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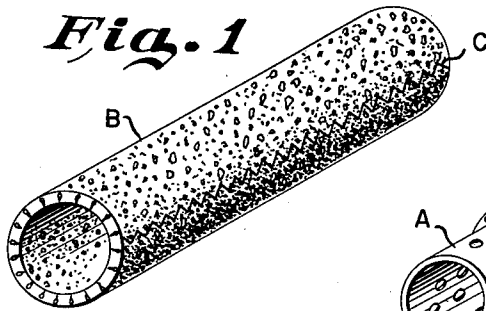
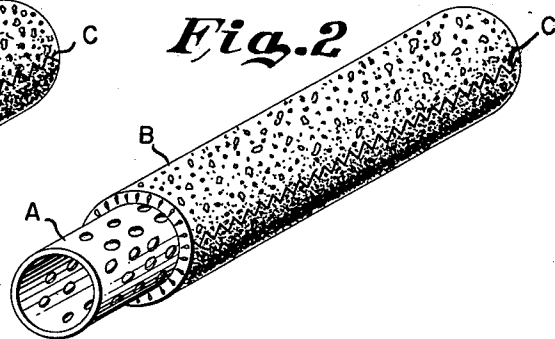
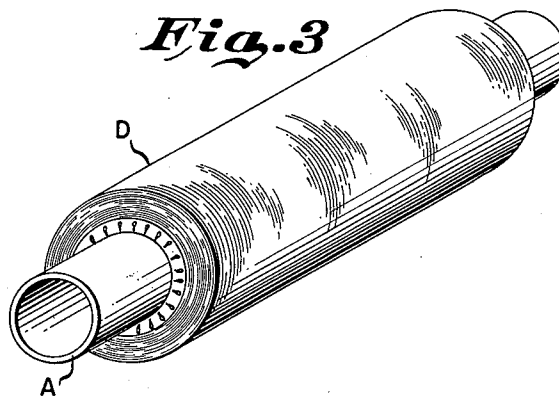
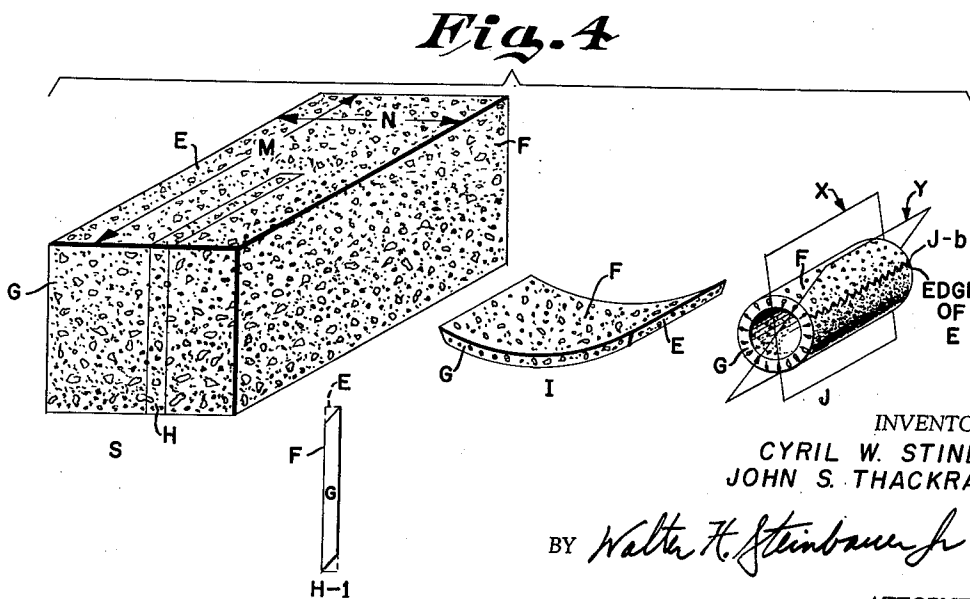
C. W. STINER ETAL

3,106,725

PACKAGE DYEING SPINDLE AND PROCESS

Filed Jan. 14, 1960

2 Sheets-Sheet 1



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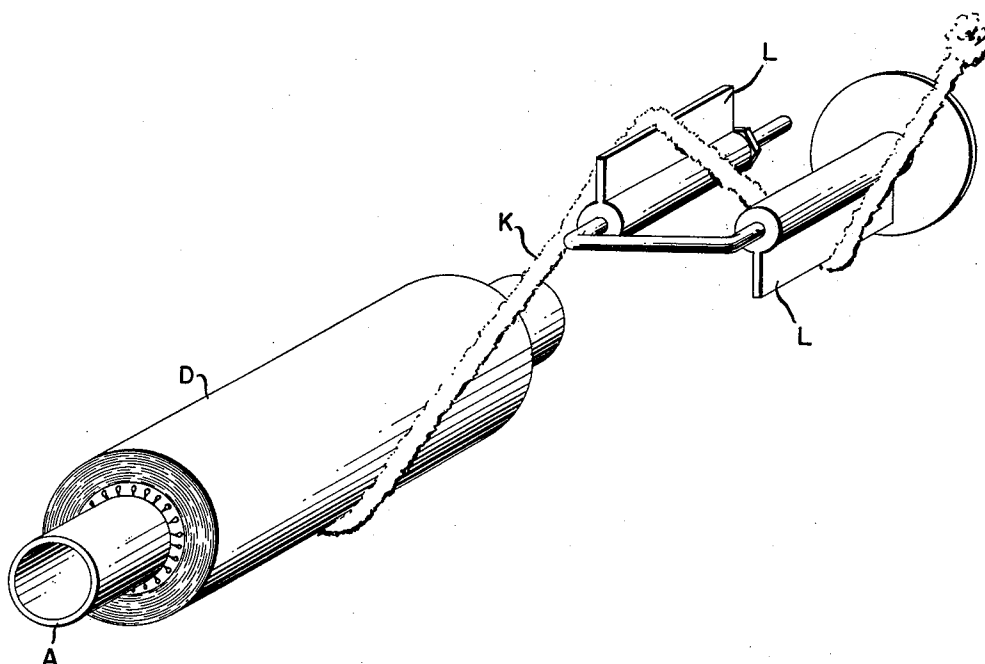
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Fig. 5



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PACKAGE DYEING SPINDLE AND PROCESS

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This invention is directed to an improvement in the process of dyeing textile yarns in package dyeing machines. In particular, this invention is concerned with the spindles used in package dyeing machines and on which the yarn is wound.

In dyeing yarns in package dyeing machines the fiber is wound onto a hollow perforated or other liquid permeable spindle and the "package" thus obtained placed over the mandrels in the machine. Dye liquor is then pumped through the yarn and spindle, the dyeing process being carried out with or without pressure at temperatures of about 180° to 235° F. Because of the elevated temperature certain yarns shrink and due to this the diameter of the package decreases and the yarn becomes so tightly compressed that it is packed onto the perforated cylinder as a hard cake which is impermeable to the dye liquor. This results not only in non-uniform dyeing, but also necessitates that the undyed fiber first be preshrunk and then wound onto another spindle for the package dyeing operation.

This problem is particularly acute with continuous filament yarns such as nylon, polyacrylonitrile, and polyethylene terephthalate.

With high bulk yarns, such as high bulk polyacrylonitrile, the yarns swell and create a similar problem. In this case, the yarn is designed to change dimensionally during the high temperature dyeing process and this change (which is a swelling-like action) causes the bulking of the fiber. Such yarn is very desirable for soft goods such as sweaters. However, the yarn wound near the spindle is compressed by the swelling of the outside layers of the fiber and this prevents the bulking action from occurring around the core of the package.

Rayon fibers are difficult to dye in alkaline liquors in the package dyeing machine because they also swell during the dyeing process. In this case uneven dyeing also occurs and renders the dyed package unsatisfactory. Cotton fibers dyed with vat dyes are also affected somewhat by uneven dyeing when dyed in the package machine.

Heretofore it has been attempted to compensate for the compression that occurs during fiber shrinkage or swelling by utilizing specially constructed cylinders having spiral or spring-mounted walls; these have been found to be generally unsatisfactory. Another practice is to first wind the perforated cylinder with several layers of cotton fiber which serves as a resilient material to take up some of the compression. Although this procedure is used in many mills it is not too satisfactory.

It is an object of this invention to provide a process for the package dyeing of textile yarns whereby the problem of caking and incomplete dyeing resulting from the shrinking or swelling of the yarn are eliminated. It is a further object to provide novel spindles for use in package dyeing. It is another object of this invention to provide a novel method of stretch-relaxing the dyed fiber to return said fiber to its original bulk form. These and other objects will become apparent in the following description and claims.

More specifically, the present invention is directed to a novel process of dyeing textile fibers in package dyeing machines wherein the fiber to be dyed is wound on a

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cylindrical spindle through which the dye liquor is pumped, said spindle consisting of a cylindrical spindle of cellulose sponge. As a preferred embodiment the novel cellulose sponge spindle utilized will be one in which the planes of the grain pattern of the cellulose sponge coincide essentially with the radial planes of the formed cylinder. The present invention also predicates patentability on a spindle per se for use in package dyeing machines, which spindle consists of a cellulose sponge cylinder, a preferred embodiment of said cylinder being one in which the planes of the grain pattern of the cellulose sponge coincide essentially with the radial planes of the formed cylinder.

The package dyeing process is well known in the art and is described in numerous articles (see for example, American Cotton Handbook, 2nd Revised Ed., 1949, page 636 or Trade Literature of Venango Engineering Co., Philadelphia, Pa., Manufacturers of Package Dyeing Machines). In general, the process is as follows: Packages are made by winding one or two pounds of yarn on spindles which are perforated, rigid tubes, spools or cotton covered springs made of wood, fiber, or metal. The packages are placed on mandrels on a carrier and fastened down with a screw nut. The loaded carriers are then placed in the machine and the machine closed. Circulation inside-out and outside-in is possible and the dyebath and other treating baths are circulated through the packages to achieve the dyeing process.

In carrying out the present invention it is required to replace the cylindrical spindle normally used in package dyeing with a cylinder of cellulose sponge. In lieu of complete replacement of the usual spindle, the outside surface of the conventional spindle may, as an alternative, be covered with a sleeve of the cellulose sponge prior to winding on it the fiber to be dyed.

The manufacture of cellulose sponge is old in the art and is fully described in an article by V. Torrey in Popular Science Monthly, vol. 146, page 132, January 1945. No changes in the sponge preparation need be made to obtain sponge useful for this invention. Preferably, sponge known as "coarse pore" sponge will be used although cellulose sponge of other porosities are operable. Cellulose sponge, manufactured by the mold process, has two mutually perpendicular directions of grain orientation which are only recognizable in the grain pattern surface.

In a preferred embodiment of this invention the cellulose sponge spindle will be constructed in a way as to have the cellulose sponge grain structure oriented in a specific manner. The grain surfaces of a block of cellulose sponge are comparable to the grain surfaces of wood. Which surfaces of a block of cellulose sponge are grain pattern surfaces are readily apparent to the art worker in the field, but even a non-skilled person can determine the grain pattern surfaces of cellulose sponge by a simple test. The grain pattern surfaces are those two parallel surfaces which yield to compression most readily. The other end grain surfaces strongly resist compression. Thus, to find the grain pattern surfaces all that need be done is to push the sponge surfaces with the fingers or hand and observe which surfaces yield easiest. This test is best carried out with air dry sponge. Naturally, in a block of cellulose sponge there are an infinite number of grain pattern surfaces each lying in planes parallel to each other. To achieve the preferred embodiment of this invention, the sponge cylinder will be constructed so that an end grain surface is parallel to the axis of the cylinder. When the sponge cylinder is made in this way it is found that it has greater resilience and can be used at least several times, thus reducing the cost of sponge per unit operation.

In order to more fully explain the present invention reference is now made to the drawings. FIGURE 1

illustrates a spindle of cellulose sponge. FIGURE 2 illustrates a sleeve of cellulose sponge B partially slipped over a conventional package dyeing machine spindle A. This sleeve is made by sewing together at C a slab of sponge as will be discussed later. FIGURE 3 illustrates the winding of textile fiber D on the sponge.

FIGURE 4 illustrates the preparation of the spindle from a block of cellulose sponge and illustrates a method for making the preferred spindle, i.e., with the planes of the grain pattern essentially coinciding with the radial planes of the formed sponge cylinder. A slab of sponge H is cut from the molded block of cellulose sponge as indicated S. The surface E of the sponge block is the grain pattern surface and surfaces F and G are end grain surfaces. The mutually perpendicular arrows M and N in the grain pattern surface E represent the dual grain direction characteristic of cellulose sponge. Slab H is preferably trimmed so its ends are on a bias as indicated H-1. Then the slab is bent as indicated I and the biased ends sewn together J-b to form the finished spindle J. Stitching the seam is done preferably on a wet sponge for ease of manipulation. The planes X and Y represent radial planes passed through the formed cellulose sponge cylinder J to illustrate that the planes of the grain pattern surfaces E coincide essentially with the radial planes of the formed sponge cylinder J.

FIGURE 5 illustrates the spindle unit of FIGURE 3 in combination with a pair of thin rectangular sharp-edged plates L, the dyed yarn K being passed, at an angle, over each of said sharp edges while stretching said yarn, the edges being opposed and spaced in the direction of fiber travel, the sharp edges providing drag on the yarn to effect high tension prior to heating the yarn to relax and bulk said yarn.

In lieu of preparing a slab of sponge and sewing its ends together, the ends may be glued, stapled, pinned, clipped or held together in an equivalent manner. Alternatively, a sponge cylinder may be made by boring it from the dry sponge block.

The dimensions of the sponge cylinder will depend upon the particular way it is used. If it is used as a sleeve over a conventional spindle it will be about 6 inches long, have an inside diameter of about $1\frac{1}{8}$ inches to fit over the standard mandrel, and will be about $\frac{1}{2}$ inch thick or sufficient to take up the shrinkage of the fiber to be wound upon it. The amount of shrinkage depends upon the kind and the amount of fiber to be made into the package. Polyester fibers shrink about 15% and nylon about 7%. As indicated, rayon fibers actually swell during the dyeing process, but create the same problem on the inside portion of the fiber because of the pressure exerted by swelling action. The use of the sponge cylinders of this invention may be used with all fibers which are dimensionally unstable during the package dyeing process.

If the sponge cylinder is to be used to entirely replace the conventional package dyeing spindles, the length will still be about 6 inches, but the inside diameter should be such as to fit over the mandrel of the machine which is about $1\frac{1}{8}$ inches. Again, the outside diameter will be determined by the kind and size of the package, but will usually be about 2 inches.

It has been observed that some slight shrinkage of the sponge cylinder itself occurs after the dyed package is removed from the machine and dried. However, this is not significant and on rewetting, the sponge cylinder swells to its original shape. In order to avoid a rewetting and dedrying step for the sponge cylinder it is advisable to treat the cylinder with a cellulosic dimensional stabilizer such as the commonly available ureaformaldehyde resins. This treatment imparts dimensional stability to the sponge cylinder and permits immediate reuse after the dyed fiber is removed. It is also advisable to avoid temperatures above 235° F. since such temperatures may have destructive effects on the sponge.

In addition to using the sponge cylinders for package dyeing machines, this invention contemplates their use in the large beam dyeing machines which may be considered as huge package dyeing machines containing a single package. These beam dyeing machines are described on pages 639 and 640 of the American Cotton Handbook heretofore referred to. In use, yarn is wound on a large core to give a beam containing several hundred pounds of yarn and this beam is placed vertically in the machine, dye liquor being pumped through the yarn as with package dyeing. In another type of beam-dyeing machine the beam, which is a core of yarn or fabric is placed in the machine horizontally. In these types of machines also, the cellulose sponge cylinders of this invention may be used to advantage.

The unexpected results obtained by using the sponge cylinder of this invention are that the fibers are more uniformly dyed due to the easy and thorough penetration of the dye liquor. Furthermore, no preshrinking is required. In addition, the preferred sponge cylinders may be repeatedly used at least about four times thus reducing their cost per cycle. In the case of dyeing high bulk polyacrylonitrile fibers, this invention provides a means for package dyeing such yarn without loss of bulking properties, especially if the dyed yarns are stressed and then stress-relaxed by heating prior to or after fabric preparation.

Representative examples illustrating the present invention are as follows:

Example 1

A slab of coarse cellulose sponge $6\frac{3}{4}$ " x 6" x $\frac{1}{2}$ " was cut from a sponge block as indicated by FIGURE 4 and the ends sewn together to produce a cylinder 6" long and having an inside diameter of $1\frac{1}{8}$ ". This cylinder was used as a spindle by first wetting it with water, squeezing out the excess and then about 12 ounces of polyethylene terephthalate filament yarn was wound on it. The package was placed over the mandrel of a package dyeing machine and a dyeing carried out in the normal manner. The dye solution consisted of 5 liters of a 1% dispersion (on the weight of fiber) of a blue dye of prototype number 499 containing 0.25% of a sulfated long chain alcohol and 2% of a naphthalene-formaldehyde sulfonic acid. The dyeing was carried out at 230° F. for about 30 minutes. The dyed yarn was observed to be level from outside to inside, was soft and contained no hard sections, the sponge having taken up all the shrinkage that occurred.

The same cellulose spindle of this example was used four times without any significant change in the results obtained.

When the dyeing of this example was repeated with a conventional steel perforated spindle, the dyed package was very hard particularly around the spindle.

When a spindle was made from cellulose sponge but having the grain pattern surface parallel to its axis, the dyeing of the yarn, according to Example 1, was successful in that a soft package and level dyeing were obtained. However, the sponge spindle had lost most of its resilience and could not be reused.

Example 2

A slab of coarse pore cellulose sponge $7\frac{1}{2}$ " x 6" x $\frac{1}{2}$ " was cut from a sponge block as indicated by FIGURE 4. The slab was wound around a $1\frac{1}{8}$ " perforated steel spindle used in package dyeing machines and the ends sewn together with cotton thread. Then, approximately 1 pound of 70 denier polyethylene terephthalate filament yarn was wound on the sponge and the package placed in the dyeing machine. A jockey red dye dispersion (prototype No. 234) was then added to the machine and the dyeing carried out at 230° F. in the usual manner. On removal from the machine the dyed yarn on the

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spindle was observed to be soft and no evidence of caking was found.

Example 3

A $\frac{5}{8}$ " thick cellulose sponge spindle was made as described in Example 1 and 12 ounces of rayon fiber wound upon it. The package was placed in a package dyeing machine and about 5 liters of a 3% dispersion (on the weight of the fiber) of a blue vat dye of phototype number 1113 were added and circulated at 120° F. for about 15 minutes. The pigment was reduced to the leuco form with 0.75% each on weight of bath of caustic and sodium hydrosulfite and circulation continued for about 20 minutes at 120° F. The dye bath was then drained, the package rinsed with warm water and a 1.5% solution of sodium perborate added. The temperature was raised to 190° F. and the oxidizing bath circulated for 10 minutes. After rinsing, soaping and again rinsing the dyed package, it was removed from the machine. The dyed package was soft throughout.

When the sponge of this example was replaced with a conventional steel tube, the dyed package was hard at the center and showed evidence of uneven dyeing at the edges.

Example 4

A cellulose sponge spindle having a 1 $\frac{1}{2}$ " inside diameter was made as described and about 12 ounces of high bulk polyacrylonitrile yarn ("Orlon" type 42) was wound on it. The package was loosely placed over the mandrel of a package dyeing machine and 5 liters of a solution containing on the weight of the fiber 3% of a mixture of lauryl and cetyl trimethylammonium bromide, 10% Glauber's salt and 2% acetic acid were added. After circulating for 10 minutes at 140° F., a solution containing 2 grams of the red dye of Example II of USP 2,734,901 was added and circulation continued for 25 minutes while raising the temperature to 202° F. After another 30 minutes, the dye bath was drained, the package rinsed with hot water and dried.

The dyed package was very soft and indicated a uniformly dyed yarn of good bulk character. A portion of the yarn was wound to skeins, being first directed over a pair of rectangular bars placed in opposed relationship to each other, but spaced along the direction of yarn travel so that the yarn followed a generally Z-shaped path in passing over them. The skeins were then heated in an oven at 200° F. for ten minutes. The yarn treated in this way showed even higher bulk than the portion that did not receive this treatment.

When the dyeing operation of Example 4 was repeated with a metal core instead of the cellulose sponge, the dyed package was very hard and not fully bulked. Bulk was not developed by running the yarn over rectangular bars and then heating it according to the procedure of Example 4.

This application is a continuation-in-part of co-pending

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application Serial No. 800,327, filed March 18, 1959, now abandoned.

As many apparently widely different embodiments of this invention may be made without departing from the spirit and scope thereof, it is to be understood that this invention is not limited to the specific embodiments thereof except as defined in the appended claims.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A spindle for package dyeing machines which spindle consists of a hollow cellulose sponge cylinder, said cellulose sponge cylinder being constructed so that the planes of the grain pattern surfaces coincide essentially with the radial planes of the formed cellulose cylinder.

2. A spindle for package dyeing machines which spindle consists of a cellulose sponge sleeve internally supported by a perforated, rigid, hollow spindle, said cellulose sponge sleeve being constructed so that the planes of the grain pattern surfaces coincide essentially with the radial planes of the formed cellulose sponge sleeve.

3. In the process of dyeing textile fibers in package dyeing machines wherein the fiber is first wound on a cylindrical hollow spindle and then followed by pumping dye liquor through said spindle and said fiber, the improvement which consists of forming said cylindrical hollow spindle with cellulose sponge so that the planes of the grain pattern surfaces of said cellulose sponge coincide essentially with the radial planes of the formed sponge cylindrical spindle.

4. In the process of dyeing textile fibers in package dyeing machines wherein the fiber is first wound on a cylindrical hollow spindle and then followed by pumping dye liquor through said spindle and said fiber, the improvement which consists of forming said cylindrical hollow spindle with a cellulose sponge sleeve internally supported by a perforated, rigid, hollow spindle, said cellulose sponge sleeve being constructed so that the planes of the grain pattern surfaces coincide essentially with the radial planes of the formed cellulose sponge sleeve.

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