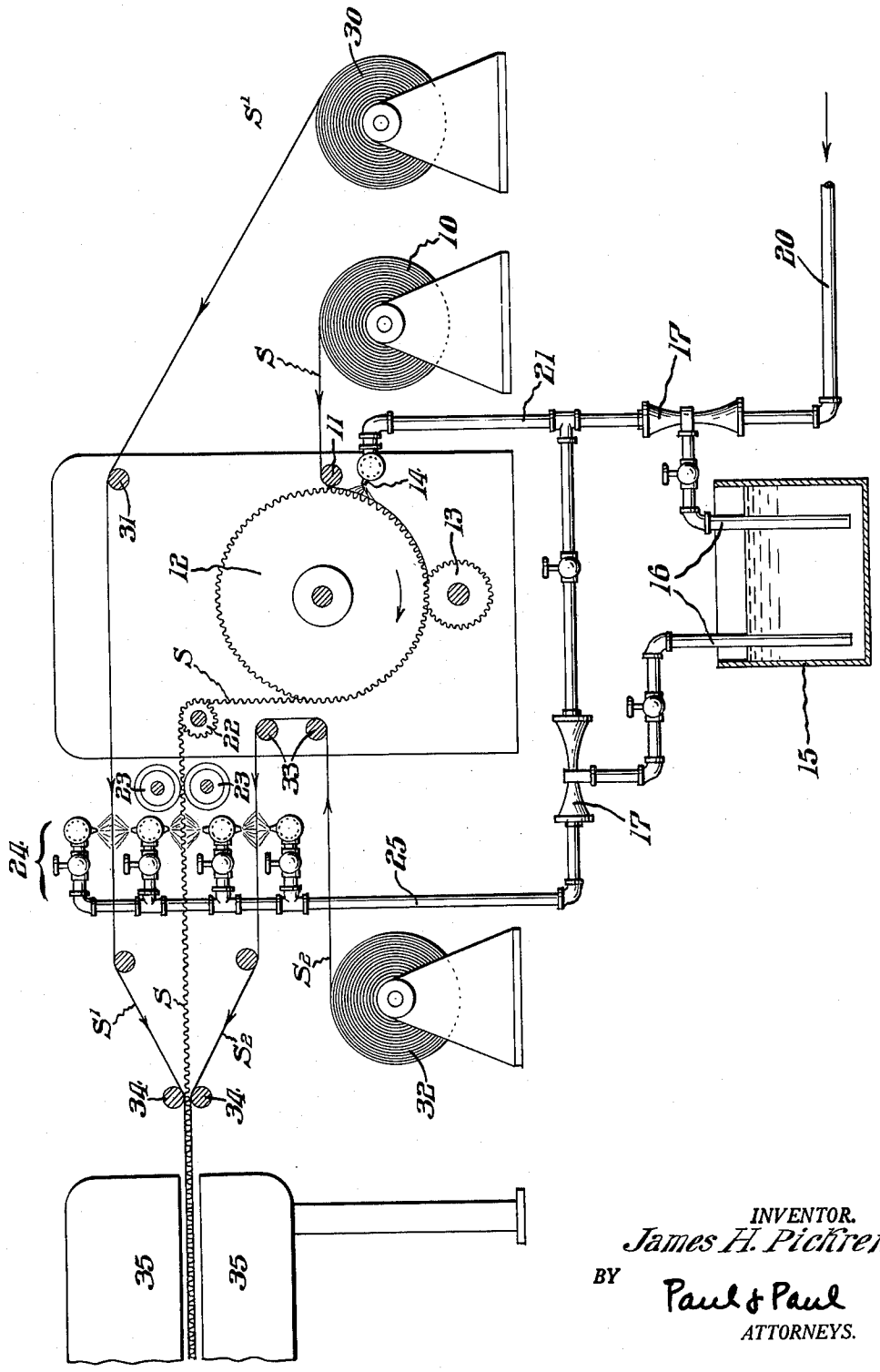
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METHOD OF TREATING, CORRUGATING AND LAMINATING A FLEXIBLE ABSORBENT SHEET MATERIAL

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METHOD OF TREATING, CORRUGATING AND LAMINATING A FLEXIBLE ABSORBENT SHEET MATERIAL

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This invention relates to a method of treating an absorbent sheet material, and more particularly concerns a method of improving the wet strength of fibrous materials such as paper and the like.

This invention further relates to a continuous method of forming finished articles constructed of fibrous material, such as corrugated fiberboard or the like, having improved characteristics of wet strength and water resistance.

It is an object of this invention to provide an improved method of enhancing the wet strength of sheet materials. Still another object is to provide a method of strengthening fibrous sheet materials such as paper and the like. Other objects and advantages of this invention will further appear hereinafter.

The drawing illustrates a preferred form of the apparatus for carrying out the method in accordance with this invention, the apparatus being arranged to produce continuously a corrugated fiberboard product.

In accordance with this invention, a sheet of absorbent material such as cloth, paper, fiberboard or the like is impregnated with steam containing a mixture of (1) urea or gelatin and (2) formaldehyde, and after the impregnation is complete the product is heated, causing a condensation reaction of the urea or gelatin with the formaldehyde to form a resin in situ which is uniformly dispersed in the sheet.

Turning now to the specific form of the invention selected for illustration in the drawings, a roll 10 of flexible absorbent sheet material S is caused to pass over an idler roller 11 and then against the surface of a corrugator roll 12. A mating corrugator roll 13 is provided adjacent the periphery of the corrugator roll 12. The sheet S is continuously subject to a plurality of sprays or jets emanating from a nozzle 14. Several jets 14 are preferably but optionally spaced along the edge of the cylinder 12, all such jets being in line so that only one is visible in the drawing.

The number 15 designates a tank containing an aqueous mixture of gelatin and formaldehyde. Pipes 16 extend upwardly from the tank 15 and are connected into the throats of venturis 17. Steam flows at a relatively high velocity through the line 20 and through the venturis 17, and the throats of the venturis accordingly have a reduced pressure causing a suction of the aqueous mixture of gelatin and formaldehyde upwardly from the tank 15. Accordingly, a mixture of gelatin and formaldehyde of predetermined proportions is fed into the throat of each venturi 17 at a rate which is proportional to the rate of flow of steam through the venturi and also to the lineal feet of travel of material through the machine. The steam, mixed with predetermined quantities of gelatin and formaldehyde, then flows upwardly through the pipe 21 to the jets 14, and it is this mixture which is expanded and projected against the surface of the sheet S as the sheet passes around the periphery of the corrugator roller 12. After corrugation, the sheet S passes over an idler roller 22, between rollers 23 and through another steam jet section 24, wherein additional jets of steam, admixed with urea or gelatin and formaldehyde as heretofore described, are supplied from the pipe 25.

Another sheet S_1, also of flexible absorbent material,

is conducted from a roller 30 over a guide 31 to the steam jet location 24, where it is treated (as heretofore described in connection with the sheet S) on both sides with a mixture of steam containing predetermined proportions of (1) urea or gelatin and (2) formaldehyde.

Similarly, another sheet of absorbent material S_2 is provided from a roll 32, which passes over rollers 33 through jets contained in the jet portion 24. The sheets S, S_1 and S_2 are then caused to flow between compression rollers 34 and between heating elements 35. The heating elements apply a proper amount of heat to the combined sheets, causing a condensation reaction of the urea and the formaldehyde or the gelatin and the formaldehyde to form a resin in situ which is uniformly dispersed in the sheets.

Because of the fact that the impregnation of the fibrous sheet is completed while all of the reactants are in an unreacted condition and in a liquid condition, and because of the fact that the are applied forcibly in the form of a jet of steam against the surface of the absorbent fibrous material, an exceptionally good and exceptionally uniform absorption and penetration of the material takes place. This process is to be distinguished sharply from processes wherein an impregnation is carried out, using a resin as the impregnating material. In accordance with this invention, the impregiation is brought about using raw materials of a condensation reaction, and after the impregnation has been completed the condensation reaction is, for the first time, started and then completed within the fibrous material.

This condensation reaction, involving urea or gelatin and formaldehyde, is not to be confused with other condensation reactions which are known in other arts. It has been found that urea or gelatin and formaldehyde are vastly superior to any other resin forming substances when applied to paper, fiberboard or other material, as a mixture with steam which is caused to jet against the sufrace of the material. Moreover, it has been found that when used on fibrous materials such as paper or fiberboard or the like, the combination of steam, urea or gelatin and formaldehyde, followed by heating in a dry condition, brings about a resinification or a condensation reaction which produces an exceedingly stable and exceedingly water resistant resin, such resin being uniformly dispersed among the fibers and possessing excellent strength qualities over long period of use.

Although the drawings show a specific form of the invention, as applied to corrugated fiberboard, it should be borne in mind that the process has application to a single sheet, whether corrugated or not. Although various alternate methods may be employed for forming the mixture of steam, urea or gelatin, and formaldehyde, the method shown in the drawings is of particular advantage since the venturis provide a uniform mixing action which is difficult to obtain otherwise, and which action provides superior results.

The solution contained in the storage tank 15 is preferably a mixture of urea or gelatin, formaldehyde and water. Where gelatin is employed, this may be a dilute solution containing, for example, about 6% by weight of gelatin and about 6% by weight of formaldehyde. The solution may be even more dilute, utilizing for example 2% by weight of each such ingredient. However, the dilution is variable within wide limits and may be selected at the convenience of the operator. Preferably, the total weight of solids is in the range of 1 to about 20% by weight, based on the total weight of solids plus water, but in any condition the mixture must be readily flowable. Although it is preferable to maintain the ratio of gelatin to formaldehyde at approximately 1–1, this is subject to wide variation since the formaldehyde may be in proportion of one half of that of the gelatin, or even less. The

pH of the solution is preferably in the range of about 2.2 to 4.5. Phosphoric acid is preferably added in an amount to create a pH within this range, and serves as a buffer.

Where urea is combined with formaldehyde, it is preferred to maintain a pH of about 4.0 to 6.8, formic acid being added as a buffer in the dilute solution. The solution preferably has a solids content of about 1% to 15% by weight, balance water, and for many purposes it is preferred to maintain, by weight, about 6% to 7% urea plus formaldehyde and 93% to 94% water. Ordinarily, only trace quantities of formic acid produce excellent results, but more may be added without interfering.

It is preferred in accordance with this method to condition the fibrous material prior to treatment by this process, by treating it with plain steam. The pressure from the steam in the preliminary process assists the impregnation of the paper in the following stages of the process.

It has been noted that the heating of the treated sheet should be carried out in a dry condition. The solution does not provide a completely workable condensation reaction as long as steam is present. Only when heating is applied in a manner to drive off any remaining water does the condensation reaction proceed to a proper stage. This factor is highly desirable, since none of the working parts of the apparatus are clogged up due to polymerization taking place prematurely, as would happen in the case of a urea formaldehyde resin employing a catalyst, for example.

Another advantage of the method in accordance with this invention is that the mixture of gelatin and formaldehyde or urea and formaldehyde needs no outside catalyst to cause the condensation reaction to take place in the pores of the paper. The dry heat in the drying mechanism causes the condensation, hence there is no concern with respect to the life of the solution prior to use. While many other condensation reaction chemicals have a very short "pot life" due to interaction between them, gelatin and formaldehyde do not react to any appreciable extent until they are dry. Although in some cases the boiling of the gelatin-formaldehyde liquid tends to give a small amount of condensation reaction, I have found that by the addition of a small amount of phosphoric acid (H_3PO_4), keeping the pH of the solution between about 2.2 and 4.5, this condition is avoided.

Referring further to the pot life of a gelatin-type solution, it has been noted that the formaldehyde actually preserves the gelatin and lengthens its pot life, which is sharply distinguishable from other resin forming chemicals, which tend to react with each other thereby shortening their pot life.

The paper product has a much higher wet strength than conventional paper. In fact, strength ratios up to as high as 20–1 and above have been obtained as compared to untreated paper. Similar proportional results have been obtained utilizing other forms of fibrous materials.

Another advantage of this invention is that it is unnecessary in many cases to utilize the conventional gluing step which has heretofore been utilized to adhere the central corrugated portion of a fiberboard product to the two flat outside sheets. The impregnation followed by drying in accordance with this invention adheres the three sheets tenaciously together, utilizing the condensation product as the adhering medium.

Paper or fibrous products in accordance with this invention not only have great wet strength, but they breathe and still have a wick action as did the untreated paper or fibrous product. Water filters through it readily, notwithstanding the fact that it has been impregnated with resin-forming chemicals which have undergone a condensation reaction.

This invention is applicable not only to fiberboard, paper and the like but may also be applied to any other flexible absorbent material such as cloth, cardboard, two-ply wood, multi-ply wood, etc.

Although this invention has been described with reference to various specific embodiments thereof, it will be appreciated that equivalents may be substituted for the specific materials, apparatus and method steps disclosed herein, and that certain features of the invention may be utilized independently of the use of other features, all without departing from the spirit or scope of the invention as defined in the appended claims.

This application is a continuation-in-part of Serial No. 679,797, filed August 19, 1957, on my behalf by Samuel Arthur Hooker and now abandoned.

Having thus described my invention, I claim:

1. In a method of treating an elongated piece of fiberboard from a plurality of flexible absorbent sheets of cellulosic material, the steps which comprise continuously moving one of said sheets over a generally cylindrical supporting surface having a corrugated formation, providing a liquid treating bath containing an aqueous unreacted mixture of (1) a substance of the group consisting of urea and gelatin and (2) formaldehyde, said composition being kept at a pH between 2.2 and 4.5 when said substance is gelatin and between about 4.0 and 6.8 when said substance is urea, whereby said substance and formaldehyde remain unreacted in the presence of water; flowing a stream of steam past said bath and constricting the flow of steam to create a venturi effect therein; withdrawing mixture from said bath and uniformly entraining same in said steam flow by means of said venturi effect, the amount of composition withdrawn from said bath and entrained in said steam being automatically regulated by the amount of steam passing through said constricted flow; directing a jet of steam containing said mixture against said sheet while said sheet is supported by said corrugated surface, said steam being under pressure and flowing at a high velocity against the surface of said sheet, whereby the sheet is impregnated with a substantially uniform essentially unreacted mixture of said substance and formaldehyde, continuously adhering substantially flat sheets to opposite sides of the sheet contacted by said steam, substance and formaldehyde, and then heating said sheet to dry same and continuing said heating in the dry condition to cause a condensation reaction of said substance and formaldehyde to form a resin in situ uniformly dispersed in said sheet.

2. In a method of treating an elongated cellulosic flexible absorbent sheet material to improve its wet strength, the steps which comprise continuously moving said sheet, providing a flow of steam between a source thereof and said sheet material; constricting said flow of steam intermediate said source and said material to create a venturi-effect therein; providing a liquid treating bath in communication with said flow of steam adjacent said constricted flow, said bath comprising an aqueous composition of (1) a substance selected from the group consisting of urea and gelatin and (2) formaldehyde, in unreacted form, said composition being maintained at a pH between about 2.2 and 4.5 when said substance is gelatin and between about 4.0 and 6.8 when said substance is urea, whereby components (1) and (2) thereof remain unreacted in the presence of H_2O; withdrawing composition from said bath and uniformly entraining the same with said steam by the action of the venturi effect created in said flow of steam, the amount of composition withdrawn from said bath and entrained in said steam being automatically regulated by the amount of steam passing through said constricted flow; directing a jet of the resulting mixture of steam and composition against the surface of said sheet material whereby the material is impregnated with a substantially uniform unreacted mixture of said substance and formaldehyde, and then heating said sheet to remove steam and moisture therefrom and continuing said heating in a dry atmosphere to effect condensation reaction between said substance and formaldehyde to form a resin in situ uniformly dispersed in said sheet.

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