Jan. 25, 1949. W. M. WENTZ 2,460,206

METHOD OF CONTINUOUS DYEING

Filed Dec. 7, 1945

2 Sheets-Sheet 1

Fig. 1.

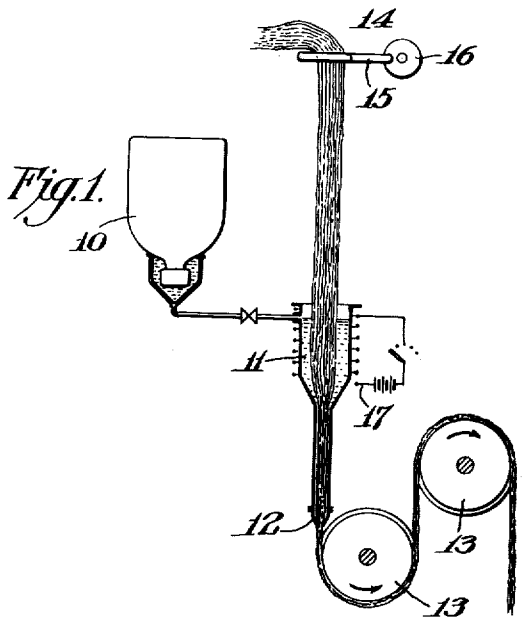


Fig. 2.

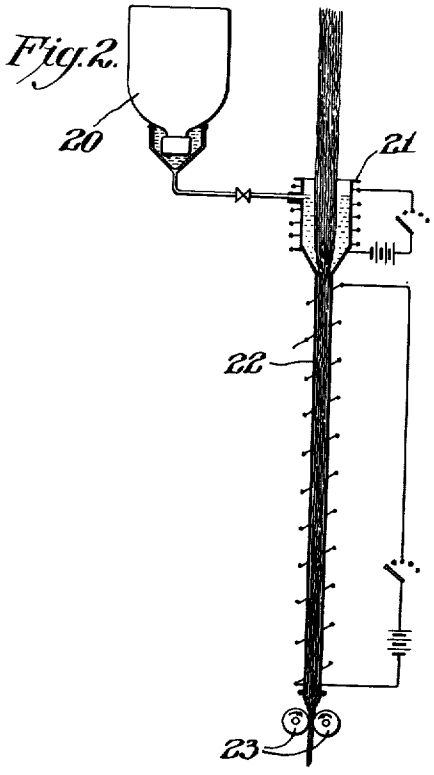
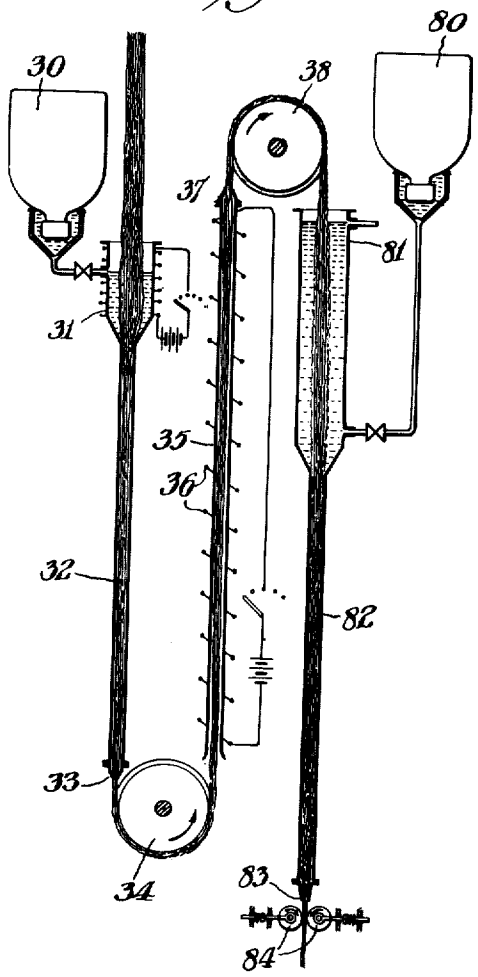


Fig. 3.



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Fig. 4.

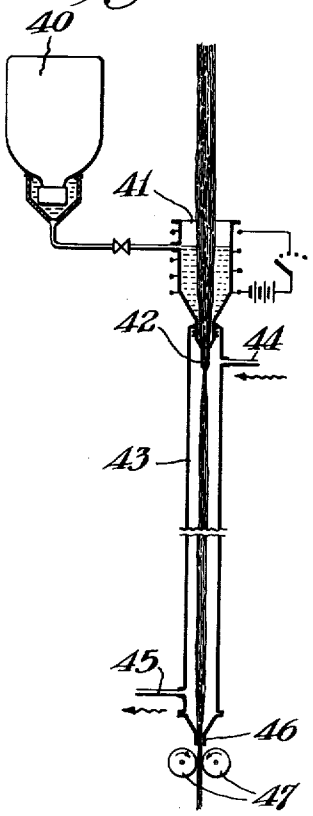


Fig. 6.

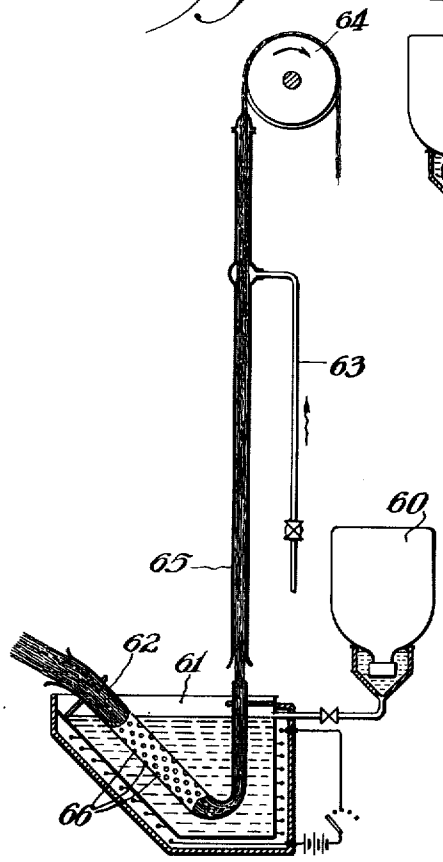


Fig. 7.

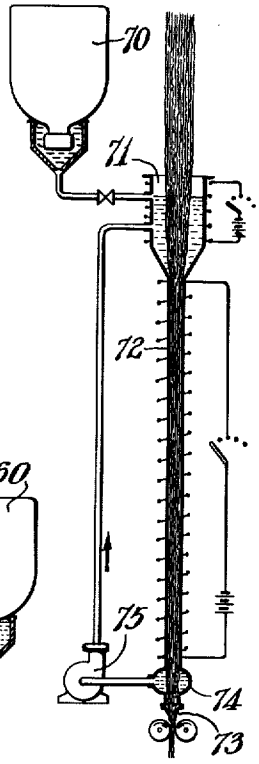
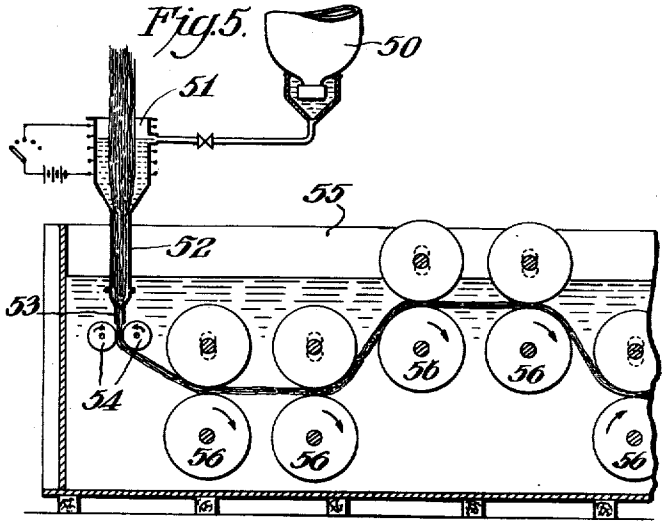


Fig. 5.



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2,460,206

METHOD OF CONTINUOUS DYEING

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Application December 7, 1945, Serial No. 633,480

4 Claims. (Cl. 8—149.1)

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This invention relates to liquid treatment of textile fibers and more particularly to the continuous dyeing and liquid treating of textile fibers in the form of top, sliver, roving, slubbing, yarn, warp, filament or tow. I shall refer hereinafter to all these forms collectively as running lengths of unwoven fiber.

The manufacture of certain styles of fabrics, for instance men's suitings, upholstery fabric and knitted goods, requires that the textile fibers be dyed at a stage previous to weaving or knitting. Excluding the methods of dyeing the fibers in the form of raw stock or loose wool, there remains for consideration the dyeing of fibers in the form of top, sliver, slubbing, roving, yarn, warp, filament or tow; in other words, fiber in the form of unwoven running lengths.

Hitherto the dyeing and treating of fibers in the aforementioned forms have been limited to batch processes. Furthermore, various and distinct types of equipment as well as special preparation is required for the different processes.

For example, worsted top because of its fragile nature is generally wound carefully on perforated spools and dyed in circulating machines.

Many methods are employed for yarns such as winding the yarns into hanks and dyeing in hand tubs or dyeing in skein dyeing machines. Yarns are also wound into packages or beams and dyed in circulating machines, or may be grouped together into warps and be banded and doubled down for dyeing in warp dyeing machines.

All of the above methods are more or less lengthy batch processes requiring special preparation for the fibers involved. Furthermore, the equipment involved is not particularly suitable for continuous dyeing or treating processes many of which require a padding or impregnation step previous to final development or fixation.

The introduction of synthetic fibers in new forms such as tow and the introduction of new continuous vat dyeing processes such as the application of vat dyes to wool have presented new problems.

Circulating machines are not particularly suitable for the dyeing of viscose rayon tow with vat colors because the tendency of the rayon to swell when wet with alkaline liquors inhibits proper circulation and penetration of the dye.

The existing methods of padding with a wetting box and squeeze rolls cannot be advantageously applied to advantage for top, sliver and tow because of the nature of the fibers and the large volume required. It is an axiom in continuous dyeing that large volumes be avoided whenever possible for reasons of control and economy.

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It is accordingly an object of this invention to provide a continuous method for dyeing and treating running lengths of unwoven fiber. Another object is to provide a method which is of a universal nature, in that it may be applied to any kind of fiber, to any stage in its preparation for weaving, and to any type of dye. A further object is to provide a method for dyeing running lengths of unwoven fiber which avoids the need for large volumes of pad liquors. A still further object is to provide a process which will enable the dyeing of fiber in the aforementioned forms with vat dyes, particularly in the case of such fibers as have not been heretofore especially adapted for dyeing with vat colors, for instance, rayon tow or wool top and wool yarn. It is also an object of this invention to provide a novel and simple apparatus for carrying out the aforegoing objects. Other and further important objects of this invention will appear as the description proceeds.

Now, according to this invention, the aforegoing objects are achieved by passing a bundle of running lengths of unwoven fiber continuously through an apparatus so designed that it impregnates the bundle with the desired dye or treating solution, then automatically squeezes out the excess liquor from the fiber bundle to a predetermined retained-liquor value before the fiber bundle is exposed to the atmosphere or passes into the next stage of treatment. In other words, my apparatus consists essentially of a dye-liquor holding vessel which is provided with a constricted, tubular opening in its bottom or wall at a point below the normal liquid level in said vessel; the bundle of fiber is threaded through said tubular opening and is moved continuously, the diameter of the tube being so chosen with respect to the diameter of the bundle that the impregnated fiber bundle is constricted as it passes through the tube and retains only a pre-determined percentage of treatment liquor in its fibers. At the same time, of course, the constricted fiber bundle acts as a plug preventing the escape of the treatment bath, through the tube.

I have found, furthermore, that when the bundle of fiber consists of unspun fiber, for instance, sliver, slubbing, roving or top, constriction in the tube gives the bundle a surprisingly increased tensile strength, which enables one to apply a considerable mechanical pull at the exit

end of the tube sufficient to move the entire bundle through the apparatus, without disrupting or disintegrating the former.

If desired, the tube may be lengthened beyond the minimum necessary for plugging and squeezing as above, and may be provided along its lengths with means for various auxiliary treatments, for instance, heating or impregnation with other liquids or gases to achieve development, fixing, oxidation and similar effects.

Various auxiliary devices and attachements may also be interposed in advance of the impregnation vessel, for instance, a shaker; for it has been found that with certain fiber lengths, such as yarn and tow, the impregnation proceeds much better if the fiber is kept open and shakes as it enters the treatment bath.

For a clearer understanding of my invention, reference is made to the accompanying drawings which form an integral part of this disclosure. In these drawings,

Figure 1 represents in conventional form a vertical section through my apparatus in its simplest form according to this invention.

Figure 2 is a similiar section, showing a modification of Figure 1, wherein the tube has been lengthened and is provided with means for heating the fiber bundle as it moves through the length of the tube.

Figure 3 is a still further modification, showing several tubes in series each adapted to continue the function of the preceding tube or to carry out a different operation upon the fiber bundle as it moves along, and all together performing a complete continuous process.

Figure 4 is a still further modification of Figure 1 wherein the tube has been lengthened and is provided with means for treating the fiber with steam or other gases as it passes through the length of the tube.

Figure 5 is a modification of Figure 1 wherein the draw rolls and delivery end of the tube are placed beneath the level of a subsequent treating bath.

Figure 6 represents in conventional form a vertical section through my apparatus which differs from Figure 1 in that the fiber constricting tube is placed above the impregnating bath.

Figure 7 is a further modification of Figure 2 wherein means are provided for drawing off the liquid expressed by the constricted outlet and returning it to the source for replenishing and reuse.

Further detailed discussion of these figures will be given in conjunction with the specific examples hereinbelow.

Now to further illustrate the practice of my invention the following examples are given without any intention to limit my invention thereto.

Example 1

For convenience of discussion, I shall choose for this example the apparatus shown in Figure 1. This apparatus consists of a feed vessel **10**, a constant-level, impregnating vessel **11** which narrows down at the bottom into a constricting outlet **12**. Grooved pulleys **13** are provided below the constricting outlet **12** to draw the fiber bundle through the apparatus, and a shaker device **14**, consisting of a finger **15** eccentrically mounted on a revolving disk **16**, may be provided at the top of tube **11**. To control the temperature of the liquid inside the impregnating vessel **11**, a thermostatically controlled heating unit, for instance a heating coil **17**, is provided surrounding the vessel. The

constricting outlet **12** is designed to compress the fiber bundle and squeeze back the impregnating liquor absorbed by it to a predetermined residual content. The latter may be set initially at an optional value between 50 and 150% by weight of the fiber bundle, and the diameter of the outlet **12** is chosen to give the selected figure.

Now, to take a specific illustrative example of my procedure, a bleached mercerized cotton warp consisting of 378 ends of 55-count, 3-ply yarn was threaded through the apparatus as above described, whose constricting outlet had an effective inside diameter of 4.5 mm. The feed tank and constant-level, impregnating vessel were charged with a vat color suspension made up as follows:

	Oz. per gal.
Ponsol Blue BF (3,3'-dichloroindanthrone)	4
"Alkanol WXN" (a wetting agent of the sulfonated aliphatic hydrocarbon class)	1

Temperature 160° F.

The dry cotton warp was drawn into the impregnating vessel, in a relatively loose tensionless manner, becoming saturated with the vat dye suspension and then into and through the restricting tube where it was compressed during its passage to retain 95% of the impregnating liquor based on its dry weight.

The impregnated or padded warp was then entered into a bath containing:

	Oz. per gal.
Caustic soda	1
Sodium hydrosulfite	1
"Alkanol WXN"	½

Temperature 140° F.

where the vat color was reduced and developed on the fiber in a conventional manner followed by oxidation and soaping.

Example 2

For the purpose of this example, the apparatus of Figure 2 was employed.

Bright viscose rayon tow, 5.5 denier, comprising 30,288 filaments was threaded through an apparatus as shown in Figure 2 consisting of a feed tank **20**, a thermostatically controlled, heated, constant-level, impregnating vessel **21**, a thermostatically controlled, heated, constricting tube **22**, having an effective inside diameter of 8 mm. and driven rolls **23** for drawing the tow through the apparatus.

The feed tank was charged with a vat dye solution made up as follows:

	Oz. per gal.
Ponsol Brown AR, double paste (C. I. 1151)	4
Caustic soda flakes	2
Triethanolamine	0.5

These were mixed together and heated to 140° F.

Sodium hydrosulfite (2.5 oz. per gallon) was then added.

The vessel **21** was initially charged with a vat dye solution made as above except that the color concentration was cut 20% to allow for selective fixation which takes place during impregnation; then, as the fiber bundle began moving through the apparatus, vessel **21** was connected to the feed vessel **20** and fed, to a constant level, with solution from said feed vessel.

The liquid level of the impregnation vessel, the speed of running and the heaters were set to provide proper fixation of the vat dye and these conditions were maintained throughout the run to insure uniform dyeing.

The dry rayon tow was drawn into the impregnating vessel in a relatively loose tensionless manner becoming saturated with vat dye solution. It then passed into the heated restricting tube where it was compressed during its passage to retain 160% of the dye liquor based on its dry weight.

The temperature of the impregnating bath was kept at 140° F. while the heating arrangements of the restricting tube were set to raise the temperature of the impregnated tow to 200° F. during its passage therethrough. The draw rolls were set with a tight squeeze to express as much of the exhausted dye liquor as possible from the dyed tow and it was then oxidized in the air or with chemicals to the final shade and rinsed with water.

Example 3

For the purpose of this example, reference is made to Figure 4.

A bleached mercerized cotton warp consisting of 378 ends of 55-count, 3-ply yarn was threaded through an apparatus as shown in Figure 4 consisting of a feed vessel **40**, a constant-level, thermostatically controlled, impregnating vessel **41**, a constricting outlet **42** having an effective inside diameter of 4.5 mm., a steam chamber **43** having a steam inlet **44**, a steam outlet **45**, and a constricted fiber outlet **46**, and driven draw rolls **47** to draw the warp through the apparatus.

The feed vessel was charged with a vat dye solution made up as follows:

	Oz. per gal.
Ponsol Jade Green, double paste (C. I. #1101)	4
Caustic soda flakes	2
Triethanolamine	0.5

Mix together and heat to 140° F.

Then add at 140° F. sodium hydrosulfite (2.5 oz. per gal.).

The vessel **41** was initially charged with a vat dye solution made as above except that the color concentration was cut 20% to allow for selective fixation which takes place during impregnation; then, as the fiber bundle began moving through the apparatus, vessel **41** was connected to the feed vessel **40** and fed, to a constant level, with solution from said feed vessel.

The liquid level of the impregnation chamber, the speed of passage and the heating and steaming arrangement were set to insure proper fixation of the vat dye on the fiber and were maintained constant throughout the run to insure uniform dyeing.

The dry cotton warp was drawn into the impregnating vessel in a relatively loose tensionless manner becoming saturated with the vat dye solution. It then passed into the constricting tube where it was squeezed during its passage to retain 95% of the dye liquor based on its dry weight. It then passed directly into and through the steam chamber.

The temperature of the impregnating bath was kept at 140° F. while the input of steam was set to bring the temperature of the impregnated warp to approximately 212° F during its passage through the steam chamber. The draw rolls were set tight to express as much of the exhausted dye liquor as possible from the warp, after which it was oxidized and soaped to the final shade.

Example 4

This example shows how my invention may be applied in conjunction with the soda-ash continuous process as given in my prior U. S. P. 2,318,132. Reference is made to Figure 5.

A sixty-fours worsted top weighing 22 grams to the yard is threaded through an apparatus as shown in Figure 5, consisting of a feed vessel **50**, a thermostatically controlled, constant-level, impregnating vessel **51**, a tube **52** having a constricting outlet **53** designed to give a liquor retention of 90% based on the dry weight of the fiber, and driven draw rolls **54**.

The constricted delivery end of the tube and the draw rolls are placed beneath the liquid level of a second machine **55** having driven rolls **56**, and resembling a worsted top back washer.

The feed vessel is charged with a vat dye solution made up as follows:

	Oz. per gal.
Ponsol Red BN, double paste (C. I. #1162)	1
Caustic soda	2
"Alkanol WXN"	0.5
Mix and heat to 120° F. then add	
Sodium hydrosulfite	2

The impregnating vessel **51** is initially charged with a vat dye solution made as above except that the color concentration is cut 10% to allow for selective fixation which takes place during impregnation, and is then connected to the feed vessel.

The soda ash development bath is made up in the second machine as follows:

	Oz. per gal.
Soda ash	1.5
Caustic soda	.05
Sodium hydrosulfite	.25
Ponsol Red BN, double paste	.05

Mix and heat to 150° F.

The dry worsted top is drawn into the impregnating vessel in a relatively loose tensionless manner becoming saturated with the vat dye solution. It then passes through the constricting tube where it is compressed to retain 80% of its dry weight. It is then drawn under the liquor level of the soda ash development bath without coming in contact with the air. After development it is oxidized to the final shade and rinsed.

Further details on the soda ash process and its chemical control are given in U. S. Patent No. 2,318,132.

Example 5 (reference is made to Figure 6)

A sixty-fours worsted top weighing 22 grams per yard is threaded through an apparatus as shown in Figure 6 consisting of a feed vessel **60**, a thermostatically-controlled, constant-level, impregnating box **61**, a perforated guide tube **62**, an insulated constricting steaming tube **65** having an inside diameter at the delivery end of 8 mm. and a steam inlet **63**, the tube **65** being placed vertically over the box **61**, and grooved pulleys **64** for drawing the top through the apparatus.

The feed vessel is charged with Du Pont Rhodamine B (C. I. #749), (0.25 oz. per gallon).

The dry worsted top is drawn into the impregnating vessel in a relatively loose tensionless manner through guide tube **62** becoming saturated with the dye solution through perforations **66** and is then drawn upward through the constricting-and-steaming tube **65**. The temperature of the impregnating bath is held at

212° F. The input of steam at point 63 is set to maintain a temperature of 212° F. during the passage of the top through the constricted steaming tube.

It will be understood that the above examples and drawing are merely illustrative and that the details of my procedure and apparatus may be varied within wide limits. Thus, the impregnating vessel described in Figure 1 and the procedure described in Example 1 are only intended to illustrate the principles involved, and do not necessarily have to go together.

While the above examples are concerned mainly with the application of aqueous dye baths, it will be clear that the same apparatus and procedure can be applied to dyeing from other liquid media, for instance, alcoholic media; also, to other processes than dyeing, for instance treatment of continuous lengths of textile fiber with liquid treatment baths for such purposes as bleaching, stripping, impregnation with water-repellency agents or with crease-proofing or other surface-modifying agents.

The apparatus of this invention may be made of any convenient material. For instance, the constricting or developing tubes may be made of glass, stainless steel or any other acid-and-alkali-resistant material which has or is capable of being finished with a smooth inner surface.

The constricting outlet at the end of the tube may be integrally formed therewith, as for instance in the case of a glass tube, or it may be detachably mounted on the end of the tube, as for instance by screw threading in the case of a steel tube. In the latter event, the same apparatus may be used for dyeing fiber bundles of different dry diameters, the nipple in each case being merely exchanged for one that will properly handle the given size bundle and reduce its retained liquor-content to the desired percentage.

The arrangement for feeding the liquid in the impregnating vessels 21, 41, etc., to a constant-level from feed vessels 20, 40, etc., in the above figures, may be replaced by any other convenient constant-level feeding device, these per se being well known.

There are many dyeing and treating processes which comprise a padding operation alone or a padding operation followed by a subsequent treatment. The impregnating vessel and restricting tube described in Figure 1 make it possible to carry out these padding operations in a small fraction of the volume required for the conventional pad box and squeeze roll arrangement. Furthermore, pad rolls are particularly adapted to evenly express the excess impregnating liquor from flat fabrics but when fiber bundles are passed between pad rolls there is a tendency for occurrence of thick and thin places in the bundle, which results in an uneven squeeze and consequently an uneven impregnation or padding. When the constricting tube is employed, the bundles in the wet plastic condition tend to equalize to the shape of the restricting tube resulting in a uniform retention of the impregnating liquor.

When the impregnating liquors contain dyes or treating compounds which partially exhaust during the impregnating step it is important that a constant-level and a constant temperature be maintained throughout the run to insure uniformity of treatment. Also, unless provisions are made to have less of these substantive ingredients in the impregnating bath at the start than are contained in the feed liquor to maintain a constant-level, the first yardage through will contain more of these ingredients than the feed liquor is set to maintain. This condition diminishes on running until conditions of equilibrium are obtained causing an undesirable taper.

When the impregnating liquors contain certain dyes or treating compounds which do not partially exhaust during the impregnating or padding operation the rigid control of temperature and level is advisable but not absolutely necessary.

As stated above this undesirable taper can be anticipated and eliminated by properly adjusting the concentration of the ingredients in the starting bath. It can also be minimized by keeping the volume of the impregnating bath to a minimum since the smaller the ratio of impregnating liquor to textile the quicker the conditions of equilibrium are reached. The apparatus and procedure described in Figure 1 and Example 1 provide a method and means especially adapted for the impregnation or padding of running lengths of unwoven fiber, requiring a minimum of volume, which is only a small fraction of that required for the conventional methods of padding.

Many dyeing and treating processes are accelerated by running at elevated temperatures. This procedure, however, is not always possible when large volumes are employed because certain dyes and treating compounds are not stable at elevated temperatures and undergo an undesirable change over a period of continued running. It will be noted that in Example 2 the feed liquor and small volume of impregnating liquor are kept at optimum temperatures while only the liquid retained in the fibers is subjected to the accelerating temperature. It has been observed that due to the quick replacement and the small volume of the impregnating bath, this too can be maintained at higher temperatures than would be possible by conventional means of impregnating or padding requiring larger volumes. The temperatures employed when using the apparatus described in Figure 2 may be varied within wide limits to produce optimum conditions for the type of process involved. Thus, heat can be applied to generate steam from the moisture retained by the fibers, or the parts of the apparatus may be jacketed and cooled with a suitable cooling medium such as cold brine.

The periods of dwell required to bring about the desired results in the various operations may be varied either by the rate of passage or by altering the effective length of passage.

Since more or less friction attends the passage of the fibers through the tube, progressively more pulling force is required to move the fibers as the length of the tube is increased. Thus, a limit to the length of tube that amay be employed for a given kind of fiber strand is reached when the tension builds up to a point that would be injurious to the fiber strand.

So that treatments may be carried out at a more practical rate of speed, means are needed to serve the three-fold purpose of supplying the pulling force to move the fibers through the tube, keep the fibers in the compressed state without further squeezing as might be the case with draw rolls and also to maintain temporarily the increased tensile strength imparted to top and slubbing by compression. This may be achieved

by an arrangement as shown in Figure 3. In this figure a feed vessel 30 feeds treatment liquid to a constant-level into the impregnating vessel 31, which narrows down into tube 32 and constricted outlet 33, substantially as shown in Figure 1. The fiber bundle after emerging from outlet 33 passes over driven grooved pulley 34, and after reversal of direction it enters a second tube 35, wherein for instance the treated fiber bundle may be heated by means of heating coils 36. After emerging through the constricting outlet 37, the fiber bundle passes over a second driven grooved pulley 38 and from there it may enter impregnating vessel 81 (provided with tube 82, constricted outlet 83, and draw rolls 84), wherein a similar cycle of treatment may be repeated or a different treatment may be applied. The relative speeds of driven pulleys 34, 38 and 84 may be adjusted and automatically regulated to keep the fiber bundle under proper tension at each stage of treatment.

Figure 7 shows an apparatus for achieving the same general purpose as in Figure 2, but in a somewhat modified manner. Just prior to the constricting outlet 73, the tube 72 is enlarged into reservoir 74 to receive the liquid expressed from the fiber bundle by the construction 73. This liquor may be continuously fed back by means of pump 75 into the impregnation-vessel 71, wherein it may be enriched by fresh dye liquor from a feed vessel 76.

Some classes of dyestuffs require gaseous treatments in their application. In Example 3 is described a treatment with steam for the application of an anthraquinone vat dye. The apparatus shown in Figure 4 may also be employed for treatments with acid vapors required for oxidation of the solubilized vat colors such as Ponsol Jade Green Soluble, or for coupling stabilized azoics, or for other gaseous treatments common to the dyeing and treating of textile fibers.

In Figure 4 it will be noted that the tube for gaseous treatments is constricted at both the entering end and the delivery end, and that the moving fibers act as a plug so to speak. Thus, steam may be employed above atmospheric pressures resulting in temperatures higher than 212° F. I have found this to be a valuable feature for certain processes.

U. S. Patent No. 2,318,133 describes a continuous process for the application of vat colors to wool. To obtain optimum results with this process it is necessary that the fabric padded with the reduced vat color enter the soda ash development bath while the vat color is still in the substantially reduced state. This cannot be satisfactorily accomplished with wool top employing the conventional padder because due to the loose nature of the top the reduced vat color oxidizes at a rapid rate immediately on leaving the squeeze rolls and before it can be entered into the developing bath. This condition prevails with cellulosic as well as animal fibers but to a lesser degree. When the process is carried out as described in Example 4 and illustrated in Figure 5, air is entirely excluded between the padding and development operations and a dyeing of very superior quality is obtained.

Running lengths of unspun textile fibers in the form of top, slubbing, etc., are fragile in nature and easily pulled apart. For this reason the wet processing of fibers in this form has hitherto been carried out in a machine wherein the running fiber lengths are supported and carried through the machine by means of a number of large driven rollers. These machines operate satisfactorily at lower temperatures, but boiling baths cannot be advantageously employed because the turbulence disarranges the loosely held fibers and often causes it to disintegrate. Figure 6 discloses a means whereby these fibers may be processed in a continuous manner at boiling temperatures.

I have found that the tensile strength of moving running lengths of otherwise loosely held fibers can be temporarily increased for an extended period of time by compressing the fibers in a tube of suitable inside diameter. The optimum inside diameter may be determined by the observation that, as friction which is attendant with the passage builds up tension, progressively more pulling force and in turn greater compression is required to impart additional tensile strength. With this observation in mind I have found that the effective length of the tube can be increased by decreasing gradually the inside diameter of the tube to hold compression and attendant friction to a minimum at the start and progressively increase compression as needed. When this type of tube is employed for impregnation or padding, the amount of liquor retained by the fibers is finally determined by the inside diameter of the delivery end of the tube.

I claim as my invention:

1. A process of dyeing textile fibers in unwoven form, which comprises passing a continuous bundle of said fiber through an impregnation bath, then through a constricted passage whereby to squeeze the fiber bundle to a predetermined moisture retention, and into a developing chamber wherein the impregnated dye liquor is fixed upon the bundle, said impregnation bath, constricted passage and developing chamber being so arranged as to form a liquid-sealed, air-excluding passage for the fiber, whereby the fiber is prevented from exposure to the atmosphere until after it has passed through the fixing stage.

2. A process as in claim 1, the developing and constriction being effected simultaneously by passing the fiber bundle from the impregnation bath into a tube having its entry port below the liquid level of the impregnation bath, and having a diameter sufficiently narrow to limit the moisture retention of the bundle to a predetermined ratio as it enters the tube, and said tube being provided with means for adjusting the temperature of the fiber bundle to the optimum developing temperature as it passes through the length of the tube.

3. A process for continuous dyeing of running lengths of unwoven and untwisted textile fiber with vat dyes, which comprises passing a bundle of said fiber continuously through an impregnation bath containing an aqueous, alkaline bath of a reduced vat dye, and through a constricting tube into a development bath, said constricting tube at its narrowest section being of a restricted diameter compared to the size of the fiber bundle whereby to squeeze said fiber bundle to a predetermined dye liquor content and being of sufficient length to enable the dye liquor to be absorbed uniformly by the fiber as it moves along the tube, said constricting tube being hydraulically continuous with said impregnation bath and having its free end immersed below the level of said development bath whereby exposure of the fiber bundle to the air and premature oxidation of the dye is prevented until after the dye has been developed on the fiber.

4. A process for dyeing of running lengths of unwoven textile fiber with vat dyes, which comprises passing a bundle of the same continuously through an impregnation bath containing an aqueous, alkaline bath of a reduced vat dye and then through a constricting tube into an oblong steaming chamber, said constricting tube having a restricted diameter compared to the size of the fiber bundle whereby to squeeze said fiber bundle to a predetermined dye liquor content, and said steaming chamber being of sufficient length to enable the dye liquor to be developed uniformly upon the fiber as it moves along the tube, said constricting tube being hydraulically continuous with said impregnation bath and having its free end immersed in said steaming chamber, whereby exposure of the fiber bundle to the air and premature oxidation of the dye is prevented until after the dye has been uniformly absorbed by and fixed upon the fiber bundle.

WILLIAM MARCY WENTZ.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
430,817	Anderson	June 24, 1890
786,774	Merrick	Apr. 4, 1905
1,001,435	Palmer	Aug. 22, 1911
1,180,267	Palmer	Apr. 18, 1916
1,209,880	Palmer	Dec. 26, 1916
1,535,251	Ramsey	Apr. 28, 1925
1,747,940	Kienle	Feb. 18, 1930
1,778,380	Conrad	Oct. 14, 1930
1,820,514	Waller	Aug. 25, 1931
2,137,256	Waldron	Nov. 22, 1938

FOREIGN PATENTS

Number	Country	Date
12,466	Great Britain, 1893	Apr. 28, 1894