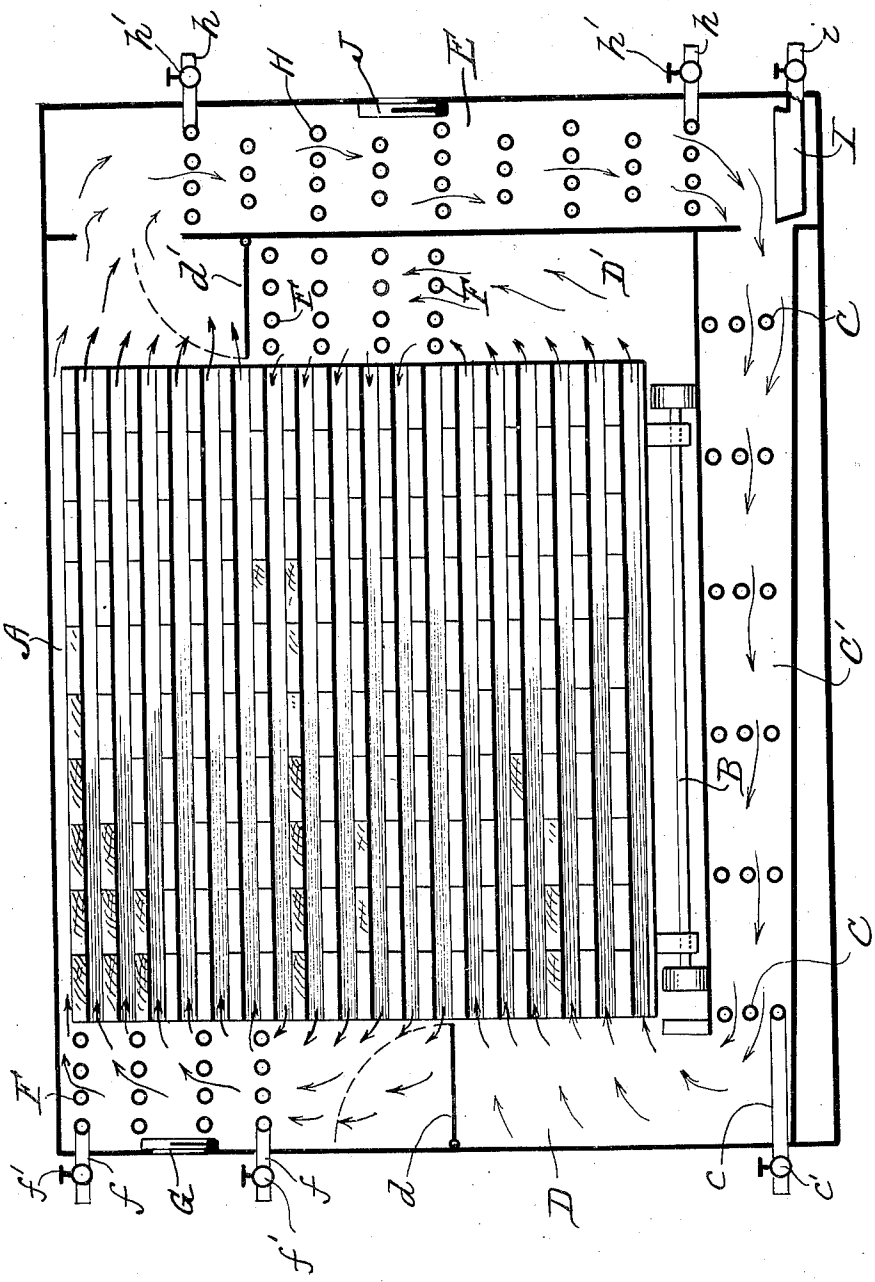
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G. D. HARRIS

ART OF DRYING

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# UNITED STATES PATENT OFFICE.

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## ART OF DRYING.

Application filed October 20, 1922. Serial No. 595,747.

*To all whom it may concern:*

Be it known that I, GORDON DON HARRIS, a citizen of the United States, residing at Freeport, county of Nassau, and State of New York, have invented a certain new and useful Art of Drying, of which the following is a specification.

Preliminary to drying certain materials, such as wood, it is desirable, by tests, to determine certain physical characteristics of said material, such as the water content thereof, and the rate at which the contained water spreads or diffuses through the fibres, and within said material, in order for the water content to reach the surface of the body of the material.

In the process of drying wood, it is known that as the contained water within the material decreases, due to surface evaporation, the spreading or diffusing of the water content becomes slower, and, further, that such spreading and diffusing of the water content does not take place uniformly throughout the mass of the material, this unequal spreading in the case of wood being due to a natural physical formation of the material, as well as the presence of one or more inherent constituents of such material. As a result of the unequal diffusion of the moisture content within the material, there occurs, at regular or irregular stages of the drying period, a dry surface on the material, i. e., a surface free or substantially free from moisture, and when heat is steadily supplied for a certain period to such dry areas by the flow of a drying atmosphere into continued contact therewith, it follows that such application of heat to such dry surfaces tends to increase the temperature of the wood, as well as to increase the temperature of the water content therein, the effect of which is to expand the water content and to disrupt the fibres, resulting in warping or checking of the wood, as well as producing an indurated or hardened surface on the wood at the previously dry areas, attaining the undesirable condition known as "case hardening".

With a view to the economical and practical drying of materials of that character wherein the diffusion of the water content takes place irregularly and unequally, the process of drying is required to be controllable at will with a view to so conditioning the drying atmosphere at different stages that such atmosphere is suited to the condition of the material. In this invention, the process is based upon a physical law demanding equalization of two bodies of different densities, one of such bodies, in this instance, being the material with a known moisture content and with a given rate of diffusion of such content, and the other body being a drying atmosphere with a determined, although controllable, humidity and temperature.

Accordingly, the drying atmosphere flowing into contact with material placed within a closed chamber is controllable as regards both the temperature and humidity of such atmosphere, at any and all stages of the evaporation, to the end that the temperature can range from high to low, or vice versa, together with the control of the humidity of such atmosphere to attain different percentages of moisture content throughout the drying period, whereby the atmosphere is suited at different stages in the drying operation to correspond with variations in the water content of the material, and particularly to the surface condition, either wet or dry, of the material undergoing treatment.

Obviously, the humidity of the atmosphere is, or should be, constantly less than the moisture present on the surface of the material, to the end that the atmosphere performs with efficiency the elimination of such surface moisture, but at certain stages in the evaporation of moisture from the material, there occurs on the surface of such material a dry condition, i. e., an area substantially free from surface moisture, so that the humidity of the atmosphere is of greater density than the dry area of the material, and at this stage in the treatment of the material the action is reversed to the end that moisture present in the atmosphere is deposited upon the dry surfaces of the material, the effect of which is to moisten the dry area of the material by the humidity carried by the atmosphere, such deposit of moisture from atmosphere to material taking place for an indeterminate period and

until the moisture within the material so spreads and diffuses therein as to reach the surface of such material at or within the previously dry areas thereof, and thereupon the evaporation again proceeds, due to the excess of moisture on the surface of the material, so that the atmosphere again takes up surface moisture from said material.

In this invention, a salient feature is the control of the temperature and of the humidity of the atmosphere at each and all stages of the drying period, whereby the density of such atmosphere is conditioned with reference to the surface moisture of the material and the rate of diffusion of the water content within the mass of such material, to the end that there may be practically obtained that condition which meets the requirements with respect to the equalization of two bodies of different densities. During the progress of the evaporation, the moisture content of the material decreases, the moisture exuding to the surface of the material and being carried away from the presence of such surface by the flow of the atmosphere. As the moisture content of the material decreases, the atmosphere is conditioned by increasing or decreasing its temperature and the humidity is varied in a certain ratio to such decreased moisture content on the surface of the material, and also to the rate of diffusion within the material, having in view, however, the presence of such percentage of humidity in the atmosphere as will result in the deposit of moisture upon the "dry" areas, so called, produced upon the surface of the material by the absence of moisture occasioned by an inequality in the diffusion of such moisture within the mass of the material itself, due to the physical formation or the inherent resinous content of such material.

The evaporation is conducted within a chamber closed to the admission of outside atmospheric air, and the control of the atmosphere within the chamber is obtained by heaters and condensers, said heaters and condensers being positioned in different zones within a circulatory path for such atmosphere, whereby the heaters act to impart to the atmosphere the heat units required to effectuate the evaporation as well as to produce the required upflow into contact with the material, whereas the condensers act upon the atmosphere for the dual purpose of chilling such atmosphere to insure its downflow within a definite part of the circulatory path and to condense a certain portion of the aqueous content of such atmosphere, which condensation eliminates to a substantial and determined degree that moisture taken up by the air from the material in the exchange of heat for moisture.

The process is carried out in various forms of apparatus, one of which is diagrammatically illustrated in vertical sectional elevation in the accompanying drawing.

The material, in the form of lumber, is stacked or piled upon a truck, B, which is introduced with the load into a chamber, A, referred to as a drying chamber, the same constituting a part of a circulatory path closed against the admission of outside atmospheric air, and through which chamber and the stacked material flows a drying atmosphere adapted to be expanded by an initial heater, C. As shown, the atmosphere flows within a bottom flue, C′, within which is positioned the initial heater, shown as coils to which steam is supplied through a pipe, $c$, controlled by a valve, $c'$. Connected to the bottom flue is an updraft flue, D, and a down-draft flue, E, said updraft flue, D, being at one end of the drying chamber, whereas a similar updraft flue, D′, is at the other end of said chamber. These updraft flues are shown as having dampers, $d$, $d'$, positioned in such relation to the drying chamber and to the flues that the atmosphere is directed to flow from the initial heater flue, C′, into a part of flue, D, thence into the lower part of the drying chamber and through the stacked material therein, thence into the lower part of flue, D′, thence back to the drying chamber on a level above the first flow of the atmosphere therein, thence into the upper part of flue, D, back again through the drying chamber, and thence into the down-draft flue, E.

The atmosphere flowing into contact with the initial heater, C, is heated to the temperature required to effect the evaporation of moisture from the material within the chamber, A, i. e., the atmosphere carries the required heat units to so act on the material as to exchange heat for moisture, and during this flow of the atmosphere within the drying chamber it is conducted and deflected into the required contact with all surfaces of the material, thus carrying out the evaporation stage of the process. During the exchange of heat for moisture, the air gives off a certain proportion of the heat units and its temperature is reduced, but to attain efficiency in the evaporation at all stages of the process, I employ compensating heaters, F, which are positioned within the flues, D, D′, and in the line of flow of the atmosphere, such heaters being shown as having sources of steam supply through pipes, $f$, provided with controlling valves, $f'$, as usual. The temperature of the atmosphere as it makes the passes into contact with the material is indicated by one or more thermometers, the position of one of which is indicated at G, in the upper part of flue, D. Obviously, a drop in the temperature of the atmosphere due to the exchange of heat for moisture will be indicated by the thermometers, but by opening the

valve or valves, *f*, the steam supply to the compensating heaters, F, may be increased for raising the atmosphere to the temperature required. The heaters are so regulated as to maintain the drying atmosphere between its upflow to, and outflow from, the drying chamber at a constant temperature, or substantially constant temperature, to the end that there shall be no appreciable variation in temperature at the different parts of the drying chamber. Obviously, the evaporation due to the exchange of heat for moisture tends to decrease the temperature of the atmosphere, but by using compensating heaters within the line of flow of the atmosphere, and by controlling said compensating heaters, the heat units radiated are apportioned to a decrease in the water content evaporated from the material under treatment.

The atmosphere flowing within the drying chamber and into contact with the material therein attains a certain moisture content and acquires a particular or specified moisture load prior to flowing into the down draft flue, E, and at this stage in the flow of the atmosphere it is brought into contact with a condenser or condensers, H, the same having the capacity for chilling the atmosphere to a specified dew point, the effect of which is to deposit all water vapor in excess of a specified dew point. As shown, the condenser, H, is a coil, or series of coils, positioned within the down draft flue, E, and adapted to be supplied with a cooling agent, such as cold water, brine, or ammonia, through pipes, *h*, provided with controlling valves, *h'*. The condensate deposited upon the condensing coils is free to drop into a collecting trough, I, with a valved discharge, *i*, leading to the exterior of the apparatus.

The humidity of the atmosphere descending within the flue, E, is indicated by the dew point made as indicated by the thermometer, the position of which is denoted at J, but the chilling of the atmosphere and the condensation of moisture is controllable by varying the volume or character of the cooling agent supplied to the condenser, H, to the end that the humid condition of the atmosphere is controllable by the deposit of a specified quantity of water vapor upon the condensers, thus establishing and maintaining a desired moisture content of the atmosphere in proportion to the surface moisture present on the material, although as the evaporation progresses, such humid condition of the atmosphere may be controlled to attain a decreased or increased moisture content in proportion to the decrease in the moisture content of the material.

The mode of procedure is apparent from the foregoing description, wherein it appears that material is loaded on the truck and deposited within the chamber, the same being closed tightly against the ingress of outside atmospheric air. Steam is supplied to the initial heater for raising the atmosphere to the desired temperature, and expanding such atmosphere to create the flow within chamber A, and into contact with the material therein. The atmosphere is directed to all surfaces of the material to effect the evaporation, and at the required stage in the exchange of heat for moisture, with the attendant ratio loss of heat, the compensating heaters, F, are brought into service with a view to radiating heat in the same ratio or proportion as that lost by the evaporation, to the end that the temperature remains constant, the effect of which is to establish and maintain a specified temperature in all parts of the drying chamber. The atmosphere makes a number of passes within the chamber and into contact with the material, so as to acquire a specified water vapor load, and thence passes out of the chamber and into flue, E, the condensers in which cool or chill the atmosphere to effect the downflow within the flue, E, whereby the atmosphere is chilled to a specified dew point and thus deposits upon the condensers all water vapor in excess of the specified dew point.

It is thus apparent that by expanding the atmosphere and cooling such atmosphere that a circulation is set up within the closed path to the exclusion of the outside air, and it is thus possible, by heating the air to a required temperature and by chilling the atmosphere to a specified dew point, to so condition the atmosphere in respect to both its temperature and humidity as to apportion such atmosphere to the water content and surface moisture of the material and the rate of diffusion or spreading of such water content within the mass of such material, the result of which is to equalize the action of the two bodies of different densities.

The process described attains economy for the reason that a contained volume of atmospheric air within a closed path is utilized for conveying the heat units to the product under treatment, and this same volume of air is used as the agency for conveying the water vapor out of the presence of the material, such water vapor being deposited in a specified amount within the cooling flue and upon the condensers, whereupon the same volume of air is heated and expanded so as to recirculate the same. The cycle of operations is repeated indefinitely throughout the drying period, with a known and determined temperature and humidity suited to attain evaporation of moisture from the material without impairing the character or physical structure of such material.

Although reference has been made to the

treatment of wood for evaporating water therefrom, it will be understood that my process is useful in the treatment of different kinds of material.

Having thus fully described the invention, what I claim as new and desire to secure by Letters Patent is:

1. In the art of drying, the process which consists in setting up the flow of an atmosphere within a closed circulatory path by alternately heating and cooling such atmosphere, and condensing a certain percentage of the aqueous content of such atmosphere at the chilling stage thereof, for controlling the humidity of such atmosphere in a definite proportion to the surface moisture of the material under treatment.

2. In the art of drying, the process which consists in setting up the flow of an atmosphere within a closed path by alternately heating and chilling such atmosphere, condensing some of the aqueous content of such atmosphere and thereby controlling the humidity thereof in a definite proportion to the surface moisture of the material under treatment, and heating such atmosphere for maintaining a constant temperature in the period of its flow between the initial heating and the subsequent chilling thereof.

3. In the art of drying, the process which consists in setting up the flow of an atmosphere within a path closed to the exclusion of outside air by initially heating and subsequently cooling such atmosphere, condensing some of the aqueous content of such atmosphere at the chilling stage thereof for controlling the humidity of such atmosphere in a definite ratio to the surface moisture of the material under treatment, and heating the atmosphere to a constant temperature in the period of its flow between the initial heating and the subsequent cooling thereof.

4. In the art of drying, the process which consists in initially heating and subsequently chilling a drying atmosphere to set up the flow of such atmosphere into contact with material, and controlling the humidity of such atmosphere by condensing the aqueous content thereof in a definite ratio to the surface moisture of such material.

5. In the art of drying, the process which consists in initially heating and subsequently chilling a drying atmosphere to set up the flow of such atmosphere into contact with material, and controlling the humidity of such atmosphere by condensing some of the aqueous content thereof in a definite ratio to a decrease in the surface moisture of such material.

6. In the art of drying, the process which consists in initially heating and subsequently cooling the atmosphere to set up a flow of such atmosphere into contact with material, condensing the aqueous content of such atmosphere to a definite dewpoint for controlling the humidity of such atmosphere in proportion to the surface moisture of the material and to its diffusion within such material, and heating such atmosphere to a constant temperature in the periods between its initial heating and the subsequent cooling thereof.

In testimony whereof, I have hereunto signed this specification at the State of New York, this 13th day of October, 1922.

GORDON D. HARRIS.