April 10, 1951 — H. E. BOWERS — 2,548,095

PRODUCTION OF CONSTRUCTION MATERIALS FROM WOOD AND OTHER VEGETABLE FIBERS

Filed Jan. 10, 1948

Fig. 1

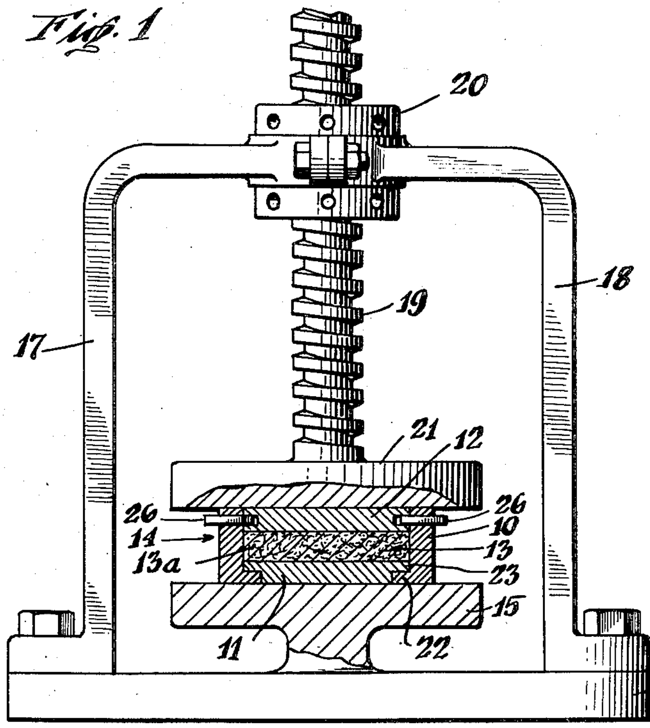


Fig. 2

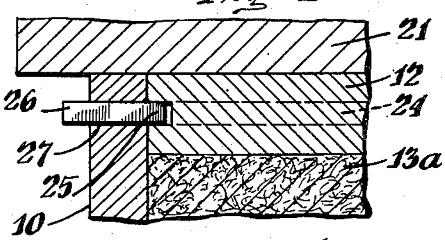


Fig. 3

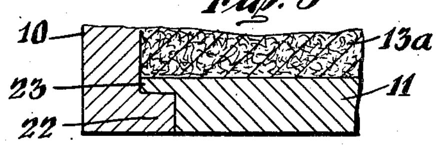


Fig. 4

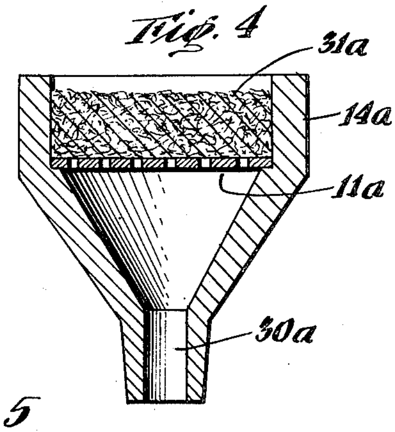
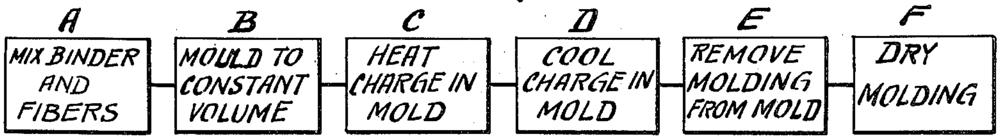


Fig. 5



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PRODUCTION OF CONSTRUCTION MATERIALS FROM WOOD AND OTHER VEGETABLE FIBERS

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8 Claims. (Cl. 18—47.5)

1

This invention relates to the production of construction materials from wood and other vegetable fibers so that the material produced therefrom will have properties similar to that of natural woods.

It is well known, of course, that there are vast quantities of offal resulting from various operations in the lumber and wood industries. At the sawmill and at the plants, where the lumber is worked up into various forms and finished products, there are quantities of offal or wood waste such as slabs, shavings, sawdust, factory waste and the like.

It is an object of this invention to utilize these so-called waste or cast off products in the production of valuable materials suitable for many uses for which the natural woods adapt themselves. In fact, products may be made in accordance with the invention having properties better adapted for many uses where the natural woods are now being used. In many instances the products made according to the invention not only possess characteristics which are more desirable than natural wood itself for many particular purposes for which natural wood is used but the invention makes it possible to dispose of the wood wastes in a way which is economically advantageous.

The problem of utilizing the wood wastes is not a new one but by reason of constantly increasing demands and progressively greater scarcity of timber the problem of making this presently existing natural resource go farther has become increasingly acute. Manifestly, a process which is economical to operate and which will produce from wood wastes other materials having properties of the natural wood itself is a rational approach to the problem of making present sources of natural wood go farther. My invention lends itself admirably to that end for it is not only useful in making use of the relatively cheap wood waste products to produce another form of useful material of woodlike character but it may be used in many instances to greater advantage than the natural wood itself. This results in a concomitant saving of the existing natural resource to the extent that the substitute material is used in lieu of natural wood.

While there have been many suggestions for utilizing the wood wastes such as sawdust, slabs, chips, and offal to produce other materials and those suggestions have contemplated the use of fibrous wood wastes with various kinds of binders and under various conditions of compression to produce various kinds of end products, none of these prior suggestions, so far as I am aware,

2

have recognized that their methods, if they were striving to produce a product having the properties of the natural wood itself, destroyed to a great degree the natural pore structure of the wood fibers. This is particularly true in those processes in which a continued or constant high compressive force is used in compressing the fibers in the presence of a binding agent or otherwise.

In accordance with one of the features of my invention I take into account the phenomenon that wood fibers under the strain of high compressive force exerted for extended time will themselves give way to the continued pressure with the result that fibers collapse and the pore structure is destroyed or greatly impaired. To avoid this result my process, inter alia, contemplates the molding of the fibrous material in the presence of a binder agent to a predetermined fixed volume. That is, I mold a predetermined definite weight of fibrous material with a predetermined weight of binder to a predetermined fixed volume, utilizing only sufficient pressure to reach the predetermined volume, after which the molding mixture is not subjected to the strain of further pressure, all to the end that a wood-like product having a predetermined apparent density may be produced without collapse or undue impairment of the pore structure of the fibers.

While the literature and many prior art patents abound in suggestions for the use of various kinds of binder agents including resins, both natural and synthetic, starch, and others, I prefer to use the less expensive binder agents. Starch may be considered as falling within that class. Although the more expensive types may be utilized in my process of molding in those cases where the cost compared to the value of the end product is warranted, it is an important object of my invention to produce an end product comparable to wood, and having properties of natural wood, at a cost which will allow the product to be produced and used on a competitive basis with natural wood for like purposes. Accordingly, I prefer in most instances to use starch as a binder for the fibrous material because it lends itself well to my purposes not only on account of its lower cost compared to many other types of binders but I have found that the starch may advantageously be gelatinized in situ in the molding itself. This, inter alia, is a further feature of my invention.

Having reference to the flow diagram shown in the drawings, one manner in which I have carried out my process may be described generally as follows. As indicated at A, a quantity of wood fibers in the form of shredded wood chips, semi-chemical pulp or rod-mill pulp, in moistened state is intimately intermixed with a predetermined amount of starch in powder form, making certain water is present in an amount sufficient to gelatinize the starch when heated as hereinafter mentioned. As indicated at B, the moistened mixture of fibers and starch is then placed in a mold in which the mixture is brought to a predetermined fixed constant volume while at the same time excess water, if present, is removed. As indicated at C, the mixture while held at this volume is then heated to a temperature sufficient to gelatinize the starch in situ. As indicated at D, the molded form is then cooled in the mold. The molded form is then removed from the mold as indicated at E, and desiccated to set the starch as indicated at F. Preferably moisture is removed until the moisture content of the molding is in equilibrium with the moisture content of the atmosphere, the former of which, generally speaking, is of the order of the moisture content of seasoned wood.

Although the novel features which are believed to be characteristic of the invention will be pointed out in the annexed claims, the invention itself as to its objects and advantages and the manner in which it may be carried out may be better understood by reference to the following description taken in connection with the accompanying drawings forming a part hereof, in which:

Fig. 1 is a view in elevation and partly in section showing a press and mold which may be used in practising the invention;

Fig. 2 is a partial view in cross-section of the mold shown in Fig. 1, at the top of the mold;

Fig. 3 is a partial view in cross-section of the mold, at the bottom of the mold;

Fig. 4 is a view in cross-section of a suction funnel for making a preform; and

Fig. 5 is a flow diagram, as above mentioned, illustrating one manner of carrying out the invention.

In carrying out the molding step of my process I preferably use a constant volume mold, as distinguished from a constant pressure mold. For illustrative purposes I have shown in the drawings, in more or less diagrammatic fashion, one form of constant volume mold. As shown in the drawing (Fig. 1) the mold itself comprises a cylindrical side wall 10, although, of course, it may have other shapes. It will be noted that the side wall has at its bottom an inwardly projecting annular flange 22. Fitting snugly, but removably, within the cylinder 10 is a base plunger 11 and a top plunger 12, the space between the plungers 11 and 12 forming a mold cavity 13. The base plunger 11 is provided with a shoulder 23 which rests upon the annular flange 22 when the bottom of the plunger 11 is flush with the bottom of the side wall 10 of the mold. The upper plunger 12 is provided with a circumferential groove 24 to receive the inner ends 25 of a plurality of pins 26 circumferentially spaced around the cylindrical wall. The pins 26 are smooth rectangular block-shaped slabs and extend through apertures 27 in the side wall 10 of the mold. The pins 26 are positioned so that when the top of the upper plunger lies flush with the top end of the side wall 10 the inner ends 25 register with the circumferential groove 24. When the plunger 12 is in the position just mentioned the plunger may be locked in place (as shown in Fig. 1) by causing the ends of the pins to extend into the groove.

The mold, designated generally by reference character 14, is designed to be used with a press. As shown, the press comprises a base plate 15 on which the mold may rest. The base plate 15 is secured to a frame base 16 from which extend upwardly the standards 17 and 18. The standards mount a jack-screw 19 for rotation, the screw being raised or lowered by turning the mounting collar 20. A jack-screw base 21 is secured to the lower end of the jack-screw.

Ordinarily in the commercial practice of my invention a more elaborate form of molding apparatus might be used but the apparatus disclosed will suffice for illustrative purposes to show the manner of carrying out my process.

According to one manner of practising my invention, a predetermined quantity of moistened wood fibers of a kind mentioned more specifically hereinafter is intermixed with a predetermined quantity of powdered starch. The mixture may be from 20 to 25 parts of starch and 80 to 75 parts of wood by weight. The water content of the mixture is preferably adjusted so that the total of water present in the batch shall be approximately equal to the combined weight of wood and starch. The mixture is then molded in a constant volume mold such as that shown in the drawing. To do this, the jack-screw 19 is raised, the mold 14, with the upper plunger 12 removed, is placed on the base plate 15 and the charge to be molded placed in the mold. The top plunger 12 is started into the mold and the jack-screw lowered. Sufficient pressure is applied to move the top plunger 12 downwardly into the mold. The jack-screw is lowered until the top surface of the plunger 12 is flush with the top end of the cylindrical side wall 10 of the mold. It may be noted that when this condition is reached the charge in the mold is not subjected to continuing additional pressure.

It may be assumed that the mold is designed to have a mold cavity 13 which is fifteen and one-fourth inches in diameter and is of a height or thickness of thirteen-sixteenths of an inch. The charge or molding designated by reference character 13*a* will, when the mold is thus closed, have a diameter of fifteen and one-fourth inches and a thickness of thirteen-sixteenths of an inch. This is the size and shape of an ordinary "carpenter drum head."

When the mold and the plungers are in the position shown in Fig. 1, the pins 26 are moved inwardly to register with the groove 24 and the plunger thus locked in place. The jack-screw is then raised and the mold may be bodily removed. No further pressure is then exerted on the molding 13*a*. The mold and its contents are then heated in any suitable way to raise the temperature of the starch binder sufficiently high to explode the starch grains and gelatinize the starch in situ in the molding. Ordinarily a temperture of 85° C. to 95° C. is sufficient although a higher or lower temperature may in some cases be satisfactory; the important consideration being to raise the temperature sufficiently high to gelatinize the starch in situ in the mixture of fibers and starch while in the mold. The heating of the mold may be done in a steam heated chamber or by other suitable heating means.

After the charge in the mold is heated enough to gelatinize the starch the mold is then cooled. The cooling may be done in the atmosphere but I prefer to cool the mold by transferring it from the heating chamber to another chamber where cool water may be sprayed upon the mold inasmuch as the metal of the mold can be more quickly brought to a temperature at which it can be readily handled.

After the molding in the mold is cooled, it is removed therefrom. This is done by moving the pins **26** outwardly out of the groove **24** to unlock the upper plunger **12** which may then be removed and the molding **13***a* can be taken out of the mold. The mold may then be used over again in the same way to make further moldings.

The cooled molding **13***a* removed from the mold will then have sufficient rigidity to be handled and it is then dried. The drying may be done in the atmosphere but I prefer to remove the moisture more quickly by placing the moist moldings in a chamber through which is passed a current of heated air. The moisture is removed until the moisture content of the molding is in equilibrium with the atmosphere or equal to that of seasoned wood which is usually in the neighborhood of 7% or more.

The following more specific examples are further illustrative of my invention.

EXAMPLE I

A carpenter drum head may be made as follows: A quantity of water soaked pine chips is defibrated by passing them through a swing hammer shredder. The moisture content of the shredded chips is determined. A quantity of wet shredded chips is then measured out which will have a dry wood content of 2.8 pounds.

A quantity of cornstarch in powder form amounting to 0.9 pound is then intermixed with with the measured quantity of wet shredded chips or fibers. This mixture should be thoroughly mixed to obtain uniform distribution of the starch throughout the charge. The water content of the charge is then adjusted so that it contains a quantity of water equal to the combined weight of wood and starch.

Sometimes it may happen that the water content of the wetted wood fibers is already greater than that which would correspond to the proportion just given. In such a case the charge may nevertheless be placed in the mold and the excess water will be squeezed out and it will flow past the peripheries of the plungers **11** and **12**. In the usual case some water will be squeezed out. The charge above mentioned wherein the water is adjusted as stated will contain 2.8 pounds of wood fibers, 0.9 pound of starch and 3.7 pounds of water. It is placed in the mold, the upper plunger inserted and placed in the press. Sufficient pressure is applied to bring the top surface of the upper plunger flush with the top of the mold. That is, the charge is pressed to a predetermined fixed volume. The upper plunger having been locked in place as indicated in Fig. 1, no further pressure is applied to the plunger. It may be noted here that in some cases less water may be used but, of course, there should be sufficient water present to gelatinize the starch.

The mold with the plungers locked into place is removed bodily from the press and heated. The heating may be done while it is in the press but I prefer to remove the mold and place it in a chamber where it can be heated with steam. Other means of heating the mold will suggest themselves. The mold is heated together with the molding charge therein to a temperature of 90° C. The temperature could be as low as 80° C. or even lower and it could be heated higher than 90° C. but I have found 90° C. to be preferable. The important consideration is to bring the mixture in the mold up to a temperature sufficiently high to gelatinize the starch in situ while the charge is held at constant volume without exerting continued additional pressure upon the charge.

The mold is then cooled and this may be done, if desired, immediately after the starch has been gelatinized. While the cooling may be done slowly in the atmosphere I prefer to cool the mold and its contents quickly by spraying water upon the mold. Of course other ways of quickly cooling the mold will suggest themselves.

After the molding has been cooled it is removed from the mold and then dried.

The drying may be done by allowing the molding to stand for several days in the atmosphere at room temperature until its moisture content is in equilibrium with the moisture in the atmosphere. I prefer to dry it more quickly in a drying chamber through which is passed a current of heated air.

When so dried the finished molding, in this instance a carpenter drum head, will have a density a little greater than natural white pine wood. The molding may be sawed, sanded and nailed as well as ordinary white pine. In fact, in comparative tests drum heads made according to the invention showed nail-holding strength twice as great as white pine. And, according to impact tests, such moldings showed an impact strength which was satisfactory although not equal to the maximum impact strength of white pine. White pine has a lower impact strength parallel to the grain than perpendicular to the grain, whereas moldings made according to the above described process have the fibers laid in random orientation and the impact strength is uniform crosswise or lengthwise.

EXAMPLE II

An amount of wood chips was measured out to provide 2.8 pounds of wood by weight. To this batch of chips was added water in the ratio of 96 parts water to 4 parts chips. The batch was then beaten in a rod mill for 12 hours to defibrate the chips. A fine and uniform mechanical pulp was thus obtained. A quantity of starch in powder form equal in weight to that of one-third of the original quantity of dry chips was then thoroughly mixed with the pulp dispersion with vigorous stirring. The mixture was then filtered through a filter cloth in a circular funnel having a cylindrical body of a diameter slightly less than that of the mold.

Referring now to the drawings, such a funnel is illustrated in Fig. 4. It comprises a cylindrical body **14***a* having an internal diameter slightly less than the diameter of the mold cavity **13** of the mold **14**; a suction nozzle **30***a* and a foraminous bottom **11***a*.

The mixture designated for purposes of illustration by reference character **31***a* was thus water laid and the fibers felted in random orientation; suction being applied to nozzle **30***a*. A firmly felted preform **31***a* of wetted wood fiber and starch was obtained by this procedure. This preform **31***a* was then transferred to the mold **14** and was molded to constant volume as described in Example I. That is, pressure was applied in the press only to the extent of closing the mold to bring the charge to a predetermined fixed volume after which further pressure was not applied so as not to subject the charge to a continuing pressure, once the mold is closed.

Having reached the predetermined constant volume, the mold was locked, removed from the press, heated to gelatinize the starch in the charge in situ in the mold, and cooled, as described in Example I. Then the molding was removed and dried until its moisture content was in equilibrium with that in the atmosphere.

The finished product was a good example of a reintegrated and reconstructed wood. Of course, the fibers were laid in random orientation while in natural wood the grain structure runs in the same general direction. However, the impact strength was superior to ordinary white pine along the direction of the grain. The nailing, sawing, and sanding properties were comparable to white pine.

EXAMPLE III

A molding was made as in Example I except that ordinary sawdust was substituted in place of the shredded wood chips. After molding and gelatinizing the starch in situ in the mold by heating, the mold was cooled, the molding removed and dried as described in Example I. The molding had sawing, sanding and nailing properties comparable to the natural wood. However, its impact strength was not as good as the impact strength of the finished product made with shredded chips.

EXAMPLE IV

A charge made up of 1.4 pounds of shredded wood chips, 1.4 pounds of sawdust, and 0.9 pound of cornstarch, and containing in the neighborhood of 5 pounds of water, was charged to the mold and the charge pressed therein until the mold was closed. The mold including the charge was then heated to gelatinize the starch, after which it was cooled. The molding was then removed and dried as described in Example I.

EXAMPLE V

A charge made up of 2.1 pounds of shredded chips, 0.7 pound of sawdust and 0.9 pound of starch and between 5 and 8 pounds of water was charged to the mold and pressed until the mold was closed. The mold was then heated to 85° C. to gelatinize the starch. It was then cooled, the molding removed and dried as described in Example I.

EXAMPLE VI

A charge made up of 3.04 parts of rod-mill pulp and .76 pound of starch and between 5 and 8 pounds of water was charged to the mold and pressed until the mold was closed. The mold was then heated to about 85° C. to gelatinize the starch. It was cooled, the molding removed and dried as described in Example I.

The moldings made according to Examples IV, V and VI had a density comparable to that of white oak. Each had good sawing, sanding and nailing properties, comparable to that of natural wood.

EXAMPLE VII

A charge made up of 1.45 pounds of sawdust, 0.7 pound of short hemp fibers, 0.7 pound of starch and between 6 and 10 pounds of water, was charged to the mold and pressed to close the mold. The mold was then heated to 85° C. to gelatinize the starch. It was cooled, the molding removed and dried. This molding containing hemp fibers with the sawdust showed enhanced impact strength over a molding in which the base was sawdust alone.

Similar moldings were made using other types of fibers with sawdust and also with shredded chips. The tests showed that the impact strength of the molding may be improved by the addition of tough plant fibers to the wood fibers, when using starch as a binder. Some tropical plant fibers, including sisal, henequen, abaca and pita floja, were found to be very effective as reinforcing fillers for the wood fibers, and particularly sawdust, when using starch as a binder agent.

EXAMPLE VIII

Charges were made up of 22 grams of sawdust, 11 grams of fiber as set forth below in Table A, 11 grams of starch and 40 to 50 grams of water. Each batch was molded to a volume of 81.9 cc. and dried as described in Example I. The results of impact tests on the series of moldings, that were prepared according to the above, are tabulated below:

Table A

Kind of Fiber	Fiber Length (Inches)	Impact Strength (foot-pounds per inch of notch)
Sisal	½	2.10
Abaca	½	2.24
Henequen	1½	2.67
Pita Floja	1½	2.14
Seed Flax Straw	1½	0.88

A control molding, which was made by substituting sawdust for fiber in the above formulation, showed an impact strength of 0.32 foot-pound per inch of notch. Thus, it is apparent that all of the above fibers have a pronounced reinforcing effect on the sawdust moldings.

If a product of greater density than those described in the above examples is desired, the density of the finished product may be increased or decreased by charging a greater or less weight of fibers to the mold having a fixed predetermined volume; the important consideration being that a predetermined weight of fibers and binder are charged to a mold and the charge is brought to a predetermined constant volume after which the fibers are not subjected to the strain of further pressure. The binder is then set in situ without collapse of the fibers or undue impairment of their pore structure. In the case of using starch as the binder agent, the starch is gelatinized in situ in the molding after which the starch is set by drying.

Accordingly, the invention is well suited for the production of a wide variety of woodlike products or material having properties of natural wood. As a base for the products or material, lignocellulose fibers from wood, or other plant fibers of that character may be used. While a preferable source of such fibers is waste or offal, it will be understood that the source need not be from so-called wastes. Economy will ordinarily govern the choice.

The terms and expressions which have been employed herein are used as terms of description and not of limitation and there is no intention in the use of such terms and expressions of excluding any equivalent of the features shown and described or portions thereof, but it is recognized that various modifications are possible within the scope of invention claimed.

What is claimed is:

1. A method of producing an article of manufacture having properties of natural wood which comprises intermixing a quantity of defibrated lignocellulose fibers with a quantity of uncooked starch and sufficient water to gelatinize the starch, thereby to form a charge, transferring the charge to a mold chamber wherein the charge is put under pressure thereby to form a shape, heating the mold chamber to a temperature sufficient to gelatinize the starch in situ in the shape, then cooling the shape and thereafter drying said molded shape to reduce its moisture content to where it is substantially in equilibrium with the moisture content of the atmosphere.

2. The method of producing an article of manufacture having properties of natural wood which comprises providing a charge of a mixture of a predetermined quantity of defibrated lignocellulose fibrous material and a predetermined amount of starch in the presence of water sufficient to gelatinize the starch, pressing the charge in a mold to a predetermined fixed volume, heating the mold to a temperature at which the starch is gelatinized in situ and, after the starch is gelatinized, treating the molded charge to reduce its moisture content to where it is substantially in equilibrium with the moisture content of the atmosphere.

3. The method of producing an article of manufacture having properties of natural wood which comprises providing a charge comprising a predetermined quantity of wood fibers and a predetermined quantity of starch in the presence of water sufficient to gelatinize the starch, pressing the charge in a mold to a predetermined fixed volume, then gelatinizing the starch in situ in the molding, and thereafter removing sufficient water from the charge to produce a molding the moisture content of which is of the same order as the moisture content of seasoned wood.

4. The method of producing an article of manufacture having properties of natural wood which comprises providing a charge comprising 80 to 75 parts of lignocellulose fibers of wood, 20 to 25 parts of starch and an amount of water sufficient to gelatinize the starch, pressing the charge in a mold to a predetermined fixed volume, heating the mold to a temperature of about 85° C. to gelatinize the starch in situ in the charge in the mold, cooling the mold, removing the molded charge and then drying it until its moisture content is in equilibrium with the moisture content of the atmosphere.

5. The method of producing an article of manufacture of the character described which comprises providing a mixture of defibrated wood and tough plant fibers together with starch in an amount about one-third of the combined weight of the fibers and enough water to gelatinize the starch, molding the mixture in a mold to a predetermined fixed volume, heating the mold to a temperature high enough to explode the starch in the mold whereby to gelatinize the starch in situ in the mixture, thereafter removing the molding from the mold and drying it so that its water content will be approximately that of seasoned white pine wood.

6. The method of producing an article of manufacture having properties of natural wood which comprises providing a charge comprising sawdust, starch in the amount of about one-third the weight of sawdust and an amount of water about the combined weights of sawdust and starch, pressing a predetermined amount of the charge in a mold to a predetermined fixed volume, heating the mold to gelatinize the starch in situ therein, thereafter removing the molding from the mold and treating it to bring its moisture content in equilibrium with the moisture content of the atmosphere.

7. The method of producing an article of manufacture of the character described which comprises shredding moistened wood chips to defibrate the wood, intermixing a predetermined quantity of the moistened defibrated wood with an amount of starch about one-third of the weight of shredded chips in the presence of an amount of water about the combined weights of wood and starch, pressing the charge in a mold to a predetermined fixed volume and discontinuing further pressing of the charge when said fixed volume is reached, then heating the charge at that volume in the mold to gelatinize the starch, cooling the charge and removing it from the mold and thereafter drying the molding thus produced.

8. The method of producing an article of manufacture of the character described which comprises beating wood chips in a mill in the presence of water to produce a fine uniform mechanical pulp, mixing with a predetermined quantity of said pulp a quantity of starch about one-third the weight of the wood, removing excess water from the mixture to form a mold charge, pressing a predetermined quantity of the mold charge in a mold to a predetermined fixed volume, then heating the mold to gelatinize the starch in situ in the mold charge at that volume, and thereafter drying the molded article.

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