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CONTINUOUS PRODUCTION OF LIGNO-CELLULOSE FIBER PRODUCT

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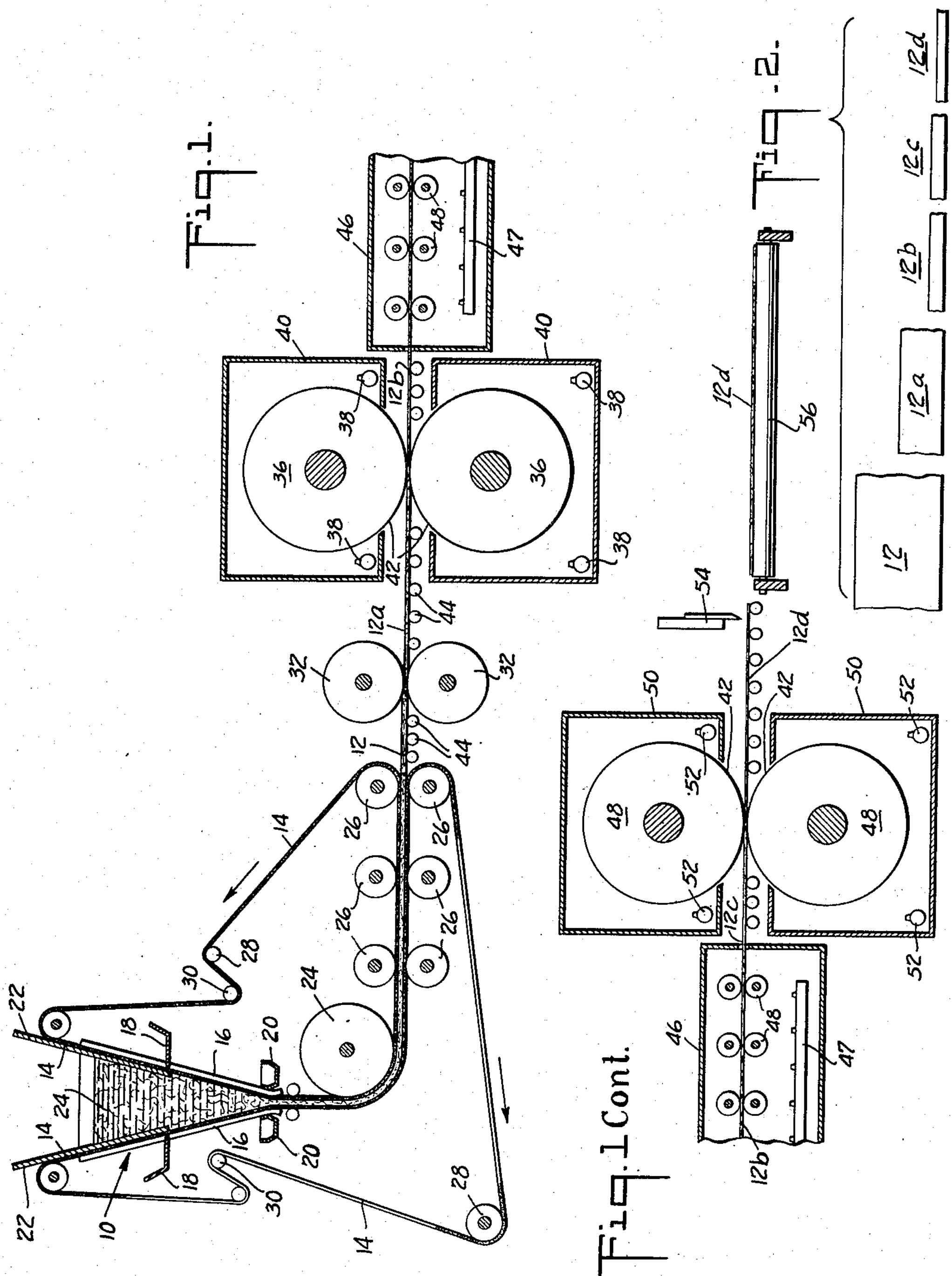

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CONTINUOUS PRODUCTION OF LIGNO-CELLULOSE FIBER PRODUCT

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2 Claims. (Cl. 92—39)

My invention relates to the production of dense ligno-cellulose products. The present invention is in the nature of an improvement on my Patent 1,663,505 issued March 20, 1928.

One object of the present invention is the provision of a process in which heated rolls can be made use of for applying heat and pressure to a sheet of ligno-cellulose fiber, and good, dense, strong sheets or boards obtained by controlling the conditions for heat and pressure application so as to get the benefits of densifying and bonding a body of ligno-cellulose fiber originally containing a material percentage of water while drying the same, and also of further densifying and bonding of the body of ligno-cellulose fiber in the substantial absence of moisture.

A further object of the invention consists in the provision of a process whereby heat and pressure are applied to the ligno-cellulose fiber material by passing a sheet thereof through rolls at increasingly high temperatures, and a drying step is performed on the fiber material between roll passes.

A further object of the invention consists in the provision of a process of hot-roll manufacture of dense ligno-cellulose products in which drying is avoided until the material is subjected to a first hot roll pass.

Further objects will appear in connection with the following description of illustrative embodiments of the invention.

A so-called wet lap of ligno-cellulose fiber formed in a suitable forming apparatus usually contains approximately 60% of water, based on the total weight of the wet lap.

The first step in the process applied to such a wet lap preferably consists in expressing surplus water. This may be accomplished in several ways. It may be effected by the heated rolls themselves, or performed in connection with the apparatus for forming the wet lap. Preferably, however, a separate pair of rolls is provided for this purpose which roll pair need not be heated, and is located between the wet lap forming apparatus and the heated rolls, and at the relatively slow speeds hereinafter described the water content may be reduced to as low as about 40% without backward flow of expelled water causing injury to the wet lap.

When such separate pair of dewatering rolls is provided, it is preferably operated at a pressure higher than that applied by the hot rolls. This avoids water being expressed by the heated rolls and possible resulting streaking of the product.

While the water content is preferably preliminarily reduced as stated, drying of the sheet preparatory to its passage through the heated pressure rolls is avoided since the fibrous material can be most readily and effectively compacted into dense state and bonded in such dense state by being dried under pressure from the state of softness which results from soaking in the forming water. My experience is that if the fiber is once dried bone dry, the original bonding properties and attainable strength and hardness, cannot be entirely restored by later addition of water.

For the reasons stated, I introduce the fiber sheet between a pair of heated rolls while still containing a substantial percentage, as 40%–60%, of water, and utilize said rolls for applying heat and pressure to densify and dry the moist fiber of the sheet, especially the surface parts thereof which come into contact with the hot rolls, and to a lesser extent the interior portion of the fiber sheet.

I have found, for example, that with relatively coarse fiber made by explosion of wood chips with a moderate degree of refinement, and conditions as stated in the examples given below, when about 6 to 18% of water remains in the board after passing through the heated rolls, the product which is of approximately 1 specific gravity at this stage, with modulus of rupture dry of approximately 5500 lbs. per square inch, remains strong and practically free from delamination. Generally stated, the numerous factors making up an entire set of conditions, such as character of fiber, thickness of wet lap, temperature, pressure and speed of travel, have to be so related that steam is not generated faster than it can escape, or else steam pressure will build up and delamination will ensue within that part of the sheet leaving the region of maximum pressure between the rolls. Such defect, once produced, cannot, so far as I have been able to learn, be entirely corrected later. As noted in the examples below, a temperature of 200° C. gave good results in the primary hot roll pass with other conditions as therein stated.

If the same treatment as given to the wet lap, in the primary hot roll pass, be now applied in a second hot roll pass to the sheet as delivered from the first set of hot rolls, and the remaining moisture converted into steam, rupture and local or extended splitting will ensue.

The next step of my process, by which such outcome is avoided, consists in applying heat, preferably without accompanying pressure, as in a hot air drier, to reduce the moisture content to such extent that harmful generation of steam will not ensue when subjected to a second pass between heated rolls.

I have found that when the moisture content is dried down to below 3 percent, (and preferably about 1 or 2 percent), the best results are secured in a subsequent hot roll pass or passes, this small remaining percentage of moisture apparently serving as a plasticizer, with improved final results as compared with results obtained upon drying until there is no further loss in weight.

The object of a subsequent or secondary hot roll pass or passes, which is the next step of the process, is to produce further densification and bonding, and to this end the temperatures or pressures, and preferably both temperature and pressure, are increased in a second hot roll pass over those used in the primary hot roll pass.

In any case the temperature applied in a secondary hot roll pass to the ligno-cellulose fiber material in such state of substantial absence of moisture (under 3%) should be over a critical figure of 210° C. which is necessary for activation of the self-bonding properties of the ligno-cellulose fiber material in such state of approximate dryness, and preferably the temperature should be 250° C., or higher, so long as objectionable charring is avoided.

The last-named hot roll pass can be repeated if desired at higher pressure. Higher temperatures may also be used, particularly if the first of the hot roll passes given in such substantial absence of moisture is carried out at a temperature under 250° C., but it is to be observed that not only is objectionable charring to be avoided but formation of gases may occur productive of delamination, and the temperature, together with the speed and pressure, should be adjusted to avoid such effects.

In the accompanying drawing, Fig. 1 is a diagrammatical vertical sectional view of apparatus for carrying out an embodiment of the process to produce hard dense strong ligno-cellulose fiber board continuously and with minimum labor cost, and Fig. 2 is an edge view, with parts broken away of the sheet and illustrating approximately the several reductions in thickness thereof.

In said drawing, reference character 10 designates a forming apparatus for forming a wet lap fiber sheet 12, and which apparatus may be constructed according to my U. S. Patent 1,875,075, and is especially well adapted to being operated slowly so as to adapt the speed for formation of the fiber sheet to the relatively slow speed adapted for producing dense hard ligno-cellulose fiber product through application of heat and pressure by means of rolls or other continuously operating members for supplying heat and pressure.

Such forming means may comprise a pair of converging strips or sheets of wire mesh material 14, 14, guided so as to approach one another as they descend by means of guide strips 16, 16, and having the bottom outlet between them continuously closed by the wet lap 12 which is formed. The water passing out through the wires 14, 14, can be collected and run to waste by the gutters 18, 18 and 20, 20. The rate of formation can be controlled as desired by means of the sliding cover plates 22, 22, which serve to limit the extent of area of the wire sheets 14, 14 exposed to contact with the stock in the trough 24.

The wire sheets 14, 14, carrying the wet lap 12 between them may be guided from vertical to horizontal direction as by means of a guide roll 24. Press rolls 26, 26, may be provided for applying pressure to the lap through wire mesh material 14 so as to reduce the water content, and suitable idler rolls as 28, 28, may be provided and also take-up rolls, 30, 30, for keeping the wire mesh material 14 under proper tension.

The wet lap sheet 12 delivered by the forming apparatus 10 is passed between a pair of dewatering rolls 32, 32, by which the water content can be reduced to a low figure, as about 40% on weight of dry fiber and the thinner sheet portion so produced is indicated at 12A.

The rolls 36, 36, of the first pair of hot rolls are heated, preferably by gas burners 38, and enclosed as indicated diagrammatically at 40, 40, except for a portion exposed where the sheet 12A is passed between the rolls. Access may be had to the rolls as at 42 for cleaning or otherwise caring for the roll surface as it turns. With conditions as stated below in my examples, this first pair of hot rolls are preferably maintained at a temperature of about 180° to 200° C. Means, not shown, are provided to apply the desired pressure to a sheet passing between the rolls. When the water in the lap is preliminarily reduced to a sufficiently low proportion before entering the rolls 36, 36, no further liquid water is expressed by rolls 36, 36. The sheet is preferably supported on conveyor rolls 44 as it passes along.

After leaving the rolls 36, 36, the sheet, reduced in thickness by the roll passage as indicated at 12B and containing preferably about 6 to 18% of water, according to the fiber stock, lap thickness, roll speed, pressure, and temperature used, is passed through a hot air drier indicated diagrammatically at 46, which may contain gas burners 47 and heat transferring rolls 48. In this drying operation, the water content is further reduced to approximately 3% or less and preferably to 1 or 2%.

The resulting substantially dried sheet indicated at 12C is now passed through the higher temperature rolls 49, 49 enclosed as indicated at 50, and heated as by gas burners 52 to a temperature over 210° C. and preferably above 250° C., as for example 270° C., means (not shown) being provided for exerting desired pressure on a sheet located between the rolls as they turn. Presence of water above about 3% is objectionable and may cause blistering. With about 1 to 2% of water, however, best results are secured. This small amount of water apparently escapes to some extent in the hot rolling operation and, so far as retained, appears to serve as plasticizer. Ordinary means (not shown) for controlling the speed of the various pairs of rolls through which the sheet is passed may of course be provided.

The finished sheet coming from between rolls 49, 49, and indicated at 12D may be cut off by cutter 54, and the cut pieces carried away by a cross conveyor 56 or otherwise disposed of. The cuts may be made at other places, as between the hot rolls when run at different speeds, or between the hot rolls and drier, etc.

Following are some examples of embodiments of the invention as applied to sheets containing a material percentage of water and giving illustrations of the results which are obtained thereby:

Example 1

Sheets of ligno-cellulose fiber wet lap about ¾ inch thick and containing about 65% of water were passed through unheated squeeze rolls 3 feet in diameter at a pressure of about 4000 lbs. per inch of width of the wet lap strip and a speed of about 4 inches per minute. The water content was thereby reduced to about 40% and the thickness of the sheet to about ⅜ inch.

The strips obtained as just described were passed at a speed of about 4 inches per minute through a pair of rolls 3 feet in diameter, each roll being heated to about 200° C. surface temperature, as shown by thermometers in wells parallel to and adjacent to the roll surface, the pressure applied being about 1000 lbs. per inch of sheet width. The sheets produced had very good surfaces and were relatively dense at and near each surface. Sheet thickness was reduced to about ⅛ inch and the water content reduced to about 6%, while the specific gravity was raised to about 1, or slightly less than 1, and the modulus of rupture after drying was about 5500 lbs. per square inch. (These sheets can be taken for use at this point, when the highest quality product is not needed.)

On removal from these press rolls, the sheets were dried in a hot air drier and the water content thereby reduced to about 1 to 2%.

These sheets were then passed at a speed of about 4 inches per minute between rolls 3 feet in diameter, both rolls of the pair heated to a temperature of 250° C. (determined as before), and at a pressure of about 1700 lbs. per inch of sheet width. Good boards were produced, with excellent surface qualities, smooth on both faces, about $\frac{1}{10}$ inch thick and having properties upon test as per the following table:

Sp. gr.	Tensile strength, lbs. per sq. in.	Mod. of rup. dry, lbs. per sq. in.	Water absorption in 40 hrs.	Percent swelling (40 hrs.)	Mod. of rup. wet (40 hrs.)
1.26	5,210	10,450	15.2	14.9	5,820
1.25	5,670	10,700	17.3	16.9	5,470
1.27	6,000	10,500	17.2	17.7	5,670
1.29	5,570	10,100	16.7	18.3	4,980
1.27	5,612	10,440	16.6	16.9	5,485 Average

Example 2

Other samples were treated the same way as just described, except that the speed through each one of the two 3 foot diameter hot roll passes was 7.5 inches per minute, 1200 lbs. pressure per inch of sheet width was used in the first hot roll pass at 200° C., and the water content after leaving this pair of rolls was about 18%, and the temperature of both rolls during the final roll pass (at 1700 lbs. per inch of sheet width) was 270° C.

The averages of the properties of these samples were as per the following table:

Sp. gr.	Tensile strength, lbs. per sq. in.	Mod. of rup. dry, lbs. per sq. in.	Water absorption in 40 hrs.	Percent swelling (40 hrs.)	Mod. of rup. wet (40 hrs.)
1.24	4,696	10,030	*Percent* 12.3	10.2	7,380

These examples are by way of illustration only, and not for limitation as to the particular roll diameter, or speed of travel recited, or in other respects.

The ligno-cellulose fiber which has been referred to is preferably raw fiber made in any way adapted to retain non-cellulose together with cellulose constituents. Completely raw fiber with no chemical digestion or addition of chemically digested fiber gives the most efficient self-bonding or welding properties, but in any case, there should be sufficient of the non-cellulose fiber constituents or encrustants to give effective self-bonding or welding properties.

Explosion, grinding and shredding are good examples of ways by which a raw fiber can be secured. The figures given herein were obtained with use of exploded pine wood fiber. Beating or other refinement is preferably not extensive. "Fiber" used in this sense includes fibers and bundles of fibers. Specific gravity means weight of the board per unit volume. The vegetable kingdom supplies numerous sources of ligno-cellulose fiber such as the wood of trees and woody material from shrubs, canes, grasses, straws, etc. While wood of trees is the preferred fiber supplying material ligno-cellulose fiber from any source can be use.

The constituents readily soluble in water are ordinarily lost in the waste water, but can be retained in the system to some extent at least if desired.

Added binders and waterproofing agents are not essential, but may be included if desired. As examples thereof, addition of about 2% of petrolatum is useful for securing enhancement of the naturally high resistance to absorption of water, and incorporation of approximately 4% of siccative material, of which tung oil is a good example, with heating conditions including the presence of oxygen to harden or set the material, is useful for enhancing the naturally high strength and increasing resistance to water.

I claim:

1. Process of making dense products of vegetable fiber containing sufficient non-cellulose to be self-bonding, which consists in passing a wet lap sheet of such fiber between pressure rolls under sufficient pressure to reduce the water content to approximately 40%, continuously advancing the sheet while making continuous application to both sides of a temperature of approximately 180–200° C. and a pressure sufficient with the temperature to reduce the water content to about 18–6%, drying the sheet so as to reduce the water content to about 1–3%, and continuously advancing the resulting sheet while making continuous application to both sides thereof of a temperature over about 210° C. and of pressure sufficient with the temperature and speed of travel to yield a sheet product of over 1.2 specific gravity.

2. A continuous process of making hard dense sheet products of ligno-cellulose fiber containing sufficient non-cellulose to be self-bonding, which consists in pressing excess water from a wet sheet of such fiber, then passing the sheet through between pressure rolls heated to a temperature sufficient to consolidate the surface portions while leaving the interior of the sheet in moist state, then passing the sheet through a drier whereby the water content of the sheet is reduced to approximately 3% or less, then passing it through between pressure rolls heated to a temperature over 210° C. and higher than the temperature of the first named rolls whereby the sheet is further hot-roll consolidated, and this time consolidated throughout to yield a substantially homogeneously dense and consolidated sheet product of over 1 specific gravity.

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