Feb. 7, 1939. C. A. ANDERSON 2,146,281

HIGH WET STRENGTH PAPER AND PROCESS FOR MAKING SUCH PAPER

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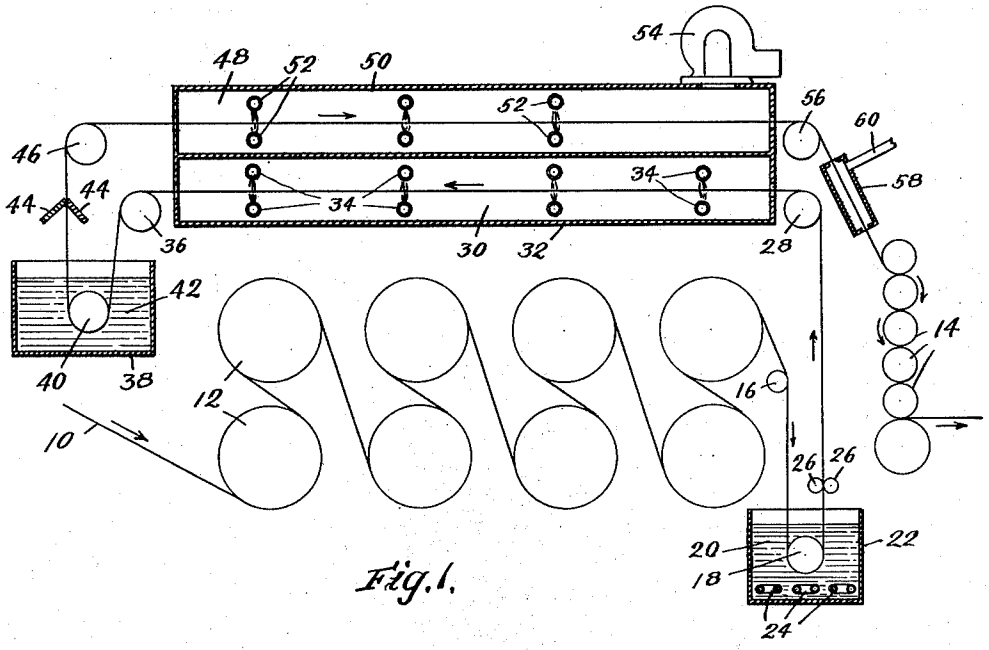


Fig. 1.

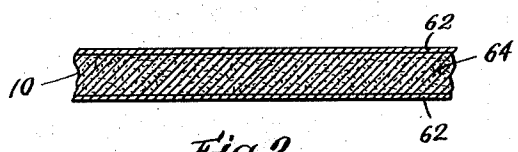


Fig. 2.

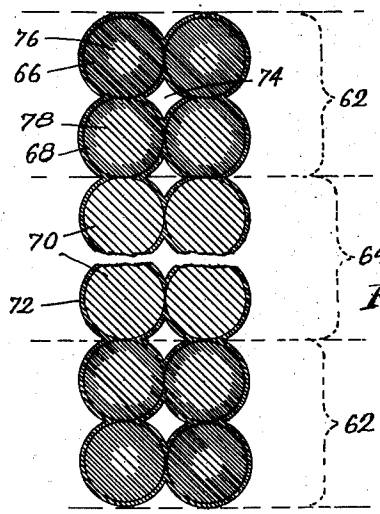


Fig. 3.

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HIGH WET STRENGTH PAPER AND PROCESS FOR MAKING SUCH PAPER

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2 Claims. (Cl. 91—68)

This invention relates to paper that is strong when wet and also when dry, and to a process and machine for making such paper.

A paper sheet as produced by a paper making machine and the usual paper making process can be made to have a satisfactory dry strength but when the paper is wet its strength is low and the paper ruptures easily. It is highly desirable to provide a paper having a high wet strength so that bags, for instance, made of the paper will not burst and spill their contents when wet and paper twine will not rupture when wet.

Hence an object of the present invention is the provision of an improved paper and a process of making the paper wherein the paper has a high wet strength without any harmful sacrifice of its dry strength, and even with an improvement thereof, and approximately the appearance of an untreated paper.

The low strength of wet paper comes from the softening of the fibres and the reduction of the bond between them. It has been proposed heretofore to provide a water impervious paper, although not a paper having both high wet and dry strength, by impregnating the paper with a glue, gelatin or the like, and then treating the paper, while the glue or gelatin is liquid, to render the glue or gelatin water insoluble throughout. Such a paper when dry has a relatively low dry strength because the treated paper, and the fibres thereof, is essentially a rigid and brittle structure easily ruptured. The treated paper when wet is also brittle since it is water impervious and thus the paper has also a low set strength. The appearance of the treated paper is altered also, and appears stiff and horny.

It is an object of my invention to provide a paper that, in addition to having a high strength when wet and also when dry, is not water impervious but is, to a substantial degree, water permeable as compared to the prior papers treated as above described. By water permeable I mean that the paper can breathe or absorb moisture and that moisture can be transferred through the sheet. The fibres of the paper of my invention are for the most part rendered water impervious or are so treated that they are not so deleteriously affected by moisture as to seriously reduce the strength of the wet sheet. There are many uses of such a paper as, for instance, in the manufacture of shoes, paper towels, and the like.

My process of providing a paper that has both a high wet and a high dry strength and the ability to breathe includes the step of impregnating the paper, preferably unsized paper, with a glue, gelatin or the like, but instead of treating the body of glue or gelatin to render it entirely water insoluble throughout the thickness of the paper I treat the glue or gelatin to render it only superficially water insoluble without converting the glue or gelatin in the interior of the sheet and in the interior of the fibres into its water insoluble form. That is to say, the glue or gelatin at and immediately under the surface of the paper is rendered water insoluble but the glue or gelatin in the interior of the paper sheet remains water soluble. The paper sheet as thus prepared is pliable and elastic when dry and hence has a high dry strength. The paper fibres are water impervious and hence the paper has a high wet strength. Such a process and the paper made in accordance with the process constitutes an object of the present invention.

A further object of the invention is the provision of a process of preparing a paper having high strength both when dry and when wet, and a paper made in accordance with the process, wherein a moisture retaining medium and particularly glycerin is incorporated with the impregnating glue or gelatin prior to the superficial conversion thereof in the paper into its water insoluble form. The glycerin is not deleteriously altered by the converting agent and serves to maintain the desirable elasticity of the sheet when dry, thereby to assist in providing the treated paper with a high strength when the paper is dry and also to protect the paper fibres against harm from the high temperature used in drying the treated paper.

Another object of the invention is a process for making a paper having a high strength both when wet and when dry, which process includes the steps of impregnating the paper sheet with a glue or gelatin solution, preferably hot, expressing surplus solution from the paper and driving the solution into the paper and the fibres, drying the impregnated paper, and then treating the paper with a converting agent, and particularly with formaldehyde, in such manner as to render the surface portions of the glue or gelatin in the sheet water insoluble while preserving the water soluble property of the glue or gelatin in the interior of the sheet and the fibres.

A further object of the invention is a paper sheet that is impregnated with a glue or gelatin, the impregnating medium at and near the surfaces of the sheet being insoluble and the medium in the interior of the sheet and between the insoluble zones being water soluble, the sheet being

characterized by having a high strength both when wet and when dry.

Another object of the invention is a paper sheet characterized as above, the sheet being unsized or containing no deleterious amount of size.

Fig. 1 is a diagrammatic view of a portion of a paper making machine with the apparatus for carrying out my process associated therewith.

Fig. 2 is an enlarged sectional detail of a paper sheet embodying the present invention.

Fig. 3 is an enlarged cross-section of the sheet of the present invention, illustrating the fibrous structure of the sheet.

The apparatus for carrying out the invention is herein illustrated as associated with the drying and calendering end of a Fourdrinier paper making machine.

While it is not essential that the paper be processed in accordance with the present invention at the time it is passing through the paper making machine it is, nevertheless, highly desirable to treat the paper in the machine as additional handling of the paper is avoided and the finished paper is immediately produced. Hence the characteristic features of a Fourdrinier paper making machine are utilized in associating my processing apparatus therewith without in any material manner disturbing the arrangement or construction of the paper making machine.

The wet paper web **10** as it comes from the Fourdrinier wire is passed about a series of heated drying rolls **12** about which the paper is dried. The paper ultimately passes to a stack of calender rolls **14** where the paper is calendered. The paper thence passes from the calender rolls and is ultimately wound into roll form.

In accordance with the present invention the dry paper web as it leaves the last drying roll of the series of drying rolls passes over a suitable guide roll **16** and downwardly between the series of drying rolls and the calendar stack, and over a roll **18** submerged on a hot glue or gelatin solution **20** contained in a tank **22** located between the driers and the calender stack. In this tank the paper web becomes impregnated with a solution of glue or gelatin containing glycerin. The tank is provided with heating coils **24** or other means to maintain the impregnating solution hot so that it can quickly and thoroughly permeate the paper and its fibres. The paper web **10** preferably is an unsized paper or at least contains no appreciable amount of sizing that will prevent the thorough impregnation of the web with the solution.

The impregnating solution consists of a water solution of animal glue or of gelatin containing glycerin. A solution containing about 13 parts by weight of glue to 100 parts by weight of water gives satisfactory results. The solution contains preferably from 10 to 15% by weight of glycerin. It is quite desirable to have the proper amount of glycerin. If the solution contains excess glycerin the quality of the sheet becomes impaired and results in a limp, weak sheet. If the amount of glycerin is insufficient the sheet is undesirably brittle. For an unsized paper sheet of about 80 pounds weight the proportions of glue and glycerin above given have been found to be satisfactory. For paper of different characteristics the proportions may desirably be varied.

The paper web upon leaving the impregnating solution passes between a pair of cooperating squeeze rolls **26** which express surplus impregnating solution from the web and also force the solution into and between the fibres of the sheet, thus assuring uniform impregnation of the sheet and a uniform cellular structure thereof. The impregnated sheet passes upwardly between the series of drier rolls and the calender stack and thence over a guide roll **28** and thence horizontally rearwardly or toward the fourdrinier wire of the paper making machine and through the drying chamber **30** of a lower drying box **32**. Within the drying chamber the paper is subjected to blasts of hot air which are directed thereonto from a series of air blast pipes **34**, which blasts thoroughly dry the impregnated paper and harden the glue or gelatin. The drying box is preferably long enough so as to thoroughly dry all weights of paper that may be made on the machine.

The dry impregnated paper web issues from the exit of the drying chamber **30** and passes about a guide roll **36** and into a tank **38** and under and about a guide roll **40** which is submerged in the liquid bath **42** of the tank. The liquid bath **42** consists of an agent which is capable of converting the glue or gelatin of the paper into its water insoluble form. Preferably the agent is formaldehyde which can be the usual 40% solution or preferably a more dilute solution as a 12% solution which is found to be satisfactory with an unsized 80 pound paper. Adjustment of the concentration of the solution permits adjustment of the depth of the water insoluble zones of the impregnating gelatin or glue in the finished paper. The excess formaldehyde on the surface of the sheet is quickly removed from the sheet and the sheet is quickly moved into a second drying chamber so as to prevent the thorough penetration of the formaldehyde solution throughout the body of glue in the sheet. The sheet passes upwardly out of the formaldehyde solution and between a pair of inclined wiping strips **44** which extend transversely across the web and engage the opposite faces thereof and serve to wipe the excess formaldehyde from the surface of the web without, however, exerting any undesirable pressure upon the web such as would cause the formaldehyde to be pressed into the interior of the web and into the fibres.

The web passes from the wipers over a guide roll **46** and thence into the drying chamber **48** of a second and upper drying box **50** which is disposed above the first drying box **32**. The web as it advances in the drying chamber **48** is subjected on opposite sides and along its length to hot air blasts issued from a series of air pipes **52**. These air blasts serve rapidly to dry the formaldehyde treated web and to remove the formaldehyde therefrom. The vapors are removed from the drying chamber **48** and discharged to some convenient locality by an exhaust fan **54**. The dry treated web issues from the drying chamber **48** and passes over a guide roll **56** and thence through the calender stack **14** and is wound into a roll. In passing between the drying chamber **48** and the calender stack the dry web preferably passes through a steam chamber **58** which receives steam or other form of water vapor through a suitable pipe **60** so that the dry paper is caused to absorb a desired percentage of moisture, approximately its normal water content, before passing through the calender stack.

It will be noted that the wet formaldehyde treated portion of the web is maintained separate from the wet glue impregnating portion of the web as it is important to keep the formaldehyde gas from the wet glue impregnated web, it having been found that if the wet glue in the web is subjected to the formaldehyde gas the de-

sired properties of the paper are changed and the paper becomes brittle and dark in color.

The formaldehyde solution in accordance with the present process is allowed to act only upon the surface of the web and is not allowed to permeate the web.

The result is a paper sheet as illustrated in Fig. 2 wherein there are zones 62 at the opposite faces of the web where the gelatin or glue is water insoluble. The glue 64 in the interior of the paper and between the insoluble zones 58 remains water soluble.

Fig. 3 illustrates in enlarged detail a cross-section of the fibres of the sheet of the invention. The fibres 66, 68, 70 are more or less impregnated with glue or gelatin and contain a layer 72 thereof on their surfaces, there being voids 74 between the fibres. The voids are more or less in communication with one another and thus are open to the surfaces of the sheet so that the sheet is more or less permeable. Hence the sheet can breathe and can absorb and give off moisture. The layers of glue or gelatin 72 on the outer fibres 66, 68 have been rendered water insoluble. The layers 72 on the inner fibres 70, 70, however, have not been materially altered and hence are essentially water soluble. The glue or gelatin within the surface of the outer fibres has been rendered water insoluble, the degree of penetration of the water insoluble zone in the fibres decreasing toward the middle of the sheet as has been diagrammatically illustrated by showing the water soluble core 76 of the outermost fibre 66 smaller than the soluble core 78 of the next inner fibre 68. The water soluble cores of the outer fibres, or in the zones 62 are received in water insoluble cores and thus are prevented from being dissolved out of the fibres although they are free to absorb moisture. The water soluble glue in the middle part 64 of the sheet is held from being carried away under ordinary usage of the sheet by the outer water insoluble regions.

The paper thus prepared has a high dry strength since the original elasticity of the paper is substantially preserved by the water soluble bodies of gelatin or glue. The paper also has a high set strength by reasons of its water insoluble zones. The glycerin content of the glue solution in the fibres of the paper retains them in a flexible elastic condition. The glycerin also protects the fibres of the sheet during the relatively high temperature to which it is subjected in the chamber 48 in removing the formaldehyde so that the odor of formaldehyde will not be apparent in the treated sheet.

I claim:

1. The process of making a high wet and dry strength water permeable flexible paper which comprises impregnating a paper with a glue containing glycerin, drying the impregnated sheet and air-hardening the glue, treating the surface only of the dried glue in the sheet with formaldehyde and removing excess formaldehyde and drying the sheet quickly to keep the formaldehyde from penetrating throughout the sheet and to render the glue at the surface of the sheet water insoluble and to retain the glue in the interior of the sheet water soluble.

2. The method of making a high wet strength pervious paper which comprises impregnating the paper with a glue solution, drying the impregnated paper to coagulate and dry the glue and to render the impregnated paper pervious, and insolubilizing the dry glue superficially only by applying a volatile hardening agent to the surface of the sheet and removing the hardening agent by heat quickly before it has time to act on the dry glue in the interior of the sheet.

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