July 26, 1966 G. F. DUGGER, SR 3,262,216

PROCESS FOR ARTIFICIALLY DRYING LUMBER

Filed Nov. 19, 1963 2 Sheets-Sheet 1

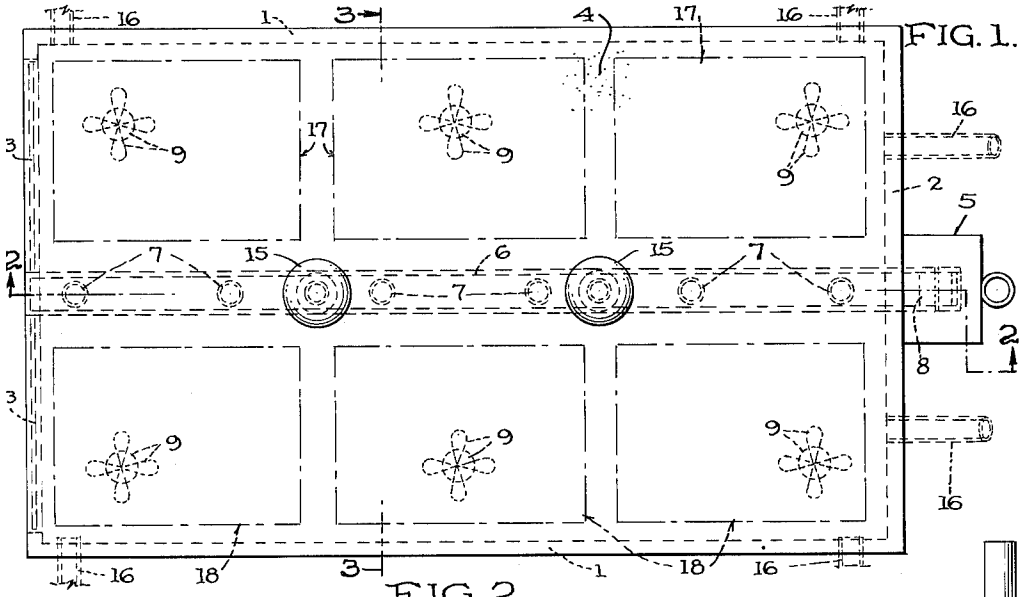

FIG. 1.

FIG. 2.

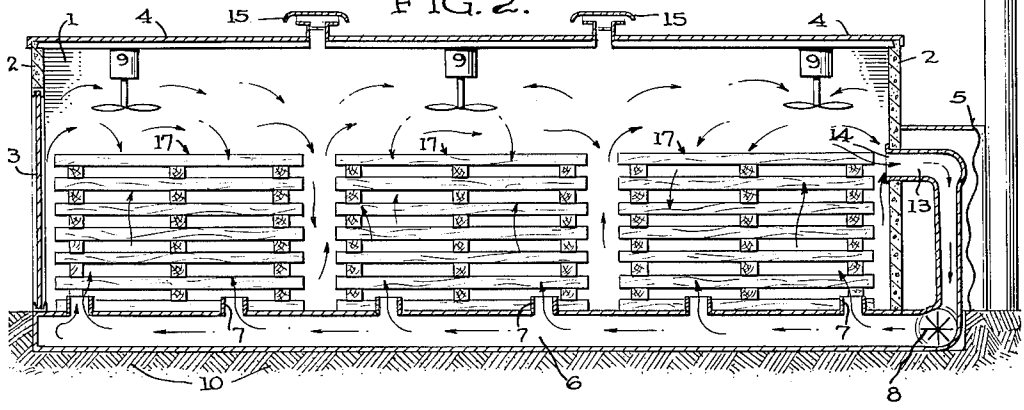

FIG. 3.

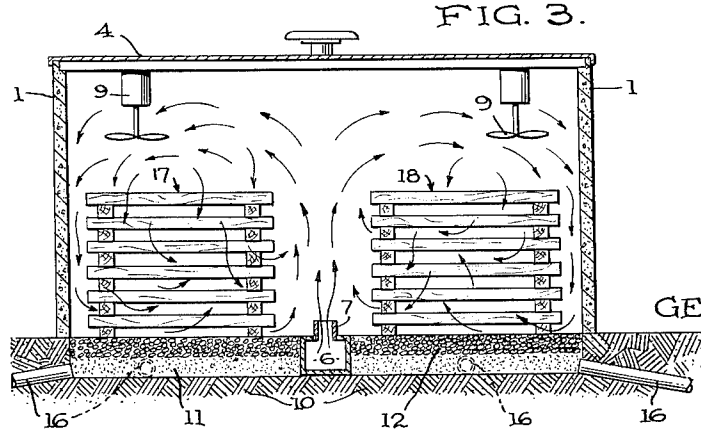

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FIG. 4.

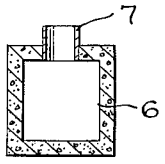


FIG. 5.

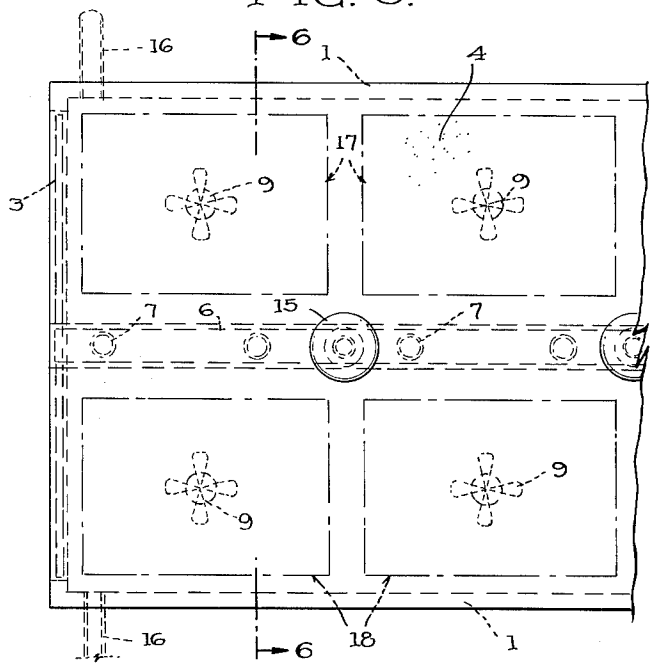
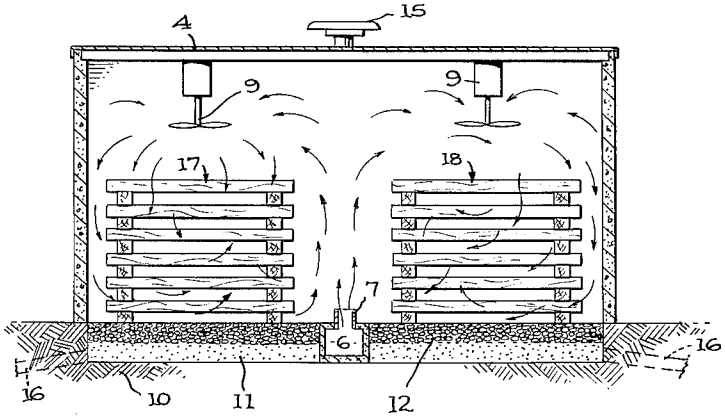


FIG. 6.



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PROCESS FOR ARTIFICIALLY DRYING LUMBER

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5 Claims. (Cl. 34—26)

This application is a continuation-in-part of my application Serial Number 205,127, filed June 25, 1962, now abandoned.

The present invention relates to a process of drying lumber and more particularly to a process of drying hard woods by artificial means.

Numerous dry kilns have been devised for artificially drying lumber. Generally, they are divided into two types—compartment kilns and progressive kilns. In the compartment kiln a load of lumber is placed in the kiln and the drying cycle is carried through all of its phases to completion. The dry lumber is then removed and the drying cycle is repeated with another load of green lumber. On the other hand, progressive kilns are equipped to handle several loads of lumber at various stages of the drying process, and the loads are moved through the kiln as each stage of the process is completed.

Both types of kilns may further be divided into those which have natural or forced circulation of the drying media, and into various sub-classes depending upon the presence or absence of other devices in the kiln. For a discussion of the various kilns see the United States Department of Agriculture handbook No. 188, Dry Kiln Operator's Manual.

By following rigid controls of temperature and humidity throughout the drying cycle it is possible to satisfactorily dry green, freshly sawn softwoods in any of the known types of kilns. Partially air dried hardwoods (about twenty percent moisture content or less) can be dried only with difficulty and only in those kilns which have elaborate means for adjusting the relative humidity. To date it has been impractical to dry green, freshly sawn hardwoods in a kiln because of excessive curing defects such as end and surface checks and cracks. This is especially the case where the hardwoods are to be put to critical uses such as furniture, loom shuttles, and etc., and where green lumber is more than one inch thick. Even in the case of kiln drying partially air dried hardwoods it has been the practice to dip the ends of the boards in wax or oil and spray or steam the lumber as the first step of the drying process in order to reduce drying defects. Furthermore, the uses of hardwoods which have been dried in this manner are limited because steaming and water spraying frequently result in spotting and streaking which are visible and unsightly through stain finishes, viz in fine furniture; or the lumber must be planed excessively to remove the blemishes.

It is the object of this invention to provide a process and means for drying green, freshly sawn hardwoods.

It is another object of this invention to provide a process and means for artificially drying green hardwoods free from curing defects without pre-treating by end dipping, steaming, and etc.

Still another object of this invention is to provide dry hardwood lumber which is free from curing defects and has an improved appearance.

Other objects and advantages will be apparent from the following description of my process.

I have found, unexpectedly, a process by which these and other objects may be met—preferably in a modified external blower compartment kiln of the forced circulation type such as the one set forth in figure 9, page 24 of the Dry Kiln Operator's Manual referred to previously. Briefly stated, the lumber is stacked in the enclosure; air

inside the kiln is maintained in circulation throughout the kiln and the stacked lumber at a high velocity; a portion of the air from the kiln is withdrawn, heated, and recirculated into the kiln in an indirect manner so as to temper the heated air to about the temperature and humidity of the air in the kiln before contacting the lumber; and moisture is gradually removed from the air and lumber by condensing and removing moisture from the air as it circulates under the lumber.

Referring to the attached drawings:

FIG. 1 is a top plan view of a dry kiln in which the present process may be carried out.

FIG. 2 is a longitudinal cross-sectional view taken on line **2—2** of FIG. 1.

FIG. 3 is a transverse cross-sectional view taken substantially on line **3—3** of FIG. 1.

FIG. 4 is a detailed cross-sectional view of the air duct **6**.

FIG. 5 is a fragmentary top view of the kiln of FIGURES 1–3 showing another fan arrangement, whereby the fans are disposed centrally over the lumber stacks; and

FIG. 6 is a transverse schematic cross-sectional view of the kiln enclosure of FIG. 5 as taken substantially on line **6—6** thereof.

When carrying out my method of drying in the preferred kiln enclosure depicted in the appended drawings, the hot air enters through orifices **7** in a pipe or tunnel **6** running the length of the kiln from the furnace **5** in the kiln enclosure having side walls **1**, end walls **2** with a door **3** in one of the end walls and a roof **4**. In place of the floor with return air slots of the conventional kiln I provide condensing means under the lumber so that the air from which moisture is removed will be recirculated into the kiln without being reheated above the temperature of the air circulating in the kiln. Preferably, natural condensing and water absorbing means are provided by resting the kiln upon a natural earth floor **10** over which about twelve inches of crushed stone **12** resting on about twelve inches of loose dirt **11** have been added. Green, freshly sawn hardwood is stacked in the customary stacks **17, 18** over the crushed stone on both sides of the hot air duct **6** so as to leave the duct and the space above it unobstructed (about twelve to eighteen inches on each side of the duct). Preferably, there should be a space of at least twelve inches between the lumber stacks and the enclosure walls for air circulation. Hot air, forced through the duct **6** by the furnace blower **8**, rises to the ceiling of the kiln. Means for maintaining the air in the kiln in constant circulation at a high velocity throughout the kiln interior and the lumber during the drying process are provided in the upper portion of the kiln. I prefer to provide fans **9** attached to the ceiling of the kiln which will circulate the air through the stacked lumber and at the same time blend and temper the entering hot air with the air in the kiln. In addition, means for returning a portion of the air in the kiln to the furnace and blower are provided. Preferably, a duct **13** connects an opening **14** in the end wall of the kiln adjacent to the furnace **5** with the blower **8** and the heat exchanging means of the furnace.

In operation the kiln is loaded with green, freshly sawn hardwood lumber. Thereupon, the kiln is closed from the outside atmosphere and the furnace is fired. As the air inside the kiln circulates therethrough at high velocity, the lumber is heated gradually and moisture is abstracted therefrom. It is readily seen that heated air from the furnace rises from the outlet orifices **7** to the ceiling where it is blended and tempered by the fans to about the same temperature and relative humidity as the air circulating inside the kiln before striking the

lumber. Thus, the temperature of the lumber gradually rises as the drying cycle progresses. During the early portion of the drying cycle, the kiln atmosphere becomes saturated with moisture from the lumber and a dense fog forms therein. The hot, moist air strikes and warms the rock layer below the lumber; and when the hot, moist air penetrates the rock layer and strikes the cool earth below, moisture is slowly condensed and removed by absorption into the ground. As a result, the moisture content of the lumber and the air in the kiln is gradually reduced. After the air has contacted the cool earth and moisture has been removed therefrom, the cooled air is warmed as it passes through the warm rock layer and reenters the kiln. Except for this tempering effect of the warm rock, the air which reenters the kiln from the condenser is not reheated.

Fresh air from the outside is not injected into the kiln in my method of drying in contradistinction to the process disclosed in Canadian Patent Number 502,176 to Guthrie. Instead, air from the kiln is passed through a closed system to the furnace, heated, and reintroduced into the kiln in such a manner as to temper the hot air before it strikes the lumber. Therefore, the fresh air door of the conventional kiln is either omitted or kept closed. Although I provide vents **15** in the top of the kiln, they are normally closed and inoperative except as hereinafter noted.

It is essential that the temperature of the lumber be raised gradually and the moisture content thereof be lowered gradually—especially during the early stages of the drying cycle to avoid curing defects in the lumber. I prefer that the temperature inside the kiln not exceed about 115 degree Fahrenheit during the first three days. Thereafter, the temperature can be gradually raised to the predetermined maximum. If the maximum temperature is not over about 150 degrees Fahrenheit, the danger of drying defects is minimized. It is also preferred that the wet thermometer bulb depression be less than about 115 degrees Fahrenheit during the first three days. of the drying cycle. The temperature inside the kiln and the moisture abstracted from the wood can be controlled by regulating the amount of heat introduced by the furnace into the kiln and the rate of air flow through the furnace. A variable speed motor on the furnace blower will control the air flow; and the heat output of the furnace can be controlled either manually or by a conventional thermostat connected to the furnace. Care must also be exercised to limit the air flow through the furnace so that the heated air does not enter the kiln enclosure at such high velocity as to interfere with the high velocity circulation of the air inside the kiln by the ceiling fans.

The lumber should be stacked so that air can be circulated efficiently through the stack. If pieces of uniform thickness and width are being dried, I prefer to stack them as in the drawings with one piece above the other in successive layers parallel to the air duct **6** through which heated air enters, and a small space between adjacent pieces in the same layers. Cross pieces (approximately 16 inches apart) are provided to separate the layers. The bottom cross pieces may be placed perpendicular to the air duct **6** and the side walls **1** to permit better circulation of air under the lumber stacks; and the bottom cross-pieces may be of greater thickness in order to raise the stack from the floor of the kiln.

When random width boards are being dried, I prefer to place the first layer of boards parallel to the air duct **6** on cross-pieces for support and with a small air space between adjacent boards. The next layer of boards is then rested on cross-pieces with each board centered over the air space between the two adjacent boards in the layer directly below. If the length of the boards will permit several stacks, I have found that air circulation is facilitated by leaving an open space between the adjacent stacks as shown in the drawings. However, when possible, the stacks should be arranged so that the circulating fans **9** are not directly above one of the open spaces between the stacks. Otherwise, the air flow through the stacks is diminished. The aforesaid stacking procedures will be recognized as conventional; and they are merely recited as the preferred methods.

A sufficient number of fans **9** or other means for circulating the air within the kiln must be provided to maintain a high velocity flow of air throughout the kiln and the lumber. The flow should be sufficient to evaporate moisture from the surface of the lumber as it forms. Otherwise, there is danger of mould formation which will damage the lumber. The high air flow is also necessary to maintain the temperature and relative humidity as uniform as possible throughout the kiln enclosure. I have found that the temperature at any point around the lumber stack can be maintained within about two or three degrees of the mean temperature inside the kiln; and it is preferred that this range be maintained for optimum drying conditions.

If the fans are directly above the lumber as in FIGURE 5, the main flow of air will be directly downwards through the lumber and against the floor from which it is reflected generally into the perimeter space between the lumber and the kiln walls. The air then rises and is recirculated by the ceiling fans. Of course, the air flow will not be uniformly in this direction because of the large number of reflective surfaces presented by the lumber, and it will tend to be a turbulent, but effective flow through the entire lumber stack: The general direction of air flow is indicated by arrows in the drawings.

I have found that the fans may be advantageously placed close to the outside walls as in FIGURE 1. In this position the main air stream flows down through the perimeter space between the lumber stacks and the walls, reflects from the condenser floor of the kiln and rises through the lumber stack from bottom to top for recirculation by the ceiling fans. By following this arrangement the hot air from the furnace is better tempered before striking the lumber, and the lumber is more evenly dried since the air first strikes the bottom layers of the lumber stack which would tend, otherwise, to contain more moisture than the upper layers. The fans may also be canted slightly toward the kiln walls so that the air is reflected from the walls to the bottom of the lumber stack and the kiln floor.

The drying temperatures may be varied according to the species of lumber to be dried, the moisture content of the lumber, and the dimensions thereof. Optimum temperatures may be easily determined by simple experimentation. Once a schedule is established for a given wood, the drying may be expedited by opening the vents under controlled conditions during the drying cycle, although this is not normally desirable and it is completely unnecessary.

The following examples are given by way of illustration without limitation of my invention except as set forth in the appended claims.

EXAMPLE I

A kiln modified in the manner described above and having a natural earth condenser was filled with freshly sawn one inch thick hardwood boards with one-eighth inch allowance for drying. The kiln was then closed and the furnace fired. The lumber was dried for about fourteen days until its moisture content was about seven percent. During the drying, the six fans located at the ceiling of the kiln were in constant operation. The temperature range (which rose steadily to a maximum) inside the kiln is set forth in Table 1.

Table 1

Day	Temp. range (° F.)
1	70–90
2	90–105
3	105–117

Table 1—Continued

4	117–125
5	125–132
6	132–140
7	140–145
8–14 (constant)	145

Upon opening the kiln, the dried lumber was found to be free from checks, cracks, honeycombs, case hardening, stains and other curing defects.

EXAMPLE II

Two inch by two inch and three inch by three inch freshly sawn maple stock of various lengths were dried in the same manner as Example I. The dried stock was free from curing defects.

EXAMPLE III

Freshly sawn two inch dimension hickory stock having a moisture content of about 65 percent was dried to less than 7 percent moisture content in a kiln with the fan arrangement of FIGURE 1. The air flow through the furnace was about 8,000 cubic feet of air per minute. The drying schedule is set forth in Table II.

Table II

Day	Temp. Range (° F.)	Wet bulb depression (° F.)
1	70–75	3
2	75–105	3
3	105–113	3
4	113–118	4
5	118–128	5
6	128–138	6
7	138–150	7
8–19	[1] 150	[2]

[1] Constant.
[2] 1° per day increase through 13th day and 3-5° per day thereafter.

EXAMPLE IV

In order to demonstrate the versatility of the present process a kiln modified in accordance with FIGURE 1 was filled with a variety of green freshly sawn dimension stock ranging from two inches to three inches selected from the following species of woods: hard and soft maple, white and yellow birch, ash, hickory, gum, pecan and cherry. The drying schedule of Table II was followed except that the maxmium temperature was 148° F. All species of wood were dried free from curing defects to less than 7 percent moisture content.

Not only is it possible to dry hardwoods free from curing defects by my process, but dried hardwoods possessing distinct aesthetic qualities which are lacking in conventionally dried woods can be produced by beginning the drying cycle within a short time after the green lumber has been sawn. In contrast to conventionally dried woods which darken as a result of the drying process (either air drying, kiln drying, or a combination thereof) my process retains substantially the original color of the freshly sawn hardwood. Moreover, mould, water, and steam stains are absent from the surface of the dried lumber. As a result, it is possible to produce distinctive, dried hardwoods characterized by their retention of substantially the same color as the freshly sawn pieces and the absence of surface stains.

Interestingly, I have found it advantageous to use limestone for the crushed stone **12** on the floor of the kiln. When limestone is used, the wood possesses a patina which is absent otherwise. Another advantage is the substantial absence of rust formation on ferrous parts of the kiln, viz the fan motors and blades, and the ducts to and from the furnace. Rusting is an acute problem in conventional kilns, on the other hand. Without wishing to be bound thereby, it is theorized that the limestone acts to neutralize volatile, acidic constituents of the wood and prevent their redeposition on the wood and the ferrous parts of the kiln.

Various other modifications may be made in the process and apparatus described. For example, artificial condensing means such as cold water coils distributed over the floor area of the kiln so that moisture is uniformly condensed under the lumber stack, or they may be added in the earth to supplement the earth condenser. Pipes **16** or other means to facilitate removal of moisture from the condensing means may be provided. The natural earth floor with loose earth and crushed stones resting thereupon as previously described is preferred; however, since it is the simplest design and it provides the most even moisture removal possible.

Although I prefer to construct the kiln of somewhat porous cinder or concrete blocks with an outside waterproofing layer, other materials may be substituted therefor. The means for introducing heated air from the furnace into the kiln may also be modified so long as the heated air is tempered to about the same temperature and relative humidity as the air in the kiln before striking the lumber.

It will be readily apparent to those skilled in the art that my drying method subjects the lumber to mild drying conditions with a gradual reduction in moisture content and a gradual rise in temperature of the lumber as the drying progresses. There is a unique cooperation among the various phases of my process which accomplish this result. The high velocity air flow within the kiln maintains uniform temperatures and humidity throughout the kiln, while, at the same time, evaporating moisture from the surface of the lumber. Air from the kiln is withdrawn, heated without moisture removal or addition of outside air, tempered by blending with the circulating air in the kiln before striking the lumber, thereby gradually raising the temperature of the kiln atmosphere and lumber. Simultaneously, the moisture content of the kiln air and the lumber is gradually reduced by uniform condensation and removal from the floor under the lumber stacks, and the air from which the moisture has been condensed is returned to the kiln without heating above the mean temperature of the air circulating therein. Therefore, it follows that the lumber is not "shocked" by abrupt temperature and moisture changes.

Unexpectedly, my mild drying conditions result in a shorter drying cycle for thick, green lumber which is about one-half the conventional drying cycle time for similar partially air dried (below 25 percent moisture content) lumber. Moreover, a kiln in which my process can be practiced can be economically constructed; and it can be made portable for use in the field.

Other modifications will be readily apparent to those skilled in the art, and it is intended to cover all modifications and variations coming within the scope of the appended claims.

In these claims "green" covers lumber having more than 35 percent moisture content; and the term "freshly sawn" covers lumber which contains substantially the moisture content of the lumber when cut.

I claim:

1. A process of drying green hardwood lumber comprising stacking the lumber in an enclosure separated from the outside atmosphere with a central open space running the length of the enclosure between lumber stacks and a perimeter open space between the enclosure walls and the lumber stacks, and thereafter simultaneously:

(a) Maintaining the air temperature and relative humidity inside the enclosure substantially uniform throughout by continuously circulating the air through the enclosure and the stacked lumber at a high velocity, the said circulation being maintained by circulation means positioned above the stacked lumber so as to move the air through the stacked lumber and reflect the air from the enclosure floor;

(b) Gradually raising the temperature of the lumber and circulating air by withdrawing a portion of air from the enclosure to a heat exchange means, and

reintroducing the heated air free from contact with the outside atmosphere into the enclosure by forced upwards flow in the central open space of the enclosure, thereby directing the hot air toward the circulation means above the lumber, and blending the hot air with the circulating air to substantially the same temperature and humidity thereof before contacting the lumber; and,

(c) Gradually reducing the moisture content of the lumber and the circulating air by reflecting the circulating air from moisture condensing and removal means on the floor under the lumber, the said moisture condensing means covering the floor area under the lumber.

2. The process following claim 1 in which the lumber is green, freshly sawn hardwood lumber.

3. The process following claim 2 in which the lumber is more than one inch thick.

4. The process following claim 1 in which:

(a) The temperature of the air circulating inside the kiln is gradually raised to less than about 115 degrees F. during the first three days of the drying cycle;

(b) The wet thermometer depression inside the kiln enclosure is less than about 5 degrees F. during the first five days of the drying cycle; and,

(c) The lumber is green, freshly sawn hardwood lumber.

5. The process following claim 4 in which the maximum temperature inside the enclosure is about 150 degrees F.

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