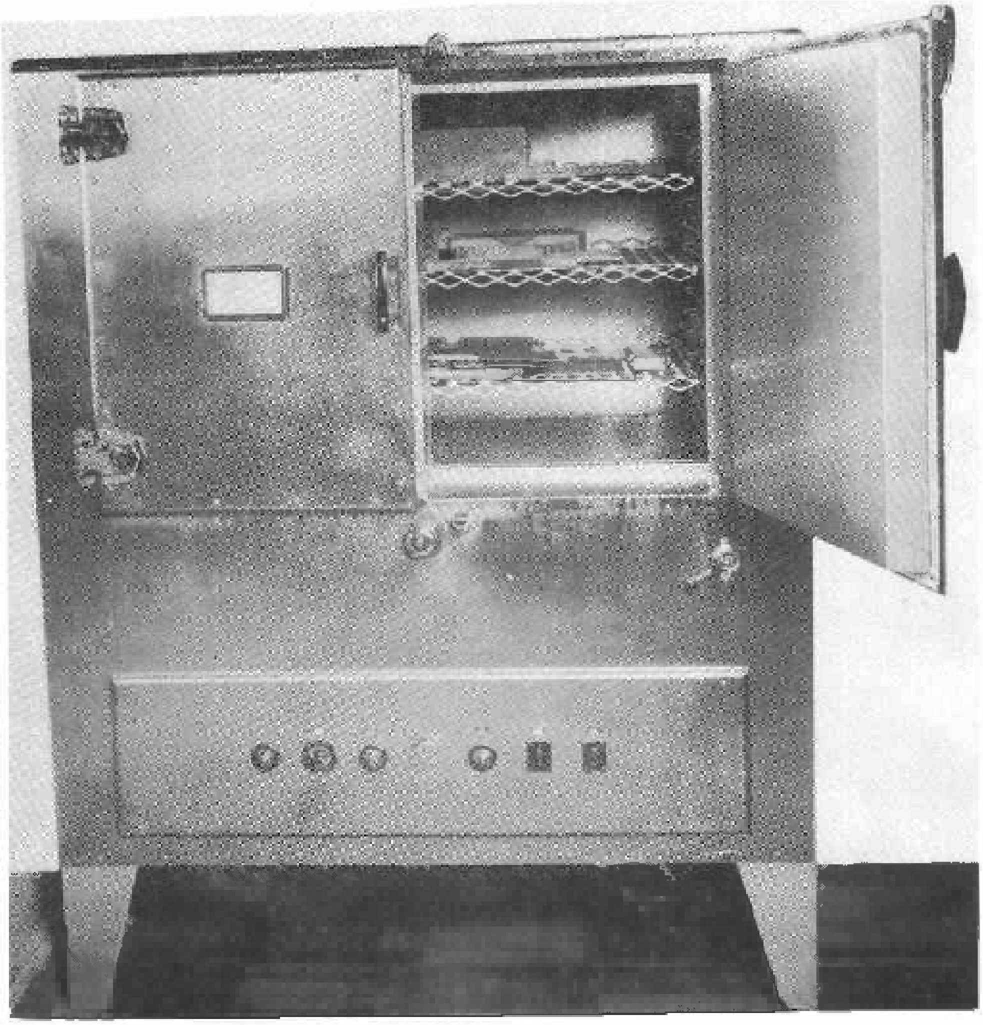


Figure 9.--Forced-air-circulation electric drying oven for drying large quantities of moisture sections.

Z M 90189 F

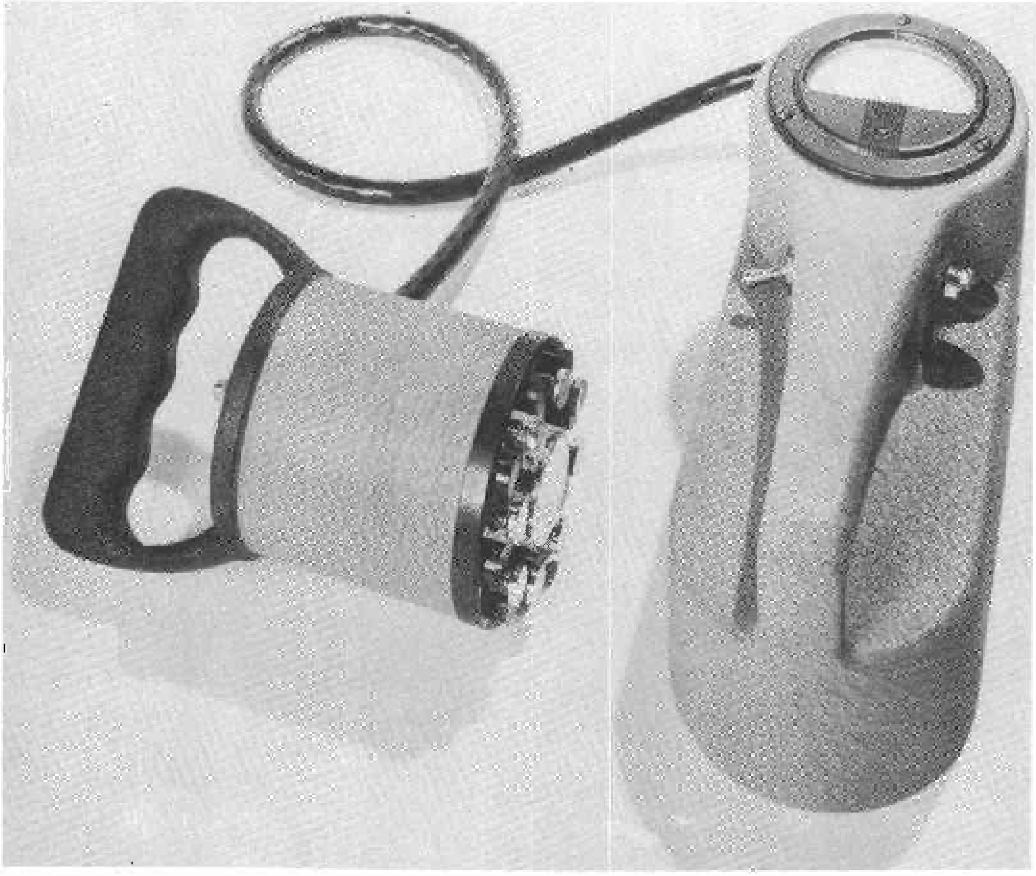
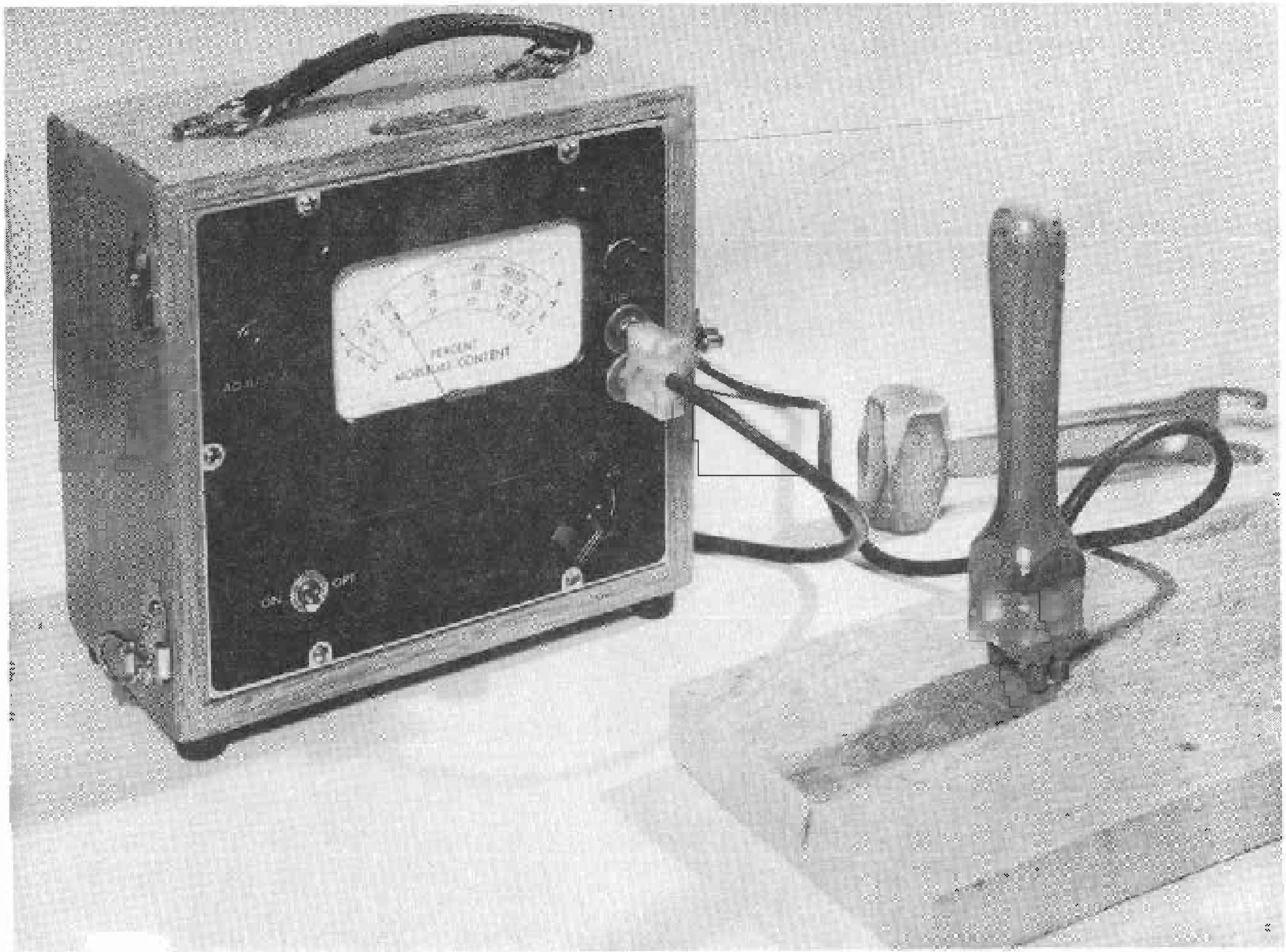


Figure 10.--Capacity or radio-frequency power-loss-type moisture meter.

Z M 86262 F



Z M 86376 F

Figure 11.--Resistance-type moisture meter.

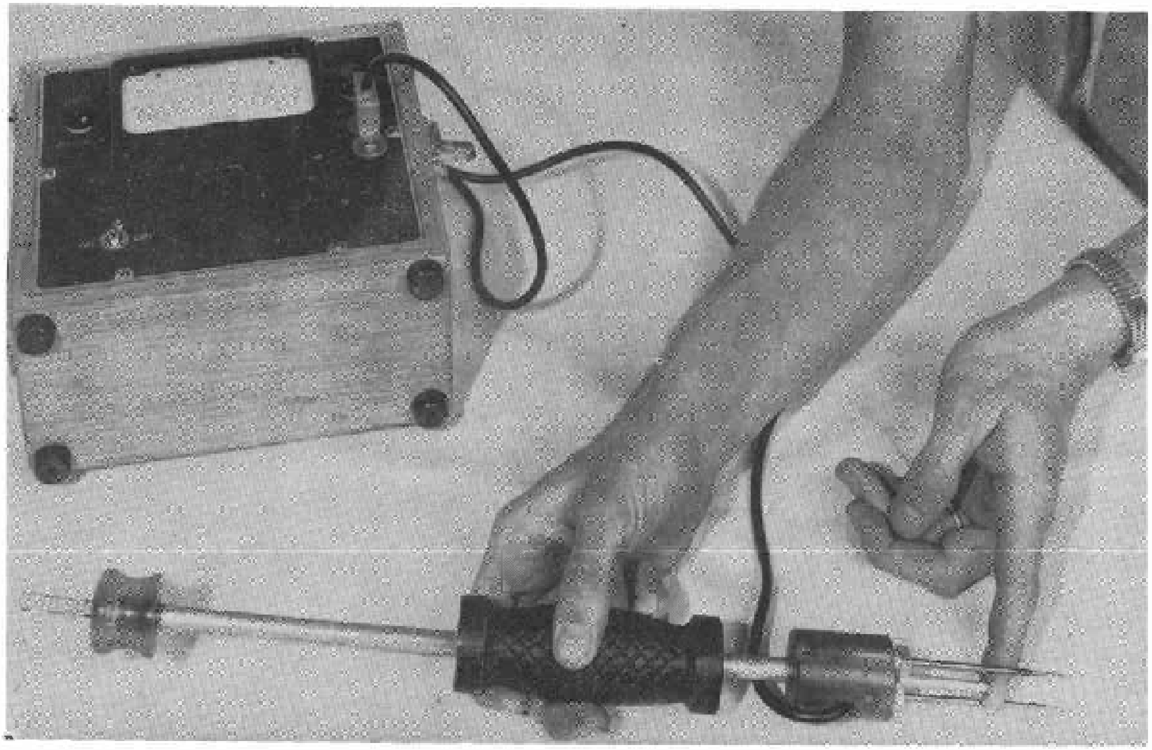


Figure 12.--Special electrode connected to a resistance meter, which is used for moisture tests on thick lumber, planks, timbers, and poles.

Z M 90105 F

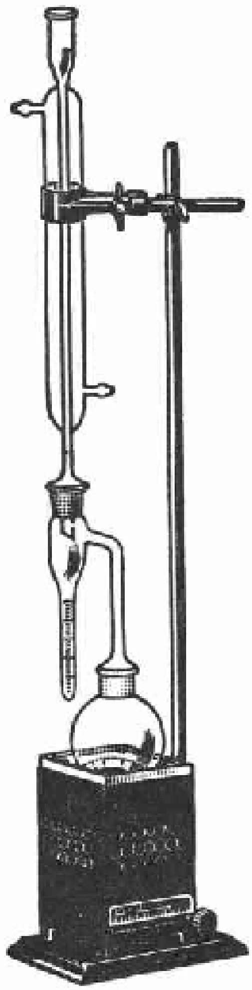


Figure 13.--Apparatus for determining moisture content by the distillation method.

Z M 68005 F

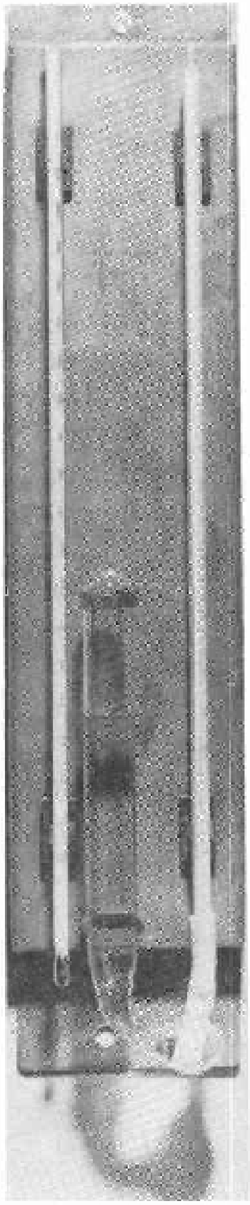


Figure 14.--Wet- and dry-bulb hygrometer made from two etched-stem glass thermometers.

Z M 86250 F

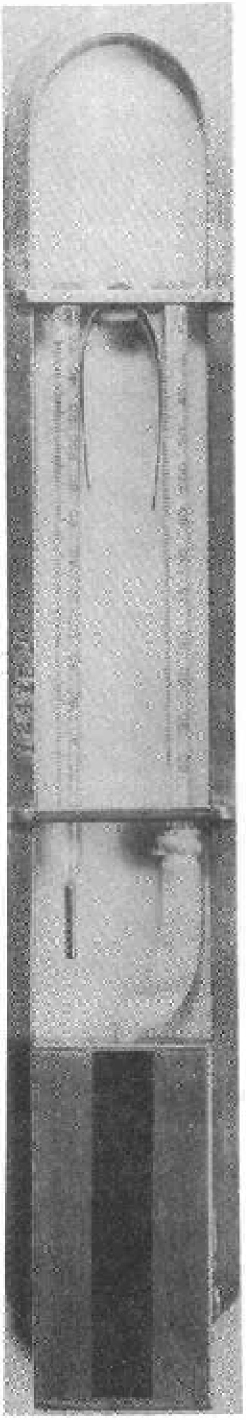


Figure 15.--Wet- and dry-bulb hygrometer with maximum thermometer.

Z M 90338 F

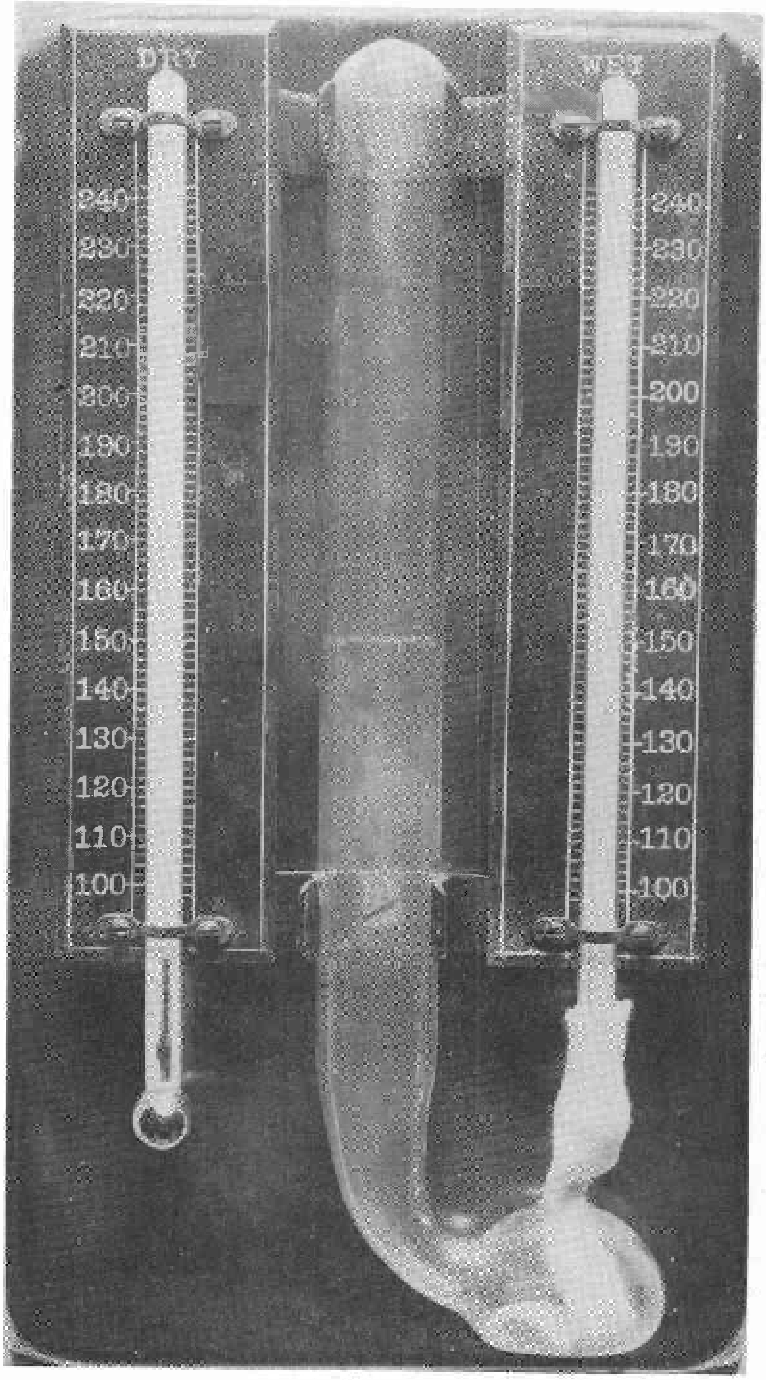


Figure 16.--Wet- and dry-bulb hygrometer with thermometer calibration on metal.

Z M 90340 F

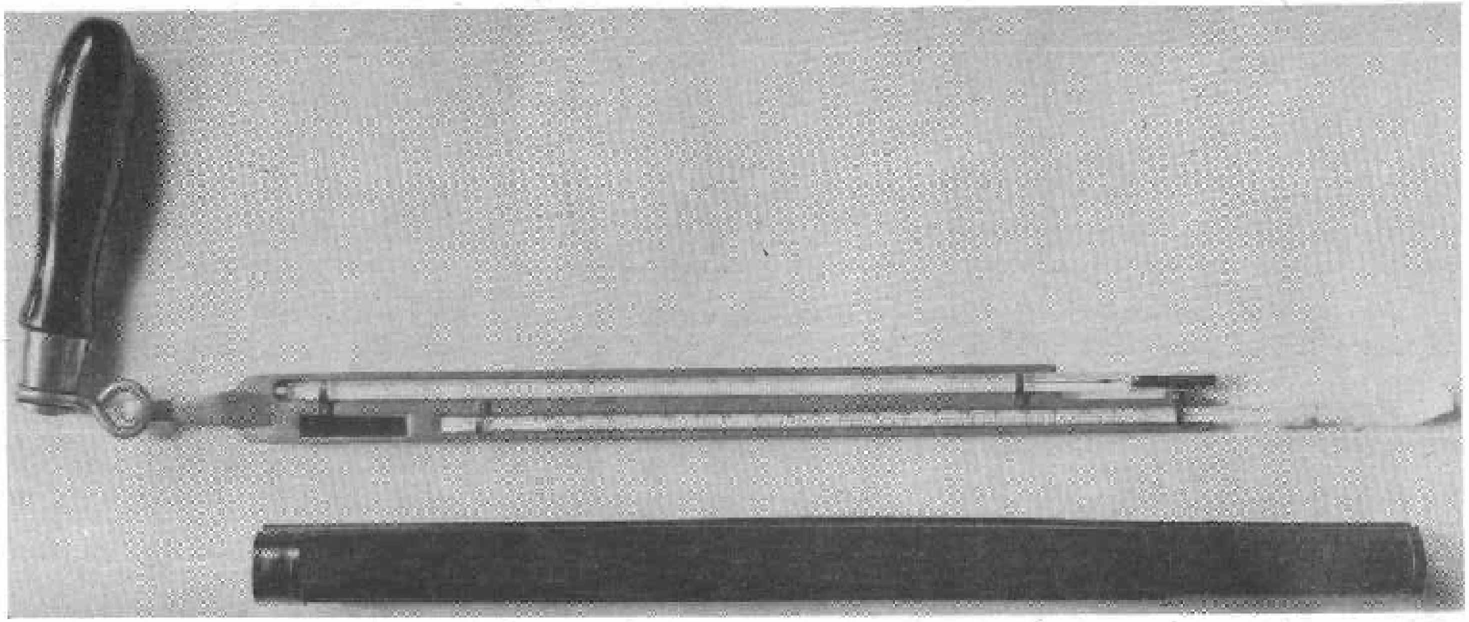


Figure 17.--Sling pshychrometer. The air circulation needed to cause evaporation from the wet wick of the sling psychrometer is obtained by whirling the instrument around the handle. The metal sleeve protects the thermometer when the instrument is not in use.

Z M 90336 F

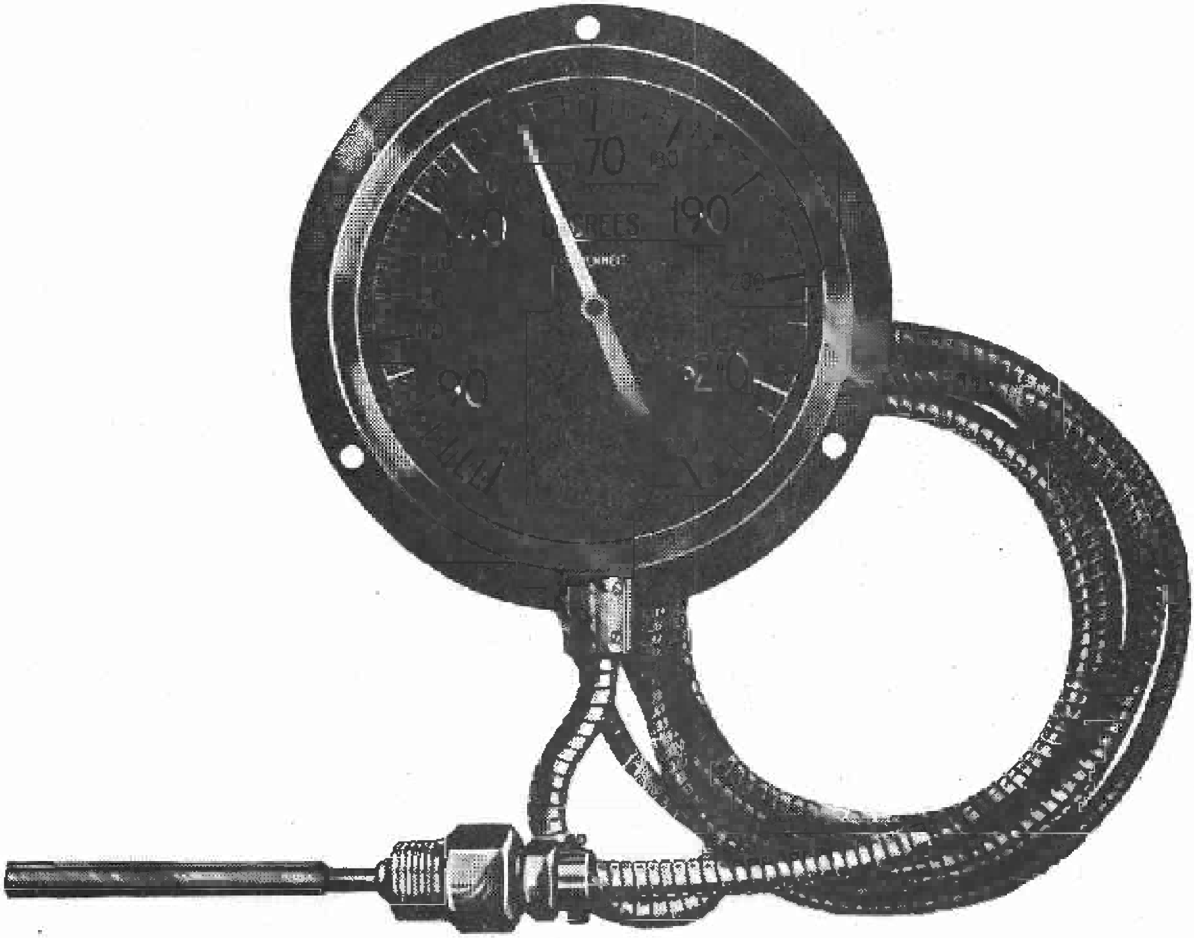
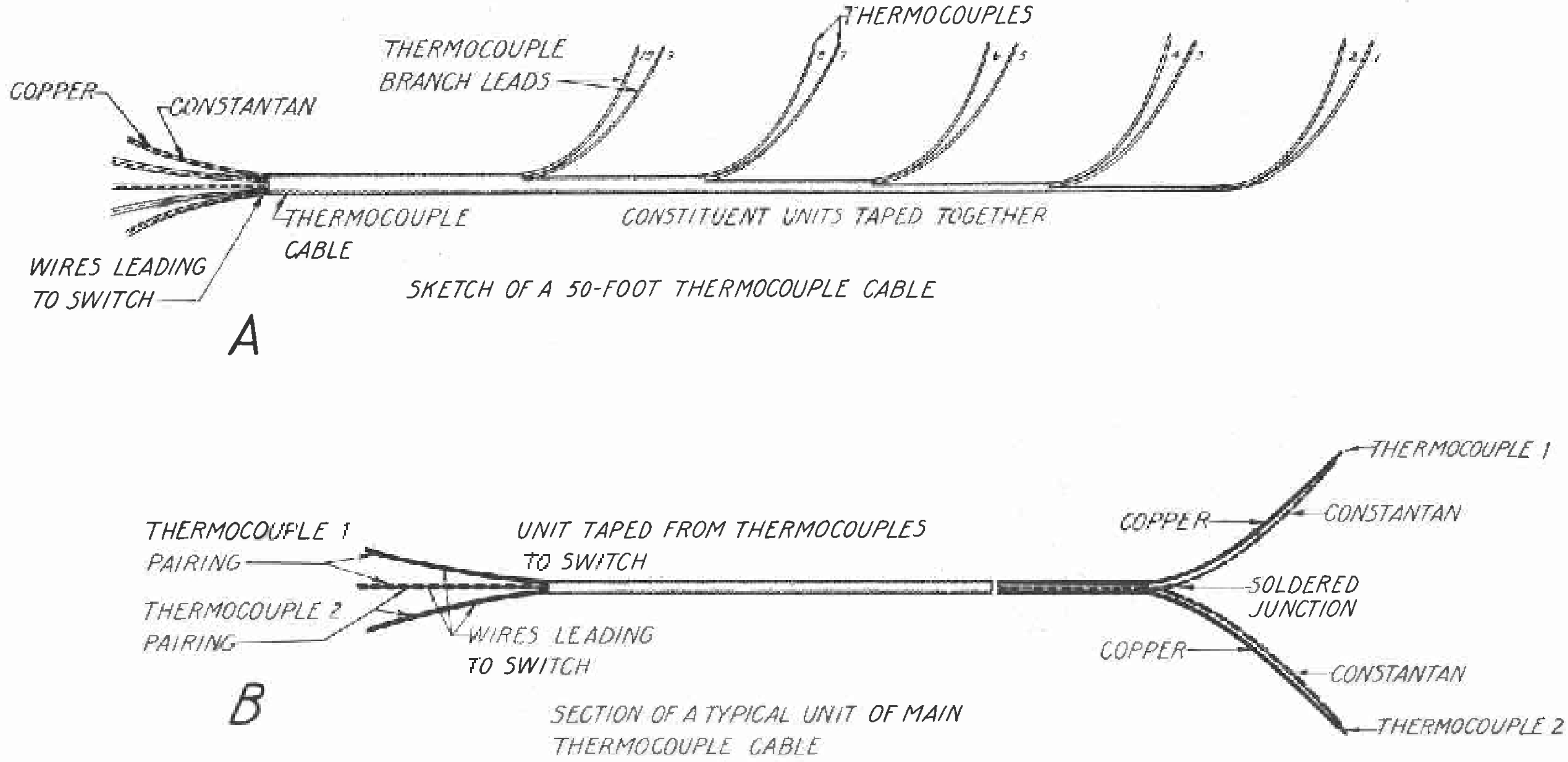


Figure 18.--Indicating pressure-spring thermometer.



Z M 60455 F

Figure 19.--Thermocouple cable and cable unit.

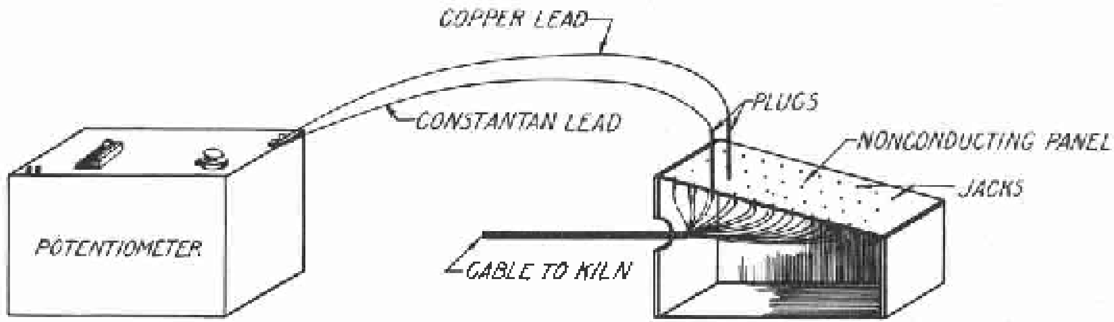


Figure 20.--Method of attaching thermocouple cable to jack box and potentiometer.

Z M 90344 F

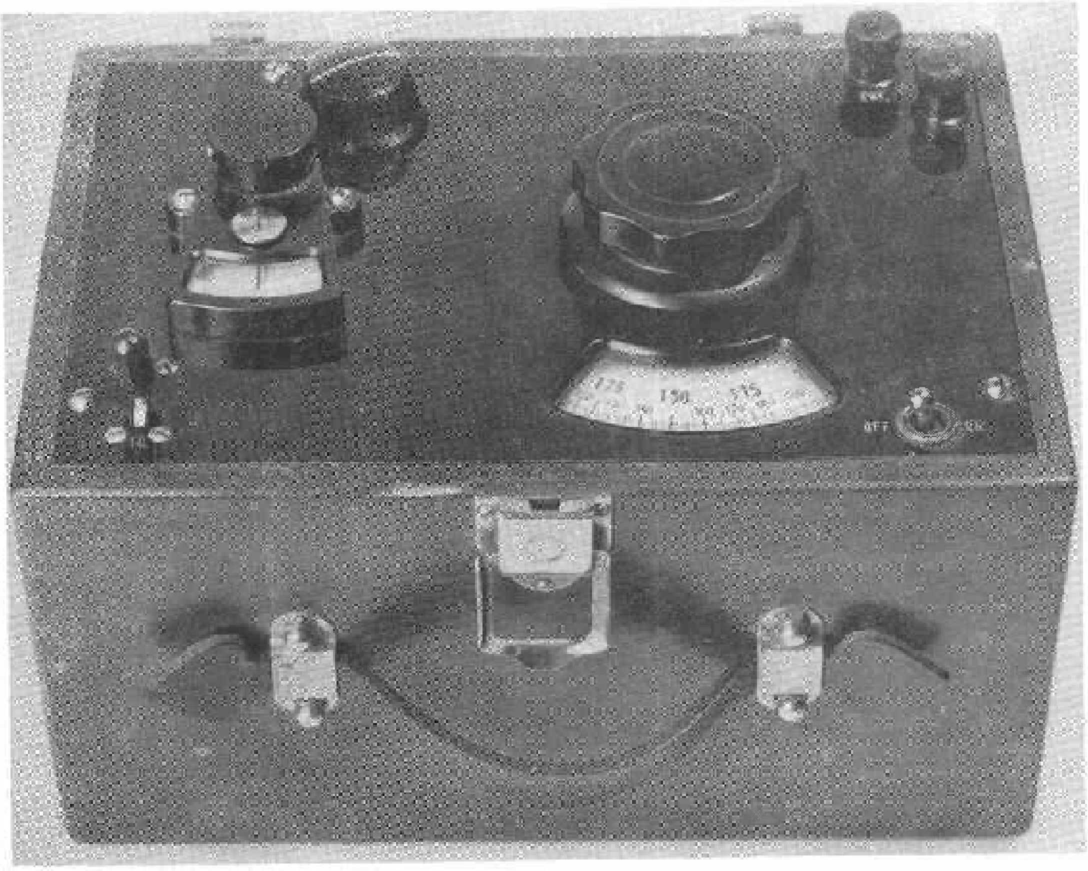


Figure 21.--Portable potentiometer used for measuring temperatures.

Z M 86246 F

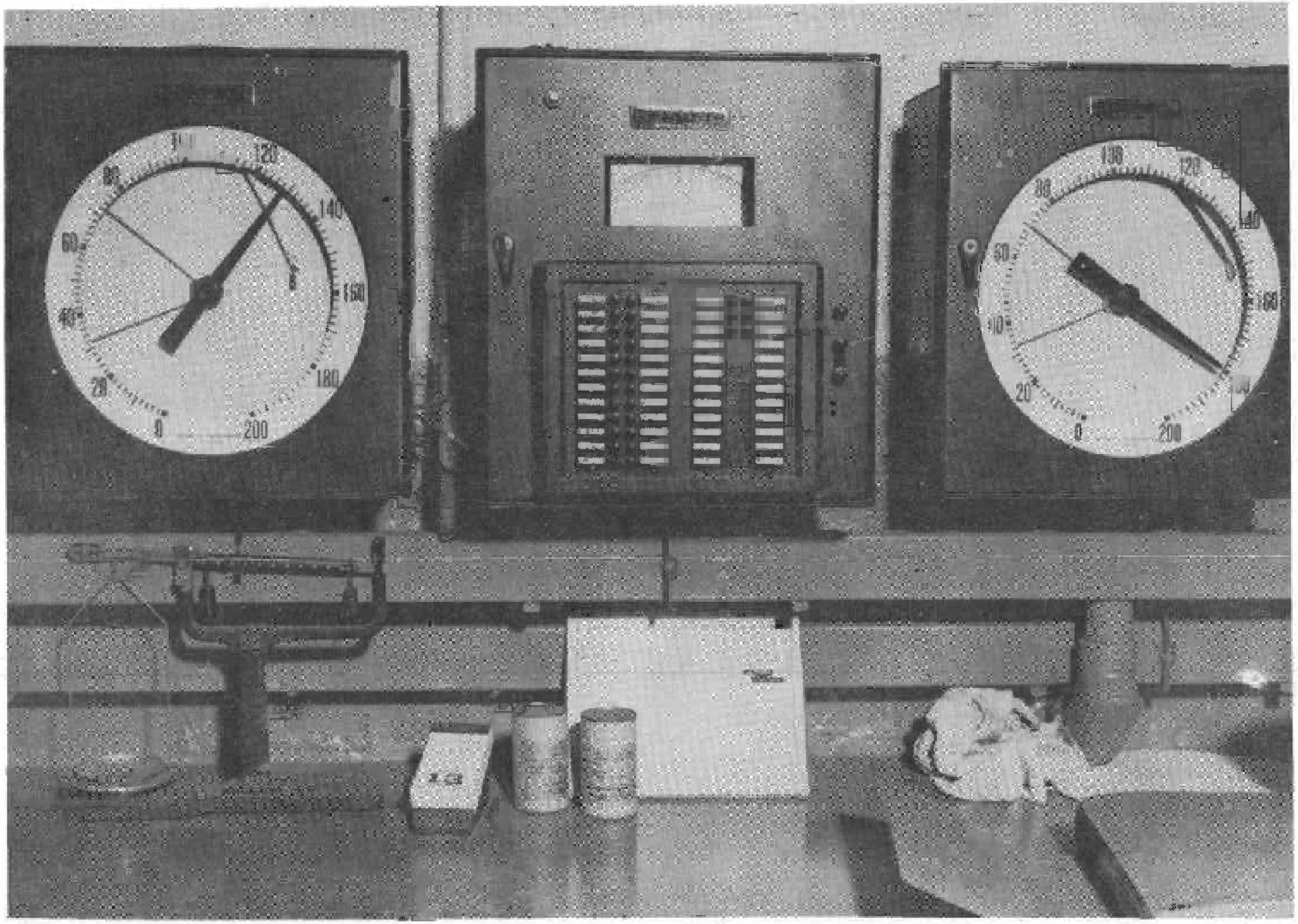


Figure 22.--Indicating recording potentiometer in dry-kiln operating room.

Z M 99177 F

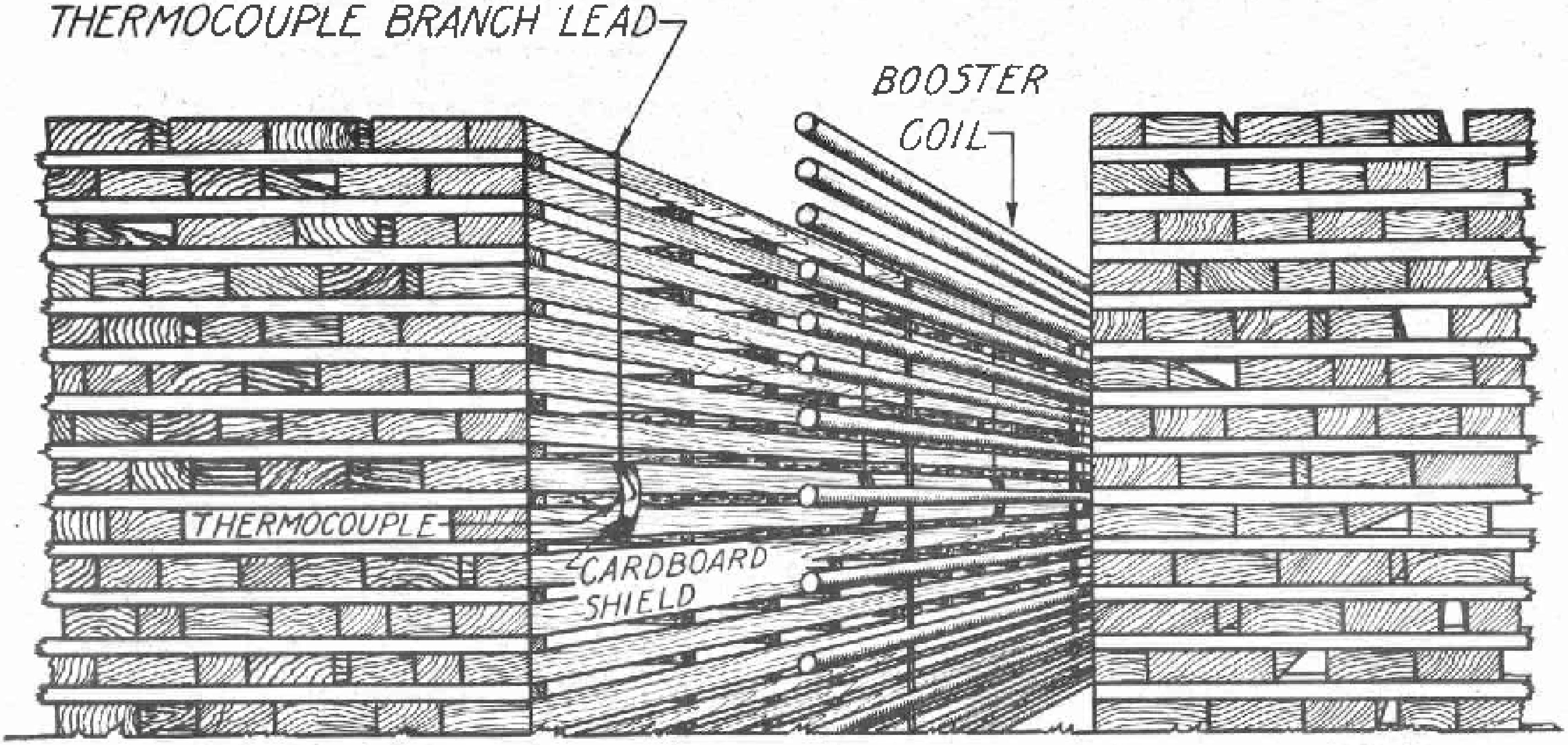


Figure 23.--Portion of kiln charge showing thermocouples shielded from direct radiation.

Z M 60136 F

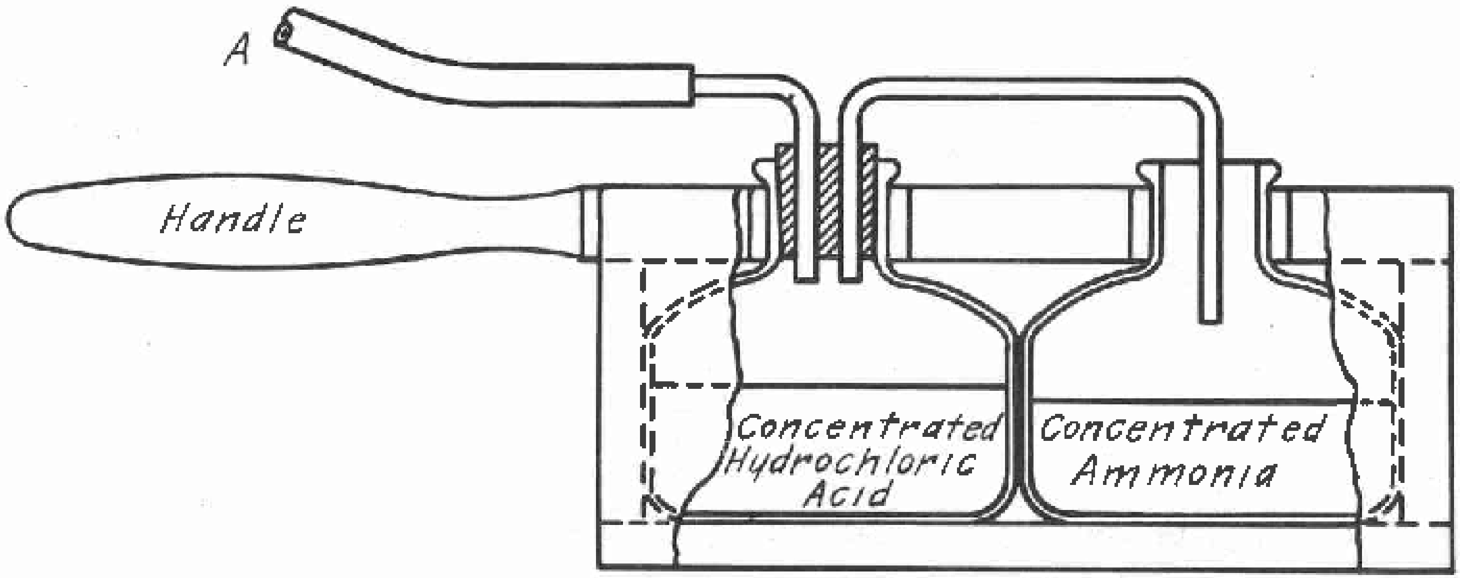


Figure 24.--A smoke machine for testing air circulation in dry kilns. The bottles used are common ink bottles. Almost any kind of bottle will do, but in order to avoid bulkiness, a comparatively narrow one is desirable. The box and its handle may be dispensed with. Two pieces of bent-glass tubing, a cork, and a rubber tube, A, complete the machine. Short lengths of glass and rubber tubing may be used instead of the bent glass, although they are not so satisfactory. The tube, A, should be long enough to allow the operator to extend the machine at arm's length while blowing into the tube. Some operators prefer to fit the end of the rubber tube with a syringe bulb; this is practically necessary when a mask is worn.

Z M 8462 F

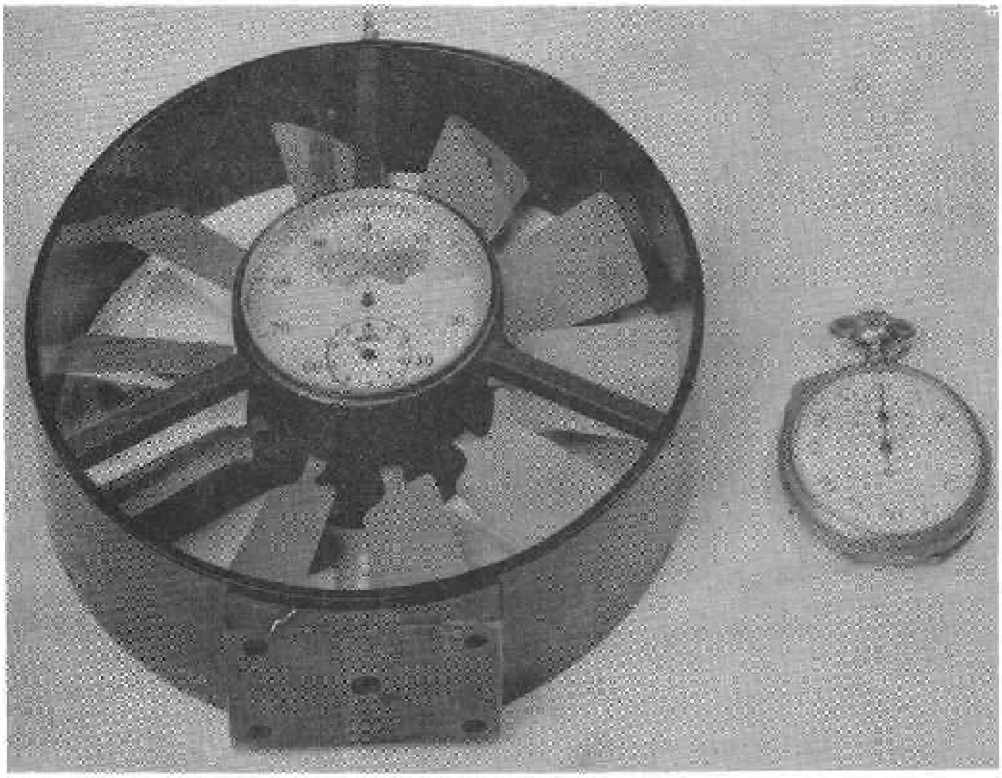


Figure 25.--Fan-type anemometer.

Z M 86248 F

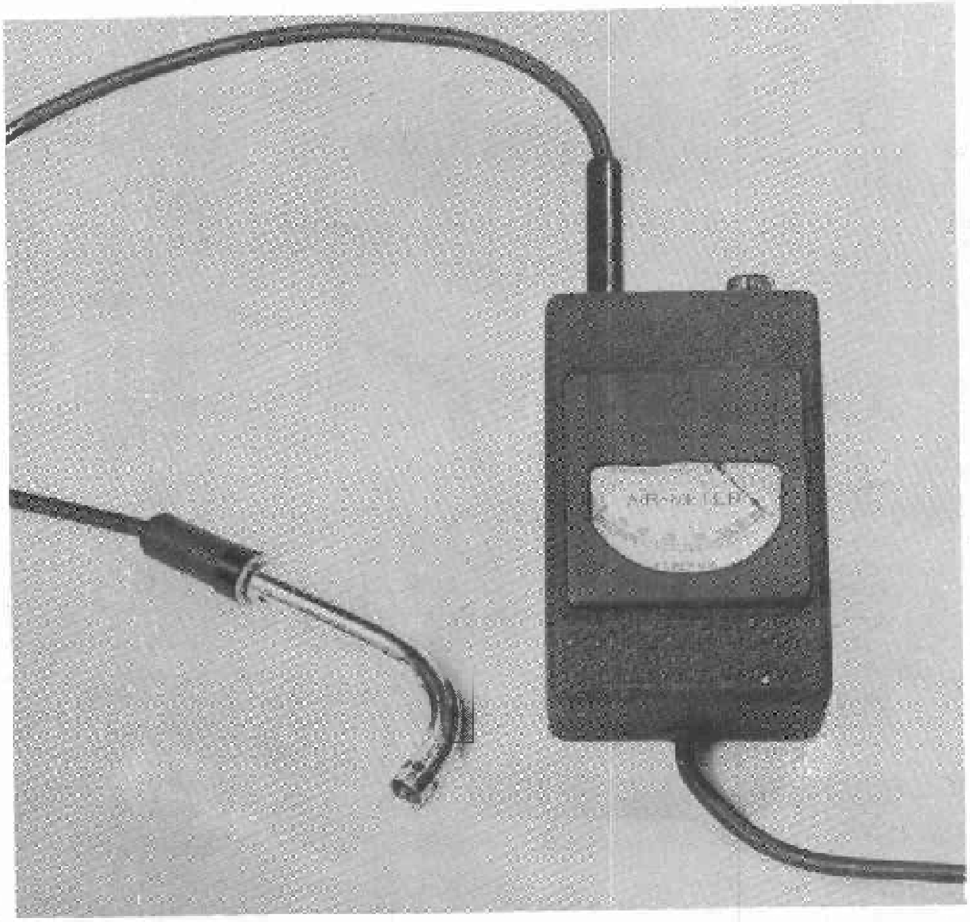


Figure 26.--Hot-wire air meter.

Z M 86244 F

Figure 27.--Velometer.

Z M 86243 F

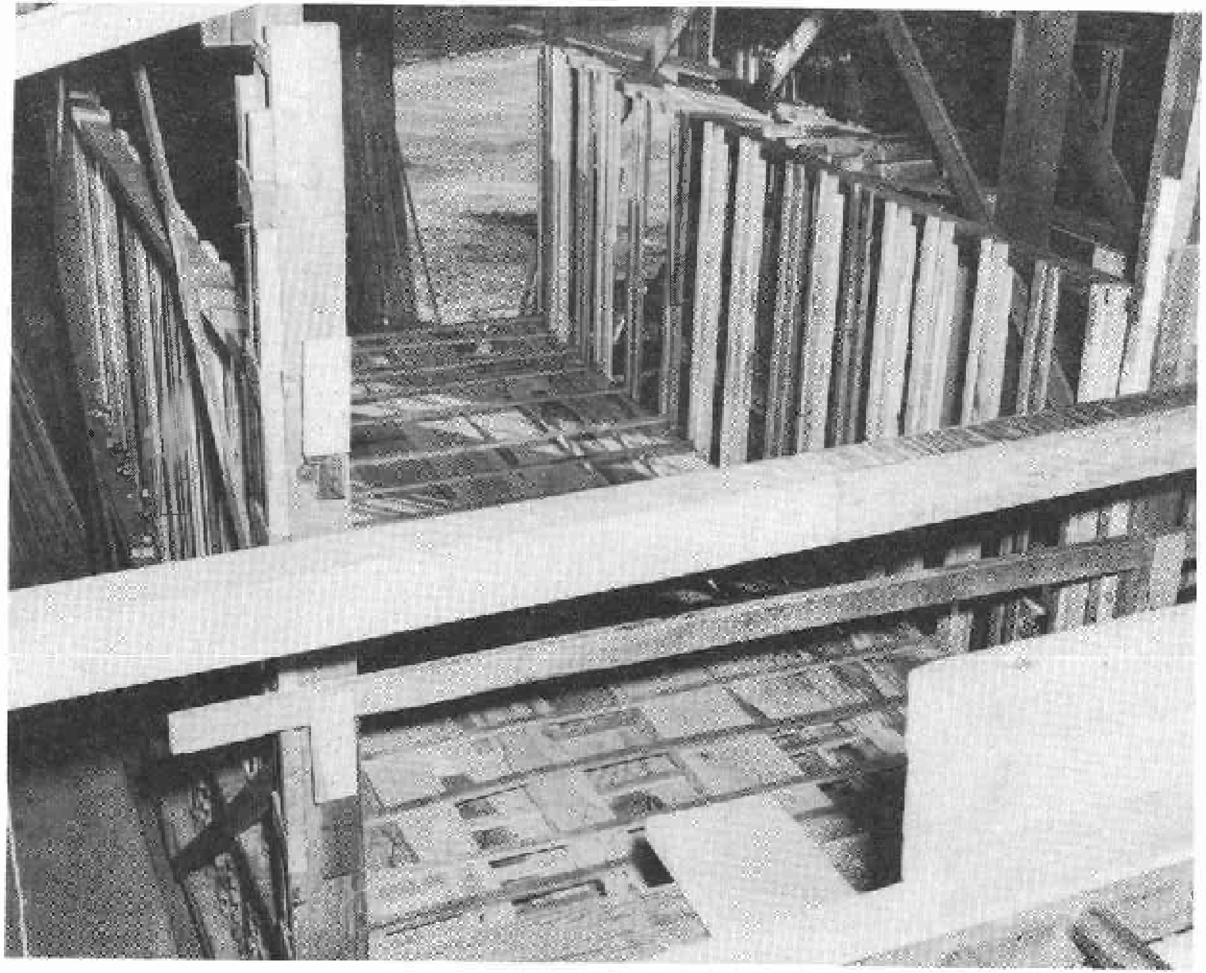


Figure 28.--Sticker Guides on both sides of loads. Guides are pivoted so that they can be pulled clear of the load of lumber when it is stacked.

Z M 90342 F

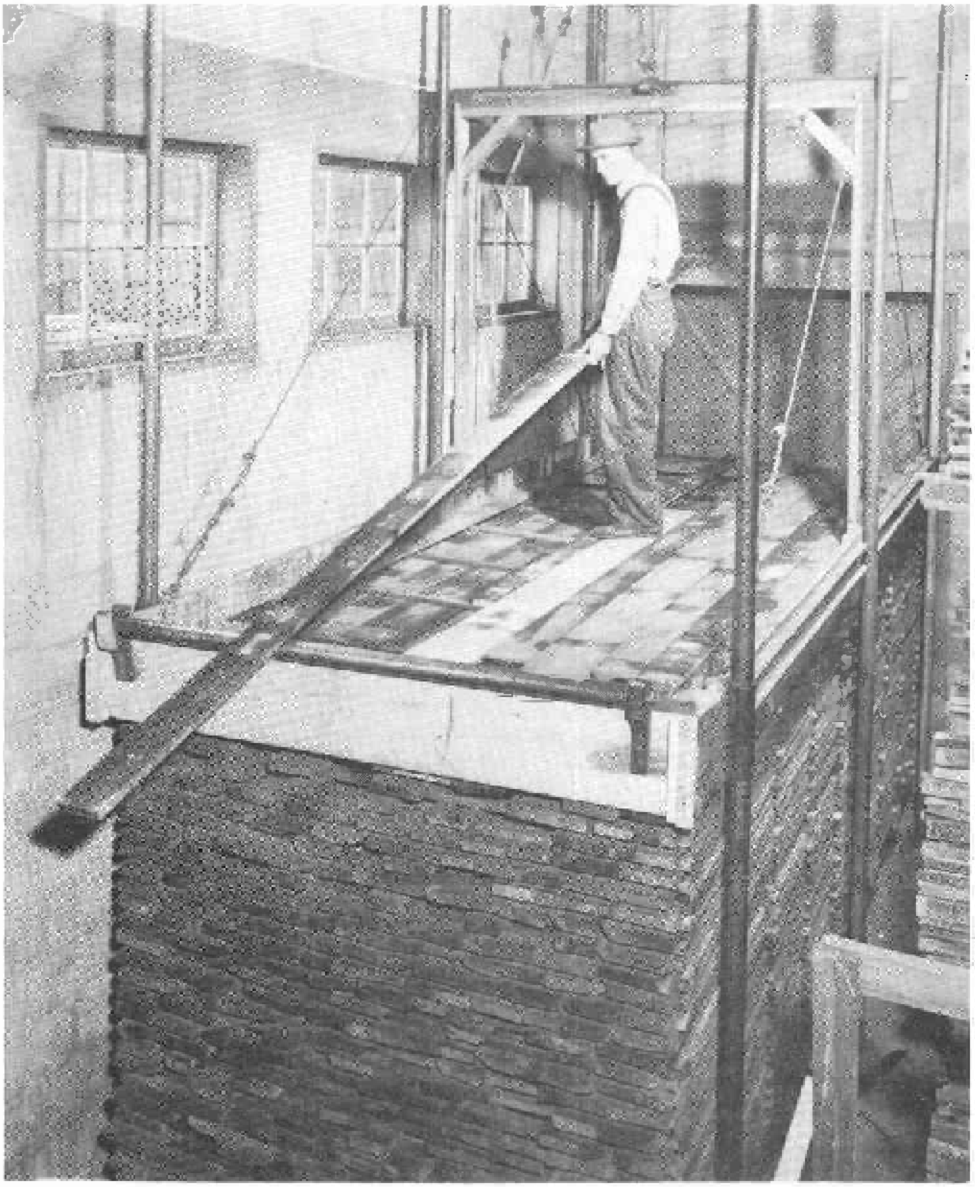


Figure 29.--Sticker-guide frame. Box frame, 2-inch by 12-inch, can be raised or lowered by means of a small electrically operated hoist attached to metal beam shown directly above head of stackerman. The frame insures good side and end alinement of the loads.

Z M 87927 F