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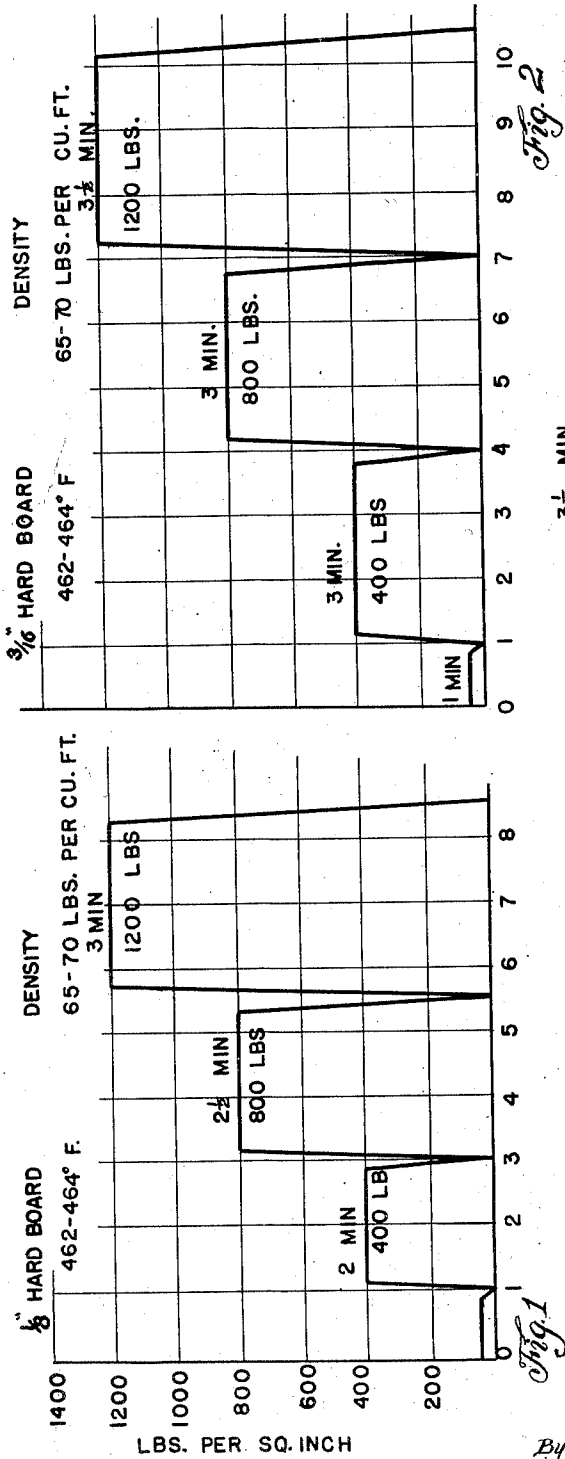
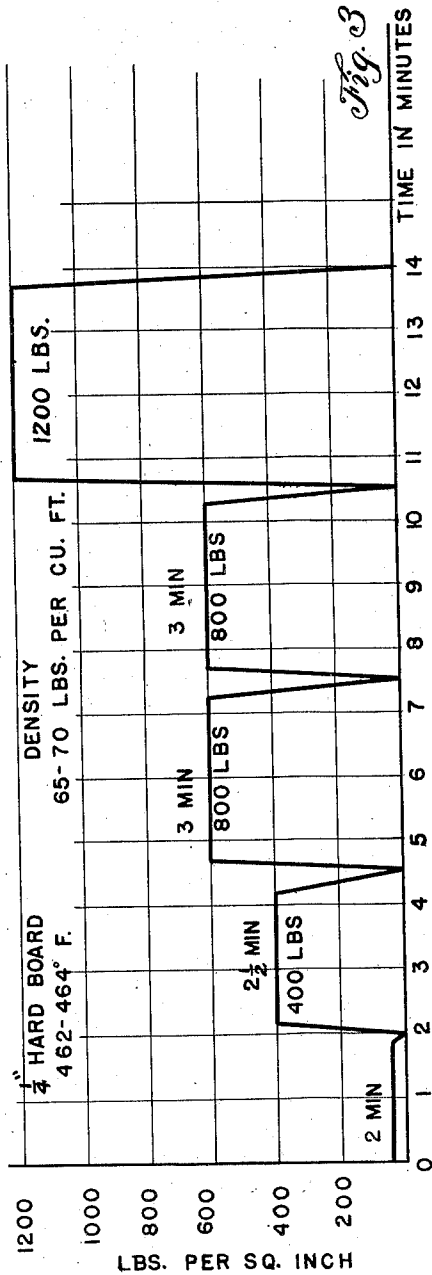
H. K. LINZELL ET AL

2,198,269

MANUFACTURE OF COMPRESSED CELLULOSIC OR WOOD PRODUCTS

Filed May 2, 1934

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

Fig. 5

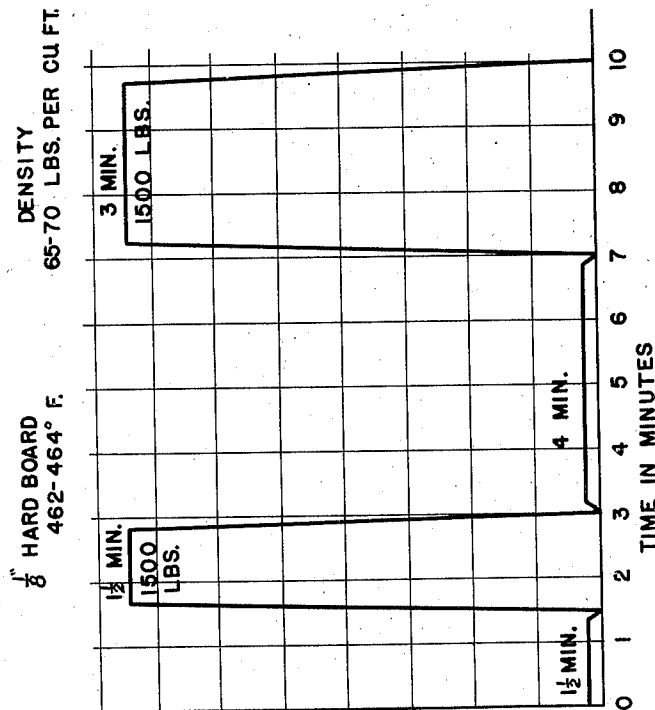
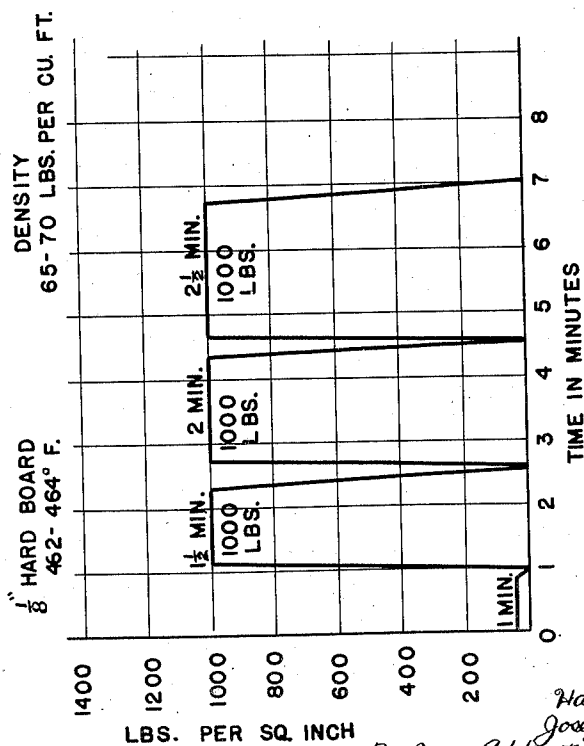


Fig. 4



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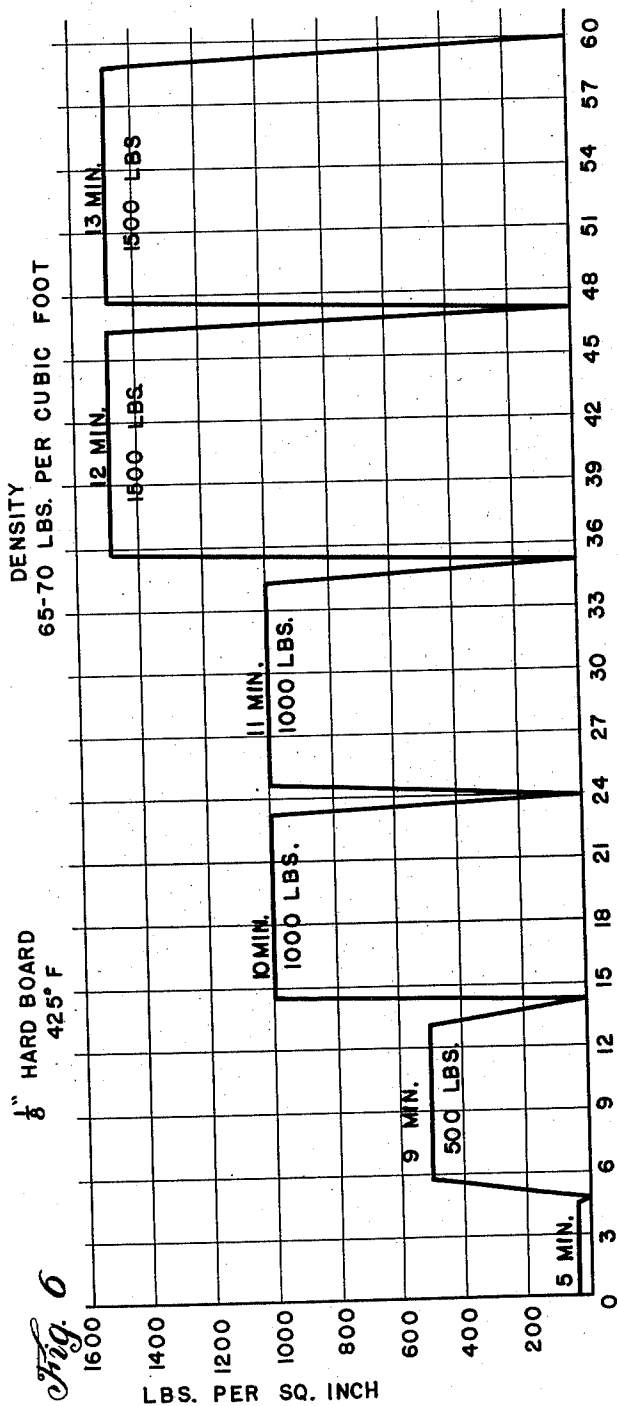


Fig. 8

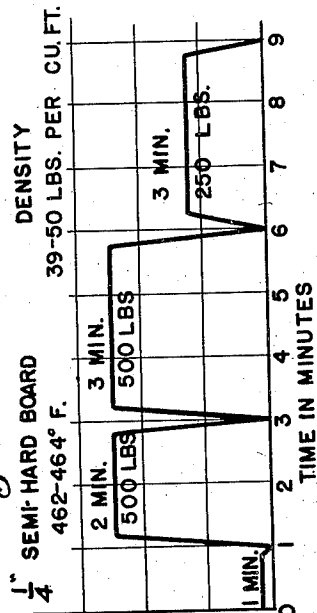
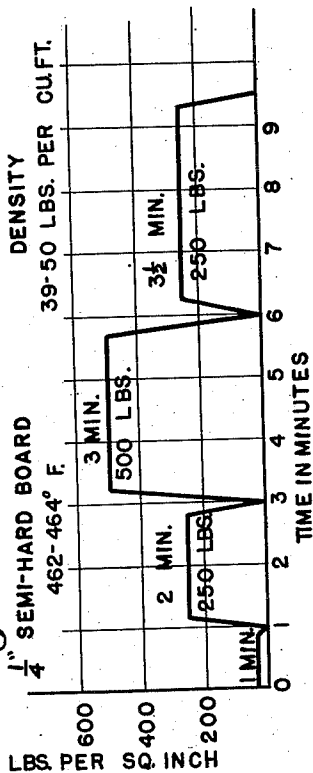


Fig. 7



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UNITED STATES PATENT OFFICE

2,198,269

MANUFACTURE OF COMPRESSED CELLULOSIC OR WOOD PRODUCTS

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Application May 2, 1934, Serial No. 723,512

7 Claims. (Cl. 92—61)

The present invention relates to an improvement in the manufacture of compressed cellulosic or wood products.

The primary object of the invention is to produce a dense, strong and water resistant product from the constituents of cellulosic raw material such as natural wood or woody material, and the therein contained fibers and natural binders, lignins, pentosans, cuto-cellulose, pecto-cellulose, and similar complexes, by a process which involves the fibrillation of the material by any suitable means and its subsequent reconstruction into a substantially grainless, hard and strong body by a dry process carried out at a temperature and an impacting pressure to bring about incipient pyrolytic decomposition of the material with concomitant formation within the same of tarry bodies, decomposition and condensation products, which, acting as binders and preservatives, greatly enhance the strength and water resistance of the product.

A further object of the invention relates to the process of producing a hard dense wood product which comprises comminuting wood by any suitable means so as to yield individual fibers and fiber bundles, causing the interlacing and intermingling of said fiber bundles into heterogeneous relationship, followed by consolidation thereof under heat and impacting pressure sufficient to bring about a pyrolytic decomposition of the wood and woody material, particularly the therein contained ligno-, cuto-, and pecto-cellulose complexes, with the formation of decomposition products such as tars, aldehydes, acids, phenols, and condensation products derived therefrom.

Another object of the invention is to modify the surface of articles having a wood or woody surface, for the combined purpose of rendering the said surface uniform, smooth and even.

A further object of the invention is to modify the surface of products composed of reconstituted fibrated cellulosic materials, such as insulating boards or other artificial boards or lumber, or any article composed in such a manner that its surface contains ligneous and cellulosic constituents.

Still a further object of the invention is to improve the surface of an article composed of cellulosic or ligneous material, or having a surface of such material, by applying against said surface a smooth heat-conducting body maintained at a temperature sufficiently high to bring about the decomposition and resinification already herein mentioned.

A more specific object of the invention is the

provision of pressing members or caul plates having pressing surfaces of black magnetic iron oxide, as this prevents the sticking of the cellulosic materials to such pressing members.

In its broadest aspects, the invention is directed to a process involving the consolidation of cellulosic material and wood or woody material by means of the combined effect of heat and impacting pressure in the substantial absence of water. Thus one takes cellulosic raw material, wood or woody material, and the like, such for example as sawdust or the material in the fibrous state, dries it and then consolidates it in suitable dies or molds under high pressure and at a temperature ranging from 400° F. up to the point where production of carbon as a result of the decomposition of the material takes place. The upper limit is the ignition point of the material.

The products thus obtained are dense and hard and constitute a synthetic or reconstructed wood which may be denser than the wood from which the original fibrous material is obtained. The density may be varied in accordance with the time, pressure and temperature employed. The natural resins, gums and adhesive matters contained in the particles of wood or woody material are softened and rendered plastic by the heat, so that while still hot the material may be subjected to heavy impactation in suitable molds, thereby becoming consolidated.

Attention is directed to the drawings accompanying this specification. These drawings, Figs. 1 to 8, are graphs showing details of the preferred methods of operation. The vertical component is in pounds per square inch pressure applied to the boards, and the horizontal component is time in minutes. Detailed descriptions of the various figures are to be found below.

It has been found by the inventors that there is a practical range of temperature, time and pressure in which, when making dense boards, vastly superior results are obtained. It has been found that at a temperature between 445° F. and 475° F., and in a time range up to 30 minutes, there is a sufficient pyrolytic decomposition or "cracking" of the ligneous material, cellulose, wood or woody material, without a corresponding loss in strength of the fiber thereof. In other words, while the decomposition brought about by the heat and time yields dark colored tarry matter, acids, aldehydes, phenols and alcohols, etc., the temperature and time are not high enough or long enough to cause a complete charring of the material; in fact, it retains its general fibrous structure but, when examined under a micro-

scope, is seen to be somewhat roughened, pitted, considerably darkened in color, and interspersed with, permeated by and covered with the definitely noticeable tarry substances. It is also believed highly probable, although the invention is not to be limited by this theory, that the simultaneous development—under the influence of the heat—of phenols, aldehydes, acids, alcohols, etc., brings about a reaction of the type of that taking place between aldehydes and phenols under the catalytic influence of the acid, with the probable formation *in situ*—both upon and in the material—of condensation products of the phenolic resin type. As is well known, such phenolic condensation products are capable of conversion into the infusible insoluble state, and in such state are highly resistant to the influence of water or other solvents. While it has heretofore been proposed to take, for example, wood flour or other cellulosic or ligneous material and to mix the same with preliminarily prepared phenolic resins, or even to treat the wood with phenols and aldehydes, and then to depend upon the formation of the desired resins within the wood, the formation of these condensation products out of the natural constituents of the wood itself under definitely controlled conditions, as herein disclosed, not only cheapens the process but produces just the type of artificial resins which are most conducive to the production of a highly satisfactory and desirable product.

In the practice of this invention, so far as it relates to dense boards, it is desirable to insure the absence of all free water. This means that the products to be consolidated are subjected to heat and pressure preferably in the completely dry state although, when merely surface-treating, by suitable modification of equipment and/or the pressing cycle used, air dry materials can also be used. In case of mere surface treatment, any vapor formed can escape readily through the open-textured interior of the material.

The invention is carried out in its preferred form in the following manner:

In the production, for example, of a slab, board or other article of artificial lumber, any suitable type of wood such as pine, hemlock, spruce, poplar, cottonwood, and the like is fibrated by any suitable known means. The wood or woody material is preferably comminuted so as to yield as long a fiber as possible. This may be accomplished by triturating, that is, grinding it by means of grindstones in the presence of water, or by any other means. Care is taken to avoid the removal of any of the woody material other than such parts thereof as are naturally water-soluble. Thus, for example, when working with western larch, the incidental removal of galactan and other water-soluble gums may take place either simultaneously with or following the grinding operation. In any event, however, in the case of wood ground in the presence of water, the fiber is separated from the water by filtration by means of a centrifuge or in any other suitable way, and the fiber is then dried so as to remove the water therefrom. The dry fiber thus obtained is then charged into suitable molds wherein it is first heated and then, while at the desired temperature, is subjected to impacting pressure. The pressure may be applied mechanically, as by means of a steam-driven ram, a screw press, a toggle press, or by means of a hydraulic press, the exact means being a matter of indifference, the main object being to apply to the heated woody fiber sufficient pressure for a sufficient

length of time to cause a coalescence and welding together of the fibers and a setting up of the tar and resinous matters produced by the effect of the heat.

As a manufacturing convenience, it will be within the scope of the present invention first to form from the mass of fibrated material, while still in the presence of water into a suitable, loosely compressed, coherent sheet such as the ordinary sheet of fibrous material long known in the art of making insulating material. Such a sheet of fibrous material is placed into a drier, wherein it is relieved of its moisture. However, it is possible, for example, to obtain or purchase insulating boards and thereupon to subject them to the process of the present invention.

As a more specific embodiment of the present invention, there will now be described the manufacture of a complete synthetic wood board. Wood such as cottonwood is suitably comminuted, as by grinding in the presence of water on a standard pulp-stone or grinder, so as to yield a fibrous mass of woody substance. Alternatively, the wood may be fibrated or broken up dry, so as to form a sort of sawdust, wood fiber, wood wool, excelsior, or the like, and the woody material thus obtained formed into a mat or wad. This may be done by blowing the dry fiber, by means of air or other gas, onto a suitable screen, while applying sufficient suction to the under side of the screen slightly to compact the resulting mat. The loose mat thus produced is then transferred to a suitable supporting sheet, as for example a sheet of blue oxidized iron, and then compressed at the temperature ranges hereinafter mentioned. Such a mat of fibers may be entirely without any applied sizing composition, but it will be within the scope of the present invention to size such fiber by spraying a size thereon prior to its compression. Alternatively, the mat may be pre-compressed in a form before being placed on the iron sheet.

However, when using the ordinary process for forming insulating board, the ground wood mass is placed into a tank and while therein is sized by means of ordinary rosin size in the manner entirely well known in the paper-making art. For instance, a solution of saponified or emulsified resin may be added and the resin then precipitated by the addition of an aluminum salt such as aluminum sulfate of the type known as "paper makers' alum." The amount of sizing in the case of cottonwood may be on the order of 1.0% of rosin on the dry weight of the fiber. The sized, or unsized, fiber is then formed into a sheet by means, for example, of an Oliver board-forming machine. Such a machine is well known in the paper and board making art, and for the purposes of this invention requires no description. The board thus formed may be somewhat compressed or compacted by being passed under light pressure between rollers for the purpose of removing the large quantity of water contained in the interstices between the fiber, and the board may then be run directly from the rollers into a drier. The drier may be of the hot-air type and preferably of the kind known in this art as a Coe drier. The board remains in this drier for a time sufficient to insure no further loss in weight, thus insuring the complete removal of the water, both free and hygroscopic. The completely dry, and preferably still warm, board is then ready for carrying out the consolidating operation. If, however, it is not desired immediately to proceed with the pressing, the dry soft

insulating board made by the process as thus far described may be stored in a dry place until ready for use, although if stored for any length of time it may absorb some moisture, in which case it is again placed in a drier to insure the removal of any moisture which the board may have picked up due to the humidity of the air in which it was stored.

In any event, the thoroughly dry slab of soft insulating board is placed between the platens of a suitable press, which may be actuated by any desired means, provided only that the required pressure per square inch may be applied to the board. In the manufacture of a board 4 by 12 feet and about $\frac{1}{8}$ inch thick, it is desirable to start with an insulating board approximately $\frac{1}{2}$ to $\frac{3}{4}$ inch thick. This board is placed between the platens of the press, these platens being heated so that the surfaces thereof will be at a temperature above 400° F. but below a temperature where complete carbonization of the fibers would take place. The actual ignition point of wood is about 527° F. The platens are first placed into superficial contact with the surface of the board, and the board is allowed thus to remain for a short time until the heat of the platens has thoroughly heated the board. Thereupon the impacting pressure is applied, most conveniently by means of a hydraulic press or its equivalent, and the board is compressed at a pressure of from 500 to 3000 pounds per square inch for a total period of about from 5 to 30 minutes, depending upon the temperature used. When using very thin material, the time may be even less. The active decomposition of the constituents of the cellulosic or woody material will soon make itself manifest by the development of a bluish and acrid smoke. In order to prevent the too great accumulation of uncondensable gases and vapors in the board, the pressure is released at the end of from one-quarter to one-half of the total pressing time, allowing the gas and smoke to escape, in which event the pressure is then again applied, and the board is subjected to the heat and pressure for the remainder of the period, depending upon the thickness of the board and the temperature. This operation of alternately compressing or impacting, and releasing, of the board may be repeated a number of times. At the end of the pressing time the pressure is released, and the board is taken out of the press.

In carrying the present invention into commercial practice, it has been found that there are distinct advantages in applying the impacting pressures in distinct stages or intervals, the pressure being either the same at each period or different in each of the periods, as will presently be explained. In any event, there is a release of pressure between the individual im-

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pactions. For example, sheets of insulating board, completely relieved of their moisture, are placed on caul plates and the assembly inserted between the platens of a hydraulic press. The temperature as measured at the surface of these platens may be, for example, between 445° and 475° F. The press is then operated so as to bring the platens into contact with the boards, but without the application of any substantial pressure, for the purpose of heating the surface of the boards to about the temperature of the platens. This usually takes from 1 to 3 minutes. During this time, which can conveniently be termed the "toasting period," the board surface

so as to prevent the adhesion of the boards to the caul plates. The pressure is then applied for a period of from 2 to 3 minutes, whereupon it is gradually released and the platens allowed to lift slightly off the boards for the purpose of allowing the escape of the accumulated gases and vapors. A bluish acrid smoke will be seen to rise from the boards and pass out between the platens. The pressure is then again applied for a further period of from two to three minutes, whereupon it is again released in the same manner as already described. The pressure is then once more applied, and at the end of another period of 2 or 3 minutes the pressure is finally released and the press opened. Thereupon the boards are quickly removed from the press and immediately subjected to a strong blast of air, preferably but not necessarily heated, to remove as much as possible of the smoke and gases from the freshly formed boards. This is done in order to remove the somewhat acrid odor which would otherwise adhere to the boards. The boards may then be passed through a passageway in which they are subjected to a blast or current of cool air in order to relieve them of heat and to allow them to assume room temperature without warping.

It has been found particularly advantageous to change the pressure during the various times that it is applied, this pressure either increasing or, in some instances, being lowered. For example, when making a hardened board $\frac{1}{8}$ inch thick and of a density of from 65 to 75 pounds per cubic foot and working at a temperature of 462° to 464° F., measured at the surface of the platens, the cycle may be substantially as that shown in Fig. 1. In this figure, as well as in those subsequently to be described, the horizontal component represents time expressed in minutes, while the vertical component represents pressure in pounds per square inch exerted on the surface of the board undergoing treatment. Thus, in Fig. 1 it will be seen that the board is subjected to the toasting operation at a pressure of not exceeding 50 pounds for a period of one minute, whereupon the pressure is released momentarily to allow the escape of the initial amount of smoke and gases formed. The pressure on the boards is then raised to 400 pounds per square inch for a period of two minutes, whereupon it is released and the platens lifted clear of the boards. The pressure is then applied to the extent of 800 pounds per square inch and kept on for a period of 2½ minutes, whereupon it is again released and the platens lifted from the board. There then follows a final application of pressure on the order of 1200 pounds per square inch for a period of 3 minutes, at the end of which time the pressure is released, the press opened and the boards removed. The total pressing time, counting from the moment the boards enter the press, and therefore including the toasting period of one minute, is thus 8½ minutes.

Referring now to Fig. 2, which is an example of the production of $\frac{1}{8}$ inch hard board at 462° to 464° F. and having a density of 65 to 70 pounds per cubic foot, it will be seen that the entire cycle is somewhat longer because of the fact that $\frac{1}{8}$ inch board is 50% thicker than $\frac{1}{4}$ inch board and that therefore the mass of material is 150% of that of the $\frac{1}{4}$ inch board. Inasmuch as the heat is abstracted from the surface of the board by the loose textured interior, it takes a little longer to get the surface of the board up to the platen temperatures, which

makes it necessary slightly to increase the toasting period in this case 50%. The cycle in Fig. 2 also consists of three intermediate pressure releases and the final pressure release, and three stages of pressure application respectively of 400, 800 and 1200 pounds per square inch, these periods being 3, 3 and 3½ minutes, respectively, as will be seen from the figure. The total time, counting from the moment that the board enters the press and including the 1½ minute toasting period at less than 50 pounds pressure, is therefore 10½ minutes.

In Fig. 3, which is an exemplification of the manufacture of ¼ inch hard board at 462° to 464° F., the cycle is somewhat different. The toasting period in this case at less than 50 pounds pressure is 2 minutes. The first application of pressure of a period of 2½ minutes is 400 pounds, followed by two separate applications of pressure of 3 minutes each at 800 pounds, and finally application of 1200 pounds pressure for 3½ minutes, or a total of 14 minutes, counting from the time the board enters the press.

In these figures, the release of pressure is indicated by the valleys between the horizontal lines indicating the duration of the application of pressure, the pressure falling to zero because the platens at that point are actually lifted clean of the boards. During the toasting period, the only pressure on the boards is that produced by the jack-rams of the press, which is just sufficient to insure the lifting of the individual platens into contact with the boards.

Alternatively, in making ½ inch hard board of a density of 65 to 70 pounds per cubic foot, at 462° to 464° F., the applications of pressure may all be of the same degree, viz., 1000 pounds. Thus, as shown in Fig. 4, the initial toasting period may be one minute, followed by release of pressure and lifting of the platens from the boards, whereupon pressure of 1000 pounds is applied for 1½ minutes, followed by pressure release and lifting of the platens just as previously described. The pressure is then again raised to 1000 pounds for 2 minutes, again released and then once more raised to 1000 pounds per square inch for a period of 2½ minutes, whereupon the pressure is released and the press is opened. The total time, therefore, including the toasting period, is 7 minutes. When operating in the manner described in Fig. 4, however, the results are not as completely satisfactory as they are when working in accordance with the conditions shown in Figs. 2 and 3, for it appears that the development of the smoke and gases tends to the formation of a fiber board which shows a slight inclination toward blistering or laminating and also has a greater tendency to stick to the caul plates than when the pressure is applied as shown in Figs. 1, 2 and 3. It will be noticed, however, that the cycle is 1½ minutes shorter and the highest pressure is 200 pounds less, that is, 1000 pounds instead of 1200 pounds.

In Fig. 5 is shown still another way of operating, making ½ inch board at 462° to 464° F. and of a density of 65 to 70 pounds per cubic foot. When working in accordance with the conditions of Fig. 5, the tendency of the board to laminate is very slight. When it is considered that the present invention is predicated upon the fact that resins are produced by the pyrolysis of the wood, it will be appreciated why a cycle such as shown in Fig. 5 is desirable. In this cycle there is the usual toasting period of 1½ minutes with a pressure of less than 50 pounds,

followed by a pressure release and lifting of the platens from the board, whereupon a pressure of 1500 pounds per square inch is applied for a period of 1½ minutes. The pressure is then released and the platens merely placed in contact with the boards, just as during the toasting period, and held that way for 4 minutes at a pressure of less than 50 pounds. During this prolonged second toasting period an opportunity is given for full development of the desired quota of resinous and tarry materials as a result of the pyrolytic decomposition of the wood. The pressure is then released to allow gases and smoke to escape by lifting the platens from the board, whereupon the pressure is again applied to the full 1500 pounds for a period of 3 minutes. During this latter period, the resins formed during the 4-minute toasting period, together with such additional resins as form during the second compression stage, are set and the board is given its final hardness. The total pressing time, including the initial toasting, is thus 10 minutes.

When working in accordance with Fig. 5, but raising the temperature say from 466° to 470° F., the total time cycle could easily be reduced to 7 minutes by shortening the intermediate toasting stage as well as the compression stages, as will be readily understood from what has been said in connection with all of the diagrams or figures thus far described.

It is also possible, although not as advantageous, to work at a lower temperature such as 425° F., but in that case the time cycle is very greatly increased. This increase in time cycle, however, is compensated for by other advantages, viz., that less pressure need be carried on the boiler that furnishes the high pressure steam for heating the platens and also that the skill of the press-operator need not be of as high order, nor need the cycles be so slavishly adhered to. In other words, the cycle illustrated in Fig. 6, which is that for the production of ½ inch hard board, is shown as being carried out at 425° F. In that case the initial toasting is 5 minutes. There is an application of pressure of 500 pounds for 9 minutes, two applications of 1000 pounds for 10 and 11 minutes, respectively, and two applications of 1500 pounds for 12 and 13 minutes, respectively, making a total time, including the toasting, of 60 minutes. It will be obvious that at 425° F. these intermediate cycles may be shifted about as to time without seriously interfering with the successful operation of the process. Furthermore, a variation in the total time of 10% in either direction would make very little difference. Where a 20-deck press, for example, is used and there is but one operator, it is quite possible that the same operator could thus handle two presses, making twenty boards at a time, having time to attend to both of them without interfering with the proper carrying out of his duties.

Referring now to Fig. 7, this illustrates the manufacture of what may be called a semi-hard board having a density of from 39 to 50 pounds per cubic foot, which is made by using stops to prevent the travel of the platens beyond the limits thereof. The stops are ¼ inch thick, so that the board will under no circumstances be thinner than ¼ inch. The cycle, it will be seen, is somewhat different. The initial toasting period is one minute. There is then an application of pressure of 250 pounds for 2 minutes, followed by the usual pressure release, followed by a cycle of 500 pounds pressure for 3 minutes, which suf-

fices to compress the board up to the limits of the stops, whereupon the pressure is released and the platens lifted as usual. The final application of pressure need therefore be only 250 pounds, because there would be no object in applying any greater pressure than would be necessary to prevent the re-expansion of the board above the limits of the stops; and in the figure shown, and in Fig. 6, this final pressure is 250 pounds per square inch. The total cycle in that particular example is 9½ minutes.

As a further exemplification of an alternative method of making the semi-hard board, the cycle may be somewhat like that shown in Fig. 8, which, in view of what has been said in connection with the previous figures, will be self-explanatory.

The platens used for heating the board are preferably lined with sheets or caul-plates of common sheet iron which has a black or blue iron oxide coating. Such sheets are sometimes known as stove iron or blue sheets and are a common article of commerce. The oxide on such sheets may be produced by heating the sheets before and during the rolling operation and consists essentially of a tightly adherent layer of the black magnetic iron oxide, having the probable formula of Fe_3O_4 . It is of course within the purview of the invention deliberately to oxidize iron or steel plates under conditions conducive to the formation of a substantially integral coating of such black magnetic iron oxide. It is not necessary to use polished or stainless steel caul plates, or to coat the sheets with chromium or nickel; in fact it has been definitely proved that such polished sheets are undesirable because the boards tend to stick to the polished sheets, while they do not stick to the oxidized or oxide-coated sheets. At any rate, when using a black magnetic iron oxide coated caul-plate, there is no sticking of the board to the heated surfaces, and this is a great advantage. It is not necessary to oil the plates unless they are of unoxidized metal, in which case a small amount of lubricant is generally required. Furthermore, it is not necessary to interpose a screen between the board and press platens in order to allow the escape of moisture, such as has been commonly used in the manufacture of pressed boards by the wet pressing processes of the prior art, because there is substantially no moisture in the board while it is in the press, and hence no provision need be made to allow for its escape. Because of the fact that no screens are used on either side of the board during the pressing operation, the board comes from the press with a very pleasing surface which, if the sheets are sufficiently smooth, is almost optically reflecting. The heat acting upon the cellulose, wood or woody material liberates therefrom by incipient decomposition, tars, phenols, aldehydes, acids, etc., which, combining as stated hereinbefore, serve to bind the fibers together into a remarkably strong, dense and coherent body having a pleasing brown to blackish-brown appearance, simulating some of the more expensive hard woods.

It is obviously within the scope of the present invention to press more than one board at a time, and this may be accomplished by the well known type of multi-platen hydraulic press.

If it is desired to produce a board which does not have the maximum density, this can readily be accomplished by placing between the platens of the press, outside the area where the boards lie, sufficiently strong blocks or slats, preferably of steel, serving as stops, which limit the degree

of compression; thus, for example, a board ¼ inch thick can be made from a dry insulating sheet ¾ inch thick by using ¼ inch blocks or slats on two or four sides of the board while it is in the press. Obviously the thickness of the board will be limited to the thickness of the stops used.

A lower density board may also be formed without the use of stops by employing pressures which may be considerably less than those hereinabove enumerated.

Thus if merely the surface of the insulating board is to be smoothened, then a smooth, hot heat-conducting body, such as a sheet of metal, a body of metal, or the platens and caul-plates of the press is employed to effect the conversion of the cellulosic and ligneous surface and to impart its heat thereto. It has been found that for this particular purpose there is a range of temperature in which superior results are obtained, and this range is substantially between 400° F. and the ignition point. The time of contact between the heat-conducting body and the ligneous and cellulosic surface may be varied from a few seconds up to one hour, depending upon the temperature; and it is also within the scope of the invention simultaneously to apply comparatively light pressure against the said surface.

For example, if the invention is to be applied for improving the surface of a sheet of fiber insulating board, the process may be carried out by placing a sheet of said insulating board between the platens of a hydraulic press, the platens being heated to such an extent that the surface temperature thereof lies above 400° F. Suitable stops to prevent undue compression of the board should be used. Carrying the temperature, for example, at 465° F. and applying to the insulating board, by means of the platens, a pressure of from 15 to 20 pounds per square inch, a contact of the platens with the board for about two minutes will generally suffice to form a satisfactory surface. On opening the press and withdrawing the board, it will be found that the board has acquired a very fine, smooth and coherent finish which is readily adapted for painting or varnishing, or the application of wall paper or ornamental plastic paints and the like. With a comparatively short time of contact, the decomposition and resinification may extend but a very short distance into the board, and the air cells naturally existing in the board are preserved substantially intact. If the temperature be carried at the lower range, say at about 400° F., the time of contact may be considerably prolonged. It may be generally stated that as the temperature is decreased the time of contact should be increased. The amount of pressure employed in general merely determines the thickness of the board. Due to the thermolytic decomposition which takes place in the fiber board, the color will be altered so that a board which before treatment is a light grayish cream, or almost white, after treatment has a pleasing brown appearance, this varying, of course, with the nature of the wood and the time of contact.

It may be stated that the temperature range for mere surface treatment is from 400° F. upward, the pressure range from mere superficial contact up to 50 pounds per square inch, and the time of contact from a few seconds up to one hour. In certain instances and with variations in the nature of the wood, contact at 400° F. for one hour will be sufficient to yield desirable

results. There is considerable latitude in carrying out this phase of the present invention, as the effects and colors may be varied as desired.

In the case of insulating board, very satisfactory results are obtained by first drying it until no further loss of weight is obtained—that is to say, until substantially all volatilizable moisture has been removed therefrom—and then to subject the board to the surface treatment.

The dense boards produced in accordance with the present invention are substantially grainless, extremely strong and highly resistant to the action of water and other solvents, and may therefore be employed in lieu of wood, and may be nailed, planed, sawed, drilled, or otherwise machined in a manner almost exactly the same as wood, except that they have the added advantage of having no definite grain.

In making dense boards by the process of the present invention, it is necessary, in order to obtain the optimum results, to correlate the various factors involved, namely, the temperature, the pressure, and the time. For practical purposes it is desirable to produce a board having a modulus of rupture of upwards of 4000 pounds per square inch. At the same time it is also desirable that the board should have a water absorption not exceeding about 25%. This means that a board weighing 100 pounds when immersed in water at room temperature for 24 hours would not absorb a sufficient quantity of water so as then to weigh more than 125 pounds. While the various factors are not related to each other by straight-line functions, it may be stated that, generally speaking, at a lower temperature, and at a given pressure, the time factor will have to be increased, while at a higher temperature, but at the same given pressure, the time factor may be reduced. Within the limits of the temperature range of the present invention, namely, from 400° F. up to active development of carbon, and within a pressure range from 500 to 3000 pounds, the length of time that the material is undergoing pressure may vary from a few minutes up to one hour. In discussing the relationship between the time, the temperature and the pressure, it is to be taken as an assumption that a dense board produced as hereinabove set forth, having at least a modulus of rupture of 4000 pounds per square inch and a water absorption not exceeding 25% on 24-hour immersion, is taken as a criterion.

It has been ascertained that within the range of 445° to 475° F. and when the board is in the press for less than 20 minutes, the most satisfactory product is obtained. The pressure may be from 500 to 2000 pounds, and preferably be-

tween 700 and 1500 pounds per square inch. At the higher temperature ranges, the pressing time may be as low as 6 or 7 minutes.

The present process, while described in connection with mechanical wood pulp (made either by wet or dry methods), is also applicable to other kinds of pulp, such as chemical wood pulp, sulfite pulp, paper pulp, chip pulp, and other forms of cellulosic raw material such as may be derived from annual plants, cotton-stalks, cornstalks, sorghum and fibrous industrial cellulosic wastes. Cellulose on heating decomposes with the formation of a variety of organic products, many of which are capable of combining to form preservatives and binding agents, which contribute to the tenacity of the resulting products.

What it is desired to protect by Letters Patent is set forth in the following claims:

1. The process of producing a consolidated cellulosic product which comprises subjecting substantially dry cellulosic material to a temperature of at least 400° F. under impacting pressure which is applied thereto by means of a member having a pressing surface of black magnetic iron oxide.
2. A hot-pressing member for pressing cellulosic matter, consisting of iron or steel having an adherent coating of black magnetic iron oxide on its pressing-surface.
3. A pressing member for hot-pressing cellulosic matter, consisting of iron or steel, the pressing-surface of which has been oxidized to the black magnetic iron oxide.
4. A pressing member for hot-pressing cellulosic matter consisting of iron or steel coated on its pressing-surface with a layer of the black magnetic iron oxide substantially integral with the body of the pressing member.
5. A press caul plate for hot-pressing cellulosic sheets consisting of an iron or steel plate having a substantially integral coating of the black magnetic iron oxide, Fe_3O_4 , on its pressing surface.
6. In the process of consolidating cellulosic material the step which comprises applying pressure thereto by means of a heated iron or steel pressing member the pressing-surface of which is provided with an adherent coating of black magnetic iron oxide.
7. The process of consolidating cellulosic material which comprises the steps of heating an iron or steel pressing member coated with black magnetic iron oxide to a temperature of approximately 400° F. or higher and applying pressure to the said material therewith.

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