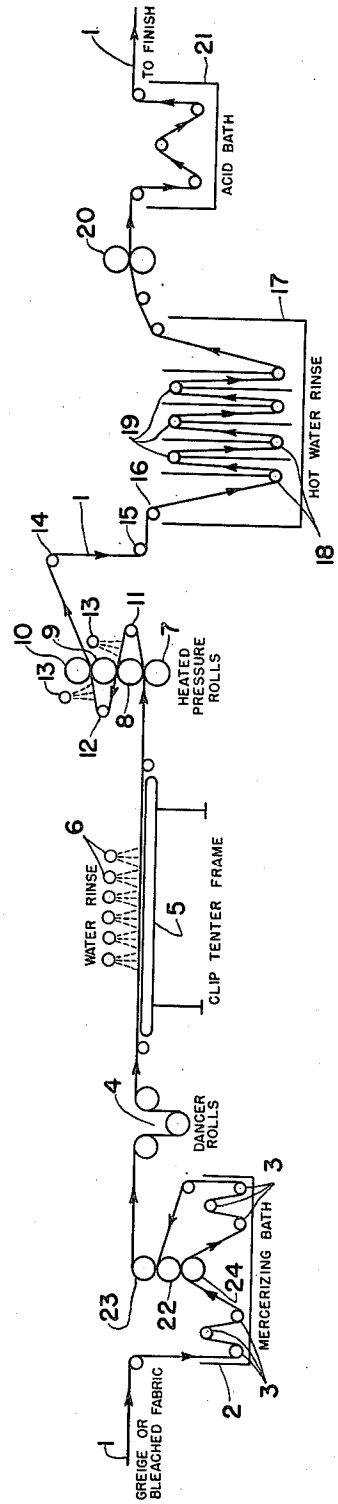
Nov. 6, 1956 R. J. COWLES ET AL 2,769,685

TREATMENT OF COTTON FABRICS TO INCREASE THEIR LUSTRE BY APPLYING MERCERIZING CAUSTIC SODA AND HEAVY PRESSURE

Filed May 10, 1952



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United States Patent Office 2,769,685 Patented Nov. 6, 1956

2,769,685

TREATMENT OF COTTON FABRICS TO INCREASE THEIR LUSTRE BY APPLYING MERCERIZING CAUSTIC SODA AND HEAVY PRESSURE

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Application May 10, 1952, Serial No. 287,084

4 Claims. (Cl. 8—125)

This invention relates to the treatment of fabrics that are formed largely or entirely of native cellulose fibers, and particularly cotton fibers, to impart thereto an increased lustre. The best lustrous cotton fabrics on the market today are either mercerized, or produced with resin impregnation and pressure calendering, but the latter are not permanent to multiple washes nor is the lustre obtained by mercerizing as high as is sometimes desired. It is known that in the usual mercerizing operation, the cotton fibers swell and become plastic, and when, as usual, the caustic soda is then washed out of the swelled fibers, by hot water the water progressively replaces the caustic soda and forms what is believed to be stable Cellulose II or Cellulose Hydrate I.

Attempts have heretofore been made to improve the lustre of fabrics by calendering the fabric during mercerization, but this is difficult because the fabric must be held under tension during both mercerization and calendering, to avoid high shrinkage. If the calendering occurs after all of the caustic soda has been removed, the fibers are not as easily given permanent flattening as when there is a small amount of caustic soda still present. While the fibers are still swelled and contain much caustic soda, any flattening is not permanent because the subsequent introduction of hot water, while rinsing, to replace the caustic soda, results in a partial return of the flattened fibers to their former condition.

We have discovered a new way to obtain a marketable cotton fabric with a very high permanent luster or gloss in volume production, and at a relatively low cost, and this luster so obtained is permanent to multiple washes of the fabric. This new lusterizing treatment can be carried out with relatively simple apparatus.

When cellulose has been impregnated with alkali of mercerizing strength to form alkali cellulose and then the caustic or alkali has been washed out in cold water, a hydrate of cellulose is formed which has been named "Water Cellulose" or "Cellulose Hydrate II". In this form the cellulose contains water in the lattice and although the lattice chains are closer together than for alkali cellulose they are not in the same form as Cellulose II or Cellulose Hydrate I which are formed when the Cellulose Hydrate II is heated or dried out. This Cellulose Hydrate II containing the water in the lattice is plastic and swollen and will more easily conform to mechanical deformations than the regular completely mercerized cellulose fabric which is Cellulose II or Cellulose Hydrate I. Only when it is thoroughly dried does Cellulose Hydrate I lose its water and the lattice of Cellulose II is formed. It needs only humid air for Cellulose II again to attract water into its lattice and it then changes into Cellulose Hydrate I, but not Cellulose Hydrate II, however. On swelling in water the lattice of Cellulose II remains unchanged. The hydrate richer in water, "Cellulose Hydrate II" (Water Cellulose) is formed only when alkali cellulose (or other cellulose which contains a high quantity of other atoms in the lattice structure which can be replaced with water, at least temporarily) is washed

in relatively cold water. In other words, when the Water Cellulose which is in a metastable (not in equilibrium) condition, is heated or dried to form Cellulose Hydrate I, the change is irreversible and it is impossible thereafter to obtain the plastic, swollen condition which is considered necessary for best luster formation as applied by any mechanical action such as that employed by pressure rolls, unless the alkali cellulose or its equivalent is first formed and then washed down to a low alkali content with cold water.

In accordance with our discovery, a woven fabric of native cellulose fibers such as cotton fibers, is first wetted with an aqueous solution of caustic soda of the usual mercerizing strength, until they swell to a maximum and become plastic. The fabric, with its fibers so swelled by the caustic soda solution, is then held against shrinkage in any suitable manner, and then rinsed with water to remove the caustic soda progressively. The ideal way is to do the entire rinsing with water at a relatively cool temperature, which would be below 105° F., and preferably not more than 100° F., in order that there be a maximum formation of Cellulose Hydrate II. In mercerizing, the fabric after being wet with the caustic soda is rinsed with hot water, in order to eliminate the caustic as quickly as possible, so that the fabric may be treated while it is traveling. If we were to use relatively cool water entirely, the treating apparatus for rinsing all of the caustic out of the fabric while it is moving would necessarily have to be of considerable length, which might be impractical in the ordinary treating plant.

We have found, however, that we can obtain good results as to luster by rinsing the fabric with hot water to remove the caustic soda until the caustic soda content of the fibers has been reduced to less than about 6%, and after that one must rinse only with cool water that is below 105° F., because otherwise there will be insufficient Hydrate II formed in the fibers. The rinsing with cool water is then continued until the caustic soda remaining in the fibers is less than about 3½%, but not necessarily fully removed. After the caustic soda content of the fibers has been reduced below about 3½%, the fabric will largely relax its tension and it is thereafter not necessary to hold the fabric taut against shrinking, although until the caustic soda is fully removed there may be some further but very slight shrinkage. With the fabric relaxed, it may be calendered while it is not held under tension, which makes it possible to use simple pressure rolls or calendering devices. Because of the maximum amount of Cellulose Hydrate II which is present, the flattened fibers will retain their flattened condition to a maximum extent during the remainder of the rinsing.

After the fibers have been permanently flattened by the calendering, the fabric with the flattened fibers may then be further rinsed with hot water, heated or dried in order to change the hydrate into Cellulose Hydrate I, and this then sets the fibers in the flattened condition, done while swollen, so that subsequent wettings with water will not cause the fibers, when swelling, to resume their former unflattened condition.

We have found that when the calendering occurs after the caustic soda content of the fibers has been reduced below about 3½%, only one heavy calendering operation is really necessary, and it is not essential that there be a plurality of calenderings separated by water rinsings of the fabric. It is preferable to pass the fabric between calendering rolls a plurality of times in rapid succession, no rinsings between calenderings being necessary, in order to more effectively flatten the fibers. We preferably employ heated calendering rolls and, therefore, when the fabric is passed in rapid succession through a plurality of pairs of calendering rolls the fabric may be dried and heated somewhat which is undesirable. Hence we prefer

to deposit on the fabric, between passes, a fine water mist just sufficient to keep the fabric moist, plastic, and cool so that the Cellulose Hydrate II will not be converted by the heat or drying into Cellulose Hydrate I which is irreversible, until the maximum flattening has occurred. This mist need not be sufficient to carry off any appreciable amount of caustic soda that may be remaining in the fibers, but merely keep the fabric cool and moist. As soon as the fibers have been flattened, the fabric is then passed through a hot water rinse or drying chamber to set the fibers in their flattened condition.

In the accompanying drawing we have illustrated schematically, in side elevation, one type of suitable apparatus that may be employed to utilize our discovery. In the drawing, a fabric web **1** of native cellulose fibers, such as cotton fibers, in either greige or bleached condition is passed through a mercerizing bath of an aqueous solution of caustic soda contained in a housing or pan **2** of any suitable construction, such as is commonly used in the mercerization of cotton fabrics. In this housing **2** the fabric web passes over rolls **3** back and forth in the bath, then over the usual dancer rolls **4**, and then to a tenter frame **5** where the fabric is pulled to its normal width and held against shrinkage widthwise by the tenter frame, and is under sufficient tension lengthwise to prevent excessive shrinking. Either pin tenter or clip tenter frames may be used very satisfactorily, but the clip tenter frames are preferred. While the fabric is held under small tension or at its normal size in this tenter frame, streams of rinse water are discharged from nozzles **6** upon the web so as to wash out the caustic soda.

This fabric, with the very small percentage of remaining caustic soda, is then passed between calendering rolls under heavy pressure one or more times successively as may be desired. The successively arranged calender rolls may be entirely separate pairs of rolls, or, as shown, a plurality of rolls **7**, **8**, **9** and **10** may be arranged in a vertical row and all pressed together under heavy pressure and all or part of them heated. The web **1** of fabric is first passed between rolls **7** and **8**, then around an idler roll **11**, then between rods **8** and **9**, then around another idler roll **12**, then between rolls **9** and **10**. Mist-creating spray nozzles **13** are arranged to deliver a fine mist of cool water to the web **1** after it leaves rolls **7** and **8** and before it passes between rolls **8** and **9**, and again after it leaves rolls **8** and **9** and before it passes between rolls **9** and **10**. The heated rolls **7**, **8**, **9** and **10** tend to dry the web and it is important to keep the fabric wet and plastic throughout the successive calenderings until the final calendering.

The calendered web is then further water rinsed with hot water such as by spraying with hot water, or, as shown, by passing it over idler rolls **14**, **15** and **16** to and through a tank **17** of hot water where the web passes back and forth through the water and over rollers **18** and **19**, during which any remaining caustic soda is removed.

This latter type of rinsing device is available on the market under the name of "Williams Unit," but any manner of final rinsing may be employed. The web may then be passed through a wringer **20** to remove excess rinsing water and then, if desired, passed through an acid bath in a tank **21** to completely neutralize any trace of caustic soda that may remain on the fabric. The web is then given any desired or usual finishing treatments.

In a recent book entitled "An Introduction to Textile Finishing," by J. T. Marsh, published by Chapman & Hall, Ltd. in 1948, pages 112 and 113, Marsh states that maximum swelling of cotton fibers by sodium hydroxide solutions occurs when using 15% caustic soda solution, but higher concentrations are required for commercial mercerization of cotton fabrics because of the preferential absorption of sodium hydroxide by the cotton fabric. The minimum concentration for swelling cotton fibers to any great extent, depending upon time and temperature of impregnation, would be about 8% of caustic soda in the aqueous solution. Since caustic soda solutions of more than 40% by weight of caustic soda in the solution are seldom used in mercerization, the maximum range for the mercerization should be between about 8% and 40% by weight of caustic soda. Commercially around 20% to 30% by weight of caustic soda in the aqueous bath is used commonly for mercerization, and that concentration gives good results in the present discovery, but about 13% to 21% by weight of caustic soda in the mercerizing bath gives excellent results. It is advisable to use substantially more than 8% by weight caustic soda in the solution for the mercerization, in order that maximum swelling of the cotton fibers can occur within the short time available for mercerization.

According to our discovery, the swollen, plastic condition of the cotton fibers, which is caused by the action thereon of the caustic solution, and the following formation of water cellulose or Cellulose Hydrate II as the caustic is replaced with cool water, can be retained by proper rinsing of the caustic soda treated fabric with cool water until the fabric has less than even 1% of alkali content. Luster can even be obtained when all of the caustic soda has been removed by rinsing with relatively cold water. This swollen condition, with cool water replacing the caustic and the formation of Cellulose Hydrate II or water cellulose during the rinsing, can be reduced or checked with hot rinse water or by drying and, therefore, it is important that in the rinsing, as the caustic content of the fibers approaches 3.5% or less, the temperature of the water be below 105° F. and preferably below 100° F. When using a relatively low temperature rinse in replacing the caustic in the fibers after swelling with mercerizing solution, it is possible to continue the rinsing prior to pressing to a very low percentage of retained caustic, even less than 0.3%, or even eliminate all of the caustic and still obtain a very good lustre, because the lower temperature rinse gives one a fabric in which the fibers retain their swelled and plastic condition and have more Cellulose Hydrate II than a hot water rinse provides. It is, therefore, important to use a relatively cool rinse below 105° F. and preferably below 100° F. in at least the final portion of the rinsing prior to pressing, if one is to have good lustre in and low shrinkage of the fabric.

The temperature of the caustic soda used for the impregnation or wetting is preferably that at which the usual mercerizing operation is carried on. The best mercerizing results are retained when the temperature of the caustic bath is from 30 to 52° F., but this requires ice or cooling apparatus and, therefore, the mercerizing bath usually varies between 50° and 90° F. It is desirable that the temperature of the caustic bath be kept as low as practicably possible in order to obtain the best results. The fabric leaving the mercerizing bath passes between squeeze rolls **22** and **23**, in order to remove excess caustic from the fabric before the fabric goes to the tenter frame, and an additional roller **24** cooperating with the roller **22** may be employed to guide the web out of and then back into the bath, so that the pressure on the web between the rollers **22** and **24** will mechanically work some of the caustic well into the fabric fibers before the fabric reaches the tenter frame.

The three rollers **22**, **23** and **24**, are pressed together under a suitable pressure, such as ordinary wringer or padder pressure, and this pressure is not necessarily heavy enough to cause any substantial permanent flattening of the fibers of the fabric passing between those rollers.

In the batch process for treating cotton fabrics by first subjecting them to the mercerizing bath and then rinsing them, it is possible and practical (since time is not then a factor) to use relatively cool water for the entire rinse until the caustic content is below about 3.5%, but where the process is a continuous process, such as is illustrated in the drawing, in order to avoid having the web move too slowly or to avoid using a tenter frame too

long, the first part of the rinse in the tenter frame may advantageously be between 160° and 190° F., and the latter part of the rinse can then be at a temperature anywhere between ice and 100° F. Due to the impracticability of using temperatures below approximately 50° F. for the water rinse, because of the cooling required, a practical range for the last part of the rinse is preferably between 50° and 90° F.

The rinsing is continued until only a minor amount of caustic remains in the cotton fibers in order to retain enough plasticity in the fibers to make them amenable to permanent mechanical deformation, and when a cool rinse is employed it is possible to reduce the caustic to a lower percentage without losing the necessary plasticity in the fibers than when the rinse water is at a higher temperature. A relationship between the temperature of the water rinse following the caustic treatment, and the amount of caustic remaining in the fabric at the end of the rinse, can be used as a measure of the plasticity or the swelling remaining in the fabric. When the temperature of the water rinse is as high as 160° F., the caustic remaining in the fabric should not be below about 2.5% if the fibers are to have sufficient plasticity to give fairly good lustre in the final product. Percentages of caustic below 1.5% are not very practical for high temperature rinsing. When the pressing deformation of the fibers occurs, the percentage of caustic soda remaining in the fibers may be lower when the temperature of the rinse water is lower.

In practical operation it is best that the fabric have only a slight slackness to very little tension at the time when the pressing to deform the fibers and create the lustre occurs, and by first reducing the caustic soda content to a very low minimum, the pressing can occur while the fabric is not in a tenter frame or under tension, which simplifies the mechanical apparatus necessary for the lustre pressing. In order that any shrinkage which does occur during the final lustre pressing, be as small as possible, the caustic soda content should be below about 3½% and preferably below about 2%. The low temperature rinse water aids in retaining more Cellulose Hydrate II, and this Cellulose Hydrate should be preserved or be present to a maximum extent at the time the fabric goes through the fiber flattening or lustre pressing mechanism. Therefore, the lustre pressing between the rolls **7**, **8**, **9** and **10** should occur as soon as practical after the final rinse prior to pressing. The pressure rolls for permanently flattening the fiber are preferably heated in order to make the flattening more effective, but the heat of the rolls tends to evaporate moisture and heat the fabric, thus reducing the plasticity of the fibers, and for that reason when more than one fiber flattening or calendering is used, it is desirable to create a fine mist of water on the fabric between the successive pressings to prevent drying of the fabric.

The lustre apparently increases proportionately with the pressure imparted at the time of lustring, provided the pressure is not sufficient to seriously damage or destroy the fibers. Therefore, the pressure should be relatively high between the rolls **7**, **8**, **9** and **10**. The lowest pressure should be at least 40 lbs. per inch of nip. When using pressing rolls having a Brinell hardness of 180 to 200, a minimum pressure of 14,000 lbs. per square inch

at the center of contact is advised. The maximum pressure is determined only by the amount of damage which would be permissible in producing the high lustre. While rolls have been indicated as the pressing medium where the fabric is continuously moving, it will be understood that when treating the fabric by the batch process, the fabric can easily be pressed between flat plates. The lustre is enhanced by increasing the temperature of the pressing surfaces, and the maximum temperature of the pressing surfaces is limited by the permissible damage to the fabric. The maximum temperature would appear to be about 400° F., depending upon the caustic soda content of the fabric and the time of contact.

It will be understood that various changes in the details, which have been herein described and illustrated in order to explain the nature of the discovery, may be made by those skilled in the art within the principle and scope of the discovery, as expressed in the appended claims.

We claim:

1. The method of treating a fabric containing largely cotton textile fibers to impart thereto an increased lustre that is permanent to multiple washes, which method comprises wetting said fabric with an aqueous solution of caustic soda of mercerizing strength until the cotton fibers thereof are plastic and swelled, holding said treated fabric under the tension commonly used in mercerization to resist shrinkage, rinsing the held fabric with water at a temperature below about 105° F. until said fabric largely relaxes its tension and the caustic soda content of the cotton fibers is reduced below about 3½ percent and not fully removed and cellulose hydrate II is produced, immediately thereafter permanently flattening the swelled cotton fibers by heavy pressure thereon in a direction approximately normal to the faces of said fabric, immediately after the flattening step setting the cotton fibers in flattened condition by changing said cellulose hydrate II to cellulose hydrate I, immediately after changing cellulose hydrate II to cellulose hydrate I removing all of the remaining caustic soda from the flattened fibers.

2. The method of claim 1 wherein the setting of the cotton fibers in the flattened condition by changing cellulose hydrate II to cellulose hydrate I is accomplished by rinsing the fabric with hot water.

3. The method of claim 1 wherein the setting of the cotton fibers in the flattened condition by changing cellulose hydrate II to cellulose hydrate I is accomplished by heating the fabric.

4. The method of claim 1 wherein the setting of the cotton fibers in the flattened condition by changing cellulose hydrate II to cellulose hydrate I is accomplished by drying the fabric.

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