

July 27, 1926.

1,593,890

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APPARATUS FOR DRYING AND THE LIKE

Filed Feb. 17, 1925

Fig. 1

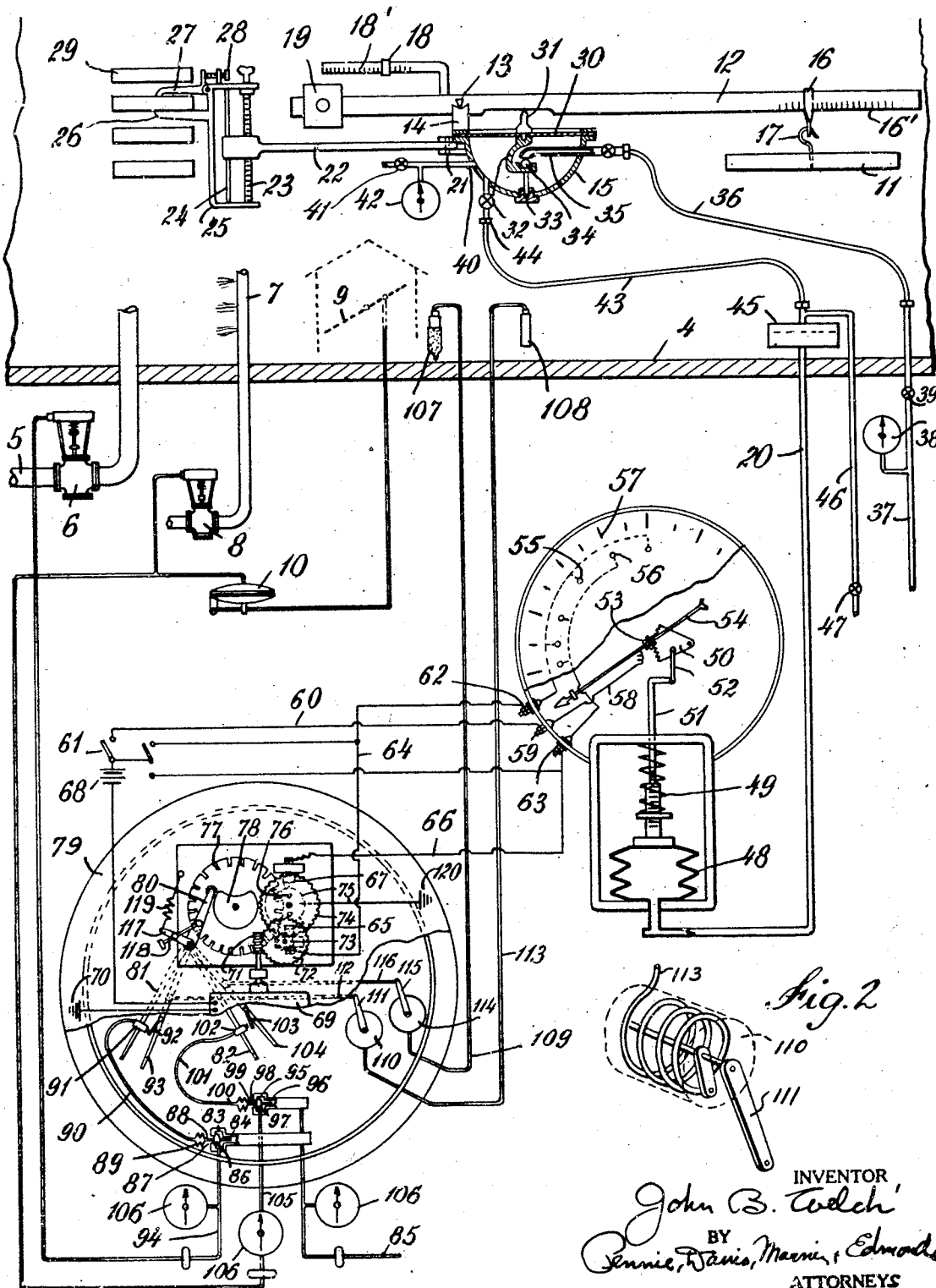


Fig. 2

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APPARATUS FOR DRYING AND THE LIKE.

Application filed February 17, 1925. Serial No. 9,768.

This invention relates to apparatus for drying and the like. Particularly, the invention relates to apparatus for drying materials, such as lumber, wood, or the like, requiring different conditions of humidity or temperature or both during the drying operation. In its more general aspect, the invention relates to apparatus for treating materials requiring progressively different conditions of an operating medium as the material being treated undergoes characteristic changes in the course of the treatment operation.

The invention has for its object the provision of an improved apparatus of the character above described. More particularly, the invention aims to provide an improved apparatus for treating materials requiring progressively different conditions of an operating medium as the material being treated undergoes characteristic changes in the course of the treatment operation, in which the condition of such operating medium is automatically controlled in response to the characteristic changes in a representative sample of the material being treated so as to progressively establish and maintain the different conditions of such operating medium required in the course of the treatment operation. As applied to drying apparatus, the invention aims to provide an improved apparatus for drying materials, such as lumber or wood, in which the temperature or humidity or both of the drying medium are automatically controlled in response to changes in a varying characteristic (such as weight or moisture content) of the material being dried as the drying progresses.

The improved apparatus of the invention is especially adapted for the drying of lumber or wood, and on this account the invention will hereinafter be more particularly described as applied to that industry. It is to be understood, however, that the improved apparatus of the invention is applicable to the drying or treatment of other materials where progressively different conditions of an operating medium are required as the material being treated undergoes characteristic changes as a result of the treatment operation.

The improved apparatus of the invention

is especially adapted for carrying out the method of drying lumber, wood, and the like, described and claimed in my copending application for Letters Patent of the United States filed May 24, 1924, Serial No. 715,516.

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 that are easily subject to splitting in drying must be treated at low temperature and 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 placed 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 operations. 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 time schedule. As a result, there is often a considerable loss of lumber due to splitting caused by too rapid drying.

In the improved apparatus of the present invention, a representative sample of the material being treated indicates or automatically prescribes the appropriate different conditions of the operating medium required in the course of the treatment operation. Thus, the representative sample is operatively associated with appropriate control means for producing an action indicative of the characteristic changes (such, for example, as changes in weight or moisture content) in the representative sample as the treatment operation progresses. This action, in the improved apparatus of the invention, regulates the pressure in a fluid pressure system or compressed air equipment in such manner that the pressure in the system varies in response to said characteristic changes and is accordingly indicative of such characteristic changes. The pressure in the system then actuates an appropriate indicator or appropriate controlling instrumentalities for establishing and maintaining different desired conditions of the operating mediums, such, for example, as different conditions of temperature or humidity or both within a lumber-drying kiln. In one of its aspects, the improved apparatus of the invention comprises a control means within the drying apparatus and responsive to characteristic changes in a representative sample of the material being dried in combination with a fluid pressure system for transmitting the action of the control means to a convenient location outside the kiln, at which location the transmitted action may be employed to actuate an indicating instrument or to actuate the controlling instrumentalities, or both, as desired.

The novel features of the invention will be more fully understood from the following description taken in conjunction with the accompanying drawing, in which:

Fig. 1 is a diagrammatic illustration of what I now consider the preferred embodiment of the invention; and

Fig. 2 is a diagrammatic perspective view of a temperature helical coil (which is simi-

lar to the humidity helical coil described below).

The apparatus illustrated in the drawing is particularly adapted for controlling the conditions of temperature and humidity within a lumber drying kiln, and is shown in the drawing as applied to that purpose. One of the walls of the kiln is represented by reference numeral 4, and it is to be understood that the apparatus shown in the drawing above this wall is located within the kiln while the apparatus shown in the drawing below this wall is located outside the kiln.

The kiln is provided with heating pipes adapted to be supplied with steam from a steam main 5. A compressed air operated valve 6 is included in the steam main 5 and is adapted to be manipulated by the automatic temperature controlling instrumentalities hereinafter described. The kiln is further provided with a spray system 7 in the supply pipe of which is positioned a compressed air operated valve 8. The kiln is further provided with a damper 9 arranged to be manipulated by the compressed air operated valve 10. The spray valve 8 and damper valve 10 are actuated by the automatic humidity controlling instrumentalities hereinafter described.

A representative sample 11 of the lumber (or other material) to be dried is appropriately associated with a special type of scales or balancing device operatively mounted within the kiln. The sample 11 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. In the drying of lumber, the sample 11 may conveniently be approximately 8 inches wide, 24 inches long and the average thickness of the lumber undergoing drying.

The scales or balancing device of the improved apparatus of the invention comprises a balance beam or arm 12 operatively supported by a pair of knife edge pivots 13, one on each side of the beam. The seats or rests of the pivots 13 are formed in posts 14 extending upwardly from a hollow semi-spherical casing 15.

A carrier 16 is movably mounted on the right-hand side of the beam 12, as viewed in the drawing. The carrier has a depending hook adapted to engage a hook 17 screwed or otherwise secured to the sample 11, whereby the sample is supported by and movable with the carrier. A weight 18 is operatively associated with the left-hand side of the beam 12, as viewed in the drawing, and is designed to exactly counter-balance the carrier 16. To this end, the carrier 16 and weight 18 are preferably of exactly the same weight and scales 16' and 18' are operatively associated with these elements so

that when the elements occupy corresponding positions with respect to these scales the beam 12 is exactly balanced so far as these elements are concerned. A counter-
 5 balance 19 is operatively associated with the left-hand side of the beam 12, as viewed in the drawing, for balancing the beam.

The fluid pressure system of the improved apparatus of the invention comprises an
 10 automatic regulator mounted within the casing 15, operated by compressed air, or other appropriate elastic fluid, and controlled by the weight of the sample of material (11) being dried, the initial moisture content of
 15 which is known but the size and weight 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 a pipe or line 20 (outside the
 20 kiln) a pressure corresponding quantitatively to the percent of moisture in the sample 11. The variations in pressure in the line 20 are then used to actuate an indicator or to actuate appropriate automatic controlling instrumentalities, or both, as desired.

The casing 15 is pivoted at 21 to a substantially horizontal arm 22. The arm 22 is carried by a vertically disposed screw 23
 30 and vertically disposed guide post 24. The screw 23 and post 24 are mounted between the arms of a U-shaped bracket 25 provided with a lower supporting extension 26 and an upper adjustable supporting extension 27.
 35 An adjusting screw 28, cooperating with the bracket 25 and supporting extension 27, permits leveling of the arm 22 and scale beam 12. The screw 23 permits adjustment of the height of the arm 22 and scale beam 12.
 40 The supporting extensions 26 and 27 are appropriately secured to the stack of lumber 29 piled within the kiln for drying. By turning the casing 15, and hence the scale beam 12, about the pivot 21, the sample 11
 45 can be swung inside of the lumber pile where it encounters substantially the same average drying influences as the lumber itself.

A circular diaphragm 30 of rubber, or other appropriate material, is operatively
 50 associated with the casing 15 and carries a centrally positioned knife edge 31 upon which operatively rests the right-hand side (as viewed in the drawing) of the scale
 55 beam 12. A valve support 32 is secured to the underside of the diaphragm 30 and is freely movable with the diaphragm, being guided by a pin 33 fitting in an appropriate opening in the bottom of the casing 15.
 60 The support 32 carries the movable element 34 of a ball valve, the stationary element of the ball valve being the inner open end of a pipe 35 extending through the casing 15.

The pipe 35 is connected by a flexible tube
 65 36 with a compressed air supply pipe 37,

outside the kiln. The compressed air supply pipe 37 may be connected with any appropriate source of compressed air, and has associated therewith a pressure gauge 38
 70 and valve 39.

A bleeder pipe 40 communicates with the interior of the casing 15 and is provided with a control valve 41 and has operatively associated therewith a pressure gauge 42.
 75 The gauge 42 is preferably calibrated in percent moisture from 0% to 200%. A flexible pipe or tube 43 communicates at one end, through a coupling 44, with the interior of the chamber 15, and at its other end is operatively connected to a reservoir 45 containing compressed air and also a liquid.
 80 A bleeder pipe 46 communicates with the flexible tube 43 and extends through the kiln wall 4 and is provided with a valve 47 outside the kiln whereby the compressed air within the casing 15 of the automatic compressed air regulator can be appropriately bled out from without the kiln.

The liquid in the reservoir 45 fills the pipe or line 20 and the metal diaphragm 48, of the bellows type as shown in the drawing. Expansion of the diaphragm 48 is opposed by a spring 49. Expansion and contraction of the diaphragm 48 is transmitted to a pivoted sector-shaped rack 50 through a rod
 90 51 and link 52. A pinion 53 meshes with the rack 50. A combined electric contact and pointer 54 is secured to the pinion 53 and is adapted to sweep over and alternately engage two series of stationary electric contacts 55 and 56. A scale or dial 57 is associated with the pointer 54 and is graduated in percentage moisture from 0% to 200%.

The movable contact pointer 54 is electrically connected by a conductor 58 to a terminal or binding post 59 and thence by a conductor 60 to one contact of a switch 61.
 105 The stationary contacts 55 are electrically connected together and to a terminal or binding post 62. The contacts 56 are similarly connected together and to a binding post 63. A conductor 64 connects the binding post 62 to a stationary contact 65, and similarly the terminal 63 is connected by a conductor 66 to a stationary contact 67.

The switch 61 is connected through a battery 68, or other appropriate source of electric energy, to one terminal of a constant speed electric motor 69, the other terminal
 120 of the motor being grounded at 70.

The shaft of the motor 69 carries a worm 71 meshing with a gear 72. A pinion 73 is secured to the gear 72 and meshes with a gear 74 to which is secured a movable contact 75. The movable contact 75 rotates with the gear 74 and has a substantially semi-circular contact element of such configuration that it is always in engagement
 125 with either one or the other of the contacts

65 and 67 and in two positions of each revolution engages both of the contacts 65 and 67.

The contact 75 carries two diametrically positioned pins 76 adapted (in consequence of the rotation of the contact 75) to alternately engage the teeth of a star wheel 77. A temperature-adjusting cam 78 is secured to the star wheel 77, and similarly a humidity-adjusting cam (not shown) is also secured to the star wheel.

The movable contact 75 is electrically grounded at 120. The contacting element of the stationary contacts 65 and 67 is preferably a pair of resilient spaced contact springs between which the contacting element of the movable contact 75 passes, as in the well-known electric knife switches.

The contacts 65 and 67, the star wheel 77 and associated elements are preferably combined and mounted in a single instrument case indicated generally by reference character 79 in the drawings.

A cam lever arm 80 is associated with the cam 78 and is operatively connected to a temperature-setting means or pointer 81. It will be understood that movement of the lever 80 is appropriately transmitted to the pointer 81. Similarly, a humidity-setting means or pointer 82 is operatively connected to and adapted to be actuated by the humidity-adjusting cam secured to the star wheel 77, not shown in the accompanying drawing for the sake of simplicity.

A duplex valve mechanism is mounted within the case 79 of the combined temperature and humidity controller illustrated in the accompanying drawing. This mechanism comprises a temperature control valve having a valve chamber 83 which communicates by a passage 84 with a compressed air supply pipe 85. The valve chamber 83 contains a valve head 86 adapted to open or close a port 87 to the atmosphere and simultaneously to close or open (respectively) the passage 84. The valve head 86 is carried by a hollow valve stem 88 providing communication between the valve chamber 83 and a bellows diaphragm 89. The diaphragm 89 communicates by a flexible tubing 90 with an air nozzle 91 mounted upon the temperature-setting pointer 81. A flapper valve 92 is mounted upon a temperature-indicating pointer 93 so as to close the air nozzle 91 as the temperature-indicating pointer 93 moves into a predetermined position with respect to the temperature-setting pointer 81. An air pipe 94 provides communication between the valve chamber 83 and the air operated steam valve 6.

The humidity control valve is of similar construction to the temperature control valve and comprises a valve chamber 95 having a passage 96 connected to the air supply pipe 85. A valve head 97 is adapted

to open or close a port 98 to the atmosphere and simultaneously to close or open (respectively) the passage 96. The valve head 97 is mounted on a hollow valve stem 99 communicating between the valve chamber 95 and a bellows diaphragm 100. The diaphragm 100 communicates by a flexible tubing 101 with an air nozzle 102 mounted on the humidity setting pointer 82. A flapper valve 103 is mounted on a humidity-indicating pointer 104 so as to close the air nozzle 102 as the humidity-indicating pointer 104 approaches within a predetermined distance of the humidity-setting pointer 82. An air pipe 105 communicates between the valve chamber 95 and the air operated spray valve 8. The air pipe 105 also communicates with the damper valve 10 for opening or closing the damper 9.

The air pipes 85, 94 and 105 are provided with pressure gauges 106 to indicate the air pressure in these lines.

The temperature indicating pointer 93 is actuated by a temperature element or dry pulp 108, while the humidity indicating pointer 104 is actuated by a wet bulb 107. The temperature element or dry bulb 108 is of the usual type, containing a volatile liquid which, when subjected to heat, volatilizes and the resulting vapor pressure is transmitted through a flexible tube 113 to a helical coil 110. The movement of the helical coil 110 is transmitted to the temperature indicating pointer 93 by means of links 111 and 112. The humidity-indicating pointer 104 is actuated in like manner by the wet bulb 107 through the flexible tube 109, helical coil 114 and the links 115 and 116.

The operation of the apparatus is substantially as follows. The initial moisture content in percent of the representative sample 11 is first determined. This may conveniently be done by the autocalculator, a device for directly measuring or indicating the moisture content of a sample of lumber. The hook 17, having been appropriately secured to the sample 11, is then used to suspend the sample from the carrier 16. The carrier 16 and weight 18 are then correspondingly moved along their respective beams until the indicating gauge 42 registers the percent of moisture contained in the sample. The sample 11 need not be of any particular weight, it only being necessary that its weight be within the range of the control scales. In other words, the exact weight of the sample need not be known, but the moisture content of the sample must be known. The carrier 16 and weight 18 will occupy corresponding positions with respect to their cooperating scales 16' and 18', respectively. Under such circumstances, the weight of the carrier is al-

ways exactly counterbalanced by the weight 18.

For purposes of explanation, let us assume that the sample 11 is found to have a moisture content of 80%. This means that the lumber to be dried has a moisture content of approximately 80%. The carrier 16, with the suspended sample 11, is then moved along the scale beam until the gauge 42 registers 80%, it being understood, of course, that the weight 18 is simultaneously moved with the carrier 16 to its appropriate counterbalancing position. Thereafter (as the moisture content of the sample 11 decreases in the course of the drying operation) the pressure gauge 42, as well as the position of the pointer 54 with respect to the scale 57, will directly indicate the actual percentage moisture content of the sample 11.

Air, or other appropriate elastic fluid, is supplied at constant pressure through the pipes 36 and 37 to the interior of the casing 15. The pressure within the casing rises until the pressure on the bottom of the diaphragm 30 is just slightly in excess of the pressure on the top of the diaphragm due to the resting of the scale beam 12 on the knife edge 31, whereupon the diaphragm slightly lifts the movable element 34 of the ball valve and the supply of air to the interior of the casing 15 is thereby interrupted by the closing of the ball valve. Air escapes from the interior of the casing 15 through the bleed valves 41 and 47, appropriately adjusted, and the air pressure within the casing thereupon becomes so lowered that the ball valve opens and compressed air again enters the casing from the pipes 36 and 37. Actually, the ball valve will open just enough to permit the air to enter the casing 15 at such a rate as to keep the pressure within the casing just sufficient to balance the weight of the sample 11, whereby the scale beam 12 is always maintained in balance, and the air pressure within the casing 15 is always directly proportional to the moisture content of the sample 11.

In other words, as the representative sample 11 decreases in weight, in the course of the drying operation, the pressure within the system automatically becomes less, because the pressure at the knife edge 31 is less, allowing a lighter pressure operating against the diaphragm 30 to seat the ball valve 34. In order to allow the escape of the excess pressure, the valve 41 allows the air to bleed through the pipe 40, and/or the valve 47 allows the air to bleed through the pipe 46, so that the air pressure within the regulator casing 15 always corresponds to a definite weight or pressure applied at the knife edge 31.

Accordingly, the pressure gauge 42, within the kiln, and the indicator (54-57), without the kiln, each directly registers the

actual percentage moisture of the sample 11 as the drying operation progresses. If desired, the readings of the indicator 54-57 may be employed as a guide for the manual adjustment of the temperature and humidity setting instrumentalities. In other words, the operator obtains from the indicator the actual moisture content of the lumber being dried as the drying operation progresses and he sets or adjusts the temperature controller and the humidity controller to establish and maintain the desired different conditions of temperature and humidity within the kiln prescribed by the drying schedule. In the improved apparatus of the invention, in its complete form, the indicator 54-57 automatically sets or adjusts the controlling instrumentalities for establishing and maintaining the prescribed conditions of temperature and humidity throughout the entire drying operation.

As the moisture content of the sample 11 decreases, in the progress of the drying operation, the contact pointer 54 engages first a contact 55 and then a contact 56, and so on alternately engaging a contact 55 and a contact 56 throughout the drying operation. When the pointer 54 engages a contact 55, the contact element 75 will be in engagement with the contact 65 and the electric motor 69 will be energized through the circuit 62-64-65-75-ground-motor-68-61-60-59-58-54-55. The motor will thereupon operate to turn the gear 74 and contact 75 through one-half revolution, when the contact 75 will move out of engagement with the contact 65, but not until the contact 75 has moved into engagement with the contact 67. As the drying progresses, the pointer 54 moves from engagement with one of the contacts 55 into engagement with the next adjacent contact 56, whereupon the electric motor is energized and the carrier 74 and contact 75 turned through half a revolution. This sequence of operations is repeated throughout the entire drying operation.

Each time the electric motor 69 is energized, one of the pins 76 engages in a tooth of the star wheel 77 and turns the star wheel through a predetermined angle. This movement of the star wheel is transmitted to the temperature-adjusting cam 78 and to the humidity-adjusting cam (not shown). In this manner, the temperature-setting pointer 81 is moved a predetermined prescribed amount as a result of its operative connection with the cam lever 80 each time the electric motor 69 is energized. Likewise, the humidity-setting pointer 82 is moved a predetermined prescribed amount each time the motor is energized.

The star wheel 77 is moved uniformly, that is, through the same angle each time the motor 69 is energized. The temperature-ad-

justing cam 78 is designed to progressively move the temperature-setting pointer 81 so as to maintain within the kiln a desired drying schedule with respect to temperature throughout the entire drying operation. Different drying schedules may be obtained, as required, by employing temperature-adjusting cams 78 of the appropriate different configuration or design.

When the valve head 86 closes the port 87 and opens the passage 84, the air supply through pipe 85 is in direct communication with the air pipe 94, thereby permitting compressed air to pass into the pipe 94 and open the steam valve 6, whereupon steam enters the heating pipes within the kiln. So long as the temperature within the kiln remains lower than the predetermined temperature prescribed by the position of the temperature-setting pointer 81, the valve 6 will remain open. As the temperature within the kiln rises (due to the open steam valve 6), the temperature-indicating pointer 93 moves towards the temperature-setting pointer 81 until the temperature within the kiln reaches the predetermined prescribed temperature, whereupon the flapper valve 92 engages and closes the air nozzle 91. This causes the air pressure to be thrown back into the bellows diaphragm 89, which thereupon expands and moves the valve head 86 to close the passage 84, thereby permitting the compressed air in the pipe 94 and steam valve 6 to escape to the atmosphere through the port 87 in the valve chamber 83. The steam valve 6 thereupon closes and shuts off the steam supply to the kiln. When the temperature within the kiln has again fallen to below the predetermined prescribed temperature, the temperature-indicating pointer 93 will move away from the temperature-setting pointer 81, causing disengagement between the nozzle 91 and the flapper valve 92. The bellows diaphragm 89 will then contract and permit the valve head 86 to return to its original position, whereupon the steam valve 6 is again opened by the action of the compressed air in the pipe 94.

In a similar manner, when the humidity within the kiln falls below the predetermined prescribed condition, the humidity-indicating pointer 104 will move towards the humidity setting pointer 82 until the flapper valve 103 closes the air nozzle 102. This causes the escape of the compressed air in the pipe 105 and the attendant appropriate manipulation of the spray valve 8 and damper valve 10 for increasing the humidity within the kiln.

As the drying operation progresses, the moisture content of the material being dried becomes lower and more severe conditions of temperature and humidity become possible. The loss in weight of the representative sample 11 sets in action the controlling

means and instrumentalities that establish and maintain these different and more severe conditions of temperature and humidity. Any appropriate or desired schedule of temperature and humidity conditions may be established and maintained within the kiln by employing a temperature-adjusting cam (47) and a humidity-adjusting cam of the proper designs.

In the apparatus illustrated in the drawing, the temperature-setting pointer 81 is adjustably connected to the cam lever arm 80 so that the cam schedule may, if desired, be adjusted to read higher or lower over the whole course of the cam's action. Thus, the pointer 81 is rigidly secured to an arm 117. The arm 117 is adjustably connected to the cam arm 80 by a threaded rod 118. The rod 118 engages screw-threaded elements secured to the arms 80 and 117 in such a manner that by turning the rod 118 the relative positions of the cam arm 80 and pointer 81 are appropriately adjusted. A spring 119 is secured to the arm 117 and holds the cam-follower of the arm 80 against the cam 78.

An appropriate scale may, if desired, be associated with the star wheel 77 whereby the moisture content of the representative sample 11 can be directly read at any time during the drying operation. This is possible because the movement of the star wheel 77 is directly proportional to the loss in moisture of the representative sample. By this means the moisture content of the material being dried can be accurately indicated wherever the controlling instrumentalities are located which may, of course, be remote from the kiln itself.

The improved apparatus of the invention is mechanically simple in construction and accurate in operation. Of the parts necessarily positioned within the kiln, there are only two points of operating contact, namely, the knife edges 13 and 31. The parts of the apparatus which must be mounted within the kiln are constructed and arranged in such a manner that substantially no injury is caused them by the hot gases and moisture within the kiln. The fluid pressure system of the apparatus is accurately and effectively controlled by the balancing device, so that the pressure in the system changes in response to changes in weight of the sample 11. Thus, the change or loss in weight of the sample 11, as the drying progresses, produces an action (pressure of the beam 12 on knife edge 31) that influences the regulator of the fluid pressure system to effect corresponding changes in the pressure in the system. And the changes of pressure in the system actuate the temperature or humidity or both controllers, or appropriate indicators, as desired.

While I have described and illustrated an

apparatus embodying a combined temperature and humidity controller in a single casing or instrument, it will be readily understood by those skilled in the art that the principles of the invention are equally applicable to an apparatus embodying a temperature controller alone or a humidity controller alone, or an independent temperature controller and an independent humidity controller.

While the embodiment of the invention herein described and illustrated is especially suited for the drying of lumber or wood, it will be understood by those skilled in the art that this particular embodiment of the invention is equally well adapted for use in the drying of other materials requiring different conditions of temperature or humidity or both in the course of the drying operation. Furthermore, the principles of the invention are applicable to many industries and uses where different conditions of one or more operating media are required in the course of a treatment operation. Thus, in many manufacturing processes, different conditions of one or more operating media are necessary as certain characteristic changes are encountered and the apparatus of the invention may advantageously be employed to automatically establish and maintain such different operating conditions in response to such characteristic changes.

I have explained my invention by illustrating and describing a certain specific embodiment thereof but various modifications of the details of construction and arrangement of parts in this embodiment of the invention will present themselves to those skilled in the art. I, accordingly, do not wish to be restricted to the particular form or construction disclosed herein by way of example for the purpose of setting forth my invention in accordance with the patent statutes. The terms of the appended claims are, therefore, not restricted to the precise structure disclosed but are intended to cover all changes and modifications within the spirit and scope of the invention.

I claim:

1. The combination in a drying apparatus having temperature varying means and a controller cooperating therewith for maintaining any desired condition of temperature within the apparatus, of a fluid pressure system, control means adapted to vary the pressure within said system in response to changes in weight of a representative sample of the material being dried as the drying operation progresses, and means responsive to the pressure in said system for adjusting said controller to maintain predetermined different conditions of temperature within the drying apparatus as the drying operation progresses.

2. The combination in a drying apparatus

having humidity varying means and a controller cooperating therewith for maintaining any desired condition of humidity within the apparatus, of a fluid pressure system, control means adapted to vary the pressure within said system in response to changes in weight of a representative sample of the material being dried as the drying operation progresses, and means responsive to the pressure in said system for adjusting said controller to maintain predetermined different conditions of humidity within the drying apparatus as the drying operation progresses.

3. The combination in a drying apparatus having temperature varying means and humidity varying means and controllers cooperating therewith for maintaining any desired conditions of temperature and humidity within the apparatus, of a fluid pressure system, control means adapted to vary the pressure within said system in response to changes in weight of a representative sample of the material being dried as the drying operation progresses, and means responsive to the pressure in said system for adjusting said controllers to maintain predetermined different conditions of temperature and humidity within the drying apparatus as the drying operation progresses.

4. The combination in a drying apparatus, of a fluid pressure system including a regulator for controlling the pressure therein, control means within said apparatus operatively associated with said regulator and responsive to changes in weight of a representative sample of the material being dried as the drying operation progresses whereby changes in weight of said sample produce corresponding changes in pressure in said system, and indicating means outside the apparatus actuated by the pressure in said system.

5. In a drying apparatus, means for producing an action indicative of the loss in weight of a representative sample of the material undergoing drying, means for causing said action to so control a fluid pressure that the pressure is indicative of the changes in weight of said sample and indicating means actuated by said fluid pressure.

6. In a drying apparatus, means for producing an action indicative of the loss in weight of a representative sample of the material undergoing drying, means for causing said action to so control a fluid pressure that the pressure is indicative of the changes in weight of said sample, and controlling instrumentalities adapted to be adjusted by said fluid pressure so as to establish and maintain different operating conditions within the drying apparatus as said representative sample changes in weight.

7. The combination in a drying apparatus

having temperature varying means and a controller cooperating therewith for maintaining any desired condition of temperature within the apparatus, of a fluid pressure system including a regulator for controlling the pressure therein, control means including a balancing device responsive to changes in weight of a representative sample of the material being dried as the drying operation progresses, said control means and said regulator being operatively so connected that changes in weight of said sample influence said regulator to effect corresponding changes in the pressure in said system, and means responsive to the pressure in said system for adjusting said controller to maintain predetermined different conditions of temperature within the drying apparatus as the drying operation progresses.

8. The combination in a drying apparatus having humidity varying means and a controller cooperating therewith for maintaining any desired condition of humidity within the apparatus, of a fluid pressure system including a regulator for controlling the pressure therein, control means including a balancing device responsive to changes in weight of a representative sample of the material being dried as the drying operation progresses, said control means and said regulator being operatively so connected that changes in weight of said sample influence said regulator to effect corresponding changes in the pressure in said system, and means responsive to the pressure in said system for adjusting said controller to maintain predetermined different conditions of humidity within the drying apparatus as the drying operation progresses.

9. The combination in a drying apparatus having temperature varying means and humidity varying means and controllers cooperating therewith for maintaining any desired conditions of temperature and humidity within the apparatus, of a fluid pressure system including a regulator for controlling the pressure therein, control means including a balancing device responsive to changes in weight of a representative sample of the material being dried as the drying operation progresses, said control means and said regulator being operatively so connected that changes in weight of said sample influence said regulator to effect corresponding changes in the pressure in said system, and means responsive to the pressure in said system for adjusting said controller to maintain predetermined different conditions of temperature and humidity within the drying apparatus as the drying operation progresses.

10. The combination in a drying apparatus, of a fluid pressure system including a regulator for controlling the pressure therein, control means including a balancing de-

vice responsive to changes in weight of a representative sample of the material being dried as the drying operation progresses, said control means and said regulator being operatively so connected that changes in weight of said sample influence said regulator to effect corresponding changes in the pressure in said system, and indicating means actuated by the pressure in said system.

11. In a drying apparatus, the combination of controlling instrumentalities adapted to be adjusted so as to establish and maintain different conditions of temperature within the apparatus, a fluid pressure system, control means adapted to vary the pressure in said system in response to changes in weight of a representative sample of the material being dried as the drying operation progresses, and means whereby the pressure in said system actuates said controlling instrumentalities.

12. In a drying apparatus, the combination of controlling instrumentalities adapted to be adjusted so as to establish and maintain different conditions of humidity within the apparatus, a fluid pressure system, control means adapted to vary the pressure in said system in response to changes in weight of a representative sample of the material being dried as the drying operation progresses, and means whereby the pressure in said system actuates said controlling instrumentalities.

13. In a drying apparatus, the combination of controlling instrumentalities adapted to be adjusted so as to establish and maintain different conditions of temperature and humidity within the apparatus, a fluid pressure system, control means adapted to vary the pressure in said system in response to changes in weight of a representative sample of the material being dried as the drying operation progresses, and means whereby the pressure in said system actuates said controlling instrumentalities.

14. In an apparatus for the treatment of materials requiring progressively different conditions of an operating medium as the material being treated undergoes characteristic changes in the course of the treatment operation, the combination of means for producing within the apparatus an action indicative of said characteristic changes in a representative sample of the material being treated, means for causing said action to so control a fluid pressure that the pressure is indicative of said characteristic changes in said sample, and indicating means outside the apparatus actuated by said fluid pressure.

15. In an apparatus for the treatment of materials requiring progressively different conditions of an operating medium as the material being treated undergoes charac-

teristic changes in the course of the treatment operation, the combination of controlling instrumentalities adapted to be adjusted so as to establish and maintain different conditions of said operating medium, means including a fluid pressure responsive to said characteristic changes in a representative sample of the material being treated, and means actuated by said fluid pressure for adjusting said controlling instrumentalities to progressively establish and maintain the different conditions of said operating medium required in the course of the treatment operation.

15 16. In an apparatus for the treatment of materials requiring progressively different conditions of an operating medium as the material being treated undergoes characteristic changes in the course of the treatment operation, the combination of controlling instrumentalities adapted to be adjusted so as to establish and maintain different conditions of said operating medium, a fluid pressure system, control means responsive to characteristic changes in a representative sample of the material undergoing treatment for regulating the pressure in said system, and means whereby the pressure in said system actuates said controlling instrumentalities.

17. In an apparatus for the treatment of materials requiring progressively different conditions of an operating medium as the material being treated undergoes characteristic changes in the course of the treatment operation, the combination of controlling instrumentalities adapted to be adjusted so as to establish and maintain different conditions of said operating medium, a fluid pressure system including a regulator for controlling the pressure therein, control means including a balancing device responsive to said characteristic changes in a representative sample of the material being treated, said control means and said regulator being operatively so connected that said characteristic changes in said

sample influence said regulator to effect corresponding changes in the pressure in said system, and means responsive to the pressure in said system for adjusting said controlling instrumentalities to progressively establish and maintain the different conditions of said operating medium required in the course of the treatment operation.

18. In an apparatus for the treatment of materials requiring progressively different conditions of an operating medium as the material being treated undergoes characteristic changes in the course of the treatment operation, the combination of a fluid pressure system including a regulator for controlling the pressure therein, control means including a balancing device responsive to said characteristic changes in a representative sample of the material being treated, said control means and said regulator being operatively so connected that said characteristic changes in said sample influence said regulator to effect corresponding changes in the pressure in said system, and indicating means actuated by the pressure in said system.

19. In an apparatus for the treatment of materials requiring progressively different conditions of an operating medium as the material being treated undergoes characteristic changes in the course of the treatment operation, the combination of a fluid pressure system including a regulator for controlling the pressure therein, control means within said apparatus operatively associated with said regulator and responsive to said characteristic changes in a representative sample of the material being treated whereby said characteristic changes produce corresponding changes in pressure in said system, and indicating means outside the apparatus actuated by the pressure in said system.

In testimony whereof I affix my signature.

JOHN BERCHMAN WELCH.