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PRODUCTION OF MULTI-LAYER BOARDS

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Fig. 1

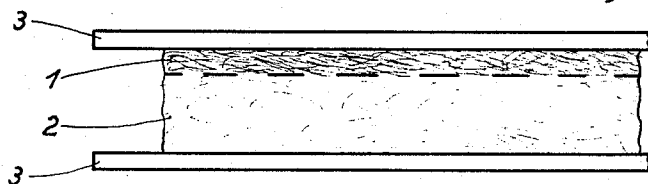


Fig. 2

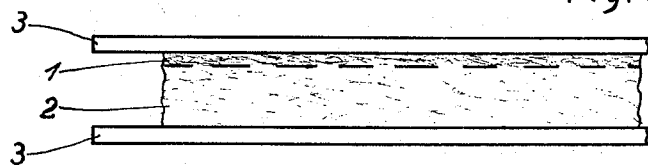


Fig. 3

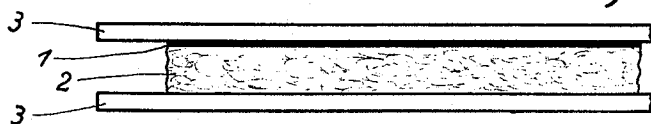


Fig. 4

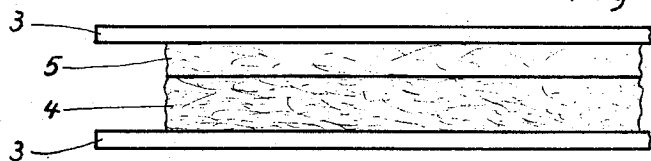
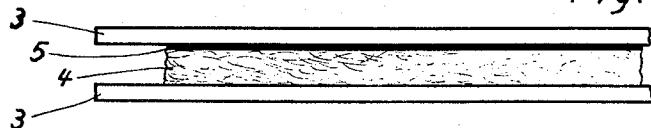


Fig. 5



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PRODUCTION OF MULTI-LAYER BOARDS

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10 Claims. (Cl. 18—47.5)

The present invention relates to the production of multi-layer boards and more particularly to a process of forming coherent multi-layered boards having at least one porous layer and at least one dense layer from wood particles such as fibers, shavings, sawdust and the like.

For various uses such as wall, ceiling and door panels it is desirable to utilize light porous boards rather than heavy compact boards, which although the latter have a greater resistance to fracture, the greater expense involved in their production is not warranted by the use to which the same are put.

In addition, light porous boards have much higher insulating properties and sound absorption properties than heavy, thick boards and the former also have a greater wearing ability.

Dense boards are particularly sensitive to the action of moisture which causes the same to bend and warp, whereas porous boards are not deformed even by high moisture action.

Prior to the present invention the formation of boards from wood particles by the use of suitable binding agents and heated presses resulted in the formation of extremely dense heavy boards having a high specific gravity.

It is therefore an object of the present invention to produce light, porous boards having a specific gravity of about 0.20–0.40.

Prior to the present invention the formation of boards from wood particles required the use of high quality wood such as veneers for the covering layers although the intermediate layer could be made of inferior quality wood particles. The production of multi-layered boards was generally carried out by a process wherein a lower layer of high quality surface material is set and upon which was placed an intermediate layer of inferior quality material and on this another surface layer of high quality material. The entire mass was then pressed between two heated plates while warming to polymerize the binding agent.

The formation of the boards was carried out under such pressure that a solid intermediate stratum was formed on each side of which was a smooth surface layer. The resulting boards had a high specific gravity and were very heavy. In fact the specific gravity was generally higher than the specific gravity of the original wood.

It is therefore an additional object of the present invention to produce light porous boards having a specific gravity lower than the specific gravity of the original wood particles.

It is another object of the present invention to produce light porous boards utilizing only wood particles of inferior quality such as wood fibers, sawdust, wood shavings and the like.

In addition, according to the known processes, the production of light, highly porous bodies, particularly with smooth surface layer was not possible since it was necessary to utilize high pressure in order to smoothen the surface layer while pressing the board during the formation thereof.

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Furthermore, light porous boards could not be produced by utilizing lower pressure during the hardening of the binding agent since the later applied high pressure used to solidify and smoothen the surface layer would cause tearing and breaking of the board because the already hardened, polymerized binding agent in the porous stratum was no longer elastic and therefore cracked upon the application of high pressure.

On the other hand, if a lower pressure was used on the outer smooth surface layers, corresponding to the elasticity or pressure resistance of the finished hardened porous intermediate layer, there was no assurance that the final board would retain its shape and dimensions.

It is therefore still another object of the present invention to provide a process of producing from wood particles light, porous boards having a specific weight which is at most 80% of the specific weight of the original wood particles and having a smooth, dense surface layer or layers whereby the pressure used to smoothen and solidify the surface layer does not cause cracking of the porous layer despite the high porosity and low specific gravity thereof.

Other objects and advantages of the present invention will be apparent from a further reading of the specification and of the appended claims.

With the above objects in view, the present invention mainly comprises a process of forming boards having at least one dense layer, comprising the steps of forming a multiple layer mass consisting of a first layer mass of wood particles being coated with a latently hardenable binding agent adapted to be hardened by heat and drying and a second layer mass of wood particles adjacent the first layer mass and being coated with a latently hardenable binding agent adapted to be hardened by heat and drying, the multiple layer mass being so constituted that upon application of heat and pressure to the same first layer mass is adapted to harden to substantial incompressibility before the second layer mass, and applying heat and pressure to the multiple layer mass so as to heat and compress the same, the second layer mass being more compressed than the first layer mass due to prior hardening to substantial incompressibility of the first layer mass while pressure is still being applied to the multiple layer mass, thus forming a multiple layer board having a highly compressed dense layer formed from the second layer mass and a less compressed porous layer formed from the first layer mass.

In other words, the second layer mass which in the finished board constitutes the dense, relatively non-porous and smooth surface layer, has a greater specific compressibility than the first layer mass which becomes the porous layer, under the same conditions of temperature and pressure for the same time period. The specific compressibility refers to the degree to which the layer mass will be compressed at a specific pressure after the application of a specific temperature for a specific time period. Thus, the first and second layer masses of the multiple layer structure are different in composition from each other and are so constituted that, upon gradually applying pressure to the multiple layer structure while applying heat, the first layer mass hardens to incompressibility before the second layer mass, and pressure is gradually applied to the multiple layer structure while applying heat so as to compress the same until the first layer mass is hardened to incompressibility while the second layer mass is still compressible, whereafter the gradual compressing of the thus partly compressed multiple layer structure is continued while applying heat, so that the second layer mass is further compressed and in this manner a multiple layer board is formed having a highly compressed layer formed from the second layer

mass and a less compressed layer formed from the first layer mass.

Although the first layer mass is not necessarily porous during the formation of the board and the second layer mass is not necessarily non-porous or dense during the formation of a board, but the same are only so in the completed board, in order to facilitate understanding of the description of the present invention, the first layer mass shall hereinafter be referred to as the porous layer mass and the second layer mass as the dense layer mass.

It is possible to give the dense layer mass the property of requiring a longer time to harden to substantial incompressibility than the porous layer mass by the adjustment of many variable conditions, either singly or in combination. These variables refer to the constitution of the different layers and to the manner in which the different layers are formed.

Each of the most important variables will be discussed separately, although it is to be understood that two or more may be combined depending on the results desired. It will also be obvious that other variables of less importance which are not mentioned here may also be employed to result in the different hardening times of the porous and dense layer masses.

In addition, it will be understood that although the present invention will generally be discussed with reference to one porous and one dense layer mass, it is possible to have any number of porous and dense layer masses limited only by practical manufacturing considerations. In general when boards with more than two layers (one porous and one dense) are desired, the board will have three layers, namely one porous layer between two outer smooth dense layers. Boards of this type may be prepared in the same manner as two layer boards.

The first variable of the composition of the different layer masses which may be controlled in order that the dense layer mass be still compressible after hardening of the porous layer mass to substantial incompressibility is the size of the particles of the different layer masses. Although the quality of the wood particles of each of the layer masses may be the same, it is possible to control the degree to which each of the layer masses is compressed, and thereby the degree of porosity and density of the different layer masses; by controlling the size of the wood particles.

Larger, thicker wood particles have a greater resistance to compression than smaller and thinner particles so that by the use of larger particles in the porous layer, the porous layer mass becomes hardened to relative incompressibility before the dense layer mass. In other words, the application of a predetermined pressure to the multi-layer mass wherein the porous layer mass is formed of larger wood particles than the dense layer mass results in further compression of the dense layer mass after the porous layer mass has hardened to a point which resists further compression thereof by the predetermined pressure. Of course much higher pressure might cause cracking of the porous layer, but simple pretesting can determine how much pressure should be applied.

It is to be understood that in referring to the degree of compression of a layer mass, the percent decrease in thickness from the original thickness is meant rather than a specific decrease in size measured in specific units such as inches or the like.

It has been found preferable according to the present invention to utilize wood particles for the porous layer having a thickness of about 0.3-0.4 mm., being about 3-5 mm. wide and about 80-150 mm. long. Generally the length of the wood particles should be about 250-500 times the thickness thereof for the porous layer. As stated, according to one variant of the present invention, the particles of the porous layer mass are preferably larger than the particles of the dense layer mass. However, it is possible to utilize the same size particles for both the porous and the dense layer masses, or even

to use larger size particles for the dense layer mass than for the porous layer mass, by varying other variables which will be later discussed.

The wood particles of the desired size may be obtained in any desired manner, i. e., by planing wood in the direction of the grain. It is also possible to use what was formerly considered as waste wood, namely saw dust and the like.

According to another embodiment of the present invention, wood particles are used for the dense layer mass which have a greater elasticity than the wood particles which are used for the porous layer mass. Thus, the less elastic particles of the porous layer mass stiffen and harden to relative incompressibility before the more elastic particles of the dense layer mass, thereby allowing for greater relative compression of the dense layer mass than the porous layer mass. The use of wood particles of different elasticity in the different layers may be used alone or in combination with the different size wood particles to achieve the result of prior hardening of the porous layer mass and thereby greater compression of the dense layer mass.

Although other processes have utilized particles approximating the size of the particles of the present invention for the production of boards, the other processes resulted in the production of heavy, non-porous boards whereas according to the present invention, light, porous boards are produced. The binding agent according to the prior processes substantially fill the spaces between the wood particles resulting in the formation of boards of high specific weight. According to the present invention, on the other hand, the wood particles are only lightly coated with the binding agent so that in the final board the porous layer has a frame-like structure with spaces between, yielding greater resiliency to the mass and thereby resulting in a lower specific gravity although the board has a high pressure and breaking resistance. The elasticity or resiliency of the wood particles remains greater when only lightly coated with the binding agent than when thoroughly penetrated by the binding agent.

According to a preferred embodiment of the present invention the elasticity and resiliency of the individual wood particles is increased by a special method of applying the binding agent, which may for example be a urea or phenol resin, to the wood particles. This is accomplished by heating the wood particles before applying the binding agent thereto so that the higher temperature of the wood particles than the temperature of the binding agent causes a rapid evaporation of solvent or dispersing agent resulting in a higher viscosity of the binding agent. The higher viscosity of the binding agent prevents penetration of the same into the pores of the wood particles so that the same are only coated with the binding agent rather than being impregnated with the same.

If the binding agent penetrates into the wood particles so that the same are impregnated therewith, rather than being coated therewith according to the above described preferred embodiment, the later hardening of the binding agent has the effect of making the wood particles brittle. The brittleness of the wood particles is disadvantageous, particularly for the porous layer wherein the elasticity and strength of the individual particles helps in the formation of a porous layer having a frame-like structure. The coating of the wood particles with the binding agent, on the other hand, so that only the surface of the particles contain binding agent which later hardens during the formation of the board, has the effect of increasing the strength of the wood particles to a great extent.

According to still another embodiment of the present invention, the wood particles of the dense layer mass have a higher moisture content than the wood particles of the porous layer mass. This variable has a number of important advantages according to the process of the present

invention in allowing for the formation of a porous layer which is relatively slightly compressed and of a dense layer which is relatively highly compressed. The less moist wood particles of the porous layer mass, because of the lower moisture content, have a greater resistance to pressure than the more moist wood particles of the dense layer mass which, because of the higher moisture content, are softer and more yieldable than the particles of the porous layer mass. In addition, since the binding agents do not harden until the same are dried, the high moisture content of the dense layer mass causes the same to harden much slower than the porous layer mass which has a lower moisture content.

Preferably, the moisture content of the porous layer mass is about 7-15% by weight and the moisture content of the dense layer mass is higher than that of the porous layer mass for the reasons given above. The moisture content of the dense layer mass may be as high as 30% or more, of greater importance than any specific moisture content is the desirability of having a higher moisture content for the dense layer mass than for the porous.

The wetness and dryness of the wood particles in a layer mass is not only dependent upon the moisture content of the individual particles, but also upon the degree of dilution of the binding agents applied to the particles of the different layer masses. Therefore, the use of more dilute binding agents can increase the wetness of the wood particles and less dilute binding agents would result in drier and therefore more resistant wood particles.

It should also be noted that the wood particles should not be too dry since this results in making the same brittle. Therefore, it is desirable to retain a certain amount of moisture in the wood particles in order to attain the optimum resistance thereof. It has been found that a moisture content of 7-15% and preferably 11% results in optimum characteristics for the wood particles.

As stated previously, the wood particles may be heated before applying the binding agent thereto in order that the binding agent may only coat the wood particles rather than thoroughly penetrate into and impregnate the same. However, the heating of the wood particles prior to the application of the binding agents thereto should not be at too high a temperature, namely a temperature which would cause loss of too much moisture from the particles. Nevertheless, the particles should be heated to a sufficiently high temperature so that a sufficient amount of the solvent or dispersing medium of the binding agent should be quickly evaporated when the binding agent is applied to the wood particles. It has been found preferably to utilize a temperature between 40-60° C. for the heating of the wood particles prior to application of the binding agent thereto.

For example, wood particles of pine wood having a thickness of about 0.3 mm. and a moisture content of about 8% are heated to a temperature of about 50° C. and a binding agent at a temperature of about 18° C. is applied to the heated wood particles. The temperature difference (32° C.) between the wood particles and the binding agent results in an evaporation of solvent from the binding agent and thereby an increase in the viscosity of the binding agent so that penetration of the binding agent in to the wood is prevented. On the other hand, the free moisture is taken up by the wood particles to a minor extent so that the same have the optimum moisture content of about 11%.

The obtaining of the desired characteristics of the wood particles may be aided by the addition to the binding agent of a viscosity reducing agent such as methylene chloride or methyl alcohol, which is highly volatile. It is thus possible to utilize lower temperatures for the heating of the wood particles prior to addition of the binding agent thereto.

The percent of binding agent added to the wood particles depends upon the strength or porosity desired for

the final board. The content may vary between 6-20% by weight for the dense layers with somewhat higher amounts for certain binding agent mixtures.

The prevention of penetration of the binding agent into the pores of the wood particles as above described gives the additional advantages of allowing for a use of lower amounts of binding agent since it is only necessary that the binding agents be on the surface of the wood particles for the binding together of the same. It is therefore particularly suitable to utilize the heating of the wood particles prior to the application of the binding agent thereto for wood particles for the porous layer, although this method of applying the binding agent may equally well be applied to the application of the binding agent to the dense layer masses.

While according to the present invention the porous layer is compressed to a relatively limited extent because of the prior hardening of the same to relative incompressibility whereby the same exerts a counter pressure against the press, it is necessary to continue to press in order to compress and solidify the outer dense layer. It is for this reason that the above variables of difference in moisture content, etc. are utilized. The greater moisture content of the dense layer mass increases the time of hardening i. e. by polymerization of the binding agent applied thereto as compared to the relatively drier porous layer mass. However, since the pressure is applied by heated plates which are in contact with the outer layers of the multiple layer mass, the greater polymerization time necessary for the outer dense layer masses is not always apparent.

Therefore, according to the preferred embodiment of the present invention, there is added to the porous layer mass and to the dense layer mass, acid and/or basic polymerization or condensation accelerators and retarders, respectively. An accelerator may be added to the porous layer mass in order to decrease the time necessary for hardening of the latently hardenable binding agent applied thereto, and/or a retarder may be added to the dense layer mass in order to increase the time necessary for hardening of the binding agent applied to the dense layer mass.

The hardening of the binding agent may be by condensation polymerization i. e. with binding agents of phenol and urea type resins and the like such as urea-formaldehyde resins, phenol-formaldehyde resin, urea-phenol-formaldehyde resins, melamine resins, melamine-urea resins and mixed polymerisates thereof, or the hardening may be by simple polymerization such as with vinyl resins, e. g. polyvinyl, polyacryl, polyvinylacetate, polyacrylates, and mixed polymerisates thereof. In addition, certain binding agents such as mixed polymerisates of urea formaldehyde harden partially by condensation and partially by polymerization. These and other binding agents may also be used, i. e. polyesters, polymethane and high molecular protein substances such as casein. Polymerization and condensation accelerators are well known and any of the common substances used for these purposes may be utilized according to the present invention. Generally acidic substances such as chlorosulfonic acid, paratoluolsulfonyl chloride and diethyl-diphenyl urea act as accelerators whereas basic substances such as hexamethylenetetramine act as retarders.

The amount of accelerator or retarder added to the different layer masses depends upon the extent of acceleration or retardation desired. It is to be noted that any type of binding agent which is latently hardenable may be utilized according to the present invention i. e. urea and phenol resins, vinyl resins, acrylic resins, etc.

According to still another embodiment of the present invention the formation of a porous and a dense layer from the different layer masses may be additionally controlled by the pressure applied to the multiple layer mass during the formation of the board. The pressure may be applied in different degrees during different time

periods according to the hardening of the different layer masses in order to control the degree of compression of the dense and the porous layer masses. For example, a predetermined low pressure may be utilized until the porous layer mass hardens so that the porous layer mass is not compressed to a great extent, and then increased pressure may be applied which because of the hardening of the porous layer does not further compress the porous layer but only compresses the dense layer mass until the same is hardened. In addition, it is possible to release the pressure after compressing the porous layer mass to a predetermined extent while continuing to heat the multiple layer mass until hardening of the porous layer, and then to further apply pressure until the dense layer mass hardens, thereby further compressing only the dense layer mass.

According to still another embodiment of the present invention it is possible to apply different binding agents to the different layer masses in order to control the time of hardening of the layer masses. It is thus possible to apply to the porous layer mass a binding agent which hardens at a lower temperature i. e. 120° C. than the binding agent applied to the dense layer mass which hardens i. e. at about 170° C. so that the porous layer mass hardens first.

The following examples are given as illustrative of the process of the present invention, the scope of said invention not however being limited to the specific examples. These examples will be better understood and are discussed with reference to the attached drawing, in which Figs. 1-3 refer to Example I and Figs. 4 and 5 refer to Example II.

Example I

This example illustrates the formation of a light board having a thickness of 20 mm. from wood particles whereby the resulting board has one dense layer and one porous layer.

In Fig. 1 may be seen the multiple layer mass consisting of a top dense layer mass 1 and a lower porous layer mass 2, both layer masses being formed of wood particles from leaved trees or conifers. The wood particles in the layer masses are about 0.3 mm. thick, 4 mm. wide and 8-150 mm. long. The moisture content of the wood particles is about 10%.

For each square meter of board there is taken for the porous layer mass 25 kg. of the wood particles from pine wood with about 450 g. of urea-formaldehyde resin in a aqueous dispersion having a viscosity of about 15 seconds running time in a Ford-discharge beaker (with a nozzle opening of about 4 mm. diameter), the aqueous dispersion having added thereto about 9% of a hardener with an acid reaction, the wood particles being sprayed and mixed with the aqueous resin dispersion.

For the dense layer mass 1 there is taken (for each square meter) about 600 g. of the same wood particles with 50 g. of urea formaldehyde resin (the same ratio of resin to wood as in the porous layer mass) however in an aqueous dispersion which is more dilute, namely the dispersion has a viscosity of about 4 seconds running time in the Ford beaker. In addition, retarders are added to the resin for the purpose of slowing the condensation, i. e. sal ammoniac.

The material of the porous layer mass is spread out flat and the material of the dense layer mass is laid thereon. The height of the porous layer mass 2 is about 30 mm. and the height of the dense layer mass 1 is about 8 mm. The multiple layer mass is placed between two pressure plates 3 which are heated at a temperature of about 160° C. and lightly pressed together for about two minutes. The porous layer mass 2 already starts to harden in this time and exerts a counter-pressure against the plates 3 while the dense layer mass 1 has not yet started to harden because of the polymerization retarders added thereto.

The pressure plates 3 are then further pressed to-

gether a predetermined extent until the same are 24 mm. apart (Fig. 2). The compression is then stopped. The dense layer mass is found to have been compressed to about 2 mm., in other words about 75% compressed whereas the porous layer mass 2 which has already hardened somewhat by condensation polymerization has the thickness of about 12 mm., in other words is compressed only about 27%.

The compression is stopped for about 2 minutes during which time the porous layer mass 2 further hardens. The pressure plates 3 are then pushed together so that the same are about 20 mm. apart (Fig. 3). The dense layer mass 1 is thereby further compressed because, due to the addition of retarding agents and the higher percentage of water from the more dilute aqueous dispersion of resin, the dense layer mass 1 is still soft and compressible. It is found that the thickness of the dense layer mass is about 1 mm., in other words it has been further compressed 50%, whereas the porous layer mass 2 which has already hardened is about 19 mm., in other words it has been compressed only about another 14%.

The condensation retarding agents in the dense layer mass are by this time no longer affected so that heating of the multiple layer mass for an additional five minutes without further compression results in complete hardening of binding agents in both layers.

The pressures applied in the above described pressing operation are as follows: In the first phase (to a thickness of about 24 mm.) a pressure of about 0.6-0.8 kg./cm.²; in the second phase (to a thickness of about 22 mm.) a pressure of about 1.2-1.4 kg./cm.²; and in the last phase a pressure of about 2.2-2.6 kg./cm.² is utilized until the final thickness of 20 mm. is attained.

The described pressing operation can also be carried out in a manner such that the compression is almost continuous, though very slow, for example the time for compression in the first phase to 24 mm. is about two minutes, the time for compression from 24 mm. to 22 mm. is also about 2 minutes and finally the compression time from 22 to 20 mm. is an additional 2 minutes.

Example II

This example, which is illustrated in Figs. 4 and 5, describes the production of a board with a porous layer and with a particularly dense, smooth surface layer by a two step method.

According to this method, a porous layer mass is formed as in Example I from a mixture of wood particles and urea-formaldehyde resin. However, in this case there is added to the dispersion of the binding agent, an agent which retards the polymerization over a long period of time. For example, ammonium carbonate is added in an amount of about 4% of the binding agent dispersion, this keeping the binding agent for a long time, in fact about 12 hours, in alkaline condition.

The thus formed mixture of wood particles, binding agent and retarding agent are placed between two heated pressure plates, heated at a temperature of about 160° C. and pressed together to a distance about 22 mm. apart. The pressing and heating time takes about 7-8 minutes.

The thus formed board is a partially hardened pre-pressed board and the binding agent is only partially polymerized or partially condensed, although it is substantially solid and hard.

To this partially hardened layer mass 4 (Fig. 4) is added a dense layer mass 5. This dense layer mass consists of about 700 g. of wood particles having a thickness of about 0.1 mm. and being about 10 mm. wide and 80-150 mm. long, upon which has been sprayed about 60 g. of the urea-formaldehyde resin in aqueous dispersion, the dispersion having a viscosity of about 8 seconds running time in a Ford beaker. In addition, condensation accelerators are added to the dispersion, for example, chlorosulfonic acid. In Fig. 4 the partially hardened mass 4 and the dense layer mass 5 is shown

between two pressure plates 3 which are heated at a temperature of about 150° C. which causes the dense layer mass to be compressed to a height of about 15 mm.

The pressure plates 3 are then continuously or at intervals, during a time period of about 2 minutes slowly pressed together until the same are about 20 mm. apart. The dense layer mass 5 is thereby highly compressed and even because the vapor released by the heat goes through the partially hardened porous mass 4 softening the hardened binding agent and preventing tearing of the layer mass while causing an inner adhesion between the particles of the porous layer mass 4 and the dense layer mass 5. The accelerators in the dense layer mass 5 speed up the condensation time of the binding agent therein so that both layer masses harden at substantially at the same time.

In this manner, due to the utilization of the resistance of the comparatively rigid porous layer mass (partially hardened) a hard, smooth and densely compressed surface layer is obtained while the texture of the porous layer is not detrimentally influenced because at the moment of highest compression of the dense layer mass, the partially hardened porous layer mass is somewhat softened due to the escaping water vapors which are then finally condensed.

Fig. 5 shows the board after final compression. The porous layer 4 is compressed from 22 mm. to 19 mm., whereas the dense layer 5 is compressed from 15 mm. to 1 mm. The heating is continued for about four more minutes to assure complete hardening of both layers.

According to another embodiment of the present invention, it is possible to add to the different layer masses different resins which polymerize, condense or harden at different temperatures so that the process may be controlled by the use of the different resins.

For example, it is possible to add to one layer a synthetic resin binding agent which hardens or polymerizes at about 20° C. whereas to the other layer a binding agent is added which hardens, polymerizes or condenses at a temperature of about 120° C.

It is also possible to form the board of three layers and the following example illustrates such process using other than true wood fibers.

Example III

A mat of glass or mineral wool about 40 mm. thick and utilizing about 4 kg. of the wool per each square meter is steeped in a solution of a polyester resin which hardens at low temperatures and which is dissolved in methylene chloride and has an organic superoxide such as benzoyl superoxide added thereto. On both sides of this layer mass is placed glass wool mattes about 1 cm. thick having the same specific weight but being steeped with a polyester resin which hardens at higher temperatures and with 2% of benzoyl superoxide added thereto.

The thus formed multiple layer mass consisting of the 4 cm. mat in the center and the two 1 cm. thick mattes, one on each side thereof, is placed between two cold pressure plates, the whole being pressed together in the cold from the original thickness of 60 mm. to a thickness of about 40 mm.

All three layers are thus pressed together about one third. After about 60 minutes the middle layer is hardened and is about 27 mm. thick. The pressure plates are then heated to a temperature of about 120° C. and simultaneously pressed together to a distance of about 33 mm. apart. The two outer layer masses are polymerized forming two layers which have a thickness of only about 3 mm. each. The thus formed multiple layer board which is obtained has the two outer layers compressed about 50% more than the middle layer.

It is also possible to add to the different layer masses different substances which react differently at different temperatures, for example at a lower temperature the substance is alkali thereby retarding the polymerization

whereas at a higher temperature the substance is acidic thereby accelerating the polymerization.

It is to be understood that the term "wood particles" as used throughout the specification and claims refers not only to ordinary wood particles but to other fiber-like and straw-like particles of plant origin other than wood and also fiber-like particles of inorganic origin. The suitable substances should have some degree of porosity so that the same can be somewhat penetrated by the binding agent and other chemical agents and also so that the same can attain a moisture content. The present invention applies to the formation of boards from "wood particles" of any origin, whether plant or inorganic. Suitable substances include different portions of the plant such as the stalk, the stem, different plants such as straw and the like and different inorganic substances such as asbestos, mineral wool and the like.

The use of inorganic substances such as mineral wool, asbestos and the like has an advantage according to the present invention of making the resulting board fire-resistant.

The term "elasticity" as used throughout the present specification and claims is used in its common sense as defined in Webster's New International Dictionary wherein it is stated that "a body is said to possess great elasticity when it is easily deformed and it is quick in recovery."

It should also be noted that the density of the layers of the board is relative so that although the "dense" layer is quite dense as compared to the "porous" layer, according to a preferred embodiment of the present invention the "dense" layer need not be completely solid and non-porous and it may in fact be somewhat porous so as to give greater sound-absorbing properties to the resulting board.

The term "to substantially incompressibility" as used in the specification and claims indicates that the substance is substantially incompressible at the pressures exerted during the process so that a solid body is formed.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be secured by Letters Patent is:

1. A process of forming boards having at least one porous layer and at least one dense layer, comprising the steps of forming a multiple layer structure consisting of a first layer mass of wood particles being coated with a latently hardenable binding agent and adapted to be hardened by heat and drying and a second layer mass of wood particles adjacent said first layer mass said second layer mass also being coated with a latently hardenable binding agent and adapted to be hardened by heat and drying, said first and second layer masses of said multiple layer structure being different in composition from each other and being so constituted that, upon gradually applying pressure to said multiple layer structure while applying heat, said first layer mass hardens to incompressibility before said second layer mass; gradually applying pressure to said multiple layer structure while applying heat so as to compress the same until said first layer mass is hardened to incompressibility and said second layer mass is still compressible; and continuing gradually compressing said thus partly compressed multiple layer structure while applying heat so that said second layer mass is further compressed, thus forming a multiple layer board having a highly compressed layer formed from said second layer mass and a less compressed layer formed from said first layer mass.

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2. A process of forming a multiple layer board, comprising the steps of forming a multiple layer structure consisting of a first layer mass of wood particles being coated with a latently hardenable binding agent and adapted to be hardened by heat and drying and two second layer masses of wood particles one on each side of said first layer mass said second layer masses also being coated with a latently hardenable binding agent and adapted to be hardened by heat and drying; said first and second layer masses of said multiple layer structure being different in composition from each other and being so constituted that, upon gradually applying pressure to said multiple layer structure while applying heat, said first layer mass hardens to incompressibility before said second layer masses; gradually applying pressure to said multiple layer structure while applying heat so as to compress the same until said first layer mass is hardened to incompressibility and said second layer masses are still compressible; and continuing gradually compressing said thus partly compressed multiple layer structure while applying heat so that said second layer masses are further compressed, thus forming a multiple layer board having two highly compressed layers formed from said second layer mass and a less compressed layer formed from said first layer mass between said highly compressed layers.

3. A process of forming boards having at least one porous layer and at least one dense layer, comprising the steps of applying a latently hardenable binding agent adapted to be activated by heat and drying to wood particles heated at a temperature about 20-70° C. higher than the temperature of said latently hardenable binding agent so as to coat said wood particles with said binding agent while preventing substantial impregnation of said wood particles by said binding agent; forming a multiple layer structure consisting of a first layer mass of the thus coated wood particles and a second layer mass of wood particles adjacent said first layer mass and being coated and partly penetrated by a latently hardenable binding agent adapted to be hardened by heat and drying, the wood particles of said second layer mass being more deeply penetrated by said binding agent than the wood particles of said first layer mass, said first and second layer masses of said multiple layer structure thus being different in composition from each other and being so constituted that, upon gradually applying pressure to said multiple layer structure while applying heat, said first layer mass hardens to incompressibility before said second layer mass; gradually applying pressure to said multiple layer structure while applying heat so as to compress the same until said first layer mass is hardened to incompressibility and said second layer mass is still compressible; and continuing gradually compressing said thus partly compressed multiple layer structure while applying heat so that said second layer mass is further compressed, thus forming a multiple layer board having a highly compressed layer formed from said second layer mass and a less compressed layer formed from said first layer mass.

4. A process of forming boards having at least one porous layer and at least one dense layer, comprising the steps of forming a multiple layer structure consisting of a first layer mass of wood particles being coated with a latently hardenable binding agent adapted to be hardened by heat and drying and containing accelerators adapted to increase the speed of hardening of said latently hardenable binding agent and a second layer mass of wood particles adjacent said first layer mass and being coated with a latently hardenable binding agent adapted to be hardened by heat and drying, said first and second layer masses of said multiple layer structure thus being different in composition from each other and being so constituted that, upon gradually applying pressure to said multiple layer structure while applying heat, said first layer mass hardens to incompressibility before said second layer mass; gradually applying pressure to said mul-

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multiple layer structure while applying heat so as to compress the same until said first layer mass is hardened to incompressibility and said second layer mass is still compressible; and continuing gradually compressing said thus partly compressed multiple layer structure while applying heat so that said second layer mass is further compressed, thus forming a multiple layer board having a highly compressed layer formed from said second layer mass and a less compressed layer formed from said first layer mass.

5. A process of forming boards having at least one porous layer and at least one dense layer, comprising the steps of forming a multiple layer structure, consisting of a first layer mass of wood particles being coated with a latently hardenable binding agent adapted to be hardened by heat and drying and containing accelerators adapted to increase the speed of hardening of said latently hardenable binding agent and a second layer mass of wood particles adjacent said first layer mass and being coated with a latently hardenable binding agent adapted to be hardened by heat and drying and containing retarders adapted to decrease the hardening time of said latently hardenable binding agent, said first and second layer masses of said multiple layer structure thus being different in composition from each other and being so constituted that, upon gradually applying pressure to said multiple layer structure while applying heat, said first layer mass hardens to incompressibility before said second layer mass; gradually applying pressure to said multiple layer structure while applying heat so as to compress the same until said first layer mass is hardened to incompressibility and said second layer mass is still compressible; and continuing gradually compressing said thus partly compressed multiple layer structure while applying heat so that said second layer mass is further compressed, thus forming a multiple layer board having a highly compressed layer formed from said second layer mass and a less compressed layer formed from said first layer mass.

6. A process of forming boards having at least one porous layer and at least one dense layer, comprising the steps of forming a multiple layer structure consisting of a first layer mass of wood particles being coated with a latently hardenable binding agent adapted to be hardened by heat and drying and a second layer mass of wood particles adjacent said first layer mass and being coated with a latently hardenable binding agent adapted to be hardened by heat and drying, the binding agent of said first layer mass being adapted to harden at a lower temperature than the binding agent of said second layer mass, said first and second layer masses of said multiple layer structure thus being different in composition from each other and being so constituted that, upon gradually applying pressure to said multiple layer structure while applying heat, said first layer mass hardens to incompressibility before said second layer mass; gradually applying pressure to said multiple layer structure while applying heat so as to compress the same until said first layer mass is hardened to incompressibility and said second layer mass is still compressible; and continuing gradually compressing said thus partly compressed multiple layer structure while applying heat so that said second layer mass is further compressed, thus forming a multiple layer board having a highly compressed layer formed from said second layer mass and a less compressed layer formed from said first layer mass.

7. A process of forming boards having at least one porous layer and at least one dense layer, comprising the steps of coating a first mass of wood particles with a latently hardenable first binding agent adapted to be hardened by heat and drying so as to form a first mass of coated wood particles; coating a second mass of wood particles with a latently hardenable second binding agent adapted to be hardened by heat and drying so as to form a second mass of coated wood particles, said first binding agent being of such composition as to harden

upon application of heat faster than said second binding agent so that upon application of equal heat and pressure to said masses of coated wood particles, said first mass of coated wood particles hardens faster to incompressibility than said second mass of coated wood particles; forming a multiple layer structure consisting of a first layer mass of said first mass of coated wood particles and of a second layer mass of said second mass of coated wood particles superimposed upon each other, said first and second layer masses of said multiple layer structure being, due to said different binding agents, different in composition from each other and so constituted that, upon gradually applying pressure to said multiple layer structure while applying heat, said first layer mass hardens to incompressibility before said second layer mass; gradually applying pressure to said multiple layer structure while applying heat so as to compress the same until said first layer mass is hardened to incompressibility and said second layer mass is still compressible; and continuing gradually compressing said thus partly compressed multiple layer structure while applying heat so that said second layer mass is further compressed, thus forming a multiple layer board having a highly compressed layer formed from said second layer mass and a less compressed layer formed from said first layer mass.

8. A process of forming boards having at least one porous layer and at least one dense layer, comprising the steps of coating a first mass of wood particles with a latently hardenable first binding agent adapted to be hardened by heat and drying so as to form a first mass of coated wood particles; coating a second mass of wood particles with a latently hardenable second binding agent adapted to be hardened by heat and drying so as to form a second mass of coated wood particles, said first binding agent being of such composition as to harden upon application of heat faster than said second binding agent and said second binding agent being adapted to more deeply penetrate said wood particles of said second mass than said first binding agent will penetrate said wood particles of said first mass, so that upon application of equal heat and pressure to said masses of coated wood particles said first mass of coated wood particles hardens faster to incompressibility than said second mass of coated wood particles; forming a multiple layer structure consisting of a first layer mass of said first mass of coated wood particles and of a second layer mass of said second mass of coated wood particles superimposed upon each other, said first and second layer masses of said multiple layer structure being, due to said different binding agents, different in composition from each other and so constituted that, upon gradually applying pressure to said multiple layer structure while applying heat, said first layer mass hardens to incompressibility before said second layer mass; gradually applying pressure to said multiple layer structure while applying heat so as to compress the same until said first layer mass is hardened to incompressibility and said second layer mass is still compressible; and continuing gradually compressing said thus partly compressed multiple layer structure while applying heat so that said second layer mass is further compressed, thus forming a multiple layer board having a highly compressed layer formed from said second layer mass and a less compressed layer formed from said first layer mass.

9. A process of forming boards having at least one porous layer and at least one dense layer, comprising the steps of coating a first mass of wood particles with a latently hardenable first binding agent adapted to be hardened by heat and drying so as to form a first mass of coated wood particles; coating a second mass of wood particles with a latently hardenable second binding agent adapted to be hardened by heat and drying so as to form

a second mass of coated wood particles, said first binding agent containing accelerators so as to harden upon application of heat faster than said second binding agent so that upon application of equal heat and pressure to said masses of coated wood particles, said first mass of coated wood particles hardens faster to incompressibility than said second mass of coated wood particles; forming a multiple layer structure consisting of a first layer mass of said first mass of coated wood particles and of a second layer mass of said second mass of coated wood particles superimposed upon each other, said first and second layer masses of said multiple layer structure being, due to said different binding agents, different in composition from each other and so constituted that, upon gradually applying pressure to said multiple layer structure while applying heat, said first layer mass hardens to incompressibility before said second layer mass; gradually applying pressure to said multiple layer structure while applying heat so as to compress the same until said first layer mass is hardened to incompressibility and said second layer mass is still compressible; and continuing gradually compressing said thus partly compressed multiple layer structure while applying heat so that said second layer mass is further compressed, thus forming a multiple layer board having a highly compressed layer formed from said second layer mass and a less compressed layer formed from said first layer mass.

10. A process of forming boards having at least one porous layer and at least one dense layer, comprising the steps of coating a first mass of wood particles with a latently hardenable first binding agent adapted to be hardened by being heated to a predetermined temperature so as to form a first mass of coated wood particles; coating a second mass of wood particles with a latently hardenable second binding agent adapted to be hardened by being heated to a temperature higher than said predetermined temperature so as to form a second mass of coated wood particles, said first binding agent being of such composition as to harden upon application of heat faster than said second binding agent so that upon application of equal heat and pressure to said masses of coated wood particles, said first mass of coated wood particles hardens faster to incompressibility than said second mass of coated wood particles; forming a multiple layer structure consisting of a first layer mass of said first mass of coated wood particles and of a second layer mass of said second mass of coated wood particles superimposed upon each other, said first and second layer masses of said multiple layer structure being, due to said different binding agents, different in composition from each other and so constituted that, upon gradually applying pressure to said multiple layer structure while applying heat, said first layer mass hardens to incompressibility before said second layer mass; gradually applying pressure to said multiple layer structure while applying heat so as to compress the same until said first layer mass is hardened to incompressibility and said second layer mass is still compressible; and continuing gradually compressing said thus partly compressed multiple layer structure while applying heat so that said second layer mass is further compressed, thus forming a multiple layer board having a highly compressed layer formed from said second layer mass and a less compressed layer formed from said first layer mass.

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