Patented May 6, 1930 1,757,756

UNITED STATES PATENT OFFICE

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ABSORBENT PAPER

No Drawing. Application filed November 9, 1927. Serial No. 232,192.

This invention relates to a process of producing a cellulose fibre mat having a high degree of porosity and suitable, because of its high porosity and other desirable properties, for various uses in the arts, as for example, blotting paper, absorbent paper, paper toweling, and also as a heat insulator, or as a base for the application of liquid coating materials in the production of coated products, such as, for example, roofing paper, artificial leather and the like.

It is known that by various treatments, cellulose fibre, for example, wood pulp, may be made up into a paper having various degrees of porosity, water absorption, etc. However, the degree of porosity attainable in prior art practice has been limited, and, in general, the strength of such products, both in the wet and in the dry state, has been low.

One object of the present invention is an improved process of producing a porous mat of cellulose fibre. Another object is to convert a cellulose fibre mat or paper into a felt-like substance useful for various purposes in the arts requiring strength, high porosity, high absorption for water and other liquids, and low heat conductivity. Still another object is to produce a strong, porous paper.

I have discovered that a cellulose fibre mat or paper having high degree of porosity and low apparent density, as well as other desirable properties, may be prepared by treating a sheet of cellulose fibre mat, for example, kraft paper, with a gelatinizing reagent under definite conditions of temperature and concentration until the required degree of gelatinization is attained, and thereafter washing out the gelatinizing reagent. During the gelatinization of the cellulose, water is taken up and the individual fibres swell to many times their original diameter. As a result, the sheet contracts somewhat in area and expands to several times its original thickness. On washing out the gelatinizing reagent, the individual fibres shrink to a point only slightly greater than the original diameter, but the thickness of the gelatinized sheet is retained. The result is a highly porous, felted sheet resembling chamois in texture and having unusual strength, both in the wet and in the dry state. This product is now several times the thickness of the original sheet and by reason of its high porosity and low apparent density it has some remarkable properties not possessed by prior products. It absorbs water and other liquids readily and in large volume. It is tough and pliable and retains its strength to a large extent even in the wet state. Because of its porosity and the peculiar conformation of its fibrous structure, this product has an extremely low conductivity for heat.

As the raw material in my process, I may use a mat of cellulose fibre in sheet form, for example, kraft, jute or sulfite paper. I prefer to use paper having cellulose fibre which is not readily soluble in the gelatinizing reagent under the conditions of use. I prefer also, in most cases, to use as a starting material paper containing little or no sizing, filler or other material capable of retarding the wetting of the fibres by the gelatinizing reagent.

As the gelatinizing reagent, I use an aqueous solution of caustic soda, caustic potash or other fixed caustic alkali at a cencentration between 2 and 11 mols caustic per hundred mols water. For many purposes I prefer to maintain the alkali concentration between 2.5 and 8 mols caustic per hundred mols water. I gelatinize the cellulose fibre the required degree by treating with the gelatinizing reagent at a temperature between the freezing point of the reagent and a point about 20° C. higher. I immerse the fibre in the gelatinizing reagent at the specified temperature until the desired degree of gelatinization is accomplished. This reaction takes place very quickly, and as a rule the treatment need not be continued for more than 15 or 20 seconds. However, this will depend somewhat on the fibre used, the thickness of the sheet, the final product to be prepared, and the presence or absence in the fibre of materials; for example, size, filler, etc., which affect the rate of wetting of the fibre by the gelatinizing reagent. By the term superficial gelatinization as used in the claims and effected in the short time mentioned above, I mean a gelatinization which does not go

substantially beyond the surface of the fibres and which does not penetrate to the interior of the fibre so as to destroy the fibre identity or to cause the production of other than the porous product described. No claims are made herein to the process of treating paper or a cellulose fibre mat with caustic alkali under conditions which result in more than a superficial gelatinization as defined above since this invention is disclosed and claimed in a co-pending application of Frederick C. Hahn, Serial No. 252,942, filed February 8, 1928.

For this gelatinization of the fibre I may work within a temperature which is within a range of about +8 to −12° C. I prefer to operate at a temperature above the freezing point of the reagent and thereby avoid changes in alkali concentration due to freezing. The most favorable temperatures for carrying out the process of the invention are contained within a range between the freezing point of the reagent and a point about 20° C. higher. In general, the solubility of cellulose fibres in dilute caustic solutions increases with decreasing temperatures, and with some grades of fibre becomes marked at temperatures near the freezing point of the solution. When using such grades of fibre it is preferable to operate at a somewhat higher temperature than otherwise. When using grades of fibre which are soluble in the gelatinizing reagent at the freezing point, it is preferable to carry out the gelatinizing reaction of a temperature which is between the upper temperature limit at which the fibre is readily soluble in the reagent and a point about 20° C. higher.

The exact procedure followed in the process of the invention may be varied within wide limits. For example, I may bring the gelatinizing reagent to the required temperature and merely dip therein the paper or sheet to be treated, until the gelatinizing reaction has proceeded to the desired degree; then remove the sheet from the reagent and wash with water to remove the gelatinizing reagent. According to another modified procedure, I may first dip the mat or paper to be treated into a caustic solution at a temperature above the gelatinizing range, then remove to a bath of the reagent at the gelatinizing temperature, and follow by washing and drying. In this case, the time required for treatment in the gelatinizing bath is reduced, since the fibre is already impregnated with the caustic solution. In still another modification of my procedure, I may treat the paper in a continuous sheet, using a continuous process by which the paper is carried on a belt through a connected series of baths in which the sheet to be treated is first immersed in caustic alkali of specified concentration, then in order through a gelatinizing bath maintained at the specified temperature, through a series of washings, and finally through a drier. If desired, the last traces of alkali may be neutralized by acid, followed by washing and drying. When using the continuous process as described above, it is possible to reduce the alkali requirements of the process to a minimum.

Another form of my process, useful in some cases, is to impregnate the paper with the alkali reagent at a temperature above the gelatinizing range, then bring about a reduction in temperature to the gelatinizing point by placing the impregnated paper between metal sheets maintained at the required temperature. When the cellulose is sufficiently gelatinized, it is removed from the metal sheets, washed and dried.

In another modification, I may impregnate the paper with the gelatinizing reagent at a temperature above the gelatinizing range, then lower the temperature to the gelatinizing point to bring about the gelatinization of the fibre, then raise the temperature above the gelatinizing range to stop the reaction.

I have also found that if pressure is applied to the cellulose fibre after the gelatinization step and while the fibre is still in the gelatinized condition, at least a portion of the fibres are welded together, which results in a marked increase in strength in the finished product and otherwise improves it. This pressure may be applied by the use of squeeze rolls, wire screening, or metal plates which may or may not be perforated.

In still another form of my process which is useful for many purposes, I modify the after-treatment of the gelatinized fibre for the purpose of depositing salt crystals within the pores of the fibre during drying and thereby increasing the puffing action on the sheet. For example: I remove the sheet from the gelatinizing bath and without washing I festoon the sheet in contact with air and allow to dry. The carbon dioxide in the air combines with the caustic in the solution which wets the sheet forming Na_2CO_3. As the sheet dries, the carbonate crystallizes out as Na_2CO_3 10 H_2O and the formation of these crystals within the pores of the sheet greatly increases the puffing action and decreases the apparent density of the sheet. Instead of air I may use carbon dioxide, stack gas or other atmosphere containing carbon dioxide or other acid gas capable of combining the caustic soda to form a water soluble crystallizable salt. To increase the volume of the salt crystals in this after-treatment, I may follow the gelatinizing bath with an after-bath in which I use a caustic soda solution of higher concentration than the gelatinizing reagent. I thus obtain an increased volume of salt crystals and corresponding increase in the puffing effect. Instead of caustic soda in the after-bath, I may use a solution of a crystallizable salt, such, for example as, sodium carbonate, sodium

sulfate, and the like, or I may use an acid salt, such, for example, as sodium bicarbonate, in such proportions that when combined with the caustic already present, a normal crystallizable salt is formed; for example, normal sodium carbonate. After the sheet is dried the sodium carbonate or other crystallized salt is removed from the sheet by washing and there remains a tough pliable sheet having high porosity and high specific volume.

I have also found in producing a porous or puffed paper product by treating with caustic soda and drying in air, that clearly improved and strictly uniform results may be obtained if the air or other carbon dioxide containing gas, which is used in drying, is carefully conditioned before entering the drier or before bringing into contact with the wet paper. To produce any given product in uniform quality, the air or other gas is conditioned so that temperture and humdity are substantially constant. Excellent products may thus be obtained by conditioning the air to a substantially constant humidity at a point above 50% humidity and to a substantially constant temperature at a point below 34° C. To obtain maximum puffing effect, the air entering the drier is conditioned to a humidity which is substantially constant at a point above 20% and at a temperature which is substantially constant at a point below 15° C. The humidity may be controlled at a given point by known methods as, for example, by passing the air through a salt solution having the required vapor pressure.

In comparison with prior art processes of producing porous cellulose fibre products, the process of the present invention has the advantage that it is more expeditious and is more economical. By the process which I have described, I am able to produce various forms of porous paper and the like which have a high absorption for water and other liquids. These products have high specific volume, low heat conductivity and are not readily separated into laminations by mechanical treatment. When used as paper toweling, my product is practically free from linting which is a common defect of paper toweling products as made by previously known processes.

As many apparently widely different variations of this invention may be made without departing from the spirit thereof, it is to be understood that I do not limit myself to the foregoing examples or description except as indicated in the following patent claims.

I claim:

1. A process for producing a porous felted cellulose fibre product which comprises treating a cellulose fibre mat in the form of a sheet with a gelatinizing reagent comprising fixed caustic alkali and water in the proportion of 2 to 11 mols caustic per hundred mols water, at a temperature between the freezing point of the gelatinizing reagent and a temperature about 20° C. above said freezing point, until the cellulose fibre is superficially gelatinized, then removing the sheet from the gelatinizing reagent and washing the sheet to substantially free it from said reagent.

2. A process for producing a porous felted cellulose fibre product which comprises treating a cellulose fibre mat in the form of a sheet and containing cellulose fibre which is not more than slightly soluble in the gelatinizing reagent under the conditions of working, with a gelatinizing reagent containing fixed caustic alkali and water in the proportion of from 2 to 11 mols caustic per hundred mols water, at a temperature between the freezing point of the gelatinizing reagent and a temperature about 20° C. above said freezing point, until the cellulose fibre is superficially gelatinized, then removing the sheet from the gelatinizing reagent and washing substantially free from said reagent.

3. A process for producing a porous felted cellulose fibre product which comprises treating a cellulose fibre mat in the form of a sheet with a gelatinizing reagent comprising fixed caustic alkali and water in the proportion of 2.5 to 8 mols caustic per hundred mols water, at a temperature between the freezing point of the gelatinizing reagent and a temperature about 20° C. above said freezing point, until the cellulose fibre is superficially gelatinized, then removing the sheet from the gelatinizing bath and washing the sheet to substantially free it from said reagent.

4. A process for producing a porous felted cellulose fibre product which comprises treating a cellulose fibre mat in the form of a sheet and containing cellulose fibre which is not more than slightly soluble in the gelatinizing reagent under the conditions of working, with a gelatinizing reagent containing fixed caustic alkali and water in the proportion of from 2.5 to 8 mols caustic per hundred mols water, at a temperature between the freezing point of the gelatinizing reagent and a temperature about 20° C. above said freezing point, until the cellulose fibre is superficially gelatinized, then removing the sheet from the gelatinizing bath, and washing substantially free from said reagent.

5. The process set forth in claim 1 in which the mat is first dipped into a caustic solution at a temperature above the gelatinizing range and the temperature then reduced to the gelatinizing point.

6. The process set forth in claim 1 in which the mat is first impregnated with the gelatinization reagent at a temperature above the gelatinizing range, the temperature then lowered to the gelatinizing point to bring about the gelatinization of the fibre, then the temperature raised above the gelatinizing range to stop the reaction.

7. A process for producing a porous felted cellulose fibre product which comprises treating a cellulose fibre mat in the form of a sheet with a gelatinizing reagent comprising fixed caustic alkali and water in the proportion of 2 to 11 mols caustic per hundred mols water, at a temperature between the freezing point of the gelatinizing reagent and a temperature about 20° C. above said freezing point, until the cellulose fibre is superficially gelatinized, then removing the sheet from the gelatinizing bath, drying the sheet in contact with a gas capable of combining with the caustic alkali to form a water soluble crystallizable salt within the sheet.

8. A process for producing a porous felted cellulose fibre product which comprises treating a cellulose fibre mat in the form of a sheet and containing cellulose fibre which is not more than slightly soluble in the gelatinizing reagent under the conditions of working, with a gelatinizing reagent containing fixed caustic alkali and water in the proportion of from 2.5 to 8 mols caustic per hundred mols water, at a temperature between the freezing point of the gelatinizing reagent and a temperature about 20° C. above said freezing point, until the cellulose fibre is superficially gelatinized, then removing the sheet from the gelatinizing bath, drying the sheet in contact with a gas capable of combining with the caustic alkali to form a water soluble crystallizable salt.

9. A process for producing a porous felted cellulose fibre product which comprises treating a cellulose fibre mat in the form of a sheet with a gelatinizing reagent comprising fixed caustic alkali and water in the proportion of 2 to 11 mols caustic per hundred mols water, at a temperature between the freezing point of the gelatinizing reagent and a temperature about 20° C. above said freezing point, until the cellulose fibre is superficially gelatinized, then removing the sheet from the gelatinizing bath, drying the sheet in contact with a gas containing carbon dioxide, washing and drying the sheet.

10. A process for producing a porous felted cellulose fibre product which comprises treating a cellulose fibre mat in the form of a sheet with a gelatinizing reagent comprising fixed caustic alkali and water in the proportion of 2 to 11 mols caustic per hundred mols water, at a temperature between the freezing point of the gelatinizing reagent and a temperature about 20° C. above said freezing point, until the cellulose fibre is superficially gelatinized, then removing the sheet from the gelatinizing bath and subjecting the sheet to an after-bath containing a crystallizable salt in higher concentration than the gelatinizing reagent.

11. A process for producing a porous felted cellulose fibre product which comprises treating a cellulose fibre mat in the form of a sheet and containing cellulose fibre which is not more than slightly soluble in the gelatinizing reagent under the conditions of working, with a gelatinizing reagent containing fixed caustic alkali and water in the proportion of from 2 to 11 mols caustic per hundred mols water, at a temperature between the freezing point of the gelatinizing reagent and a temperature about 20° C. above said freezing point, until the cellulose fibre is superficially gelatinized, applying pressure to the gelatinized fibre, then removing the sheet from the gelatinizing reagent and washing substantially free from soluble salts.

12. A process for producing a porous felted cellulose fibre product which comprises treating a cellulose fibre mat in the form of a sheet and containing cellulose fibre which is not more than slightly soluble in the gelatinizing reagent under the conditions of working, with a reagent containing fixed caustic alkali and water in the proportion of from 2 to 11 mols caustic per hundred mols water, at a temperature between the freezing point of the gelatinizing reagent and a temperature about 20° C. above said freezing point, drying the fibre by contacting with a carbon-dioxide-containing gas of initially substantially constant temperature below 34° C. and humidity above 50%, and washing the cellulose fibre to substantially free it from the soluble salts.

13. A process for producing a porous felted cellulose fibre product which comprises treating a cellulose fibre mat in the form of a sheet with a gelatinizing reagent comprising fixed caustic alkali and water in the proportion of 2 to 11 mols caustic per hundred mols water, at a temperature between the freezing point of the gelatinizing reagent and a temperature about 20° C. above said freezing point, until the cellulose fibre is superficially gelatinized, applying pressure to the gelatinized fibre, drying the fibre by contacting with a carbon-dioxide-containing gas of initially substantially constant temperature below 34° C. and humidity above 50%, and washing the cellulose fibre substantially free from the soluble salts.

14. A process for producing a porous felted cellulose fibre product which comprises treating a cellulose fibre mat in the form of a sheet and containing cellulose fibre which is not more than slightly soluble in the gelatinizing reagent under the conditions of working, with a reagent containing fixed caustic alkali and water in the proportion of from 2 to 11 mols caustic per hundred mols water, at a temperature between the freezing point of the gelatinizing reagent and a temperature about 20° C. above said freezing point, drying the fibre by contacting with a carbon-dioxide-containing gas of initially substantially constant temperature below 15° C. and humidity above 20%, and washing the cellulose fibre substantially free from the soluble salts.

15. A process for producing a porous felted cellulose fibre product which comprises treating a cellulose fibre mat in the form of a sheet with a gelatinizing reagent comprising fixed caustic alkali and water in the proportion of 2 to 11 mols caustic per hundred mols water, at a temperature between the freezing point of the gelatinizing reagent and a temperature about 20° C. above said freezing point, until the cellulose fibre is superficially gelatinized, applying pressure to the gelatinized fibre, drying the fibre by contacting with a carbon-dioxide-containing gas of initially substantially constant temperature below 15° C. and humidity above 20%, and washing the cellulose fibre substantially free from the soluble salts.

In testimony whereof, I affix my signature.

GEORGE L. SCHWARTZ.