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Shen

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[54] **METHOD AND APPARATUS FOR PRESSING PARTICLEBOARD**

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[51] **Int. Cl.**[2] **B29J 5/00**

[58] **Field of Search** 264/109, 120, 82, 122, 264/101

[56] **References Cited**

UNITED STATES PATENTS

3,280,237	10/1966	Corbin et al.	264/109
3,354,248	11/1967	Haas et al.	264/120
3,619,450	11/1971	Futo	264/109

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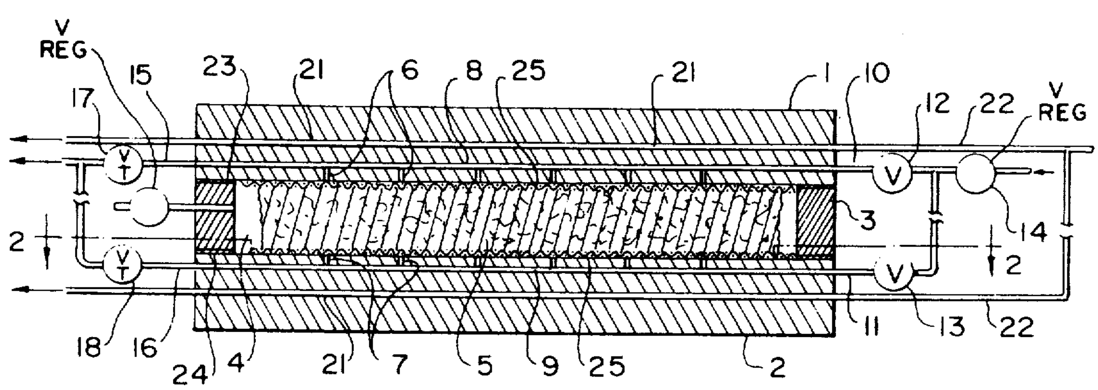
[57] **ABSTRACT**

The invention relates to a method for pressing particleboard whereby steam under pressure is introduced into the particleboard mat during pressing. The invention provides for reduced press time, improved particleboard quality and makes practical greater board thickness. The apparatus comprises a pair of platens having apertures and associated conduits for steam and exhaust, and means for enclosing the mat while steam is being injected. Steam is introduced into one platen and exhausted through the other.

5 Claims, 4 Drawing Figures



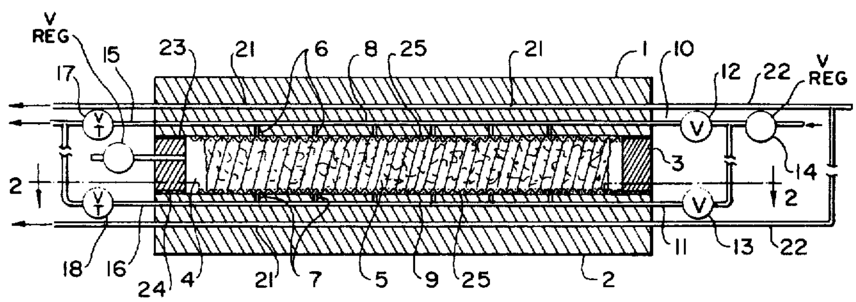

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FIG. 1

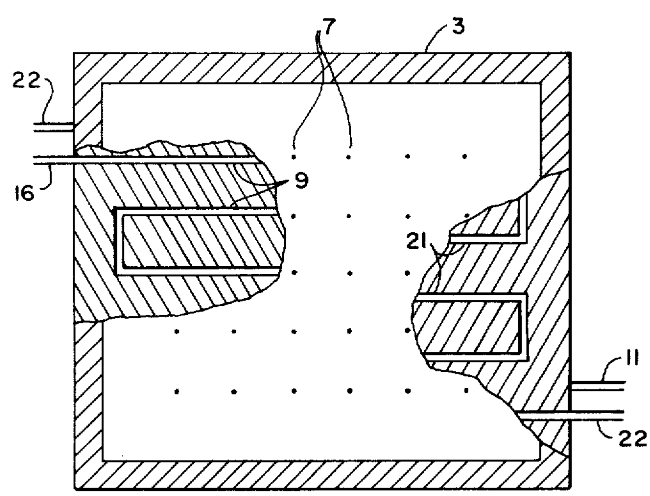
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FIG. 2

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SHEET 2

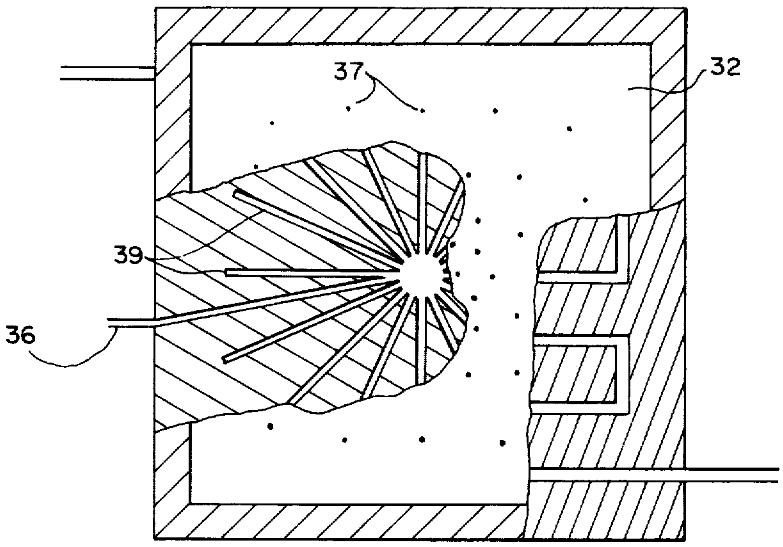

FIG. 3

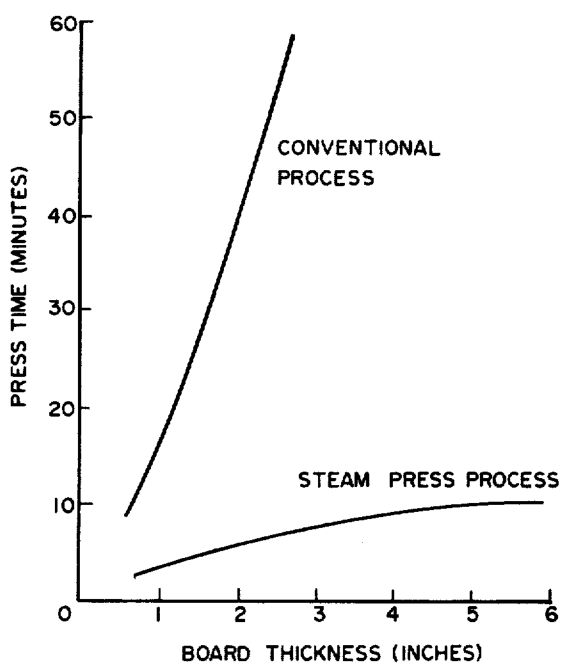

FIG. 4

METHOD AND APPARATUS FOR PRESSING PARTICLEBOARD

This invention relates to a method for pressing particleboard, and more particularly to a method and apparatus comprising the introduction of steam under pressure into the particleboard mat during the pressing thereof.

In the production of particleboard, a thermosetting adhesive binder is mixed with wood particles, a mat is formed and pressed. In conventional pressing the heat required to cure the adhesive binder is transferred predominately by conduction from the surfaces of the hot press platens and some time is required to raise the temperature at the center of the mat. With increasing mat thickness, press time does not vary linearly with board thickness but increases more rapidly.

In the classic "steam shock" or "steam jet" technique the surface layers of the mat are given a high moisture content, for example, by spraying with water. As the hot platens contact the surface layers of the mat the water vaporizes and moves towards the center of the mat. In this way the temperature of the core can be raised more quickly. This technique has the limitation that the amount of moisture must be optimumly balanced because the higher the moisture content, the faster the temperature rise, but also the longer the press time to eliminate the excess moisture which interferes with the curing of the adhesive binder and causes blisters. With this method there is also difficulty in applying water at the bottom surface of the mat because of the hot caul plate on which the mat is formed.

It has been proposed to reduce press time by passing low pressure steam through the mat from one edge to the other during conventional hot pressing. However, with this method it was found that the maximum temperature which could be reached in the center of the mat at the discharge side was 100°C. The main drawbacks of this method are that temperatures and moisture gradients develop along the steam flow direction across the mat which would probably result in warping of a full size (4 × 8 foot) board, and that larger mats would require a longer time for the steam to pass through.

In the commercial production of particleboard, press time is the "bottleneck" on the production line and is the major factor in determining production efficiency. With increased board thickness production efficiency is decreased further. Another disadvantage of conventional pressed particleboard is that it is susceptible to thickness swelling when exposed to moisture unless treated after pressing.

It has been found that since a particleboard mat is normally porous in construction, it is possible to force steam under pressure through the mat by means of apertured press platens. The injected steam provides rapid heat transfer to the mat for rapid curing of the adhesive binder. Steam is injected through an apertured platen on one side of the mat and exhausted through another apertured platen on the opposite side of the mat. By confining the mat in a suitable chamber and restricting the exhaust, elevated temperatures and pressures can be maintained within the chamber to obtain both rapid cure of the adhesive binder and a relaxation of the compressive stresses placed on the wood particles when the mat is originally compressed to the desired board density. The steam can be rapidly released from the mat at the end of the cycle with the release of pressure from the chamber through the apertures in the platens.

In accordance with the present invention particleboard is pressed using a press including a pair of platens wherein each platen has apertures opening to one surface thereof which is adjacent to the other platen and chamber defining means enclosing the region between the platens. The process comprises pressing a mat comprising wood particles and a thermosetting adhesive binder between the platens, introducing steam under pressure into the mat through the apertures of one platen and exhausting the steam through the apertures of the other platen, restricting the exhaust rate to maintain an elevated pressure and temperature within the chamber for a time sufficient to cure the adhesive binder, and releasing the steam pressure from the chamber and separating the platens for removal of the particleboard.

Valves associated with the chamber and steam source provide means for pressurizing the chamber, controlling the steam flow through the mat and releasing the pressure from the chamber.

An object of this invention is to provide a method for pressing particleboard with shorter press time.

Another object is to provide for the making of particleboard having a thickness greater than has previously been practical or economical in a flat press process.

Another object is to provide particleboard which has improved characteristics particularly with respect to water absorption and thickness expansion.

Yet another object of this invention is to provide dimensional stabilization of the particleboard with the pressing operation.

The invention will be further described with reference to the drawings in which:

FIG. 1 is a schematic sectional view of the apparatus;

FIG. 2 is a sectional view taken at 2—2 of FIG. 1;

FIG. 3 shows an alternate embodiment of a portion of the apparatus;

FIG. 4 shows an example of the typical relationship between press time and board thickness for a conventional process and the steam-press process of the present invention.

Referring to FIG. 1 the apparatus comprises a pair of press platens **1** and **2** which are adapted to be moved relative to one another by suitable means (not shown). Between the platens **1** and **2** is an annular sealing frame **3** of the desired thickness, which rests on the lower platen **2**. When the platens are pressed together against the sealing frame member **3**, a sealed chamber **4** for the mat **5** is defined. The inner face of the platens have a plurality of apertures **6** and **7** interconnected with passageways **8** and **9**, respectively, which communicate with a pressurized steam source through conduits **10** and **11**. Inlet valves **12, 13,** and **14** control the steam input. The passageways **8** and **9** also connect with conduits **15** and **16**. Exhausting and release of steam pressure are controlled by valves **17** and **18**.

Each platen includes passageway means **21** connected with conduits **22** to a source of a heating fluid, preferably also steam, which keeps the platens at the desired temperature.

In operation, the particleboard mat **5**, preferably prepressed and contained by two screens **25** for ease of handling, is placed on the lower platen **2** within the sealing frame **3**. The platens **1** and **2** are brought together relative to one another in sealing engagement with the frame member **3**, defining a chamber **4**. In order to raise the pressure within the chamber quickly steam inlet valves **12** and **13** are opened, while the outlet valves **17** and **18** remain closed. After the desired pressure is reached, the steam inlet valve **13** is closed and the outlet valve **18** is opened partially to allow steam to flow through the mat **5** while maintaining the desired pressure in the chamber **4**. After the desired steaming time the inlet valve **12** is closed and all exhaust valves are opened to release the steam pressure before the press is opened. During the above operation the temperature of the platens is controlled by the temperature of the heating fluid through the passageways **21**. The temperature of the platens is preferably 5° to 20°F higher than that of the steam injected.

The apparatus of FIG. **1** also provides for changing the direction of steam flow. By correctly manipulating the inlet valves **12** and **13** and the outlet valves **17** and **18** the steam can be injected into the mat through the top or bottom platen **1** and **2** respectively. It was found that for thick boards, reversing the steam flow direction at some point during the steam injection operation, provides for more uniform and rapid heating of the mat.

In the alternate embodiment of FIG. **3**, radial passageways **39** are used to facilitate varying the spacing of the apertures **37** radially from the center of the platen **32** to provide uniform steam flow to all portions of the mat. The density at the edges of a laterally unconfined mat will be lower hence the porosity of the mat in this region will be higher. Having more widely spaced apertures at the edges provides more uniform flow through all regions of the mat.

In the following examples the apparatus used was generally of the type shown in FIGS. **1** and **2**. All particleboard mats were prepressed for ease of handling. The platens **1** and **2** each had dimensions of 24 × 24 × 2 ⅝ inches. Passageways **8** and **9** were formed 3 inches apart, ½ inch from each platen's inner surface. The apertures **6** and **7** were spaced 2 ½ inches along the passageways **8** and **9** respectively. Asbestos gaskets **23** and **24** were placed between the platens **1** and **2** and the sealing frame member **3** to enable the chamber **4** to maintain steam pressures of at least 300 psi with a press force of approximately 150 tons. When the desired steam pressure was reached within the chamber **4** the outlet valve **18** was opened to allow steam flow of about 0.4 to 0.5 lb. per minute while maintaining the pressure within 2 percent. After the desired steam time had elapsed the inlet valve was shut off and the exhaust valves opened to release the pressure in the chamber and the mat. The release time was normally less than

30 seconds. The indicated "press time" refers to the time for the whole press cycle from the time the press was loaded until opened. "Steam-time" indicates the duration of steam flow through the mat. Platen temperature was maintained above the steam temperature to prevent condensation. Steam-pressing refers to the pressing method according to the present invention while conventional pressing refers to pressing without the use of steam injection.

EXAMPLE 1

Wood of two species, poplar (Populus grandidentata Michx) and sugar maple (Acer saccharum Marsh) was cut into flakes or made into splinters by hammer-milling veneer. All the flakes and splinters had a moisture content between 6 and 9 percent before resin application.

A commercially available, liquid phenol-formaldehyde resin containing 43 percent solids at pH 11.6 to 11.9 was used for all boards. It was sprayed on in a laboratory rotating drum blender.

No paraffin was used in any of the boards.

Three types of board were made: a homogeneous board (splinters-⅛ to ¼ inches screened, with 4 percent resin content); flakeboard (flakes-0.035 × 1 ½ × ⅛ to 2 inches, with 5 percent resin content); and a three-layer board made with fine splinters (**1/16** inches screened, with 8 percent resin content) on face layers and coarse splinters (⅛ to ¼ inches screened with 6 percent resin content in the core).

The pressed board was weighed immediately and then cut in half. Each half was weighed again and its thickness measured. One half was immediately placed in an oven for a 16-hour post-cure at 220°F and oven-dry weight determination. The other half was conditioned to equilibrium at 70°F and 65 percent relative humidity. The same conditioning was given to the post-cured halves before testing. Density was calculated on the basis of oven-dry weight and conditioned volume.

Torsion-shear strength was measured on 1-inch square specimens, systematically sampled from each half board. The normal torsion-shear strength was obtained from ten specimens which were tested dry. The wet torsion-shear strength was measured on another ten specimens which had been subjected to an accelerated aging treatment (2-hour immersion in boiling water) and were tested wet.

All the torsion-shear values reported are averages of ten measurements made at the centre plane. The internal bond strength in psi is about 11.3 times the torsion-shear value in ft-lb for a 1-inch square specimen.

Thickness expansion and water absorption tests

BOARD TYPE & THICKNESS	STEAM PRES-SURE (psig)	STEAM TEMP. (°F)	PLATEN TEMP. (°F)	PRESS TIME [STEAM TIME] (min.)	OARD HICK-NESS (in.)	DEN-SITY (pcf)	MOISTURE CONTENT (HOT BOARD) (%)	FAILING TORQUE (ft.-lb.) DRY	FAILING TORQUE (ft.-lb.) WET	THICK-NESS EXPAN-SION (%)	WATER ABSOR-PTION (%)
MAPLE SPLINTERS	200	388	400	2 [1]	0.949	44.7	12.4	12.9	4.4	10.0	60.3
1-inch	200	388	400	3 [2]	0.929	45.7	13.4	13.5	4.6	10.8	59.0
	200	388	400	4 [3]	0.903	45.8	11.6	13.0	5.3	9.2	56.6
	200	388	400	5 [4]	0.894	45.9	13.0	13.5	5.1	12.0	53.9
	200	388	400	6 [5]	0.900	45.9	13.5	12.6	4.9	9.1	57.9
	200	388	400	8 [7]	0.891	46.4	12.1	13.6	5.7	9.0	55.3
	200	388	400	10 [9]	0.889	44.6	11.6	11.5	4.7	8.4	57.3
	260	410	415	3 [2]	0.924	56.8	13.1	21.0	8.7	9.6	38.4
(CONVENTIONAL PRESS)			400	20	0.984	40.9	2.1	10.8	4.5	23.4	89.2
			400	25	0.981	41.0	1.5	13.6	5.2	23.5	90.5
			400	30	0.983	43.2	1.2	11.5	4.3	24.4	89.5
			400	20	0.984	47.0	3.2	13.0	2.3	34.4	83.5

-Continued

BOARD TYPE & THICKNESS	STEAM PRES-SURE (psig)	STEAM TEMP. (°F)	PLATEN TEMP. (°F)	PRESS TIME [STEAM TIME] (min.)	OARD HICK-NESS (in.)	DEN-SITY (pcf)	MOISTURE CONTENT (HOT BOARD) (%)	FAILING TORQUE (ft.-lb.) DRY	WET	THICK-NESS EXPAN-SION (%)	WATER ABSOR-PTION (%)
			400	25	0.986	45.2	2.4	12.6	2.6	34.0	89.0
			400	30	0.985	44.2	1.9	14.0	2.9	32.0	88.8
			400	20	0.986	53.1	4.2	24.8	4.1	42.9	79.6
2-inch	200	388	400	2 [½]	2.014	47.3	9.6	15.1	3.2	11.1	54.4
	225	396	405	5 [3]	1.953	42.7	10.1	11.2	4.9	10.8	55.6
	225	396	405	5 [3]	1.950	42.5	10.6	11.2	4.7	11.0	60.0
	225	396	405	5 [3]	1.952	42.5	10.5	11.4	4.9	10.1	58.3
	250	405	415	2 [1]	1.986	47.3	9.7	16.8	5.3	8.9	51.3
(CONVENTIONAL PRESS)			400	50	2.013	47.6	6.2	16.9	0.0	56.6	94.6
5-inch	200	388	400	11 [4]	4.894	45.6	15.8	14.2	5.2	9.7	57.6
MAPLE FLAKES	200	388	400	6 [3]	1.967	43.0	10.6	15.8	4.7	9.2	57.6
2-inch	225	396	400	6 [3]	1.962	42.1	10.0	12.7	4.9	9.0	54.2
POPLAR FLAKES	150	367	380	5 [3]	1.945	41.0	14.0	7.5	3.6	11.7	58.0
2-inch	150	367	380	5 [3]	1.875	37.1	15.1	6.2	2.0	11.3	68.7
	150	367	380	5 [3]	1.856	35.7	14.7	5.4	2.9	10.5	72.6
	200	388	400	7 [4]	1.843	45.2	14.2	8.6	3.9	9.4	57.2
	200	388	400	7 [4]	1.845	45.3	14.0	8.6	3.7	9.6	56.7
3-inch	225	396	405	7 [5]	2.895	35.5	15.2	4.6	2.7	7.6	67.1
	225	405	405	7 [5]	2.875	37.5	14.7	4.9	2.9	9.8	58.5
	225	396	405	5 [3]	2.965	35.9	14.2	4.5	2.5	15.2	80.0
	120	350	380	7 [5]	2.902	38.5	14.6	6.0	1.3	13.1	82.5
POPLAR SPLINTERS (THREE-LAYER)											
2-inch	200	388	400	5 [3]	1.897	37.5	13.6	4.3	2.1	11.7	57.3
3-inch	225	396	405	7 [5]	2.886	36.6	15.0	4.3	1.9	10.2	57.8

were carried out on 1-inch square specimens from both the post-cured and control half of each board. For 1-inch thick board, ten specimens were placed face to face with their upper edge 1 inch below water level. The water temperature was kept within 2° of 70°F during the 24-hour soaking period. Thickness and weight increase were recorded on a percent of original basis at 1, 2, 4, 6, and 24 hours.

The table indicates that the dry torsion-shear strengths were generally the same for steam-pressed and conventionally pressed board, but the wet torsion-shear strengths were higher for steam-pressed board after the accelerated aging treatment referred to above. The steam-pressed board showed substantial improvement of dimensional stability. Both thickness expansion and water absorption were reduced.

The series of 7 1-inch maple boards show the effect of steaming time at 200 psi. In general board quality was not significiantly improved by prolonging the steam time.

EXAMPLE 2

About 28 lb. of hammer milled hard maple particles (>1/16, <¼ mesh size) were sprayed with a commercial liquid phenol-formaldehyde resin (4 percent solid resin based on oven dry particle weight), and measured into 6 lb. batches, and each batch was formed and pre-pressed into a 1 ½ inch mat. A series of 1-inch boards (43–48 pcf density) was made from these mats at saturated steam pressures varying from 50 to 300 psi with two different steaming times (½ and 3 min.).

It is evident that the highest steam pressure (300 psi, 423°F) combined with a 3-min. steam time, produced the board having the least thickness expansion. The same steam pressure combined with a ½-min. steam time resulted in the board having the highest torsion-shear strength. It appeared that a higher steam pressure or a longer steam time would further reduce the thickness expansion but at the expense of torsion-shear strength. This was confirmed by one board, steam-pressed at 300 psi steam pressure (423°F) for 9 min. which showed a lower torsion-shear strength (10.9 ft-lb) and a lower thickness expansion (5.2 percent), than the boards steam-pressed at 300 psi for ½ and 3 min.

EXAMPLE 3

Hammer milled spruce particles (¼–1/20 mesh size) were sprayed with a commercial liquid urea-formaldehyde resin (10 percent solid resin on oven dry particle weight). Several batches of this material, each 5.7 lb (10 percent moisture content) were formed into

	STEAM-PRESS CONDITIONS: STEAM PRESSURE (psig)	STEAM TEMP. (°F)	PLATEN TEMP. (°F.)	STEAM TIME (min.)	THICKNESS (in.)	DENSITY (pcf)	FAILING TORQUE (ft.-lb.) DRY	WET	THICKNESS EXPANSION (%)	WATER ABSORPTION (%)
1	50	297	350	½	0.977	45.1	8.0	0	23.2	91.6
2	100	338	350	½	0.970	46.0	9.8	1.1	18.4	68.3
3	150	367	380	½	0.959	44.2	9.2	1.6	14.1	71.8
4	200	388	400	½	0.958	44.3	13.2	2.4	12.1	65.4
5	250	405	415	½	0.942	45.6	14.6	2.2	13.6	63.3
6	300	422	430	½	0.942	46.7	16.9	5.6	10.1	54.3
7	50	297	350	3	0.975	43.0	11.5	1.9	18.2	72.7
8	100	338	350	3	0.963	43.0	12.5	2.4	12.9	74.6
9	150	367	380	3	0.946	43.9	12.9	4.8	9.8	60.5
10	200	388	400	3	0.900	45.8	13.0	5.3	10.6	56.6
11	250	405	415	3	0.899	45.9	12.0	5.1	7.0	52.6
12	300	422	430	3	0.879	48.3	11.6	4.9	8.7	50.0
13	300	422	430	9	0.828	44.2	10.9	2.7	5.2	56.3

15 × 15-inch mats. The mats were prepressed at 150 psi pressure to consolidate the mat to 1 ½ inch thick for easy handling. The prepressed mats were steam-pressed into 1 inch thick boards at various steam pressures with different press and steaming time as shown in the following table. However the press close time (½ min.), steam release time (1 min.), and platen temperature (350°F) were constant. Torsion-shear strength and thickness expansion for 5 steamed-pressed boards and one conventionally-pressed board are also shown.

	Steam Pressure (psi)	Steam Temp. [Platen Temp.] °F	Press Time [Steam Time] (min.)	Density (pcf)	Torsion-Shear (ft-lb)	Thickness Expansion (%)
Steam Pressed						
1	30	269	3 [1 ½]	40.3	12.6	8.2
2	50	297	3 [1 ½]	42.0	13.0	7.0
3	100	338	2 [½]	40.3	11.2	7.9
4	100	338	3 [1 ½]	42.1	12.6	5.8
5	100	338	5 [3 ½]	42.6	1.8	(delaminated)
Conventionally Pressed						
6		[350°] 15		43.3	12.7	16.1

It was further found that there was a significant difference in springback (permanent swelling after the specimen had been boiled in water for 2 hours and reconditioned to reach equilibrium at 70°F and 65 percent relative humidity) between steam-pressed and conventionally-pressed boards. The springback for steam-pressed poplar flake-boards was found to be 2 to 5 percent while for conventionally pressed boards it was 21 to 33 percent.

Ths moisture content of steam-pressed boards was found to be reduced by 1 to 2 percent from an initial moisture content ranging from 11 to 14 percent. Lower steam pressure or a longer steam time tended to produce boards with lower moisture content than did higher steam pressure or a shorter steam time. It was also found that thick boards had higher moisture contents than thin boards and that flakeboards had higher moisture contents than homogeneous boards after steam pressing.

The optimum steam time for proper curing is determined partly by the porosity of the particleboard and also the nature of the thermosetting adhesive binder. It was found that a less porous mat required longer steam-time and/or higher steam-pressure. Porosity is dependent on the wood particle configuration and board density. For example, flakeboard is less porous than a homogeneous splinter board of the same wood species and density.

Press time is shortened by increasing steam temperature, pressure and steam flow rate through the mat.

For the laboratory press used, it was found that for a 1 inch phenolic bonded flakeboard the steam consumption for the steam-press process was in the order of one third that of the convention process in which steam is used to heat the press platens.

It will be understood that other means for maintaining platen temperature such as electrical heating means may be used in place of steam.

It will be evident that particleboard thickness will be determined by the spacing of the platens due to the sealing frame with allowance for springback which is dependant on the physical properties of the mat and the pressing condition.

The present invention is not to be limited to thickness of 5 inches or less but appears to be equally applicable to thickness of greater than 5 inches.

It will be understood that the present process is not limited to the use of the apparatus described herein.

What is claimed is:

1. A process for pressing particleboard in a press including a pair of platens wherein each platen has apertures opening to one surface thereof which is adjacent to the other platen and chamber defining means enclosing the region between said platens, comprising the steps of:

a. compressing a mat comprising wood particles and a thermosetting adhesive binder between said platens to the desired particleboard thickness;

b. introducing steam under pressure into the compressed mat through the apertures of one platen with sufficient pressure to pass through the mat from one surface thereof to the other surface thereof, and exhausting the steam through the apertures of the other platen, restricting the exhaust rate to provide an elevated and substantially uniform pressure and temperature condition within the chamber while steam is passed through the mat, for a length of time sufficient to cure the adhesive binder; and

c. releasing the steam pressure from the chamber and separating the platens for removal of the particleboard.

2. The process of claim **1** wherein the press platens are maintained at a temperature at least equal to that of the steam.

3. The process of claim **1** wherein exhausting of the steam is delayed until the pressure within said chamber defining means reaches a predetermined magnitude.

4. The process of claim **1** wherein the direction of steam flow is reversed.

5. The process of claim **1** wherein said mat is pre-pressed prior to being pressed between said platens.

* * * * *