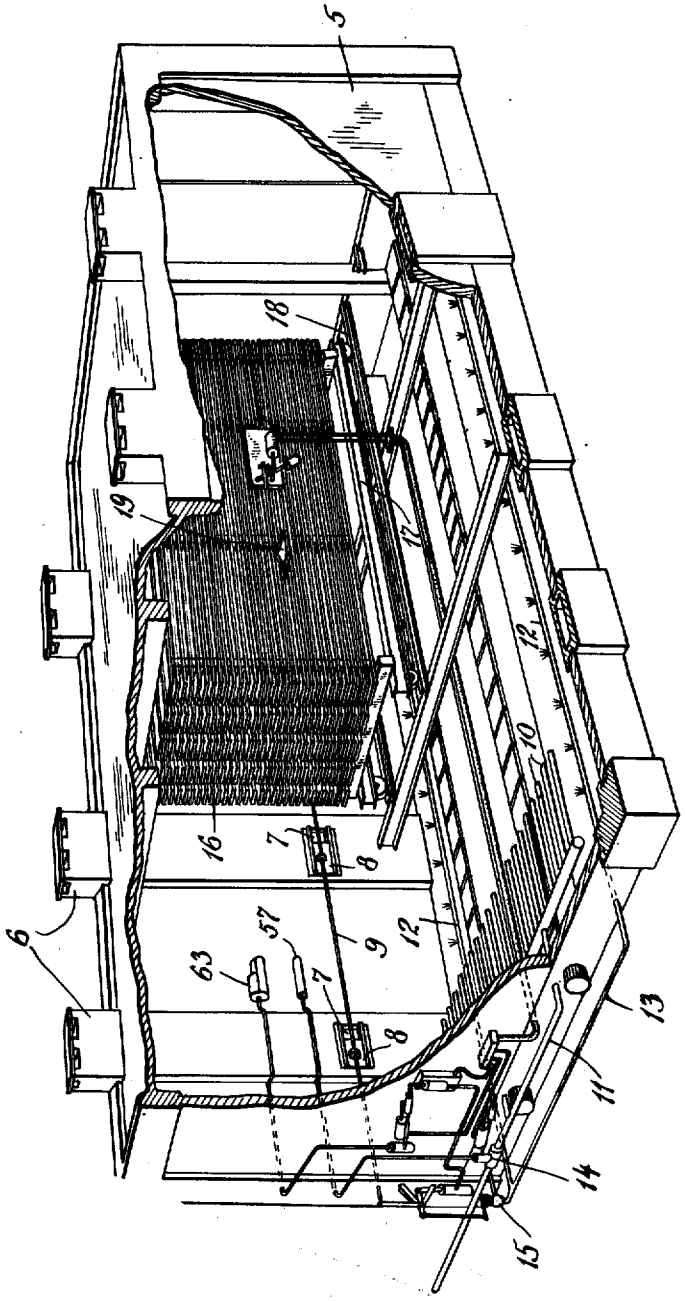
Dec. 29, 1925. 1,567,559

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DRYING WOOD, LUMBER, AND THE LIKE

Filed May 24, 1924 6 Sheets-Sheet 1

Fig. 1.



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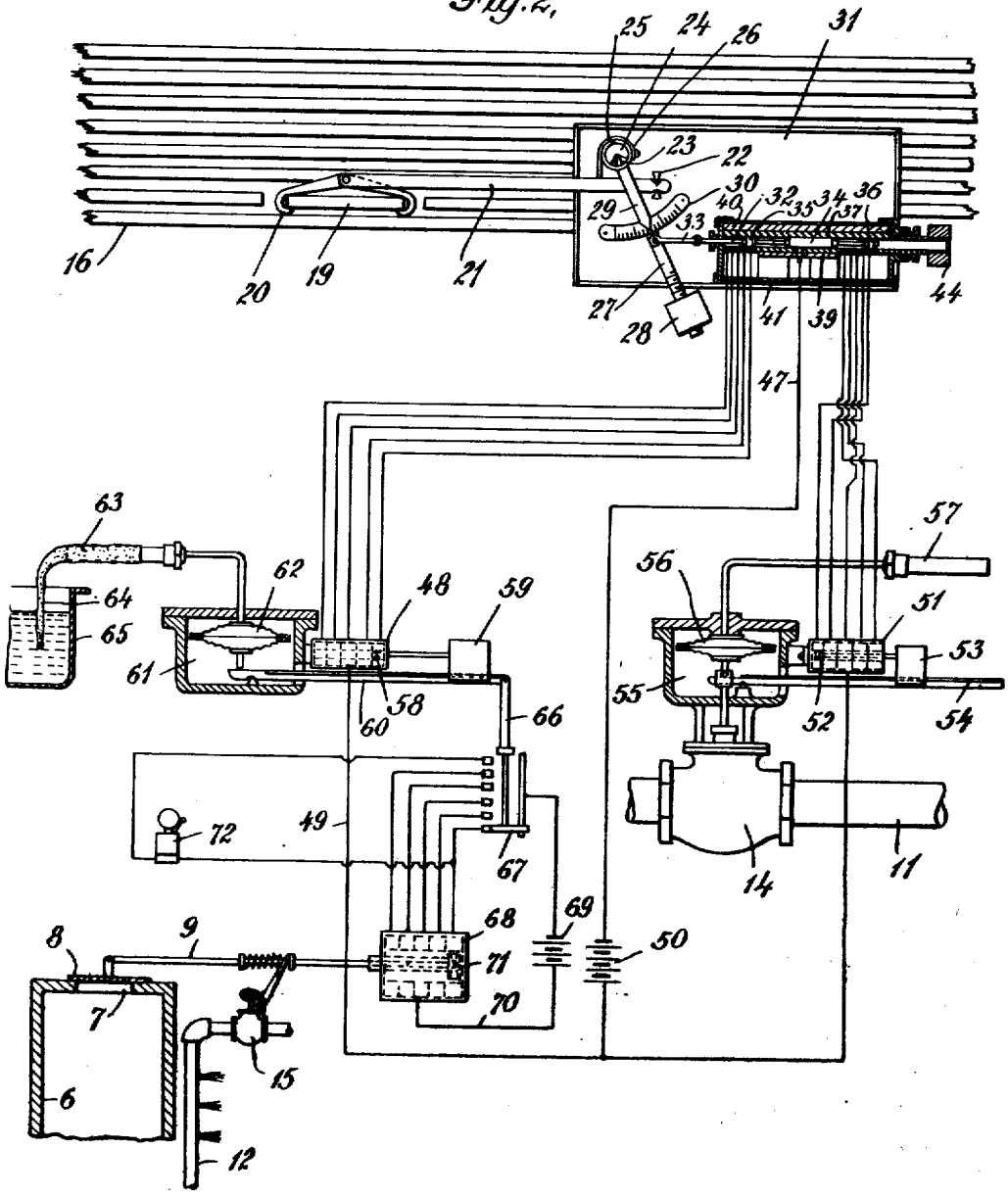
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Fig. 2.



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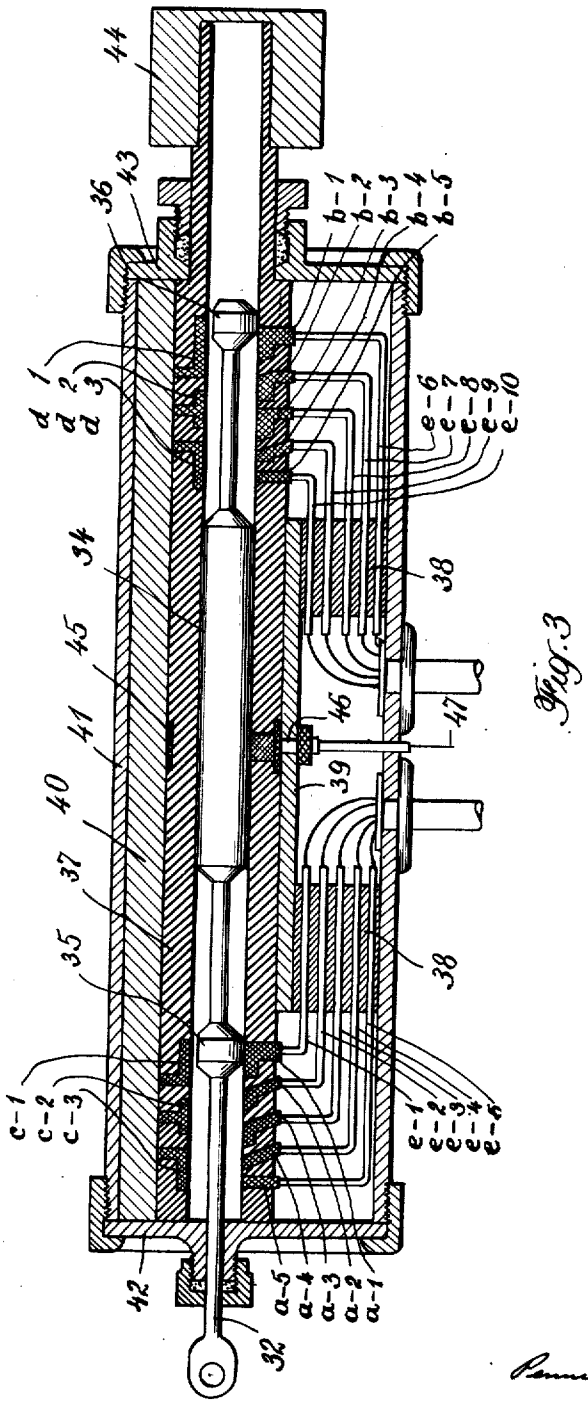


Fig. 3

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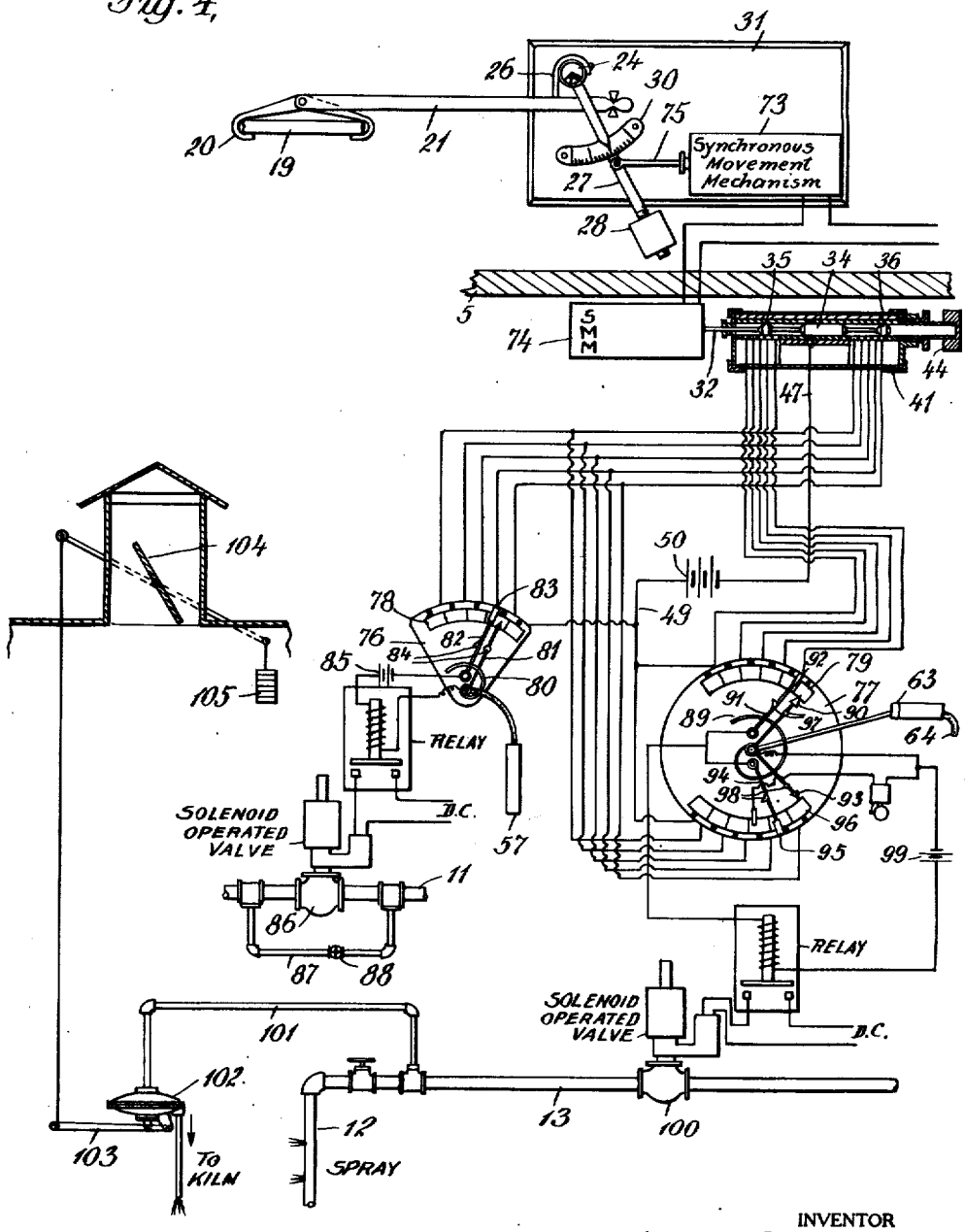
Dec. 29, 1925. 1,567,559

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DRYING WOOD, LUMBER, AND THE LIKE

Filed May 24, 1924 6 Sheets-Sheet 4

Fig. 4.



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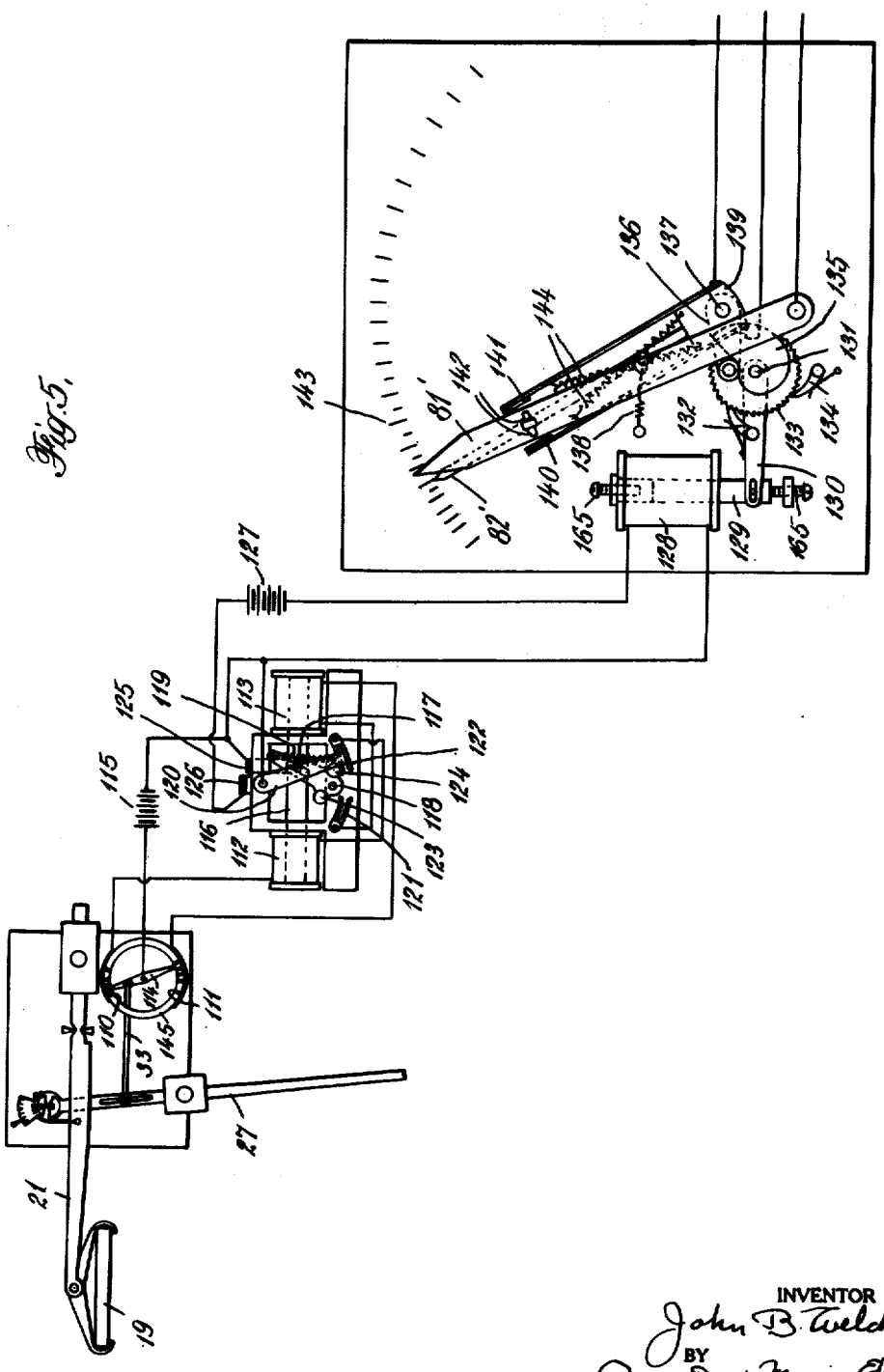
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Fig. 5.



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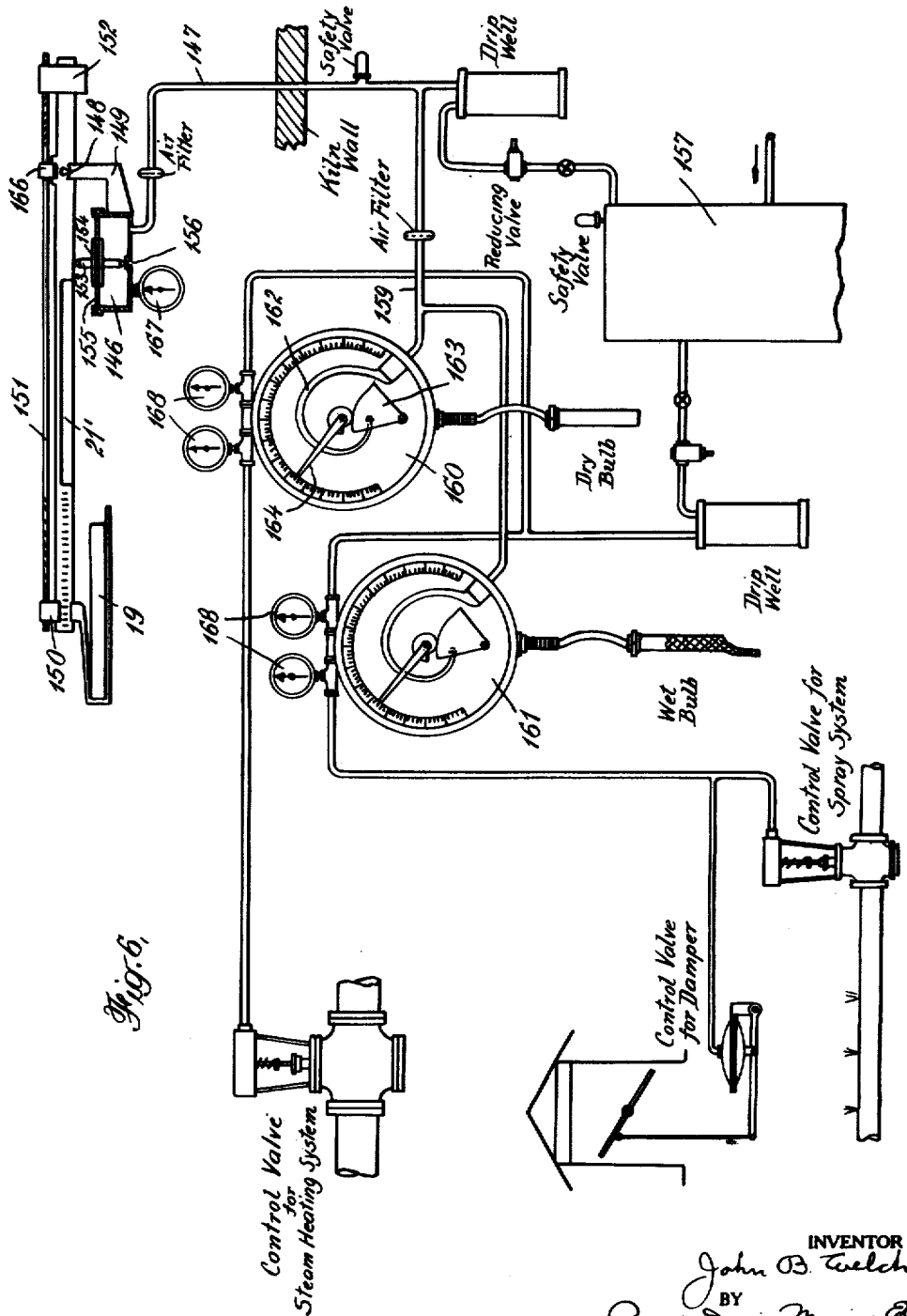


Fig. 6.

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UNITED STATES PATENT OFFICE.

JOHN BERCHMANS WELCH, OF NEW ORLEANS, LOUISIANA.

DRYING WOOD, LUMBER, AND THE LIKE.

Application filed May 24, 1924. Serial No. 715,516.

To all whom it may concern:

Be it known that I, JOHN B. WELCH, a citizen of the United States, residing at New Orleans, in the parish of Orleans, State of Louisiana, have invented certain new and useful Improvements in Drying Wood, Lumber, and the like; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

This invention relates to the art of drying materials, such as lumber, wood, or the like, and has for its object the provision of an improved method of drying such materials. More particularly, the invention aims to provide a method of drying materials, such as lumber or wood, in which the temperature and humidity of the drying medium are automatically controlled in response to changes in a varying characteristic (such as weight or moisture content) of the material undergoing drying as the drying progresses.

The invention relates especially to the drying of lumber or wood and will be described throughout this specification as applied to that industry. It is to be understood, however, that the principles of the invention are applicable to the drying of other materials where different conditions of temperature and humidity are required in the course of the drying operation.

The controlling factors in the drying of lumber, and of wood generally, are the moisture content of the wood, the thickness of the wood and the species. Woods which are easily subject to splitting in drying must be treated at a low temperature and a high humidity. If the wood has a high percentage of moisture the starting temperature must be lower and the humidity higher than if the same wood had been air-dried down to a low moisture content before being put in the drying kiln. In other words, the moisture content of the wood is the controlling factor for any particular thickness and species.

In the careful drying of wood, the moisture content of the wood is first determined and the appropriate temperature and humidity of the drying medium for that moisture content are thereby established. After the wood has been dried down to a lower moisture content, more severe conditions of temperature and humidity of the drying medium are allowable. Heretofore, in the careful drying of wood, it has been necessary for the operator to periodically go into the kiln, take a sample of the wood undergoing drying, and make a moisture determination of that sample in order to find out if the moisture content is low enough to permit or warrant a new setting of the conditions of temperature and humidity. In practice, this necessitates daily weighing of samples from each kiln to determine the appropriate conditions for the drying operation. Often, even in the hands of a skillful operator, the drying proceeds too far before conditions are changed, and then again conditions are sometimes changed before the lumber or wood is dry enough to stand the altered conditions of temperature and humidity.

The high temperatures and humidity within a lumber drying kiln make the duty of entering the kiln for obtaining samples most arduous, and on this account, the drying is seldom controlled by the moisture content of the wood as it should be, but is more often based on a time schedule. This schedule is set after the moisture content of the wood is determined and before drying commences. If everything proceeds without interruption, good drying may be accomplished. However, any interruptions in the drying, such as low steam pressure, shutting down of the kilns or boilers for repairs, changes in weather conditions which affect the temperature within the kiln, and a variety of other causes, often slow up the actual drying so that the lumber or wood is not able to stand the increasing temperature and decreasing humidity called for by the drying schedule. As a result, there is often a considerable loss of lumber due to splitting caused by too rapid drying.

The present invention contemplates an improved method of drying materials such as wood or lumber in which the material itself, according to its moisture content, from within the drying kiln, automatically prescribes the appropriate temperature and humidity

conditions which are required throughout the entire drying operation. Thus, the invention involves the control and adjustment of the conditions of temperature and humidity of the drying medium in response to the decreasing moisture content of the material undergoing drying. In carrying out the invention, an appropriate representative sample of the material undergoing drying, such as a slab where lumber is being dried, is subjected to the action of the drying medium in exactly the same manner as the entire bulk of material being dried and is operatively associated with appropriate control instrumentalities without the kiln for effecting predetermined changes in the conditions of temperature and humidity within the kiln as the moisture content of the sample decreases.

The novel features of the invention will be understood from the following description taken in conjunction with the accompanying drawings which illustrate what I now deem to be the best modes of carrying out the invention. In the drawings:

Fig. 1 is a diagrammatic perspective view of a lumber drying kiln equipped for the practice of the invention,

Fig. 2 is a diagrammatic view of the control instrumentalities of Fig. 1,

Fig. 3 is an enlarged view of the main controlling switch, and

Figs. 4, 5 and 6 are diagrammatic views of modified arrangements of control instrumentalities.

Referring to Fig. 1 of the drawings, the kiln proper comprises an enclosed brick structure 5. The side walls of the kiln are provided with flues 6 open to the atmosphere at their upper ends and communicating by ports 7 with the interior of the kiln. The ports 7 are controlled by movable dampers 8 attached to an operating rod 9 extending through one end of the kilns.

A series of steam pipes 10 are placed on the floor of the kiln and are appropriately connected to a steam main 11 outside the kiln. The steam pipe 11 is provided with a control valve 14. A series of spray pipes 12 are also arranged within the kiln and communicate with a supply main 13 outside the kiln. A control valve 15 is placed in the spray pipe 13.

The lumber 16 to be dried is piled on a truck 17 arranged to run upon and be supported by rails 18 within the kiln. Preparatory to the drying operation, the lumber is appropriately piled on the trucks and these are then run into the kiln. The control sample is then arranged to actuate the control instrumentalities in accordance with the principles of the present invention and the kiln is then closed and in ordinary operation need not again be opened until the lumber is completely dried.

The control sample 19 is a representative sample of the wood to be dried and may conveniently be approximately eight inches wide and twenty-four inches long. This sample is placed on a special type of scales within the kiln. The sample is preferably so positioned that the action thereon of the drying medium within the kiln is fairly representative of the action of that medium throughout the kiln.

The sample 19 is carried by a pair of depending grab hooks 20 pivotally mounted near one end of a horizontally positioned balance arm 21. The balance arm is operatively supported by a pair of stationary knife edges 22 cooperating with notches near the other end of the arm and by a stationary knife edge 23 above the arm and intermediate its ends but relatively nearer the end cooperating with the knife edges 22. The edge of the pivot 23 cooperates with a V-shaped recess in a cylindrical block 24. The block 24 is surrounded by and secured to a tube 25. A flexible strap 26 is secured at one end to the tube 25 and passing over the top of the tube is fastened at its other or depending end to the balance arm 21.

A depending rod 27 is secured to the tube 25. The rod 27 is screw-threaded at its lower end and a counterweight 28 is threaded thereon. The tube 25 (or rod 27, as desired) carries a pointer 29 arranged to sweep across a cooperating stationary scale 30.

The stationary knife-edge pivots 22 and 23 and the scale 30 may conveniently be mounted on a portable panel 31. This panel may also advantageously carry the electrical controlling switch or other device of the instrumentalities for transmitting movements of the balance arm 21 to a desired point outside the kiln. Fig. 3 of the drawings is an enlarged view of the controlling switch illustrated in Figs. 1 and 2. This switch comprises a movable metallic rod 32 connected at one end by means of a pivoted link 33 to the rod 27. The rod 32 carries a relatively long central contact member 34 and two short contact members 35 and 36. The contact members 34, 35 and 36 cooperate with predetermined pairs of contact members mounted on the inner surface of a rotatable hollow cylinder 37 of insulating material, such for example, as bakelite. The hollow cylinder 37 shown in Fig. 3 has two pairs of contact members, but it is to be understood that the hollow cylinder may, if desired, be provided with only one pair of such contact members, but usually will be provided with a plurality of pairs of such contact members. As shown in Fig. 3, there are ten contact members (*a*–1–2–3–4–5 and *b*–1–2–3–4–5) in one pair and six (*c*–1–2–3 and *d*–1–2–3) in the other.

The contact members of the cylinder 37 extend through the wall of the cylinder and

are adapted at the outer surface of the cylinder to engage with appropriate contact brushes carried at the ends of conductors (*e*–1–2–3–4–5–6–7–8–9–10). These conductors are mounted in blocks 38 and are connected to insulated wires designated in the drawings by the same reference numerals as the corresponding conductors.

The cylinder 37 is mounted to turn or rotate in a cylindrical support or bearing provided by the members 39 and 40. The entire controlling switch is enclosed in a cylindrical casing 41, closed at one end by a cap 42, which also provides a bearing for the movable rod 32. The other end of the casing 41 is closed by a cap 43 which provides a bearing for the extended end of the cylinder 37, to which end is secured a knob 44 for turning the cylinder.

The cylinder 37 carries near its center a circumferential contact ring 45 which is electrically connected to the contact member 34 and engages a stationary contact 46 carried by the member 39. A conducting wire 47 is connected to the contact 46.

The conductors *e*–1–2–3–4–5 are connected to one terminal of the five coils of a solenoid 48. The other terminal of the five coils of the solenoid 48 are connected by a common conductor 49 to one terminal of a battery 50 or other appropriate source of electric energy. The other termnial of the battery is connected to the conductor 47. Similarly, the conductors *e*–6–7–8–9–10 are electrically connected to the five coils of a solenoid 51.

The movable armature 52 is adapted to move a counterweight 53 along the arm 54 of a regulator 55. The regulator 55 is operatively connected to the control valve 14. As shown in Fig. 2 of the drawings, the valve regulator 55 is of the diaphragm type. The expansion-contraction chamber 56 of the regulator is operatively connected with a temperature responsive device 57 positioned within the kiln. The device 57 may be any of the well-known types of expansion and contraction thermometers. As represented in the drawings, the device 57 is of the gas type and expansion and contraction of the gas in the device, in response to changes in temperature to which the device is subjected, is transmitted directly to the chamber 56 of the regulator. The regulator also includes the pivoted balance arm 54. This arm is secured to the valve actuating stem of the regulator, and the position of the weight 53 on the arm determines or sets the counterbalancing action and therefore the adjustment of the control valve 14.

The movable armature 58 of the solenoid 48 is adapted to move a weight 59 along the balance arm 60 of a regulator 61. The expansion-contraction chamber 62 of this regulator is operatively connected with a wet bulb or temperature responsive device 63. The device 63 includes a wick 64 dipping into a receptacle 65 containing water. By means of the wick 64 the surface of the device 63 is always covered with a film of water. In the lumber drying industry, it is customary to call the device 63 the wet bulb and the device 57 the dry bulb. The wet bulb 63 is positioned within the kiln as indicated in Fig. 1 of the drawings.

The outer end of the balance arm 60 is connected by a link 66 to a movable contact 67. The contact 67 is arranged to connect the terminal of one of the five coils of a solenoid 68 to a battery 69, or other source of electric energy and to the common terminal 70 of the solenoid coils. The movable armature 71 of the solenoid 68 is arranged to actuate the valve 15 for the spray pipes 12 within the kiln. The armature 71 is also arranged to actuate the rod 9 of the dampers 8. These various elements are more or less diagrammatically indicated in Figs. 1 and 2 of the drawings for the sake of simplicity.

In its two extreme positions (upper and lower as shown in Fig. 2) the contact 67 is arranged to energize the right-hand coil of the solenoid 68. When this coil is energized the position of the armature 71 is such that the ports 7 are completely closed by the dampers 8 and the valve 15 is open full. In its uppermost position the contact 67 also effects the ringing of an alarm bell 72. Moving from its right-hand towards its left-hand position, the armature 71 of the solenoid 68 gradually closes the valve 15 and consecutively adjusts the damper 8 so that the port 7 is one-fourth open, one-half open, three-fourths open and full open.

A control sample 19, which is representative of the wood to be dried, having been selected and its moisture content determined, is placed between the grab hooks 20. The position of the weight 28 is then adjusted upon the rod 27 so as to balance the control sample 19 and place contact members 35 and 36 in operative association with contact members a^1 and b^1 respectively, which through their electrical connections actuate means for establishing the initial conditions of temperature and humidity for the drying operation. If one inch gum, having a moisture content of 200% based on bone dry weight, is to be dried the initial temperature of the kiln, or dry bulb temperature, should be 160° F., and the humidity should be such as corresponds to a wet bulb temperature of 155° F.

With contact members 36 and b^1 engaging each other, the circuit through the coil at the left of solenoid 51 will be closed, thereby attracting the movable armature 52 moving the weight 53 to an appropriate predetermined position upon the arm 54 to counterbalance the gas pressure within the chamber 56. This position of the weight 53 has been

predetermined to maintain a dry bulb temperature of 160° F. If the temperature within the kiln rises, the increased pressure within the dry bulb 57 is transmitted to the valve regulator 55 to close the valve 14.

As the control sample 19 dries a predetermined amount, contact member 36 moves to the left to engage contact member b^2 and closes the circuit through the next adjacent coil of solenoid 51. The counterbalance weight 53 is thereby moved further out on the arm 54 a predetermined amount to counterbalance a greater gas pressure within the dry bulb 57 and the valve regulator 55 to correspond with an increased temperature within the kiln, for example, 170° F. As the wood being dried (or the control sample 19) continues to dry further down to its final moisture content, the contact member 36 moves to and consecutively engages contact members b^3, b^4, etc., thereby establishing the appropriate drying temperature as required by the moisture content of the wood. The arm 54 has previously been calibrated so that each of the various positions of the weight 53 thereon establishes and maintains definite temperature conditions within the kiln.

For each position of contact member 36 there is a corresponding position for contact member 35. Thus, while contact member 36 engages contact member b^1, contact member 35 will engage contact member a^1 to establish the appropriate initial humidity conditions for drying. The operation for the control of humidity is in principle the same as for the control of the temperature. Thus, as contact member 35 engages consecutively contact members a^1, a^2, etc., the circuits through the coils from the right to the left of the solenoid 48 respectively will be closed to attract the armature 58 and move the weight 59 to appropriate positions on the arm 60 to counterbalance the expansion and contraction of the regulator 61 operated by the expansion and contraction of the gas in the wet bulb 63, which is placed in the position where the humidity is to be controlled. For a constantly decreasing humidity the wet bulb temperature is lowered as the drying proceeds, therefore the weight 59 is set on the arm 60 progressively nearer the regulator 61.

If for any reason the humidity within the kiln varies from the desired point, for example increases, the wet bulb temperature increases causing the gas pressure to increase, raising the outer end of the arm 60. The link 66 and movable contact 67 rises accordingly to close a circuit through one of the coils of the solenoid 68, which attracts the armature 71 and moves the rod 9 to partially shut the valve 15 to the spray and open the dampers 8. If the humidity still rises, the wet bulb temperature will continue to rise and the expansive force in the wet bulb will raise the movable contact 67 to close the circuits through the coils of the solenoid 68 to move the rod 9 until the dampers 8 are wide open and the spray is tightly shut. The apparatus will remain in this condition until the humidity drops to the desired point, and if it falls below the desired point, the temperature at the wet bulb will decrease to such an extent that the contraction of the gases in the wet bulb will reduce the pressure within the regulator 61 sufficiently to allow the movable contact 67 to lower again to close the circuits through the various coils of the solenoid 68 and operate the dampers and spray as needed.

If by chance the water supply to the wet bulb fails, the wick on the wet bulb becomes dry and this bulb then operates as a dry bulb. This is an exceedingly dangerous condition for the wet bulb temperature would be equal to the dry bulb. Under such circumstances, that is, whenever the wet bulb controller goes higher than the desired setting, normally the dampers would be wide open and the sprays off. To provide against this the movable contact 67 will close a circuit through an alarm bell 72 and the coil at the right of the solenoid 68 to close all dampers and open all sprays, and thereby protect the drying of the wood. When this occurs, the alarm bell notifies the operator that the wet bulb has gone dry, but assures that his lumber is protected by means of the open spray and closed dampers. Instead of ruining the wood by rapid drying, the drying is merely slowed down until the operator can restore the flow of water to the wet bulb.

It will be understood that for each movement of the armature 58 within the solenoid 48 with simultaneous setting of the counter balance weight 59, the movable contact 67 will assume a position corresponding thereto so that the solenoid 68 will move the armature 71 to a position within the solenoid 68 corresponding to the position of the armature 58 within the solenoid 48.

In the modified arrangement of control instrumentalities illustrated in Fig. 4, I have provided means whereby the instrumentalities, including the rod 32 and the contact members 34, 35 and 36 which are moved in response to a change in a characteristic of the material being dried, may be placed outside of the kiln walls 5. This is accomplished by the provision of a synchronous movement mechanism of the electrodynamic type or of a mechanical type. In Fig. 4 of the drawings the synchronous movement mechanism is of the electrodynamic type and comprises two electrically connected induction devices 73 and 74 so arranged that movement of the rod 75, which is connected

to rod 27, is synchronously transmitted to the rod 32.

Fig. 4 illustrates a further modification in the control instrumentalities previously described whereby an electrically operated temperature controller 76 and an electrically operated humidity controller 77 may be employed.

The conductors e^1, e^2, e^3, e^4, and e^5 are connected to one terminal of the five coils of an electromagnet 78 associated with the electrically operated temperature controller 76. The other terminal of the five coils of the electromagnet 78 is connected by a common conductor 49 to one terminal of a battery 50 or other source of direct current. The other terminal of the battery is connected to the conductor 47. Similarly, the conductor e–6–7–8–9–10 are electrically connected to the five coils of an electromagnet 79 associated with the electrically operated humidity controller 77.

The dry bulb 57 is operatively connected to the open end of a helix 80 which is secured to the shaft of the indicating pointer 81 of the temperature controller 76 so that a variation in the gas pressure from the dry bulb turns the pointer 81 to indicate the temperature within the kiln The temperature controller 76 carries an arm 82 pivoted at one end and having a contact 83 adapted for association with the coils of the electromagnet 78. The arm 82 and pointer 81 carry contacts 84 adapted for engagement when the pointer 81 moves opposite the arm 82. The contacts 84 are electrically connected through a battery 85 to a relay. The relay is operatively connected to an electrically operated valve 86, either motor-driven or actuated by a solenoid, in pipe 11 for controlling the steam supply to pipe 10 within the kiln. A small by-pass pipe 87 having a hand operated valve 88 is provided in the pipe 11 circumscribing the valve 86 to permit a small amount of steam to go through the pipe 11 when the valve 86 is closed.

The wet bulb 63 is operatively connected to the open end of a helix 89 of the humidity controller 77. The construction of the humidity controller is identical with the temperature controller 76 and comprises a pointer 90, and an arm 91 having a contact 92 adapted for association with the coils of the electromagnet 79.

The humidity controller 77 is provided with an additional pointer 93 associated with the helix 89. An additional arm 94 is also provided carrying a contact 95 adapted for association with the coils of an electromagnet 96 which are electrically connected to conductors e–1–2–3–4–5.

Pointer 90 and arm 91 are provided with contacts 97 which engage when the pointer 90 moves opposite arm 91. Likewise, pointer 93 and arm 94 are provided with contacts 98 adapted for engagement when the pointer 93 moves opposite arm 94. Contacts 97 and 98 are electrically connected through a battery 99 and an alarm bell to a relay. The relay is operatively connected to a solenoid operated valve 100 in pipe 13 leading to the sprays 12. The valve 100 is normally kept closed by a spring. A by-pass pipe 101 connects steam pipe 13 with a motor damper valve 102 of common construction. The force of steam in the valve 102 causes its diaphragm to expand and actuate a lever arm 103 to close damper 104 against its counterbalance 105.

The operation of the apparatus illustrated in Fig. 4 is the same in principle as that illustrated in Figs. 1, 2, and 3. At the start of the drying operation, contact member 36 engages contact member b^1 to close the circuit through the right hand coil of electromagnets 78 and 96 which attract contact 83 on arm 82 and contact 95 on arm 94 respectively. This sets arms 82 and 94 at the same temperature position which is the dry bulb temperature The steam valve 86 is open so the temperature in the kiln continues to rise until the pointer 81 moves opposite arm 82 and contacts 84 engage to close the circuit through the relay. The relay then energizes the solenoid of valve 86 to shut off the steam supply to pipes 10 until the temperature within the kiln falls below the point at which contacts 84 engage. The circuit through the relay will now be opened and the solenoid operated valve 86 will also be opened so as to allow steam to pass into pipes 10.

When contact member 36 engages contact member b^1 contact member 35 engages contact member a^1 to close the circuit through the right hand coil of solenoid 79 which attracts contact 92 on arm 91. If the humidity becomes lower than the point set by arm 91, the temperature of the wet bulb 63 rises and pointer 90 approaches arm 91 until contacts 97 engage to close the circuit through the relay and energize the solenoid of valve 100 and allow the spray to enter the kiln, and at the same time allow steam to pass to the motor damper valve 102, causing the damper 104 to close.

If the supply of water to the wet bulb should fail, the wet bulb would go dry and the provisions for the control of humidity would not operate as contemplated. Under such circumstances the wet bulb would operate like the dry bulb and the gas pressure therein would increase to cause pointer 93 to approach arm 94 until contacts 98 engage. The circuit through the relay would now be closed, and the valve 100 opened, exactly as in the case of low humidity, and the alarm bell sounded.

The apparatus shown, the contact mem-

bers 34, 35, and 36 on the rod 32 are always started from the same positions within the cylinder 37 regardless of the moisture content, thickness, or species of wood, or other material being dried. It is sometimes desirable or necessary to start or stop the drying operation under different conditions of temperature and humidity. For example, when drying one inch gum having an initial moisture content of 200 per cent, based on bone dry weight, the initial dry bulb temperature should be about 160° F. and the wet bulb temperature about 155° F. When drying wood or other material having a different initial moisture content, thickness, or different species, the conditions of temperature and humidity, or dry bulb and wet bulb temperatures, at the start and finish of the drying operation must be different if satisfactory drying is to be accomplished. These conditions may be brought about by employing different pairs of contact members engaging contact members 35 and 36. When employing contact members *a*–1–2–3–4–5 and *b*–1–2–3–4–5 engaged by contact members 35 and 36 respectively, an initial dry bulb temperature of 160° F. and wet bulb temperature of 155° F. is secured and a finishing dry bulb temperature of 180° F. and wet bulb temperature of 150° F. When a lower initial and a higher finishing dry bulb and wet bulb temperatures are necessary or desirable, I replace contact members *a*–1–2–3–4–5 and *b*–1–2–3–4–5 by a different pair of contact members, such for example, as contact members *c*–1–2–3 and *d*–1–2–3. This may be done by turning knob 44, as shown in Fig. 3, until the appropriate pair of contact members are in the position there occupied by the contact members *a*–1–2–3–4–5 and *b*–1–2–3–4–5. It will be clear that when the contact members *c*–1–2–3 and *d*–1—*a*–3 are thus turned to operating position, contact members c^1 and d^1 will close the circuit between contact members 35 and 36 and the conductors previously engaged by contact members a^2 and b^2 respectively when the latter were in operating position. Likewise, it will be observed that any initial or finishing dry bulb and wet bulb temperature may be obtained by merely turning the knob 44 until the appropriate pair of contact members are brought to operating position within the cylinder 37, there being a pair of contact members suitable for each initial moisture content, species, or thickness of material to be dried.

The movement of the scale arm 27 is relatively slow, and the electrical contacts controlled by the scale arm are consequently retained in engagement for some length of time. As a result of this condition, the windings of the various solenoids in the control instrumentalities are energized for a corresponding length of time, and I have found that this may lead to difficulties as a result of undue heating of the solenoid windings. In Fig. 5 of the accompanying drawings, there is represented a control equipment in which the slow movement of the scale arm produces rapid energization of the solenoid windings followed immediately by interruption of the circuit connections of the windings, although the scale arm contacts may be engaged for sometime thereafter. In other words, there is a quick make-and-break of the solenoid winding circuits for a slow make-and-break of the scale arm contacts.

The scale switch, as diagrammatically represented in Fig. 5 comprises a series of contacts 110 electrically connected to one terminal of a solenoid or relay winding 112, and a second series of contacts 111 electrically connected to one terminal of a solenoid or relay winding 113. The other terminals of the windings 112 and 113 are electrically connected to a movable contact 114 actuated by the scale arm 27. A battery 115 is in the common circuit connection between the contact 114 and the windings 112 and 113.

An armature piston 116 is operatively arranged to be moved towards the left (Fig. 5) when relay winding 112 is energized and towards the right (Fig. 5) when relay winding 113 is energized. The piston 116 carries a pin 117 engaging in a slot in a rocker cam 118 so that when the winding 112 is energized the cam is turned counter-clockwise, and when the winding 113 is energized the cam is turned clockwise. A spring 119 mechanically connects the cam 118 with a movable switch arm 120 adapted to engage with either of two spring contacts 121 and 122. The cam 118 is electrically connected to the movable switch arm 120 through the metallic frame of the instrument or through the spring 119.

The cam 118 carries two lugs 123 and 124 adapted to engage with and lock the switch contacts 121 and 122, respectively, in such a manner that the piston 116 can move almost its completed distance towards the winding 112 (or the winding 113) before the spring 119 will act to throw the arm 120 from engagement with contact 121 into engagement with contact 122, or vice versa.

The piston 116 carries a flexible contact 125 arranged to have a sweeping engagement with a stationary contact 126, as the piston is moved in response to the energization of first one and then the other of the windings 112 and 113. The contacts 125 and 126 are included in an electrical circuit with a battery 127 and a solenoid or relay winding 128.

An armature plunger 129 is operatively mounted with respect to the winding 128. At its lower or outer end the armature 129

is pivotally connected to a lever arm 130 which in turn is pivotally mounted on a shaft or spindle 131. The lever arm 130 carries a spring-pressed pawl 132 cooperating with a ratchet 133 secured to the shaft or spindle 131. A holding pawl 134 is also mounted in operative engagement with the ratchet 133. Setting screws 165 are provided for determining the movement of the armature 129 each time the winding 128 is energized. Adjustment of the screws 165 permits adjustment of the number of teeth of the ratchet 133 moved each time the winding 128 is energized.

The ratchet 133 is always moved in the same direction by the armature 129. A cam 135 is secured to the spindle 131. Movement of the cam 135 actuates a cam lever arm 136 secured to a shaft or spindle 137. A pointer 82′ is also secured to the shaft 137. A spring 138 (secured at one end to the pointer 82′) is arranged to hold the cam follower of the lever 136 against the cam 135.

A block of insulating material 139 is also secured to the shaft 137 and is accordingly moved with the pointer 82′. Electrical contact arms 140 and 141 are secured to and carried by the block 139. An indicating pointer 81′ is operatively associated with the dry bulb (or wet bulb) within the kiln and is actuated in response to changes in temperature (or humidity) within the kiln. The pointer 81′ carries an electrical contactor 142 adapted to engage with either of the arms 140 and 141.

When the solenoid winding 128 is energized (in response to predetermined movements of the scale arm 27), the ratchet 133 is turned a predetermined amount, which is equal for each movement of the plunger 129. This turning of the ratchet sets the contact arms 140 and 141 to a predetermined temperature indicated on the scale 143 by the pointer 82′. It will be observed that by using the cam arrangement a variable movement of the pointer 82′ is obtained for equal movements of the ratchet, and this is necessary because the scale for the temperature controller is not uniform. When the temperature element or dry bulb in the kiln operates the pointer 81′, the contactor 142 engages with the contact arm 140 or 141 and this opens or closes the valve on the steam main. For this purpose, it will be understood that the contacts 140, 141 and 142 are included in appropriate electrical circuits for actuating the valve on the steam main. The pointer 81′ and temperature element and cooperating equipment may be of any usual temperature indicator or controller type. The contact arms 140 and 141 are provided with springs 144 for pulling these arms back when the pointer 81′ returns to its neutral position.

By making contacts 110 and 111 operate the ratchet 133 and cam 135 for certain percentage moisture conditions, the cam can be designed to effect any desired schedule of both humidity and temperature, as well as take care of the variable scale graduations. In this way, the contacts 110 and 111 bring about operation of the cam 135, regardless of the thickness or the kind of wood, for moisture contents of 100%, 20%, 40%, 30%, 25%, 20%, 15%, 10%. The cam 135 can thus be designed to give any desired schedule of temperature and humidity control.

It will be understood that the pointers 81′ and 82′ correspond in function with the pointers 81 and 82 of Fig. 4 of the accompanying drawings. It will also be understood that the same type of control equipment may be used in conjunction with the wet bulb instrument as with the dry bulb instrument.

In Fig. 5 of the accompanying drawings, I have shown a construction of scale switch which I prefer to employ in conjunction with the equipment illustrated in this Figure 5. Corresponding parts in Figs. 2 and 5 are indicated by the same reference numerals. The contacts 110 are carried in the top segment of a ring of insulating material 145, preferably made of bakelite. The contacts 111 are carried in the bottom segment of the ring 145. The movable contact 114 (connected to the pivoted link 33) is arranged to alternately engage with the contacts 110 and 111. It will be understood that the contacts 110 and 111 are positioned in the ring at the percentage points where it is desired to change the temperature and humidity conditions as hereinbefore described.

As the moisture dries from the sample 19, the arm 27 moves toward a vertical position and this movement is so transmitted to the contact 114 that the contacts 110 and 111 are alternately engaged. This results in the periodic energization of the winding 128 with the attendant results hereinbefore described.

In Fig. 6 of the accompanying drawings there is diagrammatically illustrated a compressed-air equipment for carrying out my present invention. This equipment comprises an automatic regulator 146, operated by compressed air, and controlled by the weight of the sample of material (19) being dried, the initial moisture content of which is known, but the size of the sample being capable of variation within reasonable limits. The automatic regulator functions in such a way as to maintain at all times in an air line 147 a pressure that corresponds quantitatively to the per cent of moisture in the sample 19. This variable air pressure in the line 147 is then used to set the valves controlling the temperature and humidity within the kiln.

The regulator 146 is operated by a scale beam 21′, balanced on a knife edge 148 fitting in a bearing fixed on a supporting frame 149, this knife edge being near one end of the beam. The beam is counterweighted to balance with all attachments in place. The sample 19 is hung or supported by a suitable holder swinging from a knife edge support 150 on the long end of the beam. The support 150 is movable along the length of the beam as a result of engagement with a threaded rod 151 mounted in suitable bearings on and parallel to the beam. On the opposite side of the main fulcrum the rod 151 is threaded in the opposite direction and a counterweight 152 is moved along this end of the beam as a result of its threaded engagement with the rod. The ratio of the pitches of the two threads on the opposite ends of the rod 151 are in inverse proportion to the ratio of the weight of the moving support 150 and suspended holder to that of the moving counter-weight 152, since this will keep the beam always in balance no matter what the position of the holder when unloaded. Hence, the sample is at all times the only thing throwing the beam out of balance. The rod 151 can be turned by means of a knurled nut 166 secured thereto.

The main beam has stops so that its maximum travel at the point furthest from the fulcrum is perhaps one-half inch to one-fourth inch.

The weight of the sample is supported by a small short flexible rod 153, the upper end of which has a knife edge engagement with the long end of the beam 21′ near the fulcrum. A round flat disk 154 and cooperating rubber or metal diaphragm 155 close the top of the air chamber of the regulator 146 and are operatively attached to the rod 153. The lower end of the rod 153 terminates in an adjustable cone fitting into and adapted to close a corresponding opening in the bottom of the regulator air chamber, thus constituting a needle release valve 156, but seat and plug taper inwardly and not outwardly as is usual. The projected area of the top of this cone is small compared with that of the disk.

Compressed air is supplied to the air chamber of the regulator 146 from any suitable source. In Fig. 6, I have illustrated a compressed-air storage tank 157 adapted to deliver compressed air to the line 147. The compressed air is supplied to the regulator in such volume that at the lowest pressure in the air chamber all of the air supplied can escape through the needle valve 156 if open all the time. Since air is entering the regulator all the time, the pressure in the air chamber will rise until the pressure on the bottom of the disk in excess of that on the needle valve overcomes the weight of the sample, and the beam will lift. But this will open the needle valve and lower the pressure. However, now the beam will immediately fall and close the valve and thus maintain the pressure. Actually, the needle valve will open just enough to allow the air to escape at such a rate as to keep the pressure just sufficient to balance the weight of the sample, thus maintaining the beam always in balance.

One might balance the beam by means of a needle valve flaring outward in place of the disk and rubber diaphragm, but such an arrangement is not particularly sensitive because the effective area varies with the amount of opening. It is well-known that a safety-valve, once open, will not seat until the pressure has fallen quite a little below that needed to open it.

For any particular point of suspension of the sample on the beam, the air pressure necessary to balance the beam is proportional to the weight of the sample. If for a specific sample containing 50% moisture, wet basis, the corresponding air pressure is say 20 pounds, then when this sample is bone dry, it will weigh half as much and the air pressure will be say 10 pounds. The air pressure gauge 167 is preferably calibrated to read directly in percent moisture, with the zero reading at say 10 pounds pressure. If now a new sample of different size, but still containing 50% moisture, wet basis, be put on the scale beam, one can adjust the pressure to the proper point, corresponding to say 20 pounds air pressure, by moving the knife edge on which the sample swings in or out on the beam, as the case requires. When the sample is dry, the pressure will have fallen to 10 pounds, and intermediate moisture contents will be accompanied by corresponding proportionate differences in air pressure.

In operating this control equipment, the sample is first mounted on the scale beam and the air turned on to the regulator. The sample is moved in or out along the beam by means of the adjusting rod 151 until the pressure gauge 167 shows the moisture content which the sample is known to contain as determined by previous test, making certain that the air is escaping properly from the needle valve. From now on the position of the indicating pointer of the pressure gauge will at all times correspond to and indicate the moisture content of the sample at any particular time in question. Hence in each particular case, only one adjustment is necessary, for variation, both in size of sample and in initial moisture content.

The air from the needle valve should pref-

erably not escape directly to the atmosphere, but should preferably first escape into an auxiliary chamber from which it makes its final escape through an orifice of such size that it will build up in this auxilliary chamber a pressure much less than that corresponding to bone dry weight of the sample, yet always in excess of some definite figure, say one pound. This auxilliary chamber should preferably be connected with a second pressure gauge, which, should the pressure fall below the critical point, will set off an alarm and shut off the heat supply of the kiln. This eliminates danger of failure to function through failure of the air supply.

If desired, the needle valve of the air regulator may be operated from the lower part of the scale beam, but it then becomes less easy to use the air escaping from it to operate a safety mechanism. It will, of course, be understood that the air regulator mechanism may be widely varied in construction.

The air control equipment posssesses the advantage of very slight movement of the sample coupled with large changes in operating air pressure. Except for short connections to plug-in points, the air pipes may be permanently located in the kiln. The relatively long scale beam makes it possible to locate the sample in the middle of the pile, and still have the main mechanism in the passage-way.

Regulation of the air pressure in the line 147, in response to variations in the moisture content of the sample 19 undergoing drying, simultaneously effects the same regulation of the air pressure in the air line 159 which is connected to the air pressure elements of the dry bulb instrument 160 and the wet bulb instrument 161. The instruments 160 and 161 may be identical in principle of operation and construction, except that the wet bulb instrument operates at a lower temperature, due to the evaporation from the wick, than does the dry bulb instrument.

The instruments 160 and 161 may be generally of the usual type of temperature controller. The only additional element to the usual temperature controller is a pressure element 162 and a cam 163. The pressure element 162 registers the pressure of the air in the air chamber of the regulator 146 and hence the moisture content of the sample undergoing drying. The cam is operated by the pressure element 162 and is designed for any desired temperature schedule. When the cam 163 is moved by the pressure element, it operates to set the control pointer 164 of the temperature controller.

The pressure element and cam may be incorporated in any suitable type of temperature controller, either electrical or air operated. These additional instrumentalities may be easily arranged to set the controls on the automatic temperature and humidity controllers, or even automatic temperature and humidity controllers combined with temperature and humidity recorders.

In Fig. 6 of the accompanying drawings, the instruments 160 and 161 are diagrammatically shown as of the air operated type. Thus the instrument 160 functions to maintain the predetermined temperature conditions within the kiln in accordance with the automatic setting of the control pointer 164, and similarly the instrument 161 functions to maintain the predetermined conditions of humidity within the kiln.

The regulator 146 is provided with a pressure gauge 167 preferably calibrated to read in percent moisture. The controllers 160 and 161 are also provided with pressure gauges 168 appropriately calibrated. The equipment is further provided with safety valves, drip wells, air filters, reducing valves and the like as required and as will be understood by those skilled in the art. The control valves for the steam heating system, spray system and damper may be of any appropriate construction designed to be actuated by the controllers 160 and 161.

From the foregoing description it will be seen that, in accordance with the present invention, the lumber or wood itself, or other material being treated, automatically prescribes the proper conditions of temperature and humidity within the kiln as the drying operation progresses. The invention eliminates the need of anyone entering the kiln after the drying operation begins for the purpose of securing samples to determine the progress of the drying operation. Moreover, regardless of whether the operating conditions have been such as to slow up the drying, the control sample will not prescribe a higher temperature or lower humidity within the kiln until the moisture content of the material being dried is lowered to the point where new and more severe conditions of temperature and humidity are permissible.

While I have herein particularly described the invention as applied to the automatic control of the conditions of both temperature and humidity within the kiln, it is to be understood that the invention is equally applicable to the automatic control of either one of these conditions in response to characteristic changes in a representative sample of the material being dried, in accordance with the hereinbefore described principles of the invention.

It will be understood by those skilled in the art that the principle of the invention is capable of being practised with various types and constructions of control instrumentalities. In this specification, I have described those control instrumentalities which I now deem the preferred modes of

carrying out the invention. It will be understood that the invention is not to be limited to the particular control instrumentalities herein described. If desired, the control sample (19) may be suspended by a wire through an appropriate opening in the roof of the kiln so that all of the control instrumentalities may be located outside the kiln.

I claim:

1. The improvement in the kiln drying of materials which require varying conditions of temperature and humidity in the course of the drying operation, which comprises producing an action indicative of changes in said material as the drying operation progresses, and employing said action to establish the desired varying conditions of temperature and humidity within the kiln as the drying operation progresses.

2. The improvement in the kiln drying of materials which require different conditions of temperature and humidity as the drying operation progresses, which comprises producing an action responsive to the progressive loss in moisture of said material as the drying operation progresses, and employing said action to progressively establish predetermined different conditions of temperature and humidity within the kiln as the drying operation progresses.

3. The improvement in the kiln drying of materials which require different conditions of temperature and humidity as the drying operation progresses, which comprises producing within the kiln a continuing action responsive to the progressive loss in moisture of a representative sample of said material as the drying operation progresses, and employing said action to progressively establish predetermined different conditions of temperature and humidity within the kiln as the drying operation progresses.

4. The improvement in the kiln drying of materials which require different conditions of temperature and humidity as the drying operation progresses, which comprises producing within the kiln a continuing action responsive to the progressive loss in moisture of a representative sample of the material being dried as the drying operation progresses, and causing said action to establish and maintain predetermined different conditions of temperature and humidity within the kiln as the drying operation progresses.

5. The improvement in the kiln drying of materials which require varying conditions of temperature and humidity in the course of the drying operation, which comprises predeterming the desired varying conditions of temperature and humidity for the material to be dried, producing an action indicative of changes in a varying characteristic of the material being dried as the drying operation progresses, and employing said action to establish the desired predetermined varying conditions of temperature and humidity within the kiln as the drying operation progresses.

6. The improvement in the kiln drying of materials which require varying conditions of temperature and humidity as the drying operation progresses, which comprises producing an action indicative of changes in a varying characteristic of said material as the drying operation progresses, and causing said action to establish and maintain the desired varying conditions of temperature and humidity within the kiln as the drying operation progresses.

7. The improvement in the kiln drying of materials which require different conditions of temperature and humidity as the drying operation progresses, which comprises predetermining the desired different conditions of temperature ad humidity for the material to be dried, producing an action indicative of changes in a varying characteristic of the material being dried as the drying operation progresses, and causing said action to establish and maintain the predetermined different conditions of temperature and humidity within the kiln as the drying operation progresses.

8. The improvement in the kiln drying of materials which require different conditions of temperature and humidity in the course of the drying operation, which comprises producing within the kiln a continuing action indicative of changes in a varying characteristic of a representative sample of said material as the drying operation progresses, and employing said action to establish the desired conditions of temperature and humidity within the kiln as the drying operation progresses.

9. The improvement in the kiln drying of materials which require different conditions of temperature and humidity during the drying operation, which comprises predetermining the desired different conditions of temperature and humidity for the material to be dried, producing within the kiln a continuing action indicative of changes in a varying characteristic of a representative sample of the material being dried as the drying operation progresses, and employing said action to establish the predetermined different conditions of temperature and humidity within the kiln as the drying operation progresses.

10. The improvement in the kiln drying of materials which require different conditions of temperature and humidity during the drying operation, which comprises producing within the kiln a continuing action indicative of changes in a varying characteristic of a representative sample of said material as the drying operation progresses, and causing said action to establish and

maintain the desired different conditions of temperature and humidity within the kiln as the drying operation progresses.

11. The improvement in the kiln drying of materials which require different conditions of temperature and humidity during the drying operation, which comprises predetermining the desired different conditions of temperature and humidity for the material to be dried, producing within the kiln a continuing action indicative of changes in a varying characteristic of a representative sample of the material being dried as the drying operation progresses, and causing said action to establish and maintain the predetermined different conditions of temperature and humidity within the kiln as the drying operation progresses.

12. The improvement in the kiln drying of lumber or wood, which comprises producing within the kiln a continuing action indicative of changes in the moisture content of a representative sample of said lumber or wood as the drying operation progresses, and transmitting said action to a point outside the kiln.

13. The improvement in the method of drying materials which require different conditions of temperature and humidity in the course of the drying operation, which comprises automatically controlling the temperature and humidity of the drying medium to which the material to be dried is subjected in response to changes in a varying characteristic of the material undergoing drying as the drying operation progresses.

14. The improvement in the method of drying materials which require different conditions of temperature and humidity in the course of the drying operation, which comprises automatically controlling the temperature and humidity of the drying medium to which the material to be dried is subjected in response to changes in a varying characteristic of a representative sample of the material undergoing drying as the drying operation progresses.

15. The improvement in the method of drying materials which require different conditions of temperature and humidity in the course of the drying operation, which comprises automatically controlling the temperature and humidity of the drying medium to which the material to be dried is subjected in response to the loss in weight of a representative sample of the material undergoing drying as the drying operation progresses.

16. The improvement in the kiln drying of materials which require different conditions of temperature and humidity in the course of the drying operation, which comprises producing a continuing action indicative of the loss in weight of a representative sample of the material being dried as the drying operation progresses, and causing said action to establish and maintain the desired varying conditions of temperature and humidity within the kiln as the drying operation progresses.

17. The improvement in the kiln drying of materials which require different conditions of temperature and humidity in the course of the drying operation, which comprises predetermining the desired different conditions of temperature and humidity for the material to be dried, producing a continuing action indicative of the loss in weight of a representative sample of the material being dried as the drying operation progresses, and causing said action to establish and maintain the predetermined different conditions of temperature and humidity within the kiln as the drying operation progresses.

18. The improvement in the kiln drying of lumber or wood, which comprises producing an action responsive to the progressive loss in moisture of a representative sample of said lumber or wood as the drying operation progresses, and employing said action to establish predetermined different conditions of temperature and humidity within the kiln as the drying operation progresses.

19. The improvement in the kiln drying of lumber or wood, which comprises producing within the kiln a continuing action responsive to the progressive loss in moisture of a representative sample of said lumber or wood as the drying operation progresses, and causing said action to establish and maintain predetermined different conditions of temperature and humidity within the kiln as the drying operation progresses.

20. The improvement in the kiln drying of lumber or wood, which comprises automatically controlling the temperature and humidity of the drying medium to which the lumber or wood to be dried is subjected in response to the loss in weight of a representative sample of the lumber or wood within the kiln as the drying operation progresses.

21. The improvement in the kiln drying of materials which require different conditions of temperature and humidity during the drying operation, which comprises causing the progressive loss in moisture of a representative sample of the material being dried as the drying operation progresses to effect predetermined adjustments of temperature and humidity controllers and thereby establishing and maintaining within the kiln as the drying operation progresses predetermined different conditions of temperature and humidity.

22. The improvement in the kiln drying of materials which require different conditions of temperature and humidity during the drying operation, which comprises

establishing, in response to the progressive loss in moisture of a representative sample of the material being dried as the drying operation progresses, the setting of temperature and humidity controllers operatively arranged to substantially maintain within the kiln conditions of temperature and humidity corresponding to the settings thereof.

23. The improvement in the kiln drying of materials which require varying conditions of temperature in the course of the drying operation, which comprises producing an action indicative of changes in said material as the drying operation progresses, and employing said action to establish the desired varying conditions of temperature within the kiln as the drying operation progresses.

24. The improvement in the kiln drying of materials which require varying conditions of temperature in the course of the drying operation, which comprises producing an action indicative of changes in said material as the drying operation progresses, and employing said action to establish the desired varying conditions of humidity within the kiln as the drying operation progresses.

25. The improvement in the kiln drying of materials which require different conditions of temperature as the drying operation progresses, which comprises producing an action responsive to the progressive loss in moisture of said material as the drying operation progresses, and employing said action to progressively establish predetermined different conditions of temperature within the kiln as the drying operation progresses.

26. The improvement in the kiln drying of materials which require different conditions of humidity as the drying operation progresses, which comprises producing an action responsive to the progressive loss in moisture of said material as the drying operation progresses, and employing said action to progressively establish predetermined different conditions of humidity within the kiln as the drying operation progresses.

27. The improvement in the kiln drying of materials which require varying conditions of temperature in the course of the drying operation, which comprises producing an action indicative of changes in a varying characteristic of a representative sample of the material being dried as the drying operation progresses, and employing said action to progressively establish and maintain predetermined different conditions of temperature within the kiln as the drying operation progresses.

28. The improvement in the kiln drying of materials which require varying conditions of humidity in the course of the drying operation, which comprises producing an action indicative of changes in a varying characteristic of a representative sample of the material being dried as the drying operation progresses, and employing said action to progressively establish and maintain predetermined different conditions of humidity within the kiln as the drying operation progresses.

29. The improvement in the method of drying materials which require different conditions of temperature in the course of the drying operation, which comprises automatically controlling the temperature of the drying medium to which the material to be dried is subjected in response to changes in a varying characteristic of a representative sample of the material undergoing drying as the drying operation progresses.

30. The improvement in the method of drying materials which require different conditions of humidity in the course of the drying operation which comprises automatically controlling the humidity of the drying medium to which the material to be dried is subjected in response to changes in a varying characteristic of a representative sample of the material undergoing drying as the drying operation progresses.

31. The improvement in the kiln drying of materials which require different conditions of temperature during the drying operation, which comprises causing the progressive loss in moisture of a representative sample of the material being dried as the drying operation progresses to effect predetermined adjustments of a temperature controller and thereby establishing and maintaining within the kiln as the drying operation progresses predetermined different conditions of temperature.

32. The improvement in the kiln drying of materials which require different conditions of humidity during the drying operation, which comprises causing the progressive loss in moisture of a representative sample of the material being dried as the drying operation progresses to effect predetermined adjustments of a humidity controller and thereby establishing and maintaining within the kiln as the drying operation progresses predetermined different conditions of humidity.

33. The improvement in the kiln drying of materials which require different conditions of temperature during the drying operation, which comprises predetermining the desired different conditions of temperature for the material to be dried, producing within the kiln a continuing action indicative of changes in a varying characteristic of a representative sample of the material being dried as the drying operation progresses, and employing said action to establish and maintain the predetermined different conditions of temperature within the kiln as the drying operation progresses.

34. The improvement in the kiln drying of materials which require different conditions of humidity during the drying operation, which comprises predetermining the desired different conditions of humidity for the material to be dried, producing within the kiln a continuing action indicative of changes in a varying characteristic of a representative sample of the material being dried as the drying operation progresses, and employing said action to establish and maintain the predetermined different conditions of humidity within the kiln as the drying operation progresses.

In testimony whereof I affix my signature.

JOHN BERCHMANS WELCH.

34. The improvement in the kiln drying of materials which require different conditions of humidity during the drying operation, which comprises predetermining the desired different conditions of humidity for the material to be dried, producing within the kiln a continuing action indicative of changes in a varying characteristic of a representative sample of the material being dried as the drying operation progresses, and employing said action to establish and maintain the predetermined different conditions of humidity within the kiln as the drying operation progresses.

In testimony whereof I affix my signature.

JOHN BERCHMANS WELCH.

Certificate of Correction.

It is hereby certified that in Letters Patent No. 1,567,559, granted December 29, 1925, upon the application of John Berchmans Welch, of New Orleans, Louisiana, for an improvement in "Drying Wood, Lumber, and the Like," errors appear in the printed specification requiring correction as follows: Page 2, line 44, for the word "kilns" read *kiln;* page 5, line 19, for the word "conductor" read *conductors;* page 10, line 86, claim 7, for the misspelled word "ad" read *and;* page 12, line 20, claim 24, for the word "temperature" read *humidity;* and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 20th day of July, A. D. 1926.

[SEAL.]

M. J. MOORE,
Acting Commissioner of Patents.

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