This invention relates to apparatus and methods for making boards, sheets and related products from fibers. The product produced is sometimes called wallboard, insulating board, paper, cardboard or felt, depending on its specific dimensions and characteristics.

One specific application of this invention is in connection with the manufacture of a fiber board for use in building construction either for insulation, for sheathing or general structural purposes although I do not wish to limit the scope of my invention to this application only.

Some of the objects of my invention are to produce a board cheaply, rapidly and uniformly with a minimum of equipment. Other objects of my invention are to improve the quality of the board in general and specifically a few of the points in which the board has been improved may consist of a stronger board, a harder board, a board relatively free from laminations and when desired a much thicker board than can readily be produced by present commercial methods.

The process which I have invented accomplishes the above and other results in a substantially automatic manner with a minimum of investment.

My process makes it possible to produce either a thick or a thin board and still obtain proper interlocking of the fibers even in considerable thickness. This also makes it possible to produce a relatively hard dense board if required as readily as to produce a board of present commercial thicknesses.

My invention includes the process of producing the board, the equipment employed and the final product produced.

Referring to the drawings:

Fig. 1 shows diagrammatically a vertical side elevation of a typical equipment assembled for producing board in accordance with my invention;

Fig. 2 shows also diagrammatically a plan of the equipment shown in elevation in Fig. 1;

Fig. 3 shows a front end elevation partly broken away of the tank member shown in the left portion of Fig. 1;

Fig. 4 shows on a somewhat enlarged scale further details of a portion of the forming mechanism;

Fig. 5 shows diagrammatically a detail of the forming mechanism and indicates the method of its operation;

Fig. 6 shows a diagrammatic cross section of a typical present commercial board in distinction to

Fig. 7 which shows diagrammatically a typical cross section of board produced in accordance with my invention;

Fig. 8 shows a modified construction of the forming mechanism which is illustrated diagrammatically in Fig. 5.

Referring to the drawings, 1 indicates a tank or container provided with a heating device 2 which may be in the form of burners or steam coils as appears most convenient. Tank 1 is provided with a charging lip 3 which receives material from a spout or chute 4, the material consisting of the fibers in suspension or such other materials which may be desired in the way of size, colloidal material, weighting material, etc. Tank 1 is provided with two agitators 5 and 6 respectively, which serve to maintain the fibers and other materials in suspension in the solvent which would ordinarily consist of water. Tank 1 is provided with a series of overflows numbered respectively 7, 8 and 9 which serve to maintain a desired level of fiber and solvent in tank 1. A forming cylinder 10 revolves so that it is partly or wholly submerged in tank 1. The forming cylinder 10 is connected by duct 11 to a suction device and therefore serves to remove water from the suspended fiber forming a mat or felt upon its surface. A porous belt 12 extends around drum 10 and pulley 13 serving to carry away the felt as it is formed. A control rotor 14 provided with a series of blades 15 serves to maintain the mat or felt produced on belt 12 at a constant uniform thickness. It is understood that member 14 may be moved laterally along members 16 and 17 to permit the forming of any desired thickness of felt on belt 12. A pair of squeeze rolls 18 and 19 serve to remove a portion of water from the felt on belt 12 as desired, the quantity of
water removed depending of course upon the space between the squeeze rolls 18 and 19. A rotating throwing member 20 is movably mounted at a controllable distance away from the surface of pulley 13. Throwing member 20 is formed from a shaft 21 and a series of blades 22, 23 and 24 which serve to engage a portion of the felt or mat on belt 12, remove it from belt 12 and throw it forcefully against belt 25 which is located beneath throwing member 20 and passes over pulleys 26 and 27. Throwing member 20 is designed to operate at relatively high speeds in order to obtain proper velocity in throwing the lumps of felt against belt 25. The speed of revolution required in throwing member 20 depends of course upon the nature of the materials being treated, the thickness of the board to be formed and the various operating speeds and characteristics of the co-acting parts.

A second pressing belt 28 is located above forming belt 25 the two belts being held together with a proper separation by stationary members 29 and 30 which are connected respectively to suction pipes 31 and 32. It will be apparent, therefore, that as the matted felt is thrown violently on belt 25 and is squeezed between top belt 28 and under belt 25 at the same time that suction is applied to remove the exhaust water and to felt the fibers. Upper belt 28 passes over pulleys 33 and 34 which may be driven at the proper velocity to cause belts 25 and 28 to travel at the same speed during the time that the felt is between them.

The action of these two belts serves to remove a portion of the water after which the board travels through guide rolls 35 and 36 to squeeze rolls indicated by 37, 38, 39 and 40. A continuous canvas belt passes around the pair of squeeze rolls 38 and 40 while another continuous canvas belt passes successively partially around squeeze roll 37, squeeze roll 38, squeeze roll 39, take-up roll 41 and guide roll 42. During this step of the process additional moisture is removed from the board placing it in condition for entering the dryer. It will be obvious that the diameter of the various squeeze rolls may be made such that thick boards will not be damaged by turning around too sharp a radius.

After leaving the set of squeeze rolls described above the board passes through a series of pairs of guide rollers 43, 44 and enters dryer 45 which may be of any commercial type. In the dryer the board is reduced to a commercial degree of dryness leaving through opening 46. The board is indicated by reference number 47. After leaving the dryer 45 the board may be given a surface treatment for producing a hard dense surface if desired and then cut into sheets of commercial size or otherwise treated.

The construction of throwing member 20 may be varied to suit requirements. In Fig. 5 a diagrammatic view of throwing member 20 and a typical construction of the throwing blades is indicated.

Referring to Fig. 5 it will be noted that some of the blades are curved forward, some backward and some of the blades have a substantially radial direction. One of the objects of this construction is to throw the lumps of felt to different points on the board in order that the fibers will not be parallel but will run in different directions in different parts of the board.

One result of this arrangement is a board in which the fibers are interlocked and in which many of the fibers extend transversely from surface to surface of the board being at the same time interlocked with a percentage of fibers which extend longitudinally of the board as well as fibers which extend from side to side. This arrangement is illustrated diagrammatically in Fig. 7. In Fig. 6 the transverse lines 48 and 49 are intended to represent the laminated condition which is typical of practically all commercial practice today. The laminated condition now existing in commercial boards is largely the result of the fact that present felting methods create a variable condition, due to the fact that when the felt is initially formed it deposits rapidly, owing to the ready passage of the solution through the thin layer of felt. On the other hand, as the thickness of the felt increases in present day equipment the rate of travel of solution through the layer of felt decreases materially and the texture of the felt is, therefore quite different at the end of the building period from that formed at the beginning of the building period. This condition is further emphasized by the practice which is followed in many machines of forming two separate felts from the solution and pressing them together as they leave, owing to the fact that little solution travels through the pressed joint, but little true felting is formed at this surface with the result that the board is not firmly bound together and there is a tendency for the finished product to separate or peel along this joint.

In the product which I have invented this difficulty is overcome because of the fact that the board is formed by forcefully throwing small uniform lumps of felt upon the making belt the force with which the lumps of felt are thrown being of course constant over the entire cross section of the board.

After the felt has been thrown upon the forming belt, it is then subjected to squeezing between canvas belts and subjected to pressure thus causing a felting action which firmly unites the various lumps of felt into a homogeneous mat or sheet.

It will, of course, be evident that the process I have invented may be applied to a wide range of different fibers and the process may
be used to produce various types, sizes, and kinds of boards.

Among the fibers which may be handled with the process and equipment I have invented are such materials as glass wool, mineral wool, asbestos fiber, hair and the various cellulose and vegetable fibers.

One of the features of my invention consists in, what may be called a double felting action, in other words I first produce the felt, as for example on belt 12 and then as a second step remove the felt thus formed in lumps throwing it violently on belt 25, thus subjecting the material to a second felting operation. Inasmuch as the lumps of felt removed from the first or pick up belt contain considerable quantities of water the combined action of the throwing, the suction and the pressure to which these lumps are subjected while on belt 25 causes a second felting action with the effect that in the second felting action the fibers are more interlocked than in the case of a single felting and lamination of the resultant product is thereby prevented.

As a result of this treatment, the product resulting has fibers arranged at substantially all angles and thoroughly interlocked.

The board after leaving the forming machine may be subjected to a surface treatment as outlined in my copending application Serial No. 284,222, filed June 9, 1928. After being given a hard surface the resultant product is particularly strong and I consider as one part of my invention a board produced in a manner here described and given a surface as described in the above copending application.

It should be understood that many mechanical changes may be made in the equipment, process and product here set forth without departing from the spirit of my invention. For example I may prefer to use metal or wire, screens or belts instead of the canvas previously referred to. I may use various shapes and types of mechanisms for removing the preliminary felt from the first belt and throwing it onto the second belt. In the case of the second belt, I may obviously support this at intervals by rollers, draw it between supporting plates or merely depend upon the pressure exerted by the belt and pulleys. Obviously I may make desired variations in the speed with which the various parts travel, the pressures exerted, the head of liquid, the degree of suction and other factors. It is the purpose of this invention to set forth the basic principles which I have devised and each kind of fiber or group of such fibers obviously requires a somewhat different treatment in order to produce the best results.

In place of belts I may use other equivalents such as porous cylinders or drums, various other mechanical substitutions will be apparent to those skilled in the art.

I may use compressed air or steam from nozzle 50 (Fig. 8) to blow felt from belt 12 to belt 25, replacing member 20 with nozzle 50.

A decided advantage of the process which I have here disclosed lies in the fact that by forming the board from particles moving at a high pressure the board is materially harder and denser than in those cases in which it is formed by the felting action of the flow of fiber suspended in water.

It will be obvious that the felting of a board by removing the suspended fibers from water as the water flows through the felt will leave sizable spaces between the fibers.

It has commonly been the practice to reduce the interstices between the fibers subsequently to formation by pressing or rolling. The pressing practice is open to definite objections which my process reduces or removes. It is relatively slow and difficult to dry the board after rolling and pressing by the processes now commonly utilized. Tremendous pressures are necessarily employed in the pressing methods which are expensive in first cost and in operation and which are slow and cumbersome. By my process and particularly by maintaining the fiber and water at a high temperature, preferably near the boiling point, the fiber is soft and flexible, readily deforms and quickly produces a hard and dense board. The use of fibers at a relatively high temperature for this process is a decided advantage though not a necessity. The high temperature naturally serves to give a fiber which is softer owing to the effect of heat on the wax, resins and other materials present in the fiber and also the effect of heat on the cellulose itself. As a matter of fact the viscosity of the water which is present with the fiber is materially lowered by the application of the higher temperature.

I have found that a somewhat unusual condition obtains when producing board by my process in that the excess water which is not evaporated during the forming process or soon after collects on the upper surface of the board and flows away instead of passing through the board as is commonly the case.

I have found that this condition is due to the fact that by very forcefully throwing the mixture of fiber and water against the forming surface the material produced is so dense that in many cases it is not readily penetrated by the water. However, in the case of certain fibers I obtain a rather desirable product by so adjusting the density of the layer produced that a portion of the water travels to the under surface of the board and the balance mainly to the upper surface.

One advantage of forming a board by the method I have here outlined lies in the fact that a finished board on leaving the form
ing machine may carry far less water than is ordinarily the case. This materially reduces the cost of drying and investment in drying equipment and floor space, as well as shortens the process and increases the output. In the case of the arrangement illustrated in Figure 8, I may deliver air to nozzle 50 at a relatively high temperature, using this air as described to force the fiber and water onto the forming belt and also to further heat the mass and remove additional amounts of water by evaporation.

I have found that it is possible to add small quantities of certain materials as for example a fraction of one percent or perhaps one or two percent of sodium silicate to the suspension of fiber in the water with good results. I am of the opinion that materials of this kind serve to still further soften the fiber and permit the manufacture of a hard and dense board. I do not wish to be confined to sodium silicate only as various alkalies such as caustic soda, sodium carbonate and other materials, even certain clays appear to materially assist in permitting the formation of a hard and dense board when added to the suspension of fiber in water.

While I have referred in this specification to the term “board” it should be understood that I do not wish to confine my invention to any particular thickness or product. I have found that the process here disclosed is well adapted to the manufacture of such materials as wall board, insulating board and similar materials as well as boards made from substances which have considerable strength, but which cannot be readily used in the ordinary paper making process, such as certain forms of pearl fiber.

However, my invention may be applied to thin sheets such as cardboard and paper, it being understood that the obvious changes familiar to those skilled in the art are necessary. Some of these changes should include the amount of water in the materials, the force with which they are delivered on the forming sheet, the nature of the sheet which receives the fiber, etc. In the case of thin sheets such as paper stock, the ordinary well known drying equipment may be employed instead of the straight line roller dryer which is illustrated.

It should be noted that in the case of board manufactured under present methods in which the fibers are first felted from a water suspension and then pressed there is a decided tendency to produce a board whose surface is harder and more dense than the inner portion. This is because of the obvious fact that the application of heat and pressure must both begin at the surface and travel toward the center of the board. In other words, present commercial boards and particularly those of a hard variety do not ordinarily show a uniform condition of hardness and density throughout the mass. This condition I can materially change and in some cases entirely overcome, for the reason that each layer of fiber is hardened as applied owing to the high velocity with which it is thrown against the sheet.

Having now fully described my invention what I claim as new and wish to secure by Letters Patent in the United States is as follows:

1. The process of forming a board from fibers which consists in first forming a preliminary grouping of said fibers on a porous support and secondly removing said preliminary grouping of said fibers from said porous support and forcefully throwing them upon a second support and finally feltting said fibers while carried by said second support.

2. The process of forming a board from fibers which consists first in forming a preliminary grouping of said fibers, second throwing portions of said preliminary grouping of fibers upon a support, third submitting said thrown portions of fibers to a felting action, and finally removing the excess water from said felted mass.

3. In the process of making board from fibers the step of forming a preliminary grouping of said fibers, removing a portion of the solution carrying said fibers and then individually removing lumps of said grouped fibers and throwing said lumps forcefully upon a felting device.

4. An apparatus for forming board from fibers consisting of a preliminary felting device, means for removing portions of the web formed on said preliminary felting device and delivering said portions to a second felting device, and means for removing the excess water from the product thus formed.

5. A machine for producing a board from fibers consisting of a preliminary felting device, a reservoir for supplying a mixture of fibers and solution to said felting device, a secondary felting device, means for removing the web in lumps from the preliminary felting device and delivering it forcefully to the secondary felting device, and means for removing the excess of solvent from the product leaving said secondary felting device.

6. The apparatus for producing a board from fibers which consists of a reservoir containing the fibers suspended in a solution, a felting device for removing a portion of the solution from said fibers thereby forming a mat or felt, means for regulating the thickness of web formed thereon, means for removing said web in pieces from said felting device, a secondary felting device arranged to receive said lumps of web when removed from said primary felting device, means for removing additional moisture from said web while on said secondary felting device.
and means for finally reducing the solution to produce a dry board.

7. The process of forming a hard dense board which consists in first partially de-watering the suspension of fiber, second removing small portions of said dewatered fiber and forcefully throwing said portions to form a sheet.

8. The process of forming a hard dense board which consists in first partially de-watering the suspension of fiber, second removing small portions of said dewatered fiber and forcefully throwing said portions to form a sheet, said fibers being in a condition of abnormal softness.

9. The process of forming a hard dense board which consists in first partially de-watering the suspension of fiber, second removing small portions of said dewatered fiber and forcefully throwing said portions to form a sheet, said fibers being heated when removed.

10. The process of forming a hard dense board which consists in first partially de-watering the suspension of fiber, second removing small portions of said dewatered fiber and forcefully throwing said portions to form a sheet, said fibers containing materials for inducing softness.

11. In the process of making board from fibers, the step of forming a preliminary grouping of said fibers, removing a portion of the solution carrying said fibers, individually removing aggregations of said grouped fibers while hot and forcefully throwing said aggregations upon the forming sheet.

12. In the process of forming a board from hot fibers and water the step of forcefully throwing aggregations of said fibers while hot upon a forming sheet and simultaneously directing a stream of heated gases upon said fibers.

13. A device for forming board from fibers consisting of a preliminary de-watering means, a means for throwing fibers treated by said preliminary de-watering means upon a moving support, and a means of supplying a stream of hot gases about said fibers as they are delivered to said moving support.

14. An apparatus for forming boards from fibers consisting of a de-watering device, a means for removing said fibers from said de-watering device, a means for forcefully throwing said fibers upon a support after leaving said de-watering device and means for drying said fibers on said support.

15. A device for forming boards from fibers comprising a de-watering means, a conveying means for removing fibers from said de-watering means, a throwing means for transferring said fibers from said conveying means to a support, and means for further de-watering and drying said board.

16. In an apparatus for forming boards, a means for conveying fibers, means for re-moving fibers from said conveyor and forcefully throwing them upon a support, and means for delivering a stream of hot gases around said fibers.

WILLIAM A. DARRAH.