

Dec. 22, 1936.

H. E. WILL

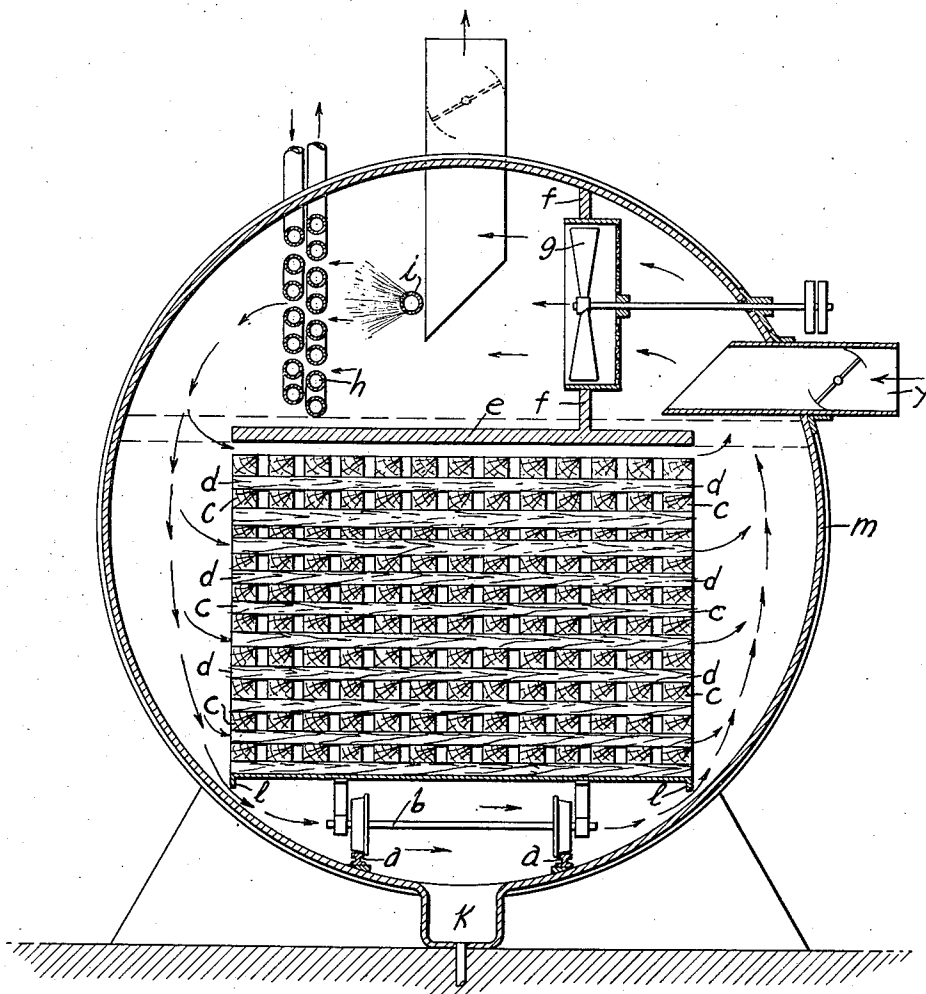
2,064,965

METHOD AND MEANS FOR TREATING WOOD

Filed Dec. 14, 1932

3 Sheets-Sheet 1

Fig. 1.



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Fig. 2.

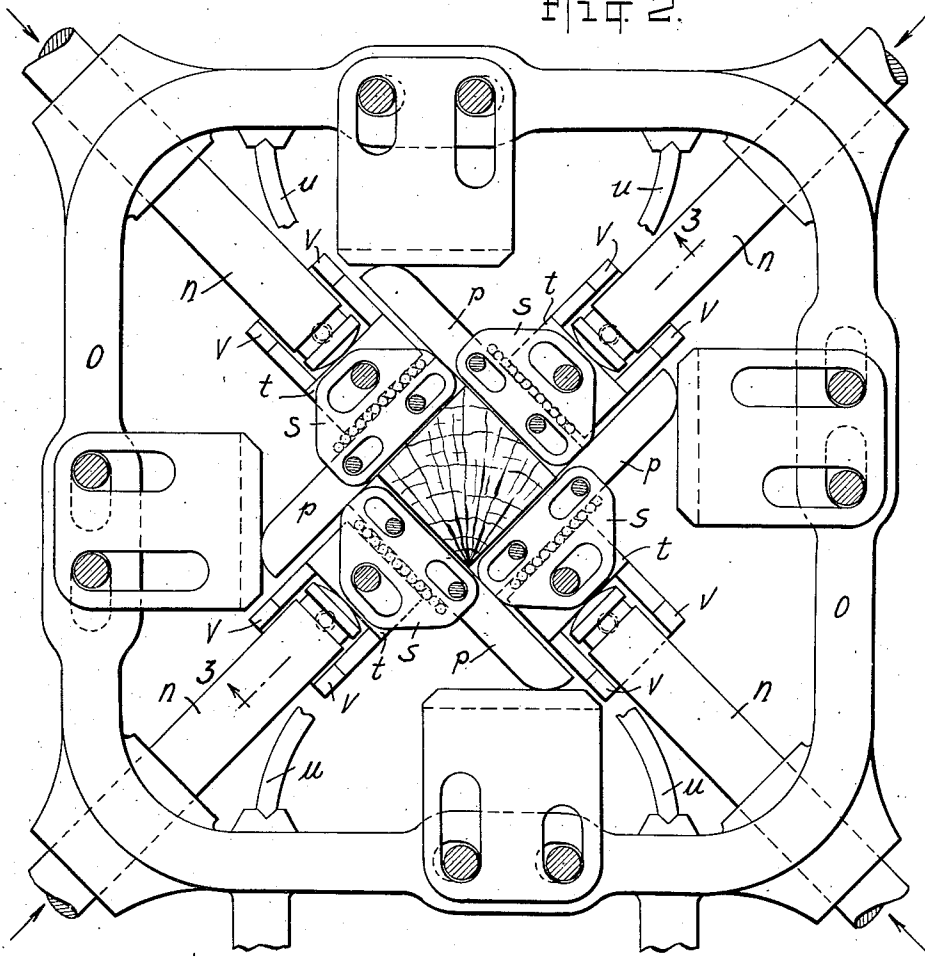
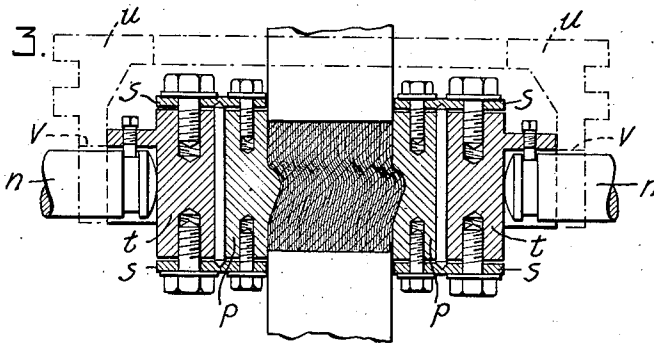


Fig. 3.



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Fig. 4.

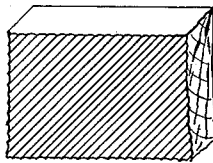
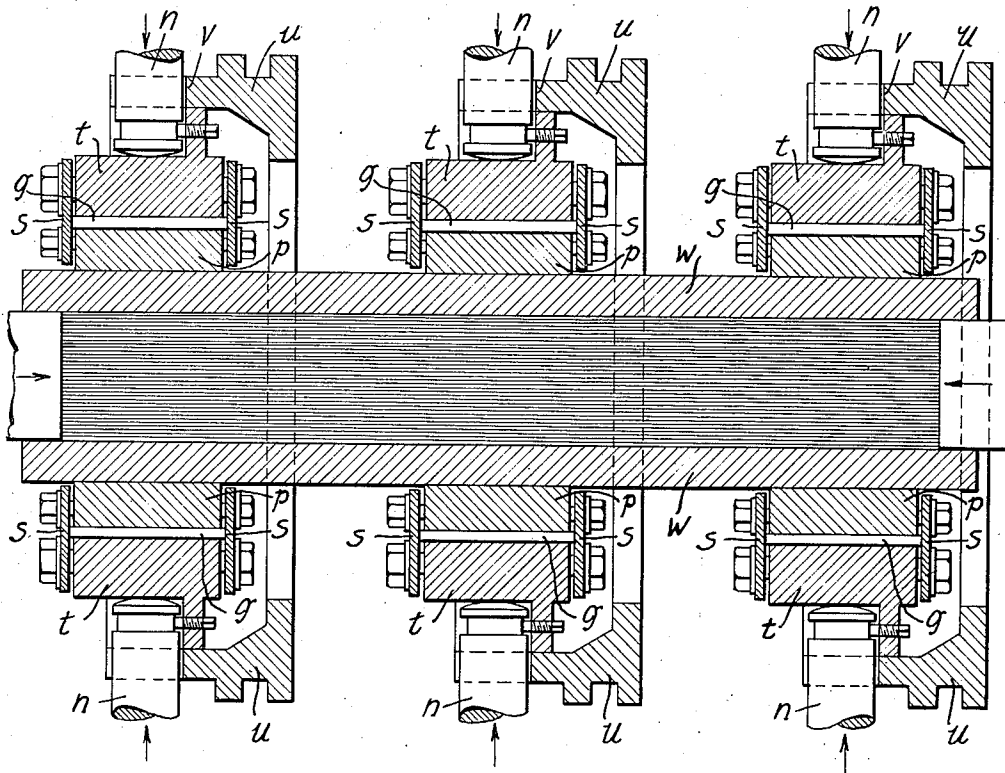


Fig. 5.



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2,064,965

METHOD AND MEANS FOR TREATING
WOOD

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Application December 14, 1932, Serial No. 647,287
In Germany December 14, 1931

6 Claims. (Cl. 21—10)

This invention refers to a method and means for treating wood and similar materials and also relates to an article produced by said method and means and known in the art under the name of "Lignokompakt", said article consisting of a compressed and otherwise treated wood which is non-swelling and non-shrinkable.

Methods used heretofore for impregnating dry heart-wood by means of steam or vapor have not been successful since steam is liable to condense in the exterior layers of the wood and to form liquid stoppers which prevent the uniform and evenly distributed penetration of the impregnating substance into the wood.

In prior art wood was dried by means of evaporation taking place at the exterior surfaces of the wood, so that the interior of the wood retained more moisture than the exterior layers; the interior, therefore, shrank less than the exterior and this developed tension and forces within the wood which caused cracks and flaws. To prevent the wood from cracking the drying process had to be interrupted by a steaming process after which the drying was resumed for some time.

An object of this invention is to provide an improved method of treating wood and similar materials, said method being free from drawbacks inherent in the previously known methods;

Another object is to provide means for producing an absolutely non-porous and non-swelling article made of wood, the pores of which have been closed by a thermal and mechanical treatment which does not include the use of a filling substance.

A further object is to provide an article which is made of wood but which has from three to six times as much strength, toughness and specific weight than normal wood, with a corresponding increase in the module of elasticity.

My method of treating wood comprises the steps or processes of drying it, impregnating it by vapors and then compressing and cooling it. Some of these steps or any parts thereof may be omitted or used in a different sequence. These steps will now be described in detail.

My process of drying wood differs from those known in prior art in that I do not steam it. After the drying process has begun, it may be temporarily interrupted by the introduction of a so-called ripening process which results in the softening of the wood for the purpose of diminishing the inner tension and the forces within said wood. The wood is softened by treating it with steam having a certain high temperature

and pressure, depending upon the nature of the wood and other conditions. The steam passes with high velocity through the wood and should not have a high degree of moisture, so that it may not deposit any condensate on the wood fibres. The deposition of the condensate is also prevented by heating the wood to a suitable temperature and by the high pressure of the steam. The drying process is practically or completely stopped while the wood is being softened.

The softened wood is dried by overheated steam or a mixture of hot steam and air. This process is carried out below the saturation point of the wood fibres and at a temperature which is at least equal to the so-called specific temperature of swelling i. e. a temperature at which the wood begins to lose its hygroscopic properties. During this process the temperature of the exterior surfaces of the wood is kept higher than the temperature of the interior of the wood and is also higher than the temperature of the saturated steam.

One of the important features of my invention is the fact that during the drying process the drying agent, namely the steam or the mixture of steam and air, is passed at a high velocity, i. e. a velocity of many meters per second, over the treated wood. The actual velocity depends on the size and quality of the treated article, etc. and is varied in the course of the treatment. The steam is superheated to an extent depending on the selected velocity. Due to this arrangement the heat is transmitted in a steady current from the drying agent to the interior of the wood, so that on a diagram the heat current would be represented by a straight line ending at zero, while a temperature diagram would be a parabolic curve. The moisture contained in the wood vaporizes uniformly and in equal amounts throughout the entire cross-section of the wood, so that the interior tension is not increased and no cracks appear in the treated article. The air contained in the interior of the wood is driven out by this inner vaporization process. Due to this feature of my method I am able to dispense with the usual step of removing the air, which was usually introduced between the drying and the impregnation steps.

My drying process is carried out below the saturation point of the fibres, the temperature of the treated material being higher than the range of the cooling temperatures. The difference between the temperature of the material and the cooling temperature is directly proportional to the percentage of the dry portions of the treated

material and inversely proportional to the amount of moisture contained in the material. This dry substance retards the normal development of the process and, due to its presence, the pressure of the evaporated moisture contained in the material becomes equal to the pressure of the saturated steam at a higher temperature; in other words, these two pressures become equal to each other at a temperature higher than that which would have existed had the dry substance been absent.

The conditions existing during the drying step of my method are somewhat similar to the conditions existing during the absorption step which will be described hereinafter.

A remarkable feature of the process lies in the fact that an increase in the amount of heat supplied to the exterior surfaces of the article is not compensated by an increase in vaporization. This may be explained by the supposition that a part of the steam situated in the interior of the wood acts catalytically in a different way from the part of steam situated in the exterior layers of the wood, the first-mentioned part of the steam being more saturated than the second-mentioned part, while the second-mentioned part is more super-heated than the first-mentioned part of the steam; thus the wet steam in the interior of the wood precipitates the vaporization, while the superheated steam in the exterior layers retards the vaporization process.

Practical experiments have shown that in the course of my drying process a great part of the moisture contained in the wood is removed by vaporization and not by a flow of moisture towards the surfaces of the wood which takes place in prior art methods.

I prefer to operate at temperatures which are higher than 100° C. and are close to the above-mentioned temperature of swelling since the features which have just been described become more apparent at these temperatures.

A characteristic feature of my method of treating wood is, consequently, a very quick and short drying step during which the hygroscopic properties of the wood are further diminished.

My drying process may be successfully employed in treating green wood. The time necessary for drying green wood is shorter than that necessary for drying ordinary wood. In both cases the vaporization takes place not only at the exterior surfaces but also in the interior of the wood and can be regulated so that the moisture is evenly and uniformly removed from the entire cross-section of the wood, and, consequently, no inner forces can arise within the wood. When a fir-timber 50 millimeters in thickness is used, its water content of 42% may be reduced to 8% in 64 hours, 300 kilograms of water being removed per cubic meter of timber. If a well preserved wood is not required, the drying period of 64 hours may be further reduced to 50 hours, while methods known in prior art require triple or quadruple the amount of time for the same result.

The wood is usually aged towards the end of the drying process. At the time the drying step is practically interrupted for a time while the wood is being subjected to a high temperature. The inner forces still existing within the wood disappear and its elasticity is diminished; chemical reactions take place within the wood fibres, resulting in a hardening of its cells.

As already mentioned, my steps of ripening, drying and aging wood may be used for treating

any other material which contains moisture, even if this moisture is bound in a colloidal form.

After my drying process has been completed, there is usually no necessity for the introduction of a separate step of removing air from the interior of the wood, although in some cases the treated article may be placed under vacuum for some time.

Next the wood is treated by suitable gaseous binding and fluxing means and impregnated. These binding means act as catalysts and cause an absorption process which begins at the exterior portions of the treated article and gradually proceeds towards the center thereof. The temperature in the interior of the article is maintained at the condensation temperature of the gaseous means, while the temperature at the external surfaces is kept at a higher level in the beginning of the absorption and is then gradually lowered.

Due to this arrangement no liquid deposits are formed within the treated article at the beginning of the treatment so that vapors and gases can freely penetrate into the wood and reach its central portions which are maintained at a temperature close to the condensation temperature.

I accomplish this important feature of maintaining the temperature of the external wood layers at a higher level than the temperature of the interior, by passing the superheated vapors at a high velocity over the external surfaces of the article. This velocity should be equal to at least a few meters per second and should be varied in the course of the treatment. The vapors should be superheated to an extent depending on the selected velocity. Thus I increase the coefficient of heat transmission and am able to select a suitably high amount of heat transmitted to the external layers of the treated article. The amount of transmitted heat depends, obviously, on the selection of a suitable temperature of the super-heated vapor and the temperature of the surfaces of the article. On the other hand, the transmitted heat increases the temperature of the exterior layers of the treated article to such an extent that the temperature within the article rises in a direction from the interior towards the exterior of the article following the course of a cubic parabola in spite of the fact that a certain amount of condensation heat is liberated by the condensed vapors in the interior of the treated article.

I prefer to treat wood so that it takes in only as much condensate as can be absorbed by the cells of the wood, and so that the excessive amount of the liquid is immediately transformed into vapor again by the heat passing through the article in a direction towards the exterior thereof. This vapor is super-heated by the dry and porous wooden article which plays the role of a superheater in this respect.

After this treatment has been continued for some time, I diminish the velocity of the gases by reducing the action of the blasting means, which will be described more fully hereinafter, and thus diminish the coefficient of heat transmission and lower the temperature of the external surfaces of the article. Then the superheating temperature also becomes lower and the absorption increases in a direction towards the exterior of the treated article.

This treatment can be successfully used for producing a high class article such as "Lignokompakt" and in that case the impregnating substance must be completely absorbed by the wood.

If an article of lesser or different qualities is required any desired amount of the impregnating substance may be supplied to the wood which may be impregnated to any desired extent.

It will be noted that this treatment is similar to that which I use for drying the wood, including the ripening and aging steps. The impregnation may include therefore the steps of preliminary impregnation, softening during the interruption, the resumption of the impregnation and aging. It can be also used for treating any material similar to wood. The vapors of the impregnating means can be used as heat transmitting means for a subsequent final drying of the wood, although as a rule steam or a mixture comprising hot steam is used for that purpose.

After the absorption has sufficiently progressed I prefer to increase the temperature for the purpose of accelerating the impregnation taking place within the wood fibres, and also for the purpose of evaporating the superfluous amount of the condensed impregnating means. This step is again similar to the drying process.

After that the treated article can be placed under vacuum for a short time in the same container in which it was dried and impregnated. The purpose of this vacuum treatment is to accelerate the action of the impregnating substance on the wood fibres. Then the wood is subjected to mechanical compression which takes place in a device to be described hereinafter.

The article is compressed in such a way that the forces acting along the width and the length of the article correspond to the compressibility or the elasticity of the wood fibres within this area. The amount of compression is selected with the view to the elimination of the hollow spaces within the wood.

Since the specific weight of similar woods may vary to a great extent, I must adjust the compressing means for each density in order to arrive at the same results. I determine the coefficient of compression in a way which will be demonstrated by the following two examples:

1st Example:—1 cubic meter wood was found to contain 360 kilograms wood paste (consisting of 245 kilograms cellulose and 115 kilograms lignine) having a specific weight of $W_s=1.46$, 5 kilograms resins, oils and fats with $W_s=1.06$ and 35 kilograms water with $W_s=1$. The wood is to absorb 13 kilograms of tar oil with $W_s=1.07$ and 7 kilograms of turpentine oil with $W_s=0.87$. The specific weight of the treated wood before compression was found to be 0.42. The coefficient of compression is determined from the following equation:

$$C = \frac{1000}{\frac{360}{1.46} + \frac{5}{1.06} + \frac{35}{1} + \frac{13}{1.07} + \frac{7}{0.87}} \approx 3.3$$

The specific weight of the compressed wood is increased to $3.3 \times 0.42 \approx 1.39$ and no hollow spaces will be found in the treated article.

2nd Example:—1 cubic meter wood contains 410 kilograms wood paste, 7 kilograms of resins, oils and fats, 40 kilograms water, 15 kilograms tar oil and 8 kilograms turpentine oil, the specific weight of treated wood before compression being equal to 0.48. Then

$$C = \frac{1000}{\frac{410}{1.46} + \frac{7}{1.06} + \frac{40}{1} + \frac{15}{1.07} + \frac{8}{0.87}} \approx 2.85$$

The specific weight of the compressed wood is equal to $2.85 \times 0.48 \approx 1.37$.

The above examples show that if the operator

desires to produce an article of a predetermined size he must begin by having a piece of wood which is 3.3 times as large as in the case of wood described in the first example, or which is 2.85 times as large as in the case of wood described in the second example.

Since the coefficient of shrinkage during drying is well known and, for instance, for the two given examples, is equal to $28 \times$ (specific weight), the dimensions of the raw wood for a finished article of any size can be easily determined.

The three-dimensional coefficient of compression is composed of different linear coefficients which depend on the strength of wood in directions parallel to the wood fibres and perpendicular to them, parallel to the concentric rings and radial to them etc.

If the tension at the end of elasticity is equal to T_e , the transverse pressure should be

$$Pt \geq C \times T_e \quad 20$$

In the case of the above-described first example with $T_e=40 \text{ kg/cm}^2$ the transverse pressure becomes equal to

$$Pt \geq 40 \times \frac{3.30}{0.4} \approx 330 \text{ kg/cm}^2 \quad 25$$

If the Poisson constant $m=4$, the longitudinal pressure in the direction of the fibres will be equal to $Pl=330 \times (4-1)=990 \text{ kg/cm}^2$.

The wood described in the second example will be subjected to practically the same pressure since in that case $T_e \approx 47 \text{ kg/cm}^2$.

After the article has been compressed, it is cooled while still remaining under the press.

After my process has been completed, the resulting article consists of a mass which is similar to wood fibres in appearance but the cells of which are hardened, bound and compressed.

The device used for treating wood comprises a cylinder or container provided with a steam generator or distributor, blasting means, and a superheater. The drying and impregnating steps of my method can be carried out entirely within this container. The device also comprises a separate heated press and cooling means. I also prefer to use some suitable means for preventing the wooden articles from cooling off on their way from the above-mentioned container to the heated press.

The vapors, gases and steam used for treating wood are all introduced into or produced within the container, they are superheated and mixed there to the desired extent and brought in contact with the wooden articles at a predetermined velocity. The vapors cause an absorption process within the wood which begins in the interior of each article and gradually spreads out towards the external layers. The articles within the container can be subjected to a vacuum treatment and the pressure of the gases and vapors can be changed from a high value to sub-atmospheric pressure or vice versa while the articles remain within the container. The wood is dried in the same apparatus, the velocity and the temperature of the heat transmitting means within the container being regulated until a uniform vaporization of moisture is obtained. The heating of the wood and the ripening and aging processes are all carried out within the same container.

A preferred embodiment of the inventive idea is illustrated in the accompanying drawings, in which:

Figure 1 is a vertical cross-section of a drying and impregnating apparatus.

Figure 2 is partly a top view and partly a horizontal section of a press used for compressing the wood.

Figure 3 is a section along the line 3—3 of Figure 2.

Figure 4 shows a compressed wooden article.

Figure 5 shows a number of presses situated one behind the other.

The device shown in Figure 1 comprises a hermetically closed heat-insulated container or cylinder *m* carrying rails *a*. A carriage *b* is supported by these rails and carries a number of wooden articles *c* placed at a certain distance from each other, each horizontal row of articles being separated from adjacent upper and lower rows by intermediate slats *d*. The slats *d* are of such size that most of the exterior surfaces of the articles remain exposed to the air.

A plate *e* which is situated within the cylinder *m* above the articles *c*, is supported by a wall *f* attached to the cylinder *m* and carrying a number of regulatable blasting devices *g*. A heating device *h* is also carried by the cylinder *m* and is situated above the plate *e*. A device *y* is used for introducing air into the cylinder and a pipe not shown in the drawings serves for removing exhaust air.

A perforated tube *i* is situated within the container *m* between the heating pipes *h* and the blasting devices *g* and extends along the entire length of the cylinder *m*. This pipe is used for introducing vapors and gases which have been produced or collected outside the cylinder.

The pipe *i* is situated within the path of the steam current and the vapors emitted by said pipe are superheated by this current before they reach the heating pipes *h* which further increase the temperature of the vapors and the steam current.

The vapors can be produced within the cylinder by providing hot surfaces between the heating pipes *h* and the blasting devices *g* and by spraying liquids over said surfaces.

An outlet *k* is used for removing the condensate from the cylinder *m*. The outlet *k* is adapted to be connected with an air pump in order to produce a vacuum within the cylinder *m*.

Plates *l* act as dams and allow only a certain predetermined amount of the circulating gases to pass under the articles *c* (this amount being sufficient to heat the bottom of the articles) while the remainder is forced to circulate among rows of articles *c*.

The distances between the walls of the cylinder *m* and the various devices within said cylinder are selected with the view to enabling the gases to maintain the required velocity while circulating within the cylinder.

The press shown in Figure 2 comprises four dies *n* used for compressing the wooden article in directions transverse to its fibres. The number of dies should correspond to the number of the article's side surfaces. The dies *n* are movable in a direction towards the center of the article and are supported by a casing *o*.

In Figure 2, two of the four dies *n* are shown in inoperative positions while the remaining dies compress the article. The pressure of the dies *n* is transmitted to the pressing jaws *p*; needle bearings *q* are used to correct the direction of the pressure and to enable the members *p* to recede from each other while being operated. The members *p* are guided by guide plates *r* which are adjustably mounted in the casing *o*.

If the treated article is a square in cross-section,

and if the forces of compression are equal to each other, the guide plates *r* are placed at angles of 45° to the dies *n*. If the compression forces are unequal, the guide plates *r* must form smaller angles with the dies *n*. If, for instance, the wooden article is rectangular in cross-section and is twice as long as it is wide, the plates *r* form an angle of about 25° with the dies *n*.

The needle bearings *q* are carried by plates *s* connected by screws with the members *p* and the intermediate pieces *t* situated between the round end-pieces of the dies *n* and the members *p*. The plates *s* are provided with slots containing the screws carried by members *p* and *t*, so that the plates *s* can slide with respect to the members *t* and *p* while the press is being operated.

A cage-shaped member *u* (Figs. 2, 3 and 5) provided with fork-shaped pieces *v* is used for holding the compressed article in position. The member *u* is moved until its pieces *v* are placed over the dies *n* and come in contact with the members *t*, keeping the compressed article under pressure during its removal from the press.

The press shown in Figure 2 is used for compressing the wooden article in directions perpendicular to its fibres. While this compression takes place the wood is also compressed by a similar press in a direction parallel to its fibres. The dies of the second-mentioned press move only a small distance, but the pressure exerted by them on the article is considerably higher than the transverse pressure.

As shown in Figure 3, the shape of the treated article can be changed during compression. The members *p* are provided for that purpose with projections and cavities which are impressed upon the article. As shown in Figure 3, the fibres of the article are not splintered during this shaping process.

A compressed wooden article is illustrated in Figure 4. This article comprises a number of projecting and receding portions which correspond to similar portions in another article so that a number of articles placed together can form one interlocking and complete whole.

Figure 5 shows three transverse presses similar to the press shown in Figures 1 and 2. These presses, situated one behind the other, are used for compressing a long wooden article. In that case I prefer to use two plates *w* extending along the entire article.

What is claimed is:

1. A method of treating wood, comprising the steps of ripening, drying and aging a wooden article, impregnating said article by placing it in the path of a gas mixture containing a superheated vapor of an impregnating substance, said vapor having a velocity of a plurality of meters per second and gradually increasing the temperature of the vapor during the last-mentioned step.

2. A method of treating wood, comprising the steps of ripening, drying and aging a wooden article, impregnating said article by placing it in the path of a gas mixture containing a superheated vapor of an impregnating substance, said vapor having a velocity of a plurality of meters per second and gradually increasing the pressure of the vapor during the last-mentioned step.

3. A method of treating wood, comprising drying an article, impregnating said article by placing it in the path of a gas mixture containing a superheated vapor of an impregnating substance, said vapor having a velocity of a plurality of meters per second, and gradually increasing

the temperature of the vapor during the last-mentioned step.

4. A method of impregnating wood, comprising placing a wooden article in the path of a gas mixture containing a superheated vapor of an impregnating substance, said vapor having a velocity of a plurality of meters per second, and gradually increasing the temperature of the vapor during the impregnation.
5. A method of treating wood, comprising drying an article, impregnating said article by placing it in the path of a gas mixture containing a superheated vapor of an impregnating sub-

stance, said vapor having a velocity of a plurality of meters per second, and gradually increasing the pressure of the vapor during the last-mentioned step.

6. A method of impregnating wood, comprising placing a wooden article in the path of a gas mixture containing a superheated vapor of an impregnating substance, said vapor having a velocity of a plurality of meters per second, and gradually increasing the pressure of the vapor during the last-mentioned step.

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