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2,889,242

MANUFACTURING OF WALLBOARD

Filed June 15, 1955

2 Sheets-Sheet 1

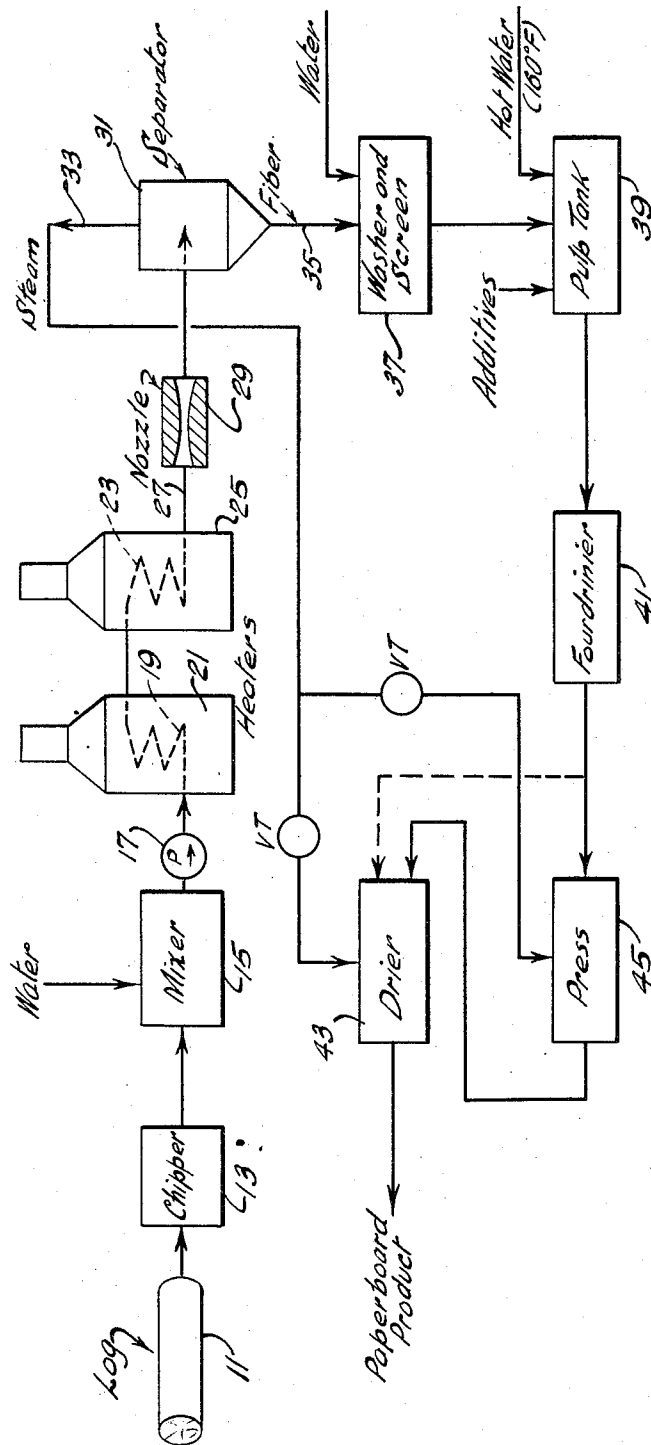


Fig. 1.

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Fig. 2.

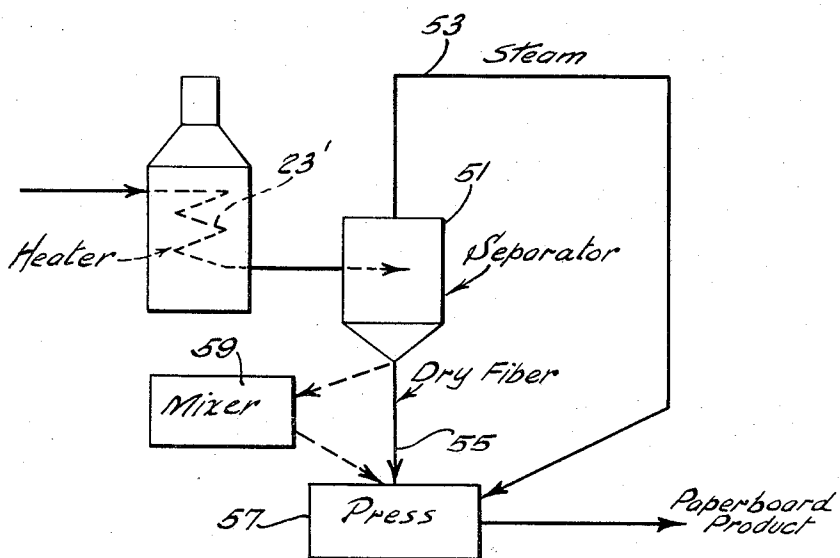
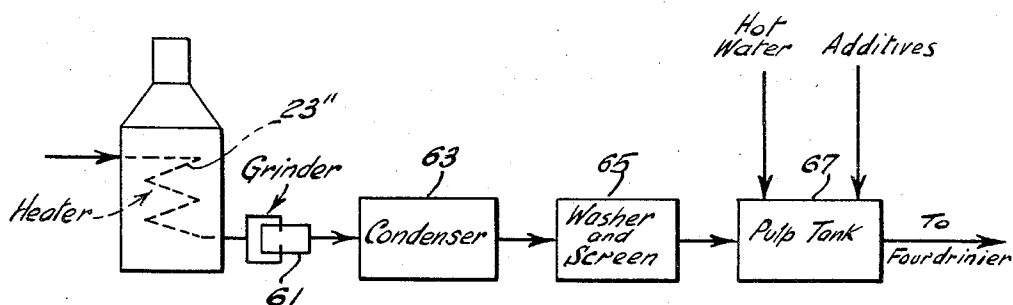


Fig. 3.



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MANUFACTURING OF WALLBOARD

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10 Claims. (Cl. 162—10)

The present invention relates to a novel method for manufacturing sheet from fragments of bonded fibrous substances, such as asbestos and such cellulosic substances as reeds, corn stalks, wood chips or coarse sawdust.

In the following description the invention will be exemplified in the manufacture of paperboard from wood, but the principles apply also to other substances.

In accordance with the present invention paperboard is manufactured by first mixing relatively coarse fragments of wood with a vaporizable liquid such as water to form a flowable mixture, such as a slurry. This mixture is then passed as a flowing stream through a heating zone, such as a long heated pipe, wherein the liquid is vaporized and there is formed a flowing dispersion of wood fragments in vapor. Then the dispersion is subjected to extreme turbulence and high velocity greater than 25 feet per second, and preferably in excess of 100 feet per second, whereby the individual particles of wood impinge against one another with great force and are disintegrated to finely divided fibers.

Afterwards the fibers are formed into paperboard in any of several advantageous ways. In one procedure the board is formed by separating off hot vapor from the disintegrated finely divided fibers, washing and screening the fibers to remove undesirable constituents, forming a thin pulp of the washed fibers in water, and then passing this pulp on to the continuously moving wire of a sheet forming machine such as a Fourdrinier. The sheet thus formed may be passed to a press and then to a drier when a high density board is desired. When a porous insulating board is desired, the sheet from the wire is passed directly to the drier for the removal of excess water without any pressing operation. Paperboard produced in this way is especially useful for structural purposes, as for wallboard.

Both the pressing and drying operations are carried out in an economical manner by passing to the drier and the press the hot vapor which has been separated from the fibers.

In another procedure for forming paperboard the hot vapor may be separated from the fibers, which are then pressed into a hard board product in the dry condition with or without the addition of suitable binding materials to supplement those naturally present.

Still another procedure involves condensing the vaporous dispersions of fibers so as to reform a slurry, which is then passed to a washer and screen before introduction into a pulp tank preceding the sheet forming operation.

Important advantages of the new method described generally above are continuity, rapidity, and economy of operation. Also, feed of the chips in a liquid makes it unnecessary to provide lock hoppers or other expensive and cumbersome means for getting the wood chips into high pressure steam. Additionally, cooking and softening of the wood fragments occurs continuously as an integral part of the process. The net result is the forma-

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tion of unusually thin fibers whereby a dense paperboard may be produced.

In the following description water will be described as the vaporizable liquid, for illustration of the principles of the invention. It is to be understood, however, that other liquids may also be used, such as light naphtha, alcohols, or other organic liquids.

In the drawings:

Fig. 1 is a schematic flow diagram showing an arrangement of apparatus for performing an embodiment of the invention wherein steam is separated from the fibers, and the paperboard is formed from a wet pulp and is subsequently dried;

Fig. 2 is a schematic flow diagram showing a part only of apparatus for performing another embodiment of the invention wherein steam is separated from the fibers and the board product is formed directly from substantially dry fibers; and

Fig. 3 is a schematic flow diagram showing a part of still another arrangement of apparatus for performing an embodiment of the invention wherein steam is condensed with the ground wood fibers.

Referring to Fig. 1, a log 11 is passed to a chipper 13 wherein the wood is chipped to form coarse fragments. Ordinarily, chip sizes for the present invention range from less than $\frac{3}{8}$ inch to about $1\frac{1}{4}$ inches in their maximum dimension. Chips in the form of coarse sawdust, for example about 8 mesh (U.S. Standard) may also be used, as may fragments of other fibrous materials mentioned previously.

The chips are passed to a slurry mixing tank 15 wherein they are mixed with water which is added in proportions to form a slurry containing between about 5% and about 65% by weight of wood fragments. The resulting flowable slurry is passed by a pump 17 into a long tube 19 coiled in a heater 21 and then through a second tube 23 coiled in a heater 25, for heating to vaporize the water content of the slurry and form a flowing dispersion of wood chips in steam. At the same time the chips are cooked and softened.

Heaters 21 and 25 may be fired in any desired manner, as by gas or oil. Also a single heater, or more than two heaters, may be employed with one or several pipe coils, as required by the specific design of any given plant. Furthermore, the tubes 19 and 23 may also be formed as short straight pipe lengths connected by return bends or even a single long pipe may be used. Pipe size depends on the size of the chips and the capacity of the plant, pipe lengths ranging from as little as 200 feet to as much as 2000 feet, and pipe diameters ranging from as little as $\frac{1}{2}$ inch to as much as 2 inches or more, ordinarily being employed.

The pump 17 maintains a high pressure on the inlet of the coil 19, such as a pressure of 300 to 2000 pounds per square inch, but this pressure decreases through the coils until it is between about 100 and 700 pounds per square inch at the outlet 27. In other words, a pressure drop of 200 to 1300 pounds per square inch through the pipe coil may be used successfully.

With the above pressure conditions, complete vaporization of the water is obtained when the dispersion is heated to a maximum temperature between about 350 and 900° F.

The dispersion from coil 23 enters a convergent-divergent nozzle 29 having a throat diameter less than the inside diameter of pipe coil 23 but sufficiently large to accommodate the largest wood fragments in the dispersion, for example ranging between $\frac{3}{8}$ inch and $1\frac{1}{2}$ inches in diameter. In passing through nozzle 29 the pressure drops substantially and the velocity of the dispersion is greatly increased to as much as several thousand feet per second. The flow of the dispersion is sufficiently turbu-

lent that the softened wood fragments impinge against one another with great force and are disintegrated to fibers.

The resulting dispersion of fibers in steam passes to a separator 31 such as a cyclone type of centrifugal separator wherein the steam passes off the top by a line 33 and the fibers leave the bottom in a fairly dry condition by a conduit 35. The pressure in the separator 31 may be atmospheric, but when the separated steam is to be reused for economy, the pressure ordinarily is considerably higher, such as 25 to 100 pounds per square inch.

The fibers from conduit 35 enter a washer and screen 37 wherein large quantities of water are brought into contact with the fibers to remove the high percentage of sugars and organic acids. These substances result from acid hydrolysis in the high temperature steam dispersion, whereby part of the hemicellulose is solubilized and the lignin is softened.

The washed fibers then are delivered to a pulp tank 39 wherein they are thoroughly mixed with hot water, for example at a temperature of 160° F., and also may be vigorously beaten to improve fiber characteristics.

Additives also may be introduced into the pulp tank to improve the characteristics of the finished board. Among such additives are mineral fillers, such as clay, talc, lime stone and others. Also, if desired, binders may be introduced at this point, such as sodium silicate, starch, asphalt and urea or melamine or phenol formaldehyde condensate resins. Another desirable addition at times is a paraffin base emulsion for water proofing the finished board.

In pulp tank 39 sufficient water is added to provide a thin pulp which may contain as little as 0.5% and as much as 5% by weight of solids, depending upon the thickness of board desired and the speed of operation of a Fourdrinier machine 41.

From pulp tank 39 the pulp is fed at a constant rate on to the moving wire of Fourdrinier machine 41 whereon the pulp is formed into a sheet of the desired thickness, which may be between 3/4 and 2 inches, for example.

The wet sheet or board from machine 41 is cut into lengths and then, when a light weight low density board is desired for insulating purposes, is passed directly into a drying machine 43 which may be of any well known type such as a platen drier, a tunnel drier or a roller drier. The temperature in the drier is maintained as hot as possible without charring the board, for example, between 180 and 500° F.

Drier 43 is heated economically by passing the off steam from separator 31 through conduit 33 into the drier, where it passes in indirect heat exchange relationship with the board from the Fourdrinier. Heating may be accomplished in other ways, as by independent gas heaters, either to supplement or to supplant the steam from separator 31.

The fibers of the sheet leaving the Fourdrinier 41 contain nearly all the lignin originally present in the wood. The greater part of this lignin has been freed from its carbohydrate bond and is in a highly reactive state. Thus the sheet from the Fourdrinier can be pressed into a dense hard paperboard before drying, to provide a board having a specific gravity of about 1.00. To accomplish this, the lengths of board from the Fourdrinier 41 are run into a hydraulic press 45 wherein they are pressed by a steam heated platen. The amount of pressure and the time of pressing are determined by the thickness and density required in the final board. Pressures as high as 2000 tons for a panel 4 x 16 feet may be used. Economy of operation is obtained by heating the platen of the press with the high temperature steam from separator 31, with or without the addition of supplemental steam as required. Independent heating means may be

used instead of by-product steam. After pressing the board, it is then passed into the drier 43 wherein the excess moisture is removed as previously described.

Instead of supplying additives to the pulp tank 39 it is often advantageous to introduce them at the mixer 15 so as to pass through the disintegrating system with the wood, and thus to become thoroughly distributed and integrated with the fibers leaving the system. This is especially desirable for mineral fillers and the like, which can be added in a relatively coarse condition in the mixer 15 and are disintegrated to an extremely fine state as they pass through the grinding system in high velocity turbulent flow. In this way a saving in cost is realized because it is only necessary to purchase relatively inexpensive coarse mineral fillers instead of more expensive fine fillers.

Referring to Fig. 2 there is shown an arrangement of apparatus whereby the board is pressed from dry fibers. The initial portion of the system is identical with that shown in Fig. 1. In this embodiment, however, the pressure drop through the pipes is relied upon to provide the high velocity turbulent flow, instead of employing a convergent-divergent nozzle as in Fig. 1. The disintegrated dispersion of wood fragments in steam passes directly from heated pipe coil 23' into cyclone separator 51 from which steam is withdrawn at the top through a line 53, and substantially dry fiber leaves the bottom through line 55. When additives are not to be employed after the cyclone, fibers enter press 57 directly and are compacted while the press is heated with steam from line 53, after which the hard board product leaves the press and passes to a drier (not shown). Ordinarily the lignin present in the wood is adequate to bind the fibers.

When additives such as binders, fillers and the like are to be employed, the fibers from the bottom of separator 51 pass into a mixer 59 wherein the fibers are thoroughly mixed with the additive before passing to the press 57. Additives also may be introduced in the mixer ahead of the heated coils, as described in connection with Fig. 1.

In this type of operation the inlet pressure to the first heater coil ordinarily will range from about 200 to 600 pounds per square inch while the pressure at the outlet of the last coil will range from about atmospheric to 150 pounds per square inch.

Referring to Fig. 3, a dispersion of wood fragments in steam from pipe coil 23" passes into a grinder 61 having a pair of 180° opposed nozzles through which two streams of dispersion are passed to impinge against one another with high velocity and with great turbulence, so that the wood fragments are disintegrated to fiber. Pressure conditions should be as described in connection with Fig. 1.

The resulting dispersion of fibers in steam flows into a condenser 63 wherein the steam is condensed to water and a slurry is reformed. This slurry then passes through a washer and screen 65 wherein the detrimental sugar and acids are removed, after which the fibers flow into a pulp tank 67 and are thereafter treated as described in connection with Fig. 1 to form the board.

In describing the invention each embodiment has been described with a different arrangement of apparatus for assuring pressure drop, high velocity and turbulence. It is to be understood, however, that such arrangements are interchangeable among the different systems within the scope of the invention.

Instead of employing a free flowing slurry as described in detail above, a thick extrudable paste of solid fragments in water may be used. A separately generated stream of vapor may be passed into the flowing paste to heat it and form a dispersion of fragments in vapor which is then treated as previously described for disintegration to fibers, and for the formation of board.

Obviously many modifications and variations of the invention, as hereinbefore set forth, may be made with-

out departing from the spirit and scope thereof, and therefore only such limitations should be imposed as are indicated in the appended claims.

I claim:

1. A method comprising the steps of mixing relatively coarse fragments of fibrous solids with a vaporizable liquid to form a flowable mixture; continuously passing said mixture as a flowing stream through a heating zone wherein said liquid is substantially completely vaporized to form a continuously flowing dispersion of fragments in vapor; subjecting said dispersion of fragments while flowing to high velocity greater than 25 feet per second and turbulence thereby disintegrating said fragments to finely divided fibers; and subsequently forming said fibers into a sheet.

2. A method in accordance with claim 1 wherein said dispersion is subjected to high velocity and turbulence by impinging opposed jets of dispersion against one another.

3. A method in accordance with claim 1 wherein said dispersion is subjected to high velocity and turbulence by passing said dispersion through a convergent-divergent nozzle from a region of high pressure to a region of low pressure.

4. A method in accordance with claim 1, also comprising incorporating particles of mineral filler with said mixture in said initial mixing step, said particles being disintegrated to a finer condition by such high velocity turbulent flow.

5. A method in accordance with claim 1, also comprising incorporating at least one binder with said fibers.

6. A method in accordance with claim 1 wherein said fragments are cellulosic, said process also comprising pulping said fibers with water before forming said fibers into a sheet, and drying said sheet after formation thereof.

7. A method in accordance with claim 1 wherein said liquid is water and said vapor is steam, and wherein said flowable mixture contains between 5 and 65% by weight of said solids.

8. A method in accordance with claim 1, also comprising, before said forming step, condensing said dispersion to form a mixture of fibers in water, removing said water and accompanying sugars and acids from said fibers, and washing said fibers free from such sugar and acids.

9. A method comprising the steps of mixing relatively coarse fragments of cellulosic material with water to form a flowable mixture; continuously passing said mixture as a flowing stream through a heating zone wherein said water is substantially completely vaporized to form a continuously flowing dispersion of cellulosic fragments while flowing in steam; subjecting said dispersion of fragments to high velocity greater than 25 feet per second and turbulence thereby disintegrating said fragments to finely divided fibers; separating steam from said finely divided fiber; forming said fibers into a sheet; and drying said sheet by passing separated steam in heat exchange relationship thereto.

10. A method in accordance with claim 9, also comprising the step of pressing said sheet before said drying step, and passing separated steam in heat exchange relationship thereto during said pressing step.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 2,889,242

June 2, 1959

Charles F. Teichmann

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

In the heading to the drawings, Sheets 1 and 2, line 2, each occurrence, and in the heading to the printed specification, line 2, title of invention, for "MANUFACTURING OF WALLBOARD" read
-- METHOD FOR MANUFACTURING A SHEET OF FIBROUS SUBSTANCE, SUCH
AS PAPERBOARD --.

Signed and sealed this 13th day of October 1959.

(SEAL)

Attest:

KARL H. AXLINE

Attesting Officer

ROBERT C. WATSON
Commissioner of Patents