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METHOD OF MAKING PAPER OF IMPROVED WET STRENGTH

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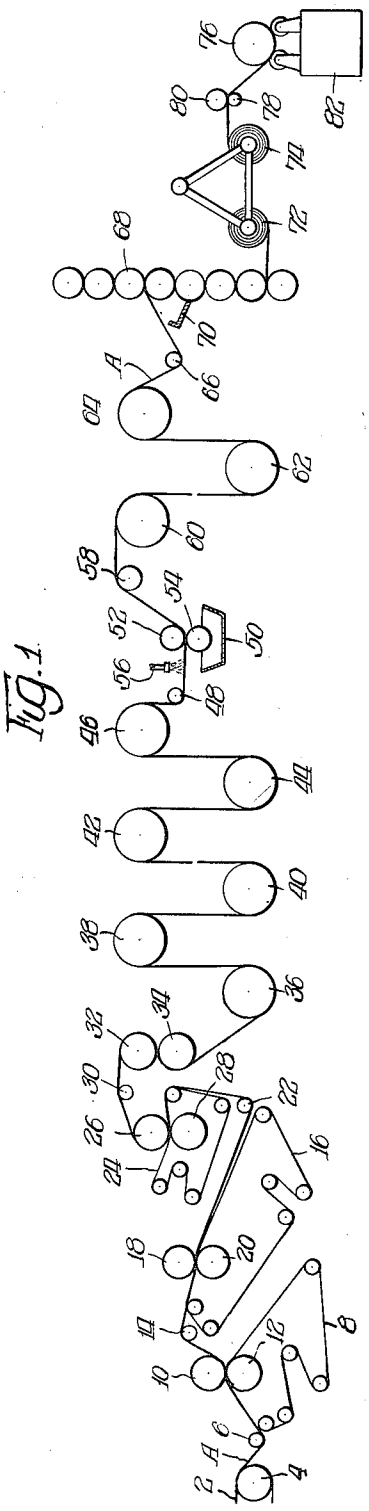


Fig. 1.

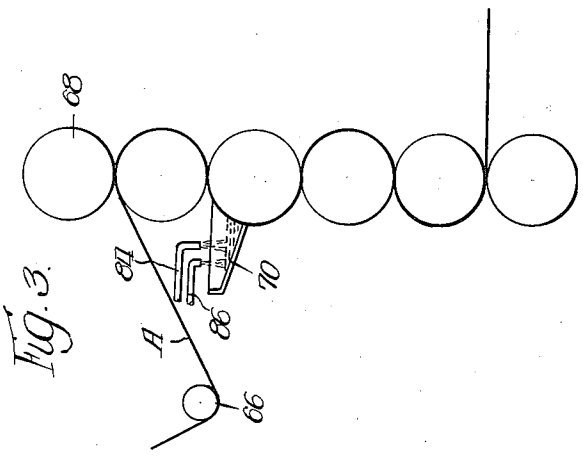


Fig. 3.

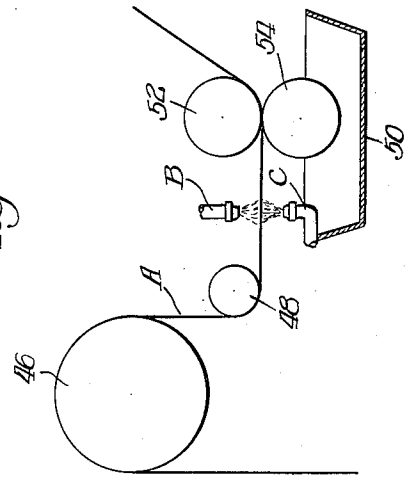


Fig. 2.

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METHOD OF MAKING PAPER OF IMPROVED WET STRENGTH

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7 Claims. (Cl. 92—40)

This invention relates to the manufacture of paper and more particularly to a new and improved method for producing paper having improved wet strength by a treatment on the paper machine.

For a long time it has been known that the treatment of paper with formaldehyde and an acid, followed by the application of heat, would produce a somewhat water-resistant paper product, but this method of treatment has never had any practical commercial success because paper when so treated becomes brittle and is thereby made unsuitable for most practical purposes. Moreover, attempts to carry out such a treatment on the paper machine have been unsatisfactory because the embrittlement of the paper which results when it is treated with formaldehyde and an acid and then dried by heating on the calender rolls often causes breakage of the paper.

One of the objects of the present invention is to provide a new and improved method of treating paper on the paper machine in order to impart increased wet strength thereto at a low cost and as simply as possible while enhancing other characteristics of the paper. Another object of the invention is to provide a new and improved method of producing paper which has the general appearance of an untreated paper but at the same time has improved wet strength. An additional object is to provide a new and improved method of producing paper which has increased wet strength but is still very water-absorptive, that is to say, a paper the fibers of which are not readily hydrated but which will take up water as rapidly or more rapidly than an untreated paper. Other objects will appear hereinafter.

In accomplishing these objects in accordance with this invention we have found that new and improved water-resistant papers can be obtained by treating paper on a paper machine with urea and formaldehyde while the paper is still in a wet state and separately adding an acid solution at a stage in the paper making process when it is no longer necessary to subject the paper to heat. Thus, we may add urea and formaldehyde either separately or together or in the form of a water-soluble partial condensation product to a formed sheet of paper while it is on the forming mechanism or at a point between the forming mechanism and the drying rolls where the paper is still in a wet and impermanent state, or between the drying rolls as in a tub sizing operation and thereafter when the paper has been dried and is no longer to be subjected to heat, we add an acid reacting substance, preferably in the form of a solution thereof. When the paper passes the last drying rolls in a paper making machine it is then customarily run through one or more columns of calendering rolls before finally being wound into a roll itself. The calendering rolls are normally chilled steel rolls which serve to iron or smooth the paper, and during the calendering operation it is customary to add some of the water which was previously removed from the paper by drying. According to a preferred embodiment of our invention, we add an acid reacting solution at this point instead of water, as is customary, and when the paper passes through the calendering rolls it is immediately wound into a tight roll. Confinement of the acid, urea and formaldehyde together in the paper while it is wound into a roll brings about a reaction with the cellulosic fibers which when the roll is allowed to stand over a period of time imparts increased wet strength to the paper without destroying its flexibility.

We have found that when an acid reacting solution is added with the urea and formaldehyde prior to the drying rolls on a paper making machine, the paper obtained is stiff, hard or brittle and is not commercially satisfactory. Furthermore, the loss of labor, time and materials which sometimes occurs because of premature embrittlement on the paper machine is such that the addition of an acid prior to the drying rolls is not commercially practicable.

Other features and advantages of our invention will be illustrated by the following description in conjunction with the accompanying drawing, in which

Figure 1 is a diagrammatic representation of a paper machine showing the course of the paper from the time it leaves the forming mechanism until it has been finished;

Figure 2 is an enlarged and somewhat modified form of a section of the apparatus shown in Figure 1;

Figure 3 is an enlarged view of a section of the apparatus in Figure 1, showing a method of adding an acid solution to the paper at the calender rolls.

In Figure 1 the diagrammatic arrangement shown is a customary layout for the manufacture of paper made on a Fourdrinier wire. It will be understood that this invention is applicable to the treatment of paper made on other types of forming mechanisms, as, for example, a cylinder machine. Generally speaking, all paper making machines include among other things, a forming mechanism, a series of press rolls, usually at least three pairs of press rolls adapted to remove

a portion of the water, a series of drying rolls adapted to remove a further portion of the water, and a series of calendering rolls to smooth the paper. The drying rolls are normally maintained at a relatively high temperature sufficient to dry the paper without burning it.

According to the arrangement of apparatus shown in Figure 1, paper sheet A formed on forming mechanism 2, which is only partly shown, leaves said mechanism, passing over couch roll 4 and under guide roll 6 to a felt or carrier 8 which carries it while it is being conveyed through the first press rolls 10 and 12. From the first press paper sheet A passes over another guide roll 14 to a second felt 16 which helps to support it while it is being carried through press rolls 18 and 20, said press rolls constituting the second press.

Paper sheet A then passes under guide roll 22 to another felt 24 which aids in carrying it to the third set of press rolls 26 and 28. From the third press, paper sheet A passes over guide roll 30 to smoothing press rolls 32 and 34 and thence to a series of drying rolls 36, 38, 40, 42, 44 and 46, said drying rolls constituting the first series of drying rolls. A greater or smaller number of drying rolls may be used, depending upon the amount of moisture which it is desired to remove. It will be understood that the illustration in Figure 1 is purely diagrammatic and the arrangement shown contemplates the use of felts in the upper and lower drying rolls such as are customarily employed.

From the last drying roll 46 of the first series of drying rolls, paper sheet A passes under a guide roll 48 and thence to an apparatus such as is ordinarily employed in tub sizing. This apparatus as shown consists of a vessel 50 and rolls 52 and 54, disposed above and within said vessel, together with spraying means 56 for applying materials to the paper sheet. In accordance with the present invention, instead of spraying the paper with a sizing solution of starch or the like, as is customary at this point, we apply urea and formaldehyde either as such, or in the form of a water-soluble partial condensation products thereof. The paper sheet is then passed over guide roll 58 to a second series of drying rolls comprising rolls 60, 62 and 64. A greater or smaller number of rolls may also be used in this second series of drying rolls and it will be understood that the customary arrangement of felts is employed.

From the second series of drying rolls paper sheet A passes under a guide roll 66 to a calender stack 68 comprising a series of eight rolls. As shown in Figure 1, a trough 70 or similar means is provided for adding an aqueous solution of an acid at this point, said aqueous solution of an acid or acid reacting material taking the place of water, which is often added at this point.

As the paper comes off the calender stack 68 it is wound into a roll 72. If desired, it may be rewound by means of the rewinding mechanism generally indicated by rolls 74 and 76 in conjunction with guide rolls 78 and 80. As illustrated, roll 76 may be supported by a suitable support 82.

In the modified arrangement shown in Figure 2, paper sheet A is sprayed with urea and formaldehyde from opposite sides by means of sprayers B and C, any excess material falling into vessel 50. After being sprayed, paper sheet A passes between rolls 52 and 54 and thence to the second series of drying rolls and the calender rolls where it is treated with an acid reacting substance as described in connection with Figure 1.

As shown in Figure 3, when paper sheet A passes under guide roll 66 to calender stack 68 a solution of an acid reacting substance is added from a suitable container or trough 70, said acid reacting substance being supplied to said container or trough as the solution therein is used up from pipes or conduits 84 and 86. If desired, a urea solution may be supplied through one of said conduits and an acid solution through the other, or urea may be added with the acid in solution. Alternatively, all three of the treating materials, namely, urea, formaldehyde and an acid in water-soluble state may be added to the paper sheet at this point. It is preferable, however, to add the formaldehyde and at least a part of the urea prior to the last series of drying rolls.

Instead of adding the urea and/or formaldehyde between the drying rolls, as illustrated in Figure 1, we may add one or both of said materials to the paper sheet between couch roll 4 and the first press rolls, or between the first and second press rolls, or between the second and third press rolls, or between the third press rolls and the smoothing rolls, or between the smoothing rolls and the first series of drying rolls, said addition being made by spraying or in any other suitable manner, as, for example, by means of a spreading machine such as described in United States Patent No. 2,111,440. We have found that the addition of urea and formaldehyde while the paper is in a wet and impermanent state, or prior to being completely dried to its normal moisture content, does not embrittle the paper and cause breakage thereof, or otherwise interfere with the paper making process provided the acid reacting solution is not added until after the paper has passed through those stages in the paper making process where is is subjected to heat.

Our process is particularly advantageous when used in the manufacture of paper made from low grade materials such as kraft, chestnut chip, jute and the like, particularly papers in which at least a part of the pulp content is sulfate pulp. Moreover, our process is especially useful in the treatment of substantially unsized papers.

In practicing our process we have been able to obtain flexible, absorbent paper which apparently possess all of the attributes and qualities of the original untreated paper with some additional characteristics that render it especially suitable for many purposes. Among these additional characteristics are a high wet strength which is not merely a surface effect but which is distributed uniformly throughout the sheet. Furthermore, we have found that the scuff-resistance is increased and that the Mullen test in both wet and dry state is increased.

We have found that by merely using relatively small amounts of urea, formaldehyde and acid solution such as would be sufficient to only dampen a sheet of paper, we are able to obtain an extremely marked improvement in the characteristics of the paper, particularly with regard to its water-resistant characteristics. At the same time, our preferred type of treatment is such that the paper is still water-absorbent and in fact, the rapidity with which it absorbs water is apparently increased. This makes our

method eminently suitable and of outstanding importance in the treatment of all types of paper where water-absorbency with a high wet strength is desired. Our method of treatment on the paper machine is particularly suitable for the preparation of paper toweling, wall paper, wrapping paper, bag paper, newsprint, paper twine and cord, paper tape, tissue papers, including cigarette papers and disposable tissues, paper filters for filtering all types of liquids and solids, paper to be used in making insulating material and sound-proofing where moisture is likely to be encountered, paper matches, paper to be used in making paper shoe soles, paper gaskets, paper to be used in making paper drums and containers, paper building materials, book and magazine papers, and papers to be used in making corrugated paper board either for the core or for the liner of said corrugated board. The application of the invention to many types of paper and to paper to be used in many other types of articles will be readily recognized.

It will be understood that our invention is subject to some variations as to the proportions and amounts of materials and the types of materials employed. While we preferably employ urea, we may use its water-soluble analogues and homologues having substantially the same characteristics, as, for example, thiourea. Likewise, instead of formaldehyde, we may use formaydehyde compounds which react similarly to formaldehyde, as, for example, paraformaldehyde and acetaldol. The formaldehyde used may be an ordinary grade of formaldehyde such as is sold in aqueous solution of about 3% to 40% concentration having a specific gravity of from .75 to .81.

The relative proportions of formaldehyde and urea may be varied, although we usually prefer that the final ratio of urea to formaldehyde be within the range of about one mole urea to about 2 moles formaldehyde. If the urea and formaldehyde are applied together, that is, as a mixture thereof, we prefer to use at least three moles of formaldehyde per mole of urea, and then separately add urea either with the acid or at another stage in the process to bring the ultimate ratio of urea to formaldehyde within the preferred ratio given above.

According to a preferred method of treatment wherein we add solutions of relatively small amounts of urea, an acid reacting substance and formaldehyde to the paper, we prefer that not more than about 6% to 10% additional water be added, based on the weight of the paper, thus making it unnecessary to employ additional drying equipment. We particularly avoid the addition of too much water when we add the acid solution at the calender rolls. If additional water is added with the other treating materials at the press rolls, we may provide suction boxes beneath the carriers or felts to assist in removing the excess water, said suction boxes being positioned beneath the felts opposite the points where the treating materials are applied. A paper sheet when being treated on the paper machine in accordance with our process will normally contain between 5% and 80% moisture. Thus, as the sheet leaves the forming mechanism, it will usually contain somewhat in excess of 80% moisture. At the smoothing presses this moisture content will be reduced to 67% water. After the first series of drying rolls it may be reduced to 10% water. When treating materials are added between the two sets of drying rolls, the moisture content may be increased to 20% and finally it may be reduced to about 5% to 10% when the paper is wound into a roll.

It is preferable in accordance with our invention that the total increase in dry weight of the paper due to the addition of urea, aldehyde and acid be not more than about 15% and not less than about 1%. Where water permeability, flexibility, and water-absorptive characteristics are not of primary importance, larger percentages of said materials may be employed. For the high wet strength coupled with good flexibility, we preferably employ said added substances in an amount sufficient to increase the dry weight of the paper by about 2% to about 5%.

In carrying out our invention we have found that certain types of acid reacting substances give much better results than others. These preferred acid reacting substances have the property of penetrating cellulosic fibers rapidly, this being particularly true of lactic acid. As a class we prefer the hydroxy carboxylic acids including mono-hydroxy mono-carboxylic acids, e. g., glycolic and lactic; mono-hydroxy di-carboxylic acids, e. g., malic, tartronic, mono-hydroxy tricarboxylic acids, e. g., citric; poly-hydroxy monocarboxylic acids, e. g., glyceric; poly-hydroxy dicarboxylic acids, e. g., tartaric, hydroxy citric, gluconic and mucic. Other acids which have been found to be suitable are the organic sulfonic acids, particularly aromatic sulfonic acids, as, for example, benzene sulfonic acid, toluene sulfonic acid and similar acids.

Instead of the free acids, acid salt solutions may be used, particularly where a one-sided effect is desired. The term "acid salt solutions" is used to describe solutions of salts in water which have a pH less than 7. Among such salts are alum, ammonium chloride, ammonium sulfite, ammonium bromide, ammonium iodide, aluminum chloride and ferric chloride. Amine salts having an acid reaction at normal temperatures may also be used.

By the addition of "a urea and an aldehyde in water-soluble form" we intend to include generically the separate addition of a water-soluble urea and a water-soluble aldehyde as well as the addition of said substances together in unreacted form or in the form of water-soluble partial condensation products.

Reference is hereby made to our co-pending application Serial No. 233,557, filed of even date herewith, and covering a method of treating cellulosic fibers in order to make them less capable of being hydrated without substantially destroying their water permeability or water absorptivity. The present application relates more specifically to a method of producing paper having these properties while the paper is being formed on the paper machine.

Having thus described the invention, what we claim as new and desire to secure by Letters Patent of the United States is:

1. A method of producing paper having improved wet strength on a paper making machine which comprises adding a urea and an aldehyde in water-soluble form to the paper while the paper is in a wet condition on the paper machine at some stage of the paper making process prior to final drying of the paper, and then separately adding to the dried paper containing said added urea and aldehyde an acidic solution, said acidic

solution being added at a point in the paper making process when the paper is no longer to be subjected to heat, the co-action between the urea and aldehyde and the acidic solution so added to the paper causing an increase in wet strength without substantially destroying its flexibility.

2. A method of producing paper having increased wet strength on a paper making machine which comprises adding a urea and an aldehyde in water-soluble form to the formed paper sheet while it is still in a wet and impermanent state between the forming mechanism and the drying rolls, and then separately adding to the paper at a point in the paper making process when the paper is no longer to be subjected to heat a solution having a pH less than 7, the co-action between said solution and the urea and aldehyde causing an increase in the wet strength of the paper without substantially destroying its flexibility.

3. A method of producing paper having increased wet strength on a paper making machine which comprises adding a urea and an aldehyde in water-soluble form to the paper on the paper making machine before the paper has passed the last drying rolls and when the paper is still in a wet condition but when the amount of moisture in the paper has been reduced to below about 10%, then further drying the paper, and then after the paper has passed the last drying rolls adding a solution having a pH less than 7, said solution being added to the paper when the paper is no longer to be subjected to heat, the co-action between said solution and the urea and aldehyde causing an increase in the wet strength of the paper without substantially destroying its flexibility.

4. A method of producing paper having increased wet strength on a paper making machine which comprises adding a urea and an aldehyde in water-soluble form to the paper at some stage of the paper making process prior to the final drying of the paper while the paper is still in a wet state, and then separately adding to the dried paper containing said added urea and aldehyde at a point in the paper making process when the paper is no longer to be subjected to heat an acidic solution, the total amount of urea, aldehyde and acidic solution being sufficient to increase the dry weight of the paper by not more than about 15% and not less than about 1%.

5. A method of producing paper having increased wet strength on a paper making machine which comprises adding urea and formaldehyde in water-soluble form to the paper at some stage of the paper making process prior to the final drying of the paper when the paper is still in a wet condition, and then separately adding to the paper after drying a solution of an aromatic sulphonic acid at a point in the paper making process when the paper is no longer to be subjected to heat.

6. A method of producing paper having increased wet strength on a paper making machine which comprises incorporating urea and formaldehyde in water-soluble form into the paper at some stage of the paper making process when the paper is still in a wet condition prior to passage of the paper through the last drying rolls, and then separately adding to said paper after drying an aqueous solution of a hydroxycarboxylic acid, said acid solution being added to the paper at a point in the paper making process when the paper is no longer to be substantially heated.

7. A method of producing paper having improved wet strength on a paper making machine which comprises adding a water soluble partial condensation product of urea and formaldehyde to the paper while the paper is in a wet condition on the paper machine at some stage of the paper making process prior to the final drying of the paper and then separately adding to the paper containing said water soluble partial condensation product an acidic solution, said acidic solution being added at a point in the paper making process when the paper is no longer to be subjected to heat, the coaction between the water soluble partial condensation product of the urea and formaldehyde and the acidic solution so added to the paper causing an increase in wet strength without substantially destroying the flexibility of the paper.

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