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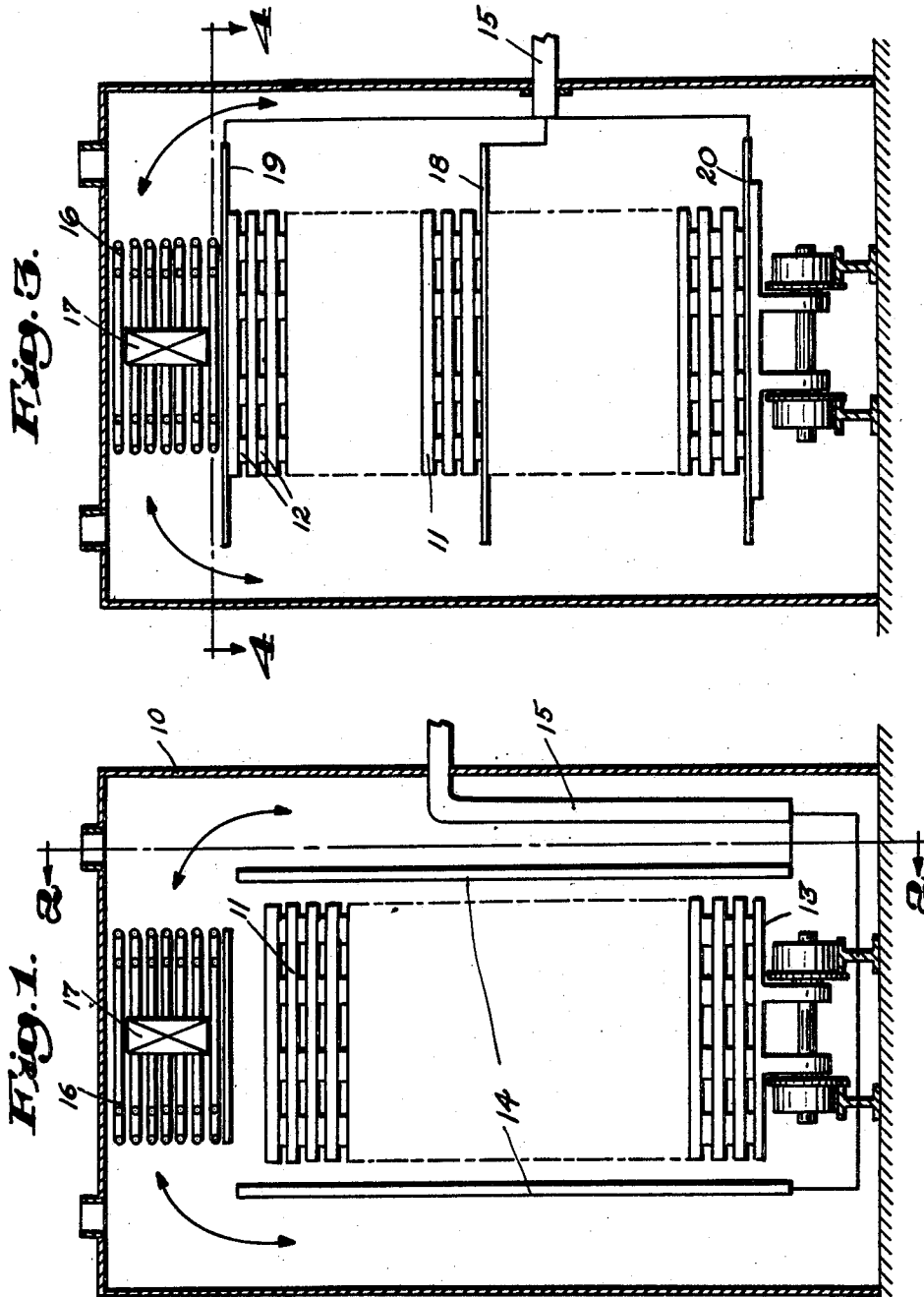
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3,496,645

LUMBER DRYING PROCESS

Filed July 12, 1968

2 Sheets-Sheet 1



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Fig. 5.

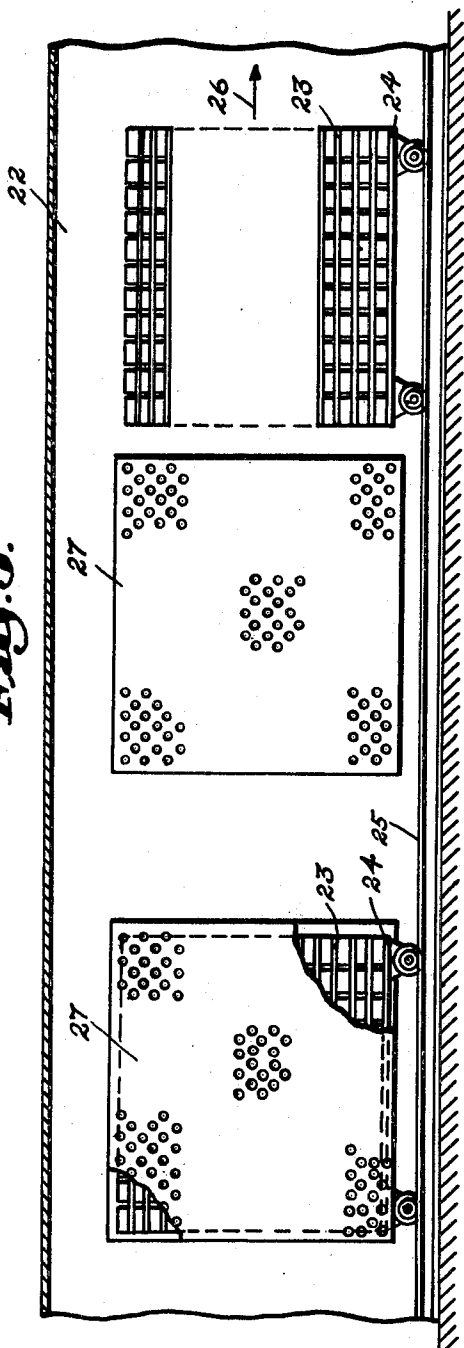


Fig. 2.

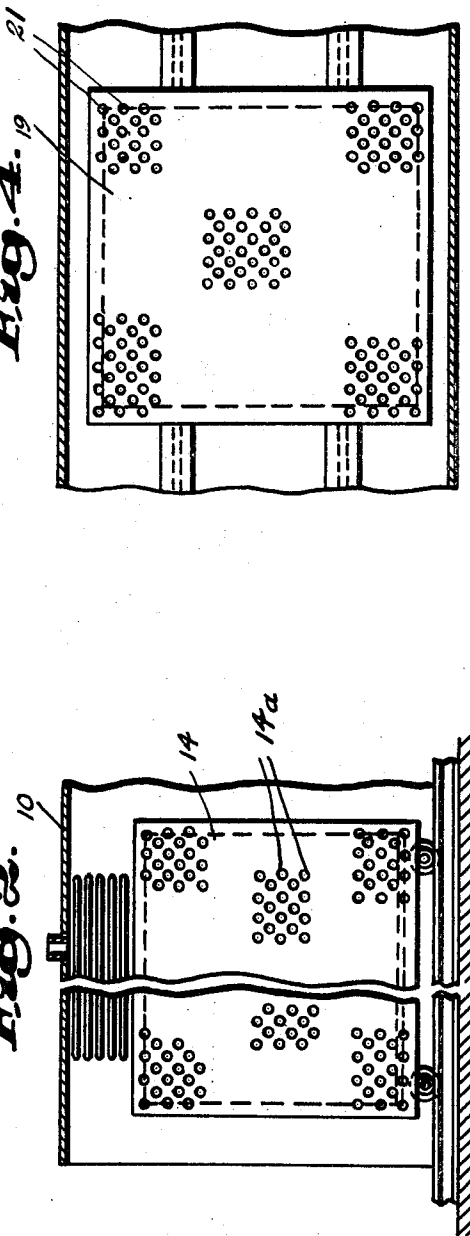


Fig. 4.

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6 Claims

ABSTRACT OF THE DISCLOSURE

A process of drying lumber by high frequency heating combined with controlled atmosphere drying. High frequency heating is applied to maintain the interior of the lumber at a temperature higher than that of the surface. The heat required for surface evaporation is supplied by a circulating controlled atmosphere which is maintained at a temperature higher than the free boiling point of the moisture at the lumber surface throughout the drying cycle.

BACKGROUND OF THE INVENTION

This invention relates to lumber drying and more particularly to processes of drying lumber by means of a high frequency electric field in combination with a circulating atmosphere controlled with respect to temperature and humidity.

One of the customary methods of drying lumber is kiln drying by circulation of a heated atmosphere of controlled humidity. In this process the heat required for evaporation is applied at the surface of the wood, and the temperature in the interior of the wood is lower than that near the surface. This temperature gradient creates a moisture vapor pressure gradient which opposes movement of moisture from the interior of the wood to the surface.

Heating by means of high frequency electric field appears to offer some advantages in drying lumber, because the wood is heated internally, reversing the normal temperature, moisture and vapor pressure gradients and causing more rapid migration of the moisture from the interior to the surface. If high frequency energy is used to supply all the heat necessary for surface evaporation, the process is quite expensive. Drying by high frequency energy alone has been found technically and economically feasible only for short pieces of expensive wood.

Experiments have also been made with drying of stacks of lumber using high frequency energy in combination with a circulating atmosphere heated by a less expensive energy source, such as steam, to a temperature of 212 degrees F. In this case, part of the heat required for evaporation is supplied by the atmosphere. This appears acceptable for drying green lumber to the fiber saturation point, about 30% moisture content. Below this point the bound water contained in the wood fiber boils at temperatures higher than 212 degrees F. and in an atmosphere of 212 degrees F., the additional heat required for evaporation must be supplied by the high frequency energy source, so that the process becomes unduly expensive.

The principal object of this invention is to provide a method of drying lumber in commercial quantities, either from green state or from air dried state, to any desired moisture content below the fiber saturation point, more quickly than is possible by methods previously used, without damage to the lumber and at a cost competitive with present kiln drying processes. Other objects, advantages, and novel features will be apparent from the following description.

SUMMARY

The process here disclosed combines the use of high frequency heating and circulating atmosphere heating. High frequency energy is relied on to maintain a tem-

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perature gradient favorable to migration of water toward the surface of the lumber and the heat required for surface evaporation is supplied by the circulating atmosphere.

Throughout the drying process the atmosphere is maintained at a temperature at or above the free boiling point of the moisture at the lumber surface. At a moisture content above the fiber saturation point, about 30%, the excess moisture is essentially free water and the free boiling point is 212 degrees F. Below the fiber saturation point the moisture in the wood is a water solution of sap constituents and its free boiling point rises as it becomes more concentrated. At 8% moisture content, the free boiling point is about 245 degrees F. and at 1-2% moisture content the free boiling point is around 300 degrees F. The temperature of the kiln atmosphere is raised progressively as the moisture content of the lumber is reduced from the fiber saturation point to the final content desired.

According to one manner of performing the process, boards are stacked in the usual manner in a stationary kiln which has electrodes on either side of the stack. A high frequency energy is applied to the electrodes continuously and the conditioned atmosphere is circulated around the lumber. The process may also be performed in a continuous kiln in which stacks of lumber are moved on cars through high frequency fields applied by a series of pairs of electrodes.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings illustrating the invention:

FIGURE 1 is a vertical cross-section through a kiln suitable for drying a stationary stack of lumber according to the process of the invention;

FIGURE 2 is a cross-section of reduced scale, partly broken away, taken along line 2—2 of FIGURE 1;

FIGURE 3 is a vertical cross-section similar to FIGURE 1 showing an alternative arrangement of electrodes;

FIGURE 4 is a cross-section of reduced scale taken along line 4—4 of FIGURE 3; and

FIGURE 5 is a vertical cross-section illustrating a continuous type of kiln for performing the process.

DETAILED DESCRIPTION

FIGURES 1 and 2 illustrate, somewhat schematically a typical closed kiln 10 for performing the drying process. A stack of boards 12, stacked with spacers 11 in the usual manner, is carried on a flat car 13. The stack is placed between a pair of electrodes 14. As best shown in FIG. 2, each electrode is a rectangular plate, large enough to cover the entire side of the lumber stack, provided with perforations 14a to allow circulation of the atmosphere. A coarse metal mesh would also be suitable for the electrodes. The electrodes are connected to the terminals of a coaxial cable 15 which is connected to a suitable source (not shown) of high frequency electric energy, of a frequency in the neighborhood of 1 to 100 megacycles.

The kiln atmosphere is heated by steam or electric coils 16, and circulated by a fan 17. The steam may be generated by the most economical fuel available at the particular location. Means are provided to regulate the moisture of the circulating atmosphere. The humidity may be raised by introducing a water spray, or lowered by venting and introduction of new air. The process is performed as follows:

GREEN LUMBER

To dry lumber from green to fully dried state, the atmosphere in the kiln is heated to 212 degrees F. or above and the high frequency field is applied to the stack to produce a surface lumber temperature somewhat below that of the atmosphere. The relative humidity is main-

tained at a high value. These conditions are maintained until the moisture content in the wood is reduced to the fiber saturation point.

The free boiling point of the moisture in the wood increases with decreasing moisture content, from the fiber saturation point down. At the fiber saturation point the free boiling point is 212 degrees. At 8% the free boiling point is about 245 degrees, and at 1% about 300 degrees. As drying progresses below the fiber saturation point, the temperature of the kiln atmosphere is progressively raised, and always maintained at or above the free boiling point. The high frequency heating is controlled to keep the temperature of the wood surface below that of the atmosphere.

AIR DRIED LUMBER

This process is especially advantageous for drying air dried lumber, which normally has a moisture content of 25% to 30%. To dry air dried lumber, the kiln atmosphere is heated to, or above, the free boiling point of the moisture in the lumber, 212 degrees F. in the case of lumber of 30% moisture content, about 220 degrees F. in the case of lumber of 25% moisture content. The relative humidity of the atmosphere is maintained at a high value. The high frequency heating is applied to heat the surface of the lumber to a temperature below that of the atmosphere. The temperature of the atmosphere is raised, as the moisture content is reduced, to keep the temperature always at, or above, the free boiling point. The temperature of the wood surface is maintained by the high frequency field at a temperature somewhat below that of the atmosphere.

FIGURES 3 and 4 disclose an alternative arrangement of the electrodes for supplying the high frequency energy to the stack. One electrode 18 is placed horizontally in the center of the stack, and two other electrodes, 19 and 20 are placed horizontally across the top and bottom of the stack respectively. The electrode 18 is connected to one terminal of the cable 15, and electrodes 19 and 20 are connected to the other terminal to set up fields of opposite polarity in the top and bottom of the stack. The electrodes may have perforations, as exemplified by the perforations 21 in FIGURE 4, or can be made of a continuous sheet. The drying process is performed in the same manner as with the electrode arrangement shown in FIGURE 1.

This method of placing electrodes may be extended to any number of electrodes but preferably an odd number. Every other electrode is connected to one lead of the power source and the remaining electrodes are connected to the other lead. If one of the power leads is at ground potential it is better to connect the set with the two outside electrodes, of a stack with an odd number, to the ground lead.

FIGURE 5 illustrates a continuous type of kiln 22. Stacks of lumber 23 are mounted on cars 24 which run on rails 25 through the kiln. The cars enter at the left hand end of the kiln and travel in the direction of arrow 26. Pairs of electrodes 27 are mounted at intervals on either side of the track so that the cars pass between them. The drying process is carried out essentially the same way as in a stationary kiln, that is the atmosphere is maintained at a temperature at, or above, the free boiling point of the moisture in the wood. In order to accomplish this, it is necessary to raise the temperature progressively toward the exit end of the kiln. The electrodes provide high frequency heating to maintain the desired temperature gradient in the wood.

Means for controlling the temperature and humidity of the kiln atmosphere and the output of the high frequency sources to maintain the desired internal temperature in the wood are not shown, as these are well known.

GENERAL CONSIDERATIONS AND ADVANTAGES OF THE PROCESS

Lumber drying by means of a controlled atmosphere alone is relatively slow because moisture can be removed only as fast as it reaches the surface. The temperature gradient set up by heating the lumber from the outside in is inherently adverse to rapid migration of water from the interior to the surface.

The use of high frequency heating alone is excessively costly because of the substantial amount of heat energy required for evaporation.

The principal requirements in practicing the process here disclosed are that the temperature of the atmosphere be maintained at or above the free boiling point of the moisture on the surface of the wood, and that the temperature of the interior of the wood be maintained higher than that of the surface. Under these conditions, high frequency heating is used only to create a temperature gradient more favorable to rapid migration of moisture to the surface than the gradient which exists when controlled atmosphere drying is used alone. This can be done with relatively low power consumptions. All the heat required for evaporation is supplied by the atmosphere which can be heated by a less expensive source of energy.

By use of the process, lumber can be dried much more rapidly than by a controlled atmosphere alone, and at comparable cost. The overall cost of operation can be considerably reduced, because of more rapid turnover and the reduction in inventory needs.

What is claimed is:

1. A process of drying lumber to a moisture content below the fiber saturation point which comprises simultaneously heating the lumber by a high frequency field to an internal temperature at least equal to the boiling point of moisture contained internally in the lumber, thereby to drive the moisture to the surface portion of the lumber for recondensation therein, and circulating a heated atmosphere around the lumber, the atmosphere being continuously maintained at a temperature at least as high as the free boiling point of condensed sap and moisture in the surface portion of the lumber throughout the drying process, the temperature in the surface portion of the lumber being maintained below the temperature of the atmosphere throughout the drying process.

2. A process as described in claim 1, in which the temperature of the atmosphere is raised in correspondence to the rise in the free boiling point of the sap and moisture at the surface portion of the lumber, as the moisture content of the lumber is reduced from the fiber saturation point to the final moisture content.

3. A process as described in claim 1, in which the lumber is arranged in a stack and disposed between a pair of electrodes which supply the high frequency field.

4. A process as described in claim 1, in which the lumber is arranged in a stack with one electrode in the center and electrodes on the top and bottom for supplying the high frequency field.

5. A process as described in claim 1, in which the lumber is passed between successive pairs of electrodes which supply the high frequency field.

6. A process as described in claim 1, in which the lumber is arranged in a stack and disposed between a plurality of electrodes, adjacent electrodes being of opposite polarity.

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