METHOD OF CHANGING THE MOISTURE CONTENT OF WOOD

Filed July 12, 1961

4 Sheets-Sheet 1
Method of changing the moisture content of wood

For sections of wood 1/8 inch thick (also shown are wood surface temperatures)

<table>
<thead>
<tr>
<th>CURVE</th>
<th>DRYER</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEMPERATURE</td>
<td>VELOCITY</td>
</tr>
<tr>
<td>A</td>
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<td>O</td>
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<tr>
<td>P</td>
<td>650</td>
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</tbody>
</table>

**Fig. 5**

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Wood surface temperatures, dryer operating at 650°F

Wood surface temperatures, dryer operating at 350°F
MOISTURE CONTENT % VS. DRYING TIME FOR SECTIONS OF WOOD 1/8 INCH THICK

DRYER TEMPERATURE - 450°F
VELOCITY - 7,000 fpm.
METHOD OF CHANGING THE MOISTURE CONTENT OF WOOD

F. H. MILLIGAN ETAL

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3,199,213

200°F

DRY BULB

180°F

DRY BULB

140°F

DRY BULB

160°F

DRY BULB

140°F

DRY BULB

WET BULB TEMPERATURE - °F

EQUILIBRIUM MOISTURE CONTENT - % OVEN DRY

FIG. 7

A1 9,000 fpm,

A2 7,000 fpm,

A3 5,000 fpm,

A4 3,000 fpm,

CONVENTIONAL EQUIPMENT

FIG. 8

TIME TO CONDITION 1/4" HARDBOARD
85% RELATIVE HUMIDITY AT 140°F

A - HARDBOARD CONDITIONED BY HIGH VELOCITY IMPINGEMENT OF HUMIDIFYING ATMOSPHERE

B - HARDBOARD CONDITIONED IN CONVENTIONAL EQUIPMENT

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METHOD OF CHANGING THE MOISTURE CONTENT OF WOOD

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This invention relates to a method of changing the moisture content of wood, that is, to reduce or to increase the moisture content to a desired point.

The term "wood" as used herein is meant to include wood in the form of strips, sheets, veneers, boards, shingles and box material whether produced from logs, stumps, or cuttings of wood by planer milling, peeling or splitting, and it also includes products commonly known as flakeboard, particle board, hardboard, plywood and composition boards, the materials of which are primarily pieces or particles of wood or other ligno-cellulosic fibre bonded together naturally or by means of resins or glues. All of the foregoing materials are, of course, generally planar in configuration having two major planar surfaces and lesser edge surfaces.

Standard methods of changing the moisture content of wood are generally referred to as air drying, kiln drying, oven drying, seasoning, curing, conditioning or humidifying. In most cases, the moisture content of the wood is reduced; although in the manufacture of such products as flakeboard, particle board, fiber board and some composite boards, it is often necessary to increase the moisture content as one of the final steps in manufacture.

Seasoning, curing, conditioning and drying are all terms which refer to the establishment of desired mechanical, physical and chemical properties in wood and wood products. Conditions of time, temperature, circulation rate and humidity when temperatures are below 212°F. govern the extent of the moisture change and also the way the change is brought about which in turn affects the properties of the wood or wood products.

Air drying is accomplished simply by stacking the material in a yard or under a shed for a period of time long enough to permit evaporation of moisture to take place.

Kiln drying, or oven drying, as presently practiced, is essentially a process of heating the wood or wood product in a closed cabinet or chamber to accelerate the removal of internal moisture by a circulating atmosphere. Regulation of temperature and humidity is used to control the degree and rate of moisture removal.

Conventional methods and equipment such as kilns, ovens and humidifying chambers presently used for changing the moisture content of wood and wood products are faster and subject to better control than is air drying. Drying lumber in a kiln, for example, is a matter of days instead of weeks or months. Drying ¾" thick softwood veneer takes 25 to 30 minutes in the roller type oven dryer widely used in the plywood industry in contrast to the several days that would be required for air or loft drying.

Conditioning or increasing the moisture content of flakeboard, particle board and fibre boards of all densities is accomplished in a few hours in a humidifying dryer, as compared to days or weeks in a loft or warehouse where conditions of temperature and humidity approximate that of the prevailing weather.

Conventional wood drying equipment operates at temperatures ranging from 160°F to 425°F. For example, lumber dried by other moisture content from the initial point to 300°F.

425°F. These dryers also circulate the atmosphere at low velocities of the order of 600 f.p.m. in lumber and shingle kilns and 600 to 3000 f.p.m. in veneer kilns with the flow of air parallel to the surface of the drying wood.

Drying wood and wood products at temperatures in excess of those mentioned above has been attempted in the past. However, it has been asserted that use of high temperatures of the drying atmosphere as a technique for reduction of drying time also results in reduction of strength, softening, chemical changes, and drying stress defects such as case hardening, checks, splits, warping and honeycombing of the wood.

In order to avoid harming or discoloring the wood, it is advisable not to allow the surface temperature to rise above 350°F, and for some species it is safer to keep this temperature below 300°F. Both time and temperature are involved in the harming and discoloring of wood. Wood may be subjected without ill effect to much higher temperatures for a short period of time than for substantially lower temperatures and extended periods of time.

However, there are some occasions on which a slight discoloration would not be objectionable. This would be the case, for example, when the veneers are used with a glue other than the phenolic resin used for producing exterior grade plywood.

The main object of the present invention is the provision of methods for drying, humidifying or equalizing the moisture content of wood which are faster, more economical and provide closer control of the conditions affecting the chemical, physical and mechanical properties of the wood being processed than is possible with existing methods.

Another object is the provision of a method of changing the moisture content of wood by the utilization of high temperatures without harming or discoloring the wood.

The method according to the present invention, contrary to general opinion, utilizes high temperatures to dry wood without any harmful effects. It has been found that it is not the high temperature of the dryer atmosphere per se that directly causes the wood defects referred to above, but it is the high temperature atmosphere used in the wood by exposure to the high temperature atmosphere or contacting with parts of the dryer that are at high temperature.

In the present method, the moisture in the wood is evaporated exceedingly rapidly, producing an evaporative cooling effect at the wood surface. This enables the wood to be dried to a low moisture content by a high temperature atmosphere without exceeding safe wood temperatures. In order to create high rates of evaporation, it is necessary to circulate the drying atmosphere over the surface of the wood at high velocities. This is preferably accomplished by directing hot gas against the surface of the wood at substantially right angles thereto. The hot drying medium is directed through one or more nozzles against the surface of the wood, but it is preferable to direct it against the wood by a plurality of nozzles throughout the entire surface of said wood. The previous research in high temperature drying has been done on simulated conventional equipment which circulates the drying atmosphere parallel to the wood surface at low velocities.

Low velocity, parallel flow does not evaporate the moisture rapidly enough to result in a significant lowering of the wood temperature. When the high temperature atmosphere is directed through a plurality of nozzles, the moisture laden air or gas can get away quickly from the surface. In other words, the gas wipes the moisture off the surface without unduly raising the surface temperature. As the moisture is wiped off the surface, it is removed by the stream of hot gas against the surface of the wood substantially nor-
mal thereto strips off or scrubs the moisture-laden boundary layer of the wood to cause rapid evaporation of moisture from said surface and simultaneously cool the surface. Thus, the hot gas stream is removing the moisture and at the same time setting up a cooling action that prevents the wood from being harmed in any way. One of the advantages resulting from the use of the present method is the evenness of the treatment over the entire surface of the wood. In the major surfaces of the wood throughout the entire areas of said surfaces. This results in the wood being dried evenly throughout both of the major surfaces thereof. Use of the prior parallel-flow types of dryer results in uneven treatment of the wood. For example, if the dryer is of the cross-circulation type, the inlet side of the dryer will be at a higher temperature than the outside side thereof. This arrangement can result in large variations in the moisture content of the dried product. Furthermore, with the prior dryer, it is difficult to control the temperature of the drying atmosphere over the wood surface. Irregularities in the flow passages around the wood deflect the gas stream with the result that the wood receives an uneven treatment. With the present method, the drying atmosphere is directed in a plurality of jets against the entire wood surfaces substantially at right angles thereto so that every part thereof receives exactly the same treatment.

The basic method of changing the moisture content of wood in accordance with this invention comprises impinging at least one stream of a moisture conditioning gaseous medium against the surface of the wood substantially normal thereto at a velocity of at least 1000 f.p.m. for a time sufficient to attain the desired moisture content in the wood. This conditioning medium may be a drying medium and/or a moistening medium. Although one comparatively large stream may be used, it is more practical to impinge a plurality of streams of the gaseous medium against the area of the surface to be conditioned. This method makes it possible to use temperatures that heretofore have been considered harmful or impossible to use. Velocities from 1000 to 11,000 f.p.m., and temperatures up to and over 650°F, have been used with very satisfactory results and without harming or discoloring the wood. For example, for drying purposes, temperatures of from 250°F to 750°F may be used to obtain satisfactory results. It is believed that higher velocities and temperatures may be used, but they are at present not considered economic since special materials are required in the equipment for strength at high temperatures, and velocities much in excess of 11,000 f.p.m. result in heavy power demand.

Direct impingement of the drying atmosphere on the drying surface of the wood provides a uniform treatment and results in a more uniform distribution of residual moisture in the dried wood than has heretofore taken place. In conventional ovens and dryers, the poor control over dryer atmosphere circulation and temperature results in a wide variation in residual moisture content. With uniform moisture distribution, the average residual moisture content can be set on or slightly below the maximum allowable level. On the other hand, with a wide variation in residual moisture content, the average must be removed from wood dried in a conventional dryer than from wood dried by the present process. Furthermore, wide distribution of results in overdrying with resulting degrade to a substantial part of the total quantity dried.

It has also been found that the moisture content of wood may be raised quickly and accurately by impinging one or more jets, preferably a plurality of jets, of a gaseous medium against the wood surface substantially normal thereto at a velocity of at least 1000 f.p.m., said gaseous medium having a dry bulb temperature less than 212°F and a wet bulb temperature adjusted to establish the desired equilibrium moisture content. Furthermore, this method may be used to balance the moisture content of wood which initially is much wetter in some areas than in others.

In the accompanying drawings:

FIGURE 1 is a side elevation of one form of apparatus for carrying out this method, most of the near wall of the apparatus being broken away.

FIGURE 2 is an enlarged fragmentary section taken on the line 2-2 of FIGURE 1.

FIGURE 3 is an enlarged fragmentary section taken on the line 3-3 of FIGURE 1.

FIGURE 4 is an enlarged vertical section taken on the line 4-4 of FIGURE 1.

FIGURE 5 is a graph showing the moisture content reduction of wood sections 1/4" thick at specified drying medium temperatures and velocities, indicating the time required and the surface temperature of the wood.

FIGURE 6 is a graph showing the time required for reducing the moisture content of a wood section 1/4" thick using a drying medium at 450°F, and at a velocity of 7000 f.p.m., and indicating the surface temperatures at different moisture content levels.

FIGURE 7 is a graph showing equilibrium moisture levels for a range of wet and dry bulb temperatures, and FIGURE 8 is a graph showing the time to humidify 1/4" hardboard, comparing drying by the present method with drying by standard procedures.

FIGURES 1 to 4 illustrate apparatus for carrying out this method. A dryer 10 has one or more drying sections, the illustrated dryer including drying sections or zones 12, 13 and 14. The apparatus includes an upper casing 18 spaced above a lower casing 19 to form a thin passage 21 therewith. Upper and lower conveyors 23 and 24 have adjacent horizontal runs 26 and 27 travelling in the direction of arrow 28 in FIGURE 1 into, through and out of passage 21. Conveyors 23 and 24 are designed to permit as much gas or air as possible to pass therethrough, and are preferably formed of wire mesh having relatively large openings therein, as shown. These conveyors are moved by a suitable source of power, not shown, so that they move pieces of wood 30 between the runs 26 and 27 thereof through the dryer 10 from its entrance end 32 to the outlet end 33.

As drying sections 12, 13 and 14 are exactly the same, only one, namely section 12, will now be described in detail. Upper casing 18 at drying section 12 forms an upper plenum chamber 36, the bottom of which is defined by a wall 37 extending from the casing 38 of the casing to a separator 39 forming the inner end of said section. A plurality of jet nozzles 42 project downwardly from wall 37 and terminate just above the horizontal run 26 of conveyor 23. Each of these nozzles opens into chamber 36. Similarly, lower casing 19 forms a lower plenum chamber 45 between an end wall 46 and a separator 47. A wall 49 extends across the plenum chamber, and a plurality of jet nozzles 51 extend from said wall and terminate near the run 27 of lower conveyor 24.

Hot gas, such as air, is directed at high velocities to upper and lower plenum chambers 36 and 45 in any suitable manner, such as by pipes 54 and 55. The hot gas is directed in a plurality of jets through nozzles 42 and 51 to the upper and lower surfaces of wood pieces 30 being moved through passage 21 by conveyors 23 and 24. It is preferable that nozzles 42 and 51 direct the gas against the wood surface substantially at right angles thereto. These nozzles are spaced throughout the two plenum chambers so that both surfaces of each piece of wood are fully covered by said jets.

The drying medium or gas escapes laterally from passage 21. One or more ducts 57 and 58 extending vertically between upper and lower casing sections 12 and 13, respectively, are provided for conveying the gas to the surrounding atmosphere, it is preferable to provide ducts 57 and 58 along opposite sides of the apparatus and extending vertically between upper and lower casings 12 and 13.
and 19 to close the sides of passage 21. The gas is taken away from ducts 57 and 58 through suitable pipes, and is either discharged to atmosphere or completely or partially recirculated in the system.

The operation of dryer 19 is obvious from the above description. The wood pieces 30 are moved by the conveyors through passage 21. In drying section 12, the hot drying medium or gas is directed in a plurality of jets at high velocity to opposite faces of the wood pieces. Section 12 only may be used, but under some circumstances, it is desirable to subject the wood to two or more different sets of drying conditions and, therefore, drying section 13 and/or 14 may also be used with section 12. The operation is exactly the same in each drying section, and it is only the drying conditions of the method that are changed. For example, the temperature and/or velocity of the drying medium in each section may be different from that of each other section. The temperature and velocity of the drying medium in the dryer are selected in accordance with the condition and type of wood being dried.

If different drying times are required in drying zones 12, 13 and 14, each zone may be provided with its own conveyors which are independent of the other conveyors so that the time the wood is in each zone may be varied as desired. Another way is to move the wood in batches, in which case the conveyor speed would be adjusted for each drying zone. However, it is preferred to make the apparatus so that the temperature and velocity of the gaseous medium may be controlled in each zone independently of the others, and to have the conveyors operate at a constant speed. With this arrangement, the time the wood is subjected to a given set of conditions is determined by the number of zones in which said conditions exist. For example, one zone may have one set of conditions, and the next two zones another set of conditions so that the wood sections would be subjected to the second set of conditions longer than to the first set.

FIGURE 5 is a graph showing a group of representative drying curves determined by drying thin wood sections in accordance with this moisture conditioning method. For example, curve A shows that wood with an initial moisture content of 35% can be dried to 5% moisture content in 3.3 minutes in a dryer atmosphere of 350°F. Impingement against the wood at 3000 f.p.m. Curve K shows that wood can be dried from 35% to 5% moisture content by the utilizing of a drying medium at 650°F. and 7000 f.p.m. in 0.93 minute without raising the wood temperature above 305°F. The graph indicates wood surface temperatures with the dryer operating at 650°F. and with it operating at 350°F.

The following Table 1 has been prepared from accumulated data and shows the time required to dry thin wood sections from 35% to 5% moisture content at various dryer atmosphere temperature and velocities.

<table>
<thead>
<tr>
<th>Material</th>
<th>Conventional Roll-Type IS-Section Veneer Dryer</th>
<th>High Velocity Dryer</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4 inch Douglas Fir Heartwood</td>
<td>140°F, 9,000 f.p.m.</td>
<td>650°F, 7,000 f.p.m.</td>
</tr>
<tr>
<td>3/4 inch Douglas Fir Sapwood</td>
<td>140°F, 9,000 f.p.m.</td>
<td>650°F, 5,000 f.p.m.</td>
</tr>
</tbody>
</table>

The curves shown in FIGURE 5 provide the basis for drying schedules applicable in a commercial dryer. For example, a single pass, 75 ft. long dryer 10 (with one drying section only) operating at 650°F. and 7000 f.p.m. (curve K) would dry thin wood sections from 35% to 5% M.C. in 0.89 minute at a conveyor speed of 84 f.p.m. A conventional roller-type, 5-line, 75 ft. long counter-current circulation dryer operating in the range of 320°F. to 340°F. would require 13.0 minutes (see Table 2) to dry the wood and the rate of output would be 5.8 f.p.m. per line or 29 f.p.m. for the entire dryer.

The curves presented in FIGURE 5 also provide the necessary information for establishment of zone conditions to secure minimum drying times when a specific limit is placed on allowable wood temperature and final moisture content. For example, it may be desired to dry thin sections of heartwood from 35% to 5% M.C. in minimum time without exceeding a wood temperature of 305°F. Using the data in FIGURE 5, a dryer with two independent drying sections may be used as follows:

Zone 1—650°F. at 11,000 f.p.m. for 0.50 minute (curve M)
Zone 2—650°F. at 7,000 f.p.m. for 0.21 minute (curve K)

This two-section schedule enables the wood to be dried in 0.71 minute as compared with 0.89 minute for a single zone dryer operating at 650°F. and 7,000 f.p.m. Wood temperatures would not exceed 305°F.

The drying processes widely employed in the plywood industry use higher atmosphere temperatures at the dry end than at the green or wet end. Consequently, the driest wood is acted upon by the hottest gases. In the present process, the practice is reversed. That is, the high temperature atmosphere is applied to the green or wet wood until the wood temperature approaches the maximum allowable limit; then the wood enters a lower temperature...
atmosphere. In prior dryers, evaporative cooling does not take place appreciably; however, in this process, the effectiveness and control of the drying operation depends upon this phenomenon.

This process is also effective in drying thin wood sections containing a high percentage of moisture. FIGURE 6 shows that wood with an initial moisture content of 106% can be dried at 5% M.C. in 3.3 minutes in a dryer operating at 450°F and 7,000 f.p.m. without the wood temperature exceeding 260°F.

Veneers dried by this process have been tested to determine if there is any adverse effect upon glueability or wood strength. The results of boil/shear tests summarized in Table 3 show that the glue bonds and wood strengths are normal.

### TABLE 3

<table>
<thead>
<tr>
<th>Veneer Thickness, Inches</th>
<th>Percent Moisture Content</th>
<th>Dryer</th>
<th>Tests</th>
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<tr>
<td></td>
<td>Initial</td>
<td>Final</td>
<td>Zone</td>
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<tr>
<td>3/16</td>
<td>4 4.1</td>
<td>1.47</td>
<td>1</td>
</tr>
<tr>
<td>3/32</td>
<td>4.2</td>
<td>4.5</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>4.3</td>
<td>4.5</td>
<td>3</td>
</tr>
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<td>4.4</td>
<td>4.5</td>
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</tr>
<tr>
<td></td>
<td>4.5</td>
<td>4.5</td>
<td>5</td>
</tr>
</tbody>
</table>

Adhesive used in test panels was American Marietta AMX81 with Fursail 1005 as compounded and used for regular plywood production. Glue spread was 64 lb./M sq. ft. double glue line.

### Notes:

- All test panels were 3-ply construction pressed at 200 p.s.i., 190°F, 16 min. for 3/16 veneers; 4 min. for 3/32 veneers.

Sometimes it is necessary to increase the moisture content of wood, and particularly with flakeboard, particle board and fibre boards of all densities. This process may be utilized to increase the moisture content of the wood. Increasing moisture content is known as "conditioning" or "humidification" and can be accomplished by this process in much less time and more uniformly than in conventional equipment. By maintaining the gaseous medium at temperatures of 200° F. dry bulb and 170° F. wet bulb (relative humidity about 50%), the moisture content of oven dry wood can be raised to 5% moisture content in much less time than is required with conventional humidification equipment as shown in FIGURE 8.

This process is valuable in equalizing the moisture content of wood. The outer layer or sapwood of the tree contains a much larger percentage of moisture than does the inner or heartwood portion. When a wood product is manufactured, a single piece often consists of mixed heartwood and sapwood. This situation creates a drying problem for if conditions of temperature and velocity are established to quickly dry the sapwood to the desired moisture content, the heartwood will often be over-dried. Conversely, if the heartwood is quickly dried to the desired moisture content, the sapwood will often remain wet.

The moisture content of wood exposed to air ordinarily is dependent upon the temperature and relative humidity of the air. This moisture content balance of wood with the surrounding atmospheric conditions is known as its equilibrium moisture content. By selecting a specific temperature and relative humidity, it is possible to bring all portions of a wood product ultimately to the desired equilibrium moisture content regardless of the initial moisture content of the wood. For example, if an atmosphere of 186° F. dry bulb and 156° F. wet bulb is maintained, wood will reach an equilibrium moisture content around 5%. Other combinations of dry and wet bulb temperatures to establish a range of desired equilibrium moisture contents are shown in FIGURE 7.

Equilibrium moisture content can be reached by exposing the wood to air where there is natural circulation or by exposing to air with forced circulation at low velocities as in conventional kilns or conditioning chambers. However, reaching equilibrium moisture content in a low circulation rate atmosphere requires considerable time. In contrast, direct impingement of an atmosphere moving at high velocity and at proper conditions of temperature and relative humidity permits establishment of equilibrium conditions in the wood in much shorter times than is possible by other methods now in use. For example, assume the piece to be dried con...
moisture present to be higher than this in some cases, but whatever the moisture level, it will rarely have a spread in values greater than this example.

**Schedule I**

Dryer schedule for 1/4-inch Douglas Fir heartwood veneer, moisture content: max. 45%, avg. 35%, min. 25%

<table>
<thead>
<tr>
<th>Zone</th>
<th>Temperature</th>
<th>Time in Zone (mins.)</th>
<th>In</th>
<th>Out</th>
<th>Percent Moisture Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>650°F</td>
<td>9,000</td>
<td>63</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>350°F</td>
<td>9,000</td>
<td>33</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>3</td>
<td>200°F dry bulb</td>
<td>7,050</td>
<td>33</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>60°F cooling</td>
<td>5,000</td>
<td>15</td>
<td>5</td>
<td>8</td>
</tr>
</tbody>
</table>

Total time in dryer, 1.88 mins.

**Schedule II**

Dryer schedule for 1/4-inch Douglas Fir F3 heartwood veneer moisture content: max. 45%; avg. 35%; min. 25%

<table>
<thead>
<tr>
<th>Zone</th>
<th>Temperature</th>
<th>Time in Zone (mins.)</th>
<th>In</th>
<th>Out</th>
<th>Percent Moisture Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>650°F</td>
<td>9,000</td>
<td>120</td>
<td>88</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>350°F</td>
<td>9,000</td>
<td>33</td>
<td>24</td>
<td>8</td>
</tr>
<tr>
<td>3</td>
<td>200°F dry bulb</td>
<td>7,050</td>
<td>33</td>
<td>24</td>
<td>8</td>
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<tr>
<td>4</td>
<td>60°F cooling</td>
<td>5,000</td>
<td>15</td>
<td>5</td>
<td>8</td>
</tr>
</tbody>
</table>

Total time in dryer, 5.58 mins.

From the above it will be seen that this relatively simple method or process may be used quickly and uniformly to reduce the moisture content, raise the moisture content or balance the moisture content of wood, simply by varying the temperature, velocity, and/or the relative humidity of the drying medium, and controlling the time of exposure of the wood to said medium.

What we claim as our invention is:

1. The method of changing the moisture content of wood of generally planar configuration which comprises drying the wood by impinging a gas at a gas temperature ranging from about 350°F to about 950°F against a major planar surface of the wood to be dried substantially normal thereto at a velocity ranging from about 3000 f.p.m. to about 11000 f.p.m. to strip off the moisture-laden boundary layer of air at the wood surface to cause rapid evaporation of moisture from the wood surface and simultaneously cool said surface to protect it from harm or discoloration and for a time sufficient to reduce the moisture content of the wood to a desired level without raising the board temperature above 350°F, said stripped-off moisture being replaced by moisture from the interior of the wood thereby rapidly adjusting the moisture throughout the wood without harmful effects.

2. The method of changing the moisture content of wood of generally planar configuration which comprises drying the wood by directing a plurality of individual small jets spaced from each other in all directions of a gas at a temperature ranging from about 350°F to about 950°F against a major planar surface of the wood to be dried substantially normal thereto at a velocity ranging from about 3000 f.p.m. to about 11000 f.p.m. to strip off the moisture-laden boundary layer of air at the wood surface to cause rapid evaporation of moisture from the wood surface and simultaneously cool said surface to protect it from harm or discoloration and for a time sufficient to reduce the moisture content of the wood to a desired level without raising the board temperature above 350°F, said stripped-off moisture being replaced by moisture from the interior of the wood thereby rapidly adjusting the moisture throughout the wood without harmful effects.

3. The method of changing the moisture content of wood of generally planar configuration which comprises drying the wood by directing a plurality of individual jets of a gas at a temperature ranging from about 350°F to about 950°F against a major planar surface of the wood to be dried substantially normal thereto at a velocity ranging from about 3000 f.p.m. to about 11000 f.p.m. to strip off the moisture-laden boundary layer of air at the wood surface to cause rapid evaporation of moisture from the wood surface and simultaneously cool said surface to protect it from harm or discoloration and for a time sufficient to reduce the moisture content of the wood to a desired level without raising the board temperature above 350°F, and quickly removing said gas from the wood, said stripped-off moisture being replaced by moisture from the interior of the wood thereby rapidly adjusting the moisture throughout the wood without harmful effects.

4. The method of changing the moisture content of wood of generally planar configuration which comprises raising the moisture content of the wood by directing a plurality of spaced individual small jets of a gas at a dry bulb temperature of from 140°F to 212°F against a major planar surface of the wood to be treated substantially normal thereto at a velocity ranging from about 1000 f.p.m. to about 11000 f.p.m. for a time sufficient and with the relative humidity of the gas adjusted to establish a desired equilibrium moisture content.

5. The method of changing the moisture content of wood of generally planar configuration which comprises raising the moisture content of the wood by directing a plurality of spaced individual small jets of a gas at a dry bulb temperature of from 140°F to 212°F against a major planar surface of the wood to be treated substantially normal thereto at a velocity ranging from about 1000 f.p.m. to about 11000 f.p.m. for a time sufficient and with the relative humidity of the gas adjusted to establish a desired equilibrium moisture content.

6. The method of changing the moisture content of wood of generally planar configuration which comprises raising the moisture content of the wood by directing a plurality of spaced individual small jets of a gas at a dry bulb temperature of from 140°F to 212°F against a major planar surface of the wood to be treated substantially normal thereto at a velocity ranging from about 1000 f.p.m. to about 11000 f.p.m. for a time sufficient and with the relative humidity of the gas adjusted to establish a desired equilibrium moisture content.

7. The method of changing the moisture content of wood of generally planar configuration which comprises raising the moisture content of the wood by directing a plurality of spaced individual small jets of a gas at a dry bulb temperature of from 140°F to 212°F against a major planar surface of the wood to be treated substantially normal thereto at a velocity ranging from about 1000 f.p.m. to about 11000 f.p.m. for a time sufficient and with the relative humidity of the gas adjusted to establish a desired equilibrium moisture content.

8. The method of changing the moisture content of wood of generally planar configuration which comprises raising the moisture content of the wood by directing a plurality of spaced individual small jets of a gas at a dry bulb temperature of from 140°F to 212°F against a major planar surface of the wood to be treated substantially normal thereto at a velocity ranging from about 1000 f.p.m. to about 11000 f.p.m. for a time sufficient and with the relative humidity of the gas adjusted to establish a desired equilibrium moisture content.

9. The method of changing the moisture content of wood of generally planar configuration which comprises raising the moisture content of the wood by directing a plurality of spaced individual small jets of a gas at a dry bulb temperature of from 140°F to 212°F against a major planar surface of the wood to be treated substantially normal thereto at a velocity ranging from about 1000 f.p.m. to about 11000 f.p.m. for a time sufficient and with the relative humidity of the gas adjusted to establish a desired equilibrium moisture content.

10. The method of changing the moisture content of wood of generally planar configuration which comprises raising the moisture content of the wood by directing a plurality of spaced individual small jets of a gas at a dry bulb temperature of from 140°F to 212°F against a major planar surface of the wood to be treated substantially normal thereto at a velocity ranging from about 1000 f.p.m. to about 11000 f.p.m. for a time sufficient and with the relative humidity of the gas adjusted to establish a desired equilibrium moisture content.
moisture throughout the wood without harmful effects; and a second stage of raising the moisture content of said wood by impinging a gas at a dry bulb temperature of from 140 to 212°F. against the planar surface of the wood to be treated substantially normal thereto at a velocity ranging from about 1000 f.p.m. to at least 11000 f.p.m. for a time sufficient and with the relative humidity of the gas adjusted to establish a desired equilibrium moisture content.

5. The method of changing the moisture content of wood of generally planar configuration which comprises a first stage of drying the wood by directing a plurality of individual small jets spaced from each other in all directions of a gas at a temperature ranging from about 350°F. to about 950°F. against a major planar surface of the wood to be dried substantially normal thereto at a velocity ranging from about 3000 f.p.m. to about 11000 f.p.m. to strip off the moisture-laden boundary layer of air at the wood surface to cause rapid evaporation of moisture from the wood surface and simultaneously cool said surface to protect it from harm or discoloration and for a time sufficient to reduce the moisture content of the wood to a desired level without raising the board temperature above 350°F., said stripped-off moisture being replaced by moisture from the interior of the wood thereby rapidly adjusting the moisture throughout the wood without harmful effects, and a second stage of raising the moisture content of said wood by impinging a gas at a dry bulb temperature of from 140 to 212°F. against the planar surface of the wood to be treated substantially normal thereto at a velocity ranging from about 1000 f.p.m. to at least 11000 f.p.m. for a time sufficient and with the relative humidity of the gas adjusted to establish a desired equilibrium moisture content.

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