Oct. 29, 1957 H. H. BELCHER 2,811,351

METHOD AND APPARATUS FOR FLUID TREATMENT OF TEXTILES

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Fig. 2

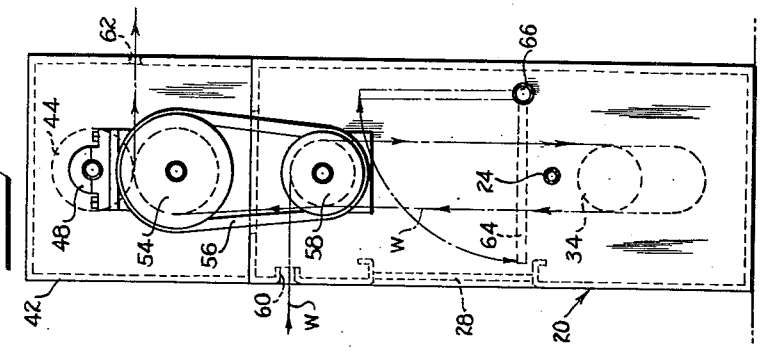
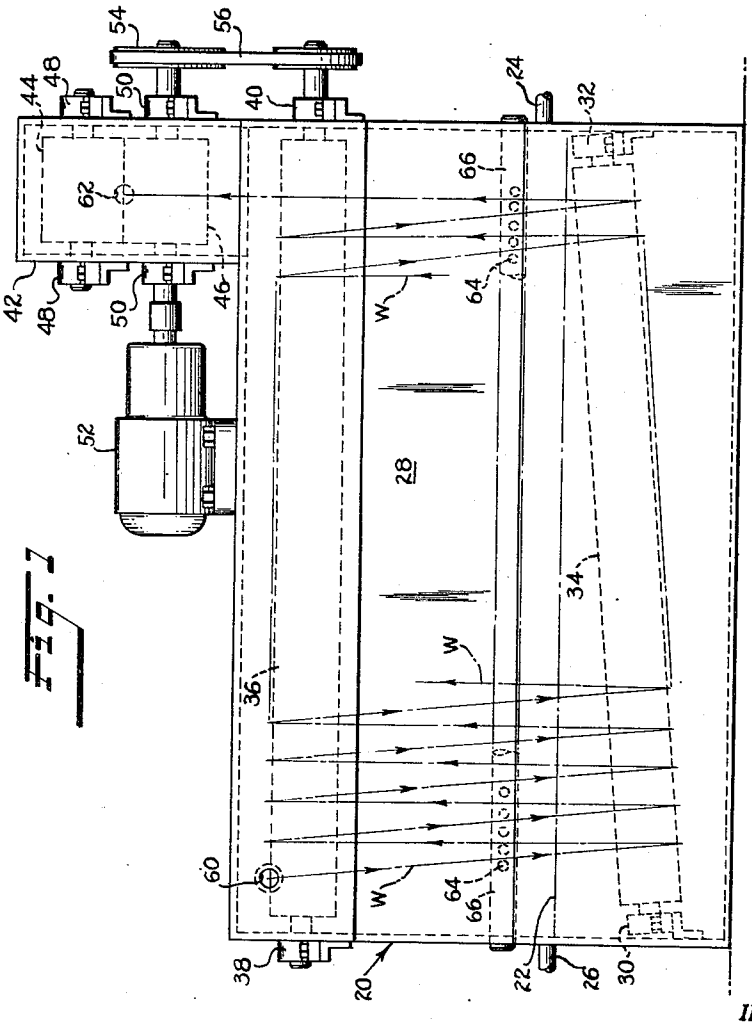


Fig. 1



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METHOD AND APPARATUS FOR FLUID TREATMENT OF TEXTILES

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This invention relates to methods and apparatus for handling continuous running lengths of materials such as textiles and more particularly to methods and apparatus for moving such materials at high speed through a fluid bath in a substantially tensionless condition.

As is well known in the art textile materials, in the conversion from raw to finished goods, are subjected to a number of physical and chemical treatments, such as washing, bleaching, dyeing and the like which involve the exposure of the fabrics to a fluid bath. In modern practice, batch processes have been discarded in favor of the much faster continuous processes in which the fabric is moved through the fluid bath in the form of a continuous web. In such processes the fabric is ordinarily moved over one or more upper and lower roll sets, the latter being immersed in the fluid bath, and the fabric is removed from the treatment chamber by a pair of nip rolls provided at the outlet end of the treatment chamber.

In such wet treatments the fabrics may tend to shorten or elongate. Consequently, if all portions of the running length of the fabric are moved mechanically through the bath at a constant speed, mechanical stresses arise in the fabric which may injure the fabric or prevent effective uniform treatment or, in the case of heavier fabrics, impose injurious stresses upon the mechanical apparatus for moving the web.

Many prior efforts have been directed toward the provision of apparatus for automatically compensating for variations in length of the moving web to eliminate or minimize the mechanical stresses in the fabric and advance the web in a susbtantially tensionless condition. The most effective known prior efforts to solve these problems are disclosed in Patents 2,474,717 and 2,618,142, the former being capable of handling materials in open width or rope form and the latter being particularly adapted for handling either relatively narrow webs or webs which are bunched laterally and commonly known as rope goods.

In each of these patents, tension in the cloth is minimized through the use of a bottom roll or rolls which are rotated at a speed such that their peripheral surface speeds are greater than the linear speeds of the fabric passing over the lower rolls.

The desired action in each of these patents depends upon slippage between the fabric and the bottom rolls when the fabric tension is low, the tension automatically providing sufficient traction on the fabric to equal the total resistance to cloth progression. Thus, the tension in the fabric while maintained at a relatively low value in the apparatus of each of the above mentioned patents nevertheless must be sufficient to overcome the resistance of the fabric to motion induced by mechanical friction and inertia of the fabric and the liquid carried by the fabric.

In the apparatus of Patent 2,474,717 mechanical friction which retards the web is produced by travel of the fabric over the stripper bar which has been found necessary to overcome the tendency of the fabric to adhere to or wrap around the lower roll and by the friction member which is deliberately used to retard the speed of the upper rollers to induce tension in the fabric to avoid overrunning or tangling and from the friction of the upper rolls.

In the apparatus of Patent 2,618,142, friction is produced by the similar stripper bar and also by contact of the fabic with guide bushings and pins which are necessary to guide the fabric in a helical path around the upper and lower rolls. Also in the apparatus of that patent, friction is introduced by the passage of the fabric over the upper rolls or bars which is minimized but not eliminated by expensive upper roll construction consisting of a plurality of independently mounted spools.

It has long been known in the art that the stability of a tensionless web handling system depends on the reduction of traction as tension is reduced so that overfeed of cloth does not occur to the point of building up an accumulation or pile of cloth at the exit side of the roll. For this reason, it was universally believed, prior to the present invention, that it was necessary to overdrive the bottom roll. Since the top roll is subjected to the weight of cloth which provides sufficient traction so that overfeed occurs even with no tension beyond the weight of the cloth the necessity for overdriving the lower roll can be definitely established in the case of dry cloth which is to be moved at slow speeds.

However, I have discovered, contrary to present practice, that, by overdriving the upper rolls the fabric web may be moved through a fluid bath at high speeds while subjecting the fabric to tensions appreciably below those produced by any known prior apparatus.

This action depends upon the dynamics of the web fabric moving at high speeds which having heretofore either been overlooked or misunderstood. I have discovered that when wet cloth is moved at high speed, the magnitude of the retarding effects of the friction caused by the passage of the fabric through the fluid bath, the resistance to motion caused by the difference between the weight of the uptravel strand full of fluid and the weight of the downtravel strand stripped of excess fluid and the power consumed in accelerating the water upwards with the uptravel strand is quite large as compared with the cloth weight effects and that slippage over an overdriven top roll occurs as tension decreases and before overfeeding of the cloth occurs. The tendency for slippage to occur before overfeed is augmented by the centrifugal force which throws the cloth away from the top roll reducing both the arc of contact and the pressure against the roll.

In accordance with another aspect of my invention I have discovered that the resistance to movement of the fabric and consequently the tension required to move it through a fluid bath in a helical path in the manner shown in Patent 2,618,142 can be further substantially reduced by the elimination of friction between the cloth and the guide bushings and pins between the upper and lower rolls. This is acomplished by inclining the axis of one of the rolls, preferably the bottom roll, with respect to the axis of the other of the rolls so that the advance of each loop is produced by the geometric relationship of the rolls rather than by mechanical guide structure. Guide pins may be used, if desired, to prevent excessive wandering of the cloth. However, the pressure of the cloth against the pins and consequently the friction on the cloth is minimized.

It is accordingly the major purpose and object of the present invention to provide novel methods and apparatus for moving continuous webs of textiles and the like at

high speed through a fluid bath under substantially reduced tension.

It is a further object of the present invention to provide novel apparatus for moving fabric webs at high speed through a fluid bath which is of simple, inexpensive and durable construction.

It is also an object of the present invention to provide novel methods and apparatus for moving fabric webs at high speed through a fluid bath with reduced power for a given linear fabric speed.

It is an additional object of the present invention to provide novel means for threading and guiding a fabric in a helical path.

It is also an important object of the invention to provide novel methods and apparatus for moving fabric webs at high speed through a fluid bath which increase the uniformity and effectiveness of the fluid treatment.

It is a further object to provide novel methods and apparatus for advancing a fabric web at high speed through a fluid bath at substantially reduced tension by the utilization in a novel manner of the dynamics of the moving web.

These and other objects are accomplished by rotating the upper rolls at a surface speed exceeding the linear speed of the fabric passing over the roll and by disposing the upper and lower rolls in a novel relationship in which the axes of the rolls are angularly related to provide an automatic substantially frictionless feed, as will become apparent as the description proceeds in connection with the accompanying drawings in which:

Figure 1 is a front elevation of a preferred form of the apparatus constructed in accordance with the present invention; and

Figure 2 is an end elevation of the apparatus of Figure 1.

The present invention is primarily adapted for use in the handling of fabrics in rope form and it has been found that for washing, bleaching and other fluid treatments the substantially tensionless feeding of fabrics in rope form greatly improves the fluid treatment. So long as the fabric progresses through the apparatus in substantially tensionless form there is a certain amount of ballooning and contracting action which seems to improve the penetration of the fluid into the fabric and thus enhance the washing, bleaching or other action. The novel threading features of my apparatus are not however limited to fluid treatments or to the handling of fabrics in rope form but are equally adapted to the handling of narrow dry webs or tapes.

Referring now more particularly to drawings, **20** indicates a vat for holding treating fluids such as dye liquor, bleaching agent or a washing fluid. The vat **20**, which may be of any conventional design and per se forms no part of the present invention, is ordinarily filled with the treating fluid to the level indicated at **22**. The fluid may be supplied through a conventional pipe connection **24** and overflowed through a pipe **26** to provide a counterflow of the treating fluid. The vat **20** is provided with one or more access doors **28** to permit manual handling of the fabric when necessary and to permit inspection and repair of the apparatus within the vat.

Rotatably mounted in corrosion resistant bearings **30** and **32** which may be mounted externally or internally of the vat below the level of the fluid **22** is a lower roll **34** which may be of any suitable form and is preferably formed of non-corrosive material such as stainless steel. It will be noted that the bearing **32** is disposed above the bearing **30** so that the axis of the roll **34** is disposed at an angle to the horizontal for a purpose to appear. A similar upper roll **36** is mounted for rotation about a horizontal axis in bearings **38** and **40**.

A nip roll housing **42** is mounted on the upper surface of the vat **20** by any suitable means and contains conventional nip rolls **44** and **46** journalled in the respective upper and lower bearing sets **48** and **50**. The nip rolls are of conventional construction and preferably are resiliently pressed together for squeezing the fabric as it exits from the treating apparatus. The lower nip roll **46** is driven by any suitable means such as an electric motor **52** and frictionally drives the upper nip roll **44**. Drive is also transmitted from the motor **52** to the upper roll **36** through the lower nip roll shaft, a pulley **54** mounted thereon and a belt or chain **56** which passes over a pulley **58** mounted on the projecting end of the upper roll shaft.

The nip roll housing and the main vat are in open communication so that the fluid squeezed from the fabric will be returned to the main vat.

The apparatus thus far described is particularly suited for handling a continuous running length of material, indicated by the broken line W, which may be either a narrow flat web or fabric in rope form. The web W enters the apparatus through an eyelet **60** which is located at one end of the vat substantially at the level of the top of the upper roll **36**. The web then passes over the upper roll **36** downwardly into the fluid bath under and around the lower roll **34** and successively around the upper and lower rolls and is finally withdrawn from the vat by the nip rolls and exits from the apparatus through the eyelet **62**.

It is a feature of the invention that both threading and advancing of the fabric in operation are accomplished automatically because of the relation of the axes of upper and lower rolls. The apparatus is initially threaded by looping the strand once around the upper and lower rolls and securing the free end to the adjacent portion of the web by an elastic connection to form a closed loop. The apparatus is then slowly operated and the fabric automatically advances toward the right of the apparatus as viewed in Figure 1 and when the initially formed loop has reached the right end of the apparatus, the elastic connection is removed and the free end passed through the nip rolls and the eyelet **62**. The mechanism having been thus automatically threaded is ready for high speed operation. In operation, the web continues to follow the path established by the initial threading.

The automatic lateral advance of the web is due to the fact that as the web leaves either of the rolls it tends to approach the other of the rolls at right angles to the axis of the latter. Accordingly, the rate of advance is determined by the relative inclination of the axes of the two rolls. By proper selection of the relative inclination of the two rolls by inclining the lower roll, the upper roll, or both, the fabric may be caused to advance at a predetermined rate without the use of guide pins or bushings. For example, assuming that the roll axes are sixty inches apart at the center of the machine and that a six inch cloth advance is desired at this point, the angle of inclination of the lower roll is the angle whose sine is 6/60. In a roll eight feet long the natural advance at the high end is 6.48 inches and at the low end 5.52 inches. This variation in advance rate will not adversely affect the operation of the machine. However, uniformly spaced light guide pins **64** mounted on a pivoting rail **66** may be swung into position after threading, if desired, to provide a constant rate of advance. In the example given, such pins would deflect the fabric only .48 inch from its natural path. Pins spaced in accordance with the natural advance of the web may be used to prevent excessive wandering of the cloth. Thus, even when the guide pins are used, the frictional contact between the web and the guide pins is minimized and the pins which are subjected only to low stresses may be of light, inexpensive construction.

While the automatic advance of the web and the elimination of the friction producing guide pins and bushings substantially reduces the tension in the fabric web, the principal feature of the present invention which contributes in large measure to the minimization of the web

tension is the relation between the linear speed of the fabric and the surface speed of the upper roller. As stated above, I have discovered that when, contrary to prior practice, the surface speed of the upper roll exceeds the linear speed of the adjacent fabric, the tension in the web is reduced below the minimum values heretofore thought obtainable.

The linear speed of the fabric is established primarily by the speed of the nip rolls 44 and 46 which withdraw the fabric from the apparatus. However, the actual linear speed of the web at any given point within the apparatus may be appreciably above or below the linear speed established by the nip rolls because of the shrinking or stretching of the fabric as it passes through the fluid bath. The fabric may stretch at one point and shrink at another, thereby producing wide variations in the linear speed of the fabric from point to point through the apparatus. I have discovered that such variations in the linear speed of the web whether uniform or non-uniform do not produce tension anywhere in the fabric beyond that necessary to overcome its resistance to progression through the bath as long as the surface speed of the upper roll exceeds the maximum linear speed of the web at the upper roll. The differential between the surface speed of the upper roll and the linear speed of the fabric ordinarily is not critical and thus does not require close control nor a change of speed ratios between the upper roll and the nip rolls for different fabrics having differing susceptibilities to stretch and shrink.

Where desired, a graduated overdrive may be obtained by the use of a tapered upper roll. Also, the relative speeds of the upper roller and the nip rolls may be obtained by introducing a conventional variable speed drive between them.

It has been found that the overdrive of the upper rolls combined with the inclination of the lower roll is sufficient to reduce the web tension to a value which will normally prevent damage to modern fabrics regardless of the wet process to which they are subjected. However, the tension in the apparatus may be further reduced if required in special instances by driving the lower roll 34, which is herein disclosed as an idler roll, either at the same peripheral speed as the upper roller 36 or at a speed such that its peripheral speed approximates the linear speed of the fabric. However, if the lower roll is overdriven, stripper bars must be employed which may largely nullify the advantage gained from the overdrive.

The presently described apparatus is effective when operating at high linear web speeds such as present day commercial speeds of 100 to 300 yards per minute. At this speed the three factors of water friction, water lift and water acceleration provide sufficient retarding action to prevent overfeed of the cloth but at the same time the forward propelling effect of each contact on the top roll effectively progresses each loop of cloth to the point of minimum tension.

This reduction in web tension, in addition to decreasing the stresses imposed on the apparatus and eliminating the possibility of injury to the fabric, also relaxes the fabric and permits increased ballooning. This assures maximum exposure of the fabric to the treating fluid, thus reducing the required immersion time and promoting uniformity of the treatment.

From the foregoing it will be apparent that I have attained the above stated objects of the invention by the provision of a new and improved method and apparatus for the high speed tensionless handling of webs of material. The apparatus is extremely simple in construction and the rolls are of simple one-piece construction which can be manufactured and replaced when required at minimum expense. By the elimination of many parts heretofore used in apparatus of this kind the expense of the mechanism has further been decreased and the power required to produce a given linear fabric speed has been consequently reduced.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. For example while I have shown an apparatus for passing a running length of material through a fluid bath in a helical path it is to be understood that the invention has equal application to an apparatus having a series of upper and lower rolls over which the moving web is successively passed as shown for example in Patent 2,474,717. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

What is claimed and desired to be secured by United States Letters Patent is:

1. A method for moving a continuous fabric web through a liquid bath at high speeds, which web may change in length during its passage through said bath, comprising the steps of removing said web from said bath at a predetermined linear speed, supporting said web over said bath in a series of downwardly concave loops, and applying a frictional rotary force to said web at said loops at a speed in excess of said predetermined linear speed by an amount exceeding the maximum variation in speed of the material resulting from the change of length of said web so that the drag resulting from withdrawal of the web from said bath exceeds the friction between said web and said force.

2. Apparatus for the high speed fluid treatment of an elongated fabric web which may change in length during treatment, comprising an enclosure adapted to contain a treating fluid, means for removing said web from said enclosure at a predetermined linear speed, upper roller means above the fluid contained in said enclosure for supporting a portion of said web within said enclosure in a series of downwardly concave loops, lower roller means positioned within the lower portion of each loop, and means to drive said upper roller means at a peripheral speed exceeding said predetermined linear speed by an amount exceeding the maximum variation in speed of the material resulting from the change of length of said web so that said upper roller means slip forward relative to the adjacent portions of said web regardless of the variations in the length of said web.

3. The apparatus as defined in claim 2 wherein the axes of the upper and lower roller means are angularly related and lie in the same vertical plane.

4. The apparatus according to claim 3 wherein the axis of the upper roller means is horizontal and the axis of the lower roller means is inclined with respect thereto.

5. Apparatus for moving a continuous fabric web at high speeds through a liquid bath comprising a container for a fluid bath, upper and lower roll means; the lower roll means being located within the container and the upper roll means being located above and in spaced relation to said container, the web passing over the upper roll means and under said lower roll means through the apparatus, pulling means for withdrawing the web from said apparatus and means for rotating the upper roll means at a peripheral speed which materially exceeds the linear speed of the fabric web coming from the container such that the drag on the fabric web coming from the container exceeds the friction between the web and the upper roll means, whereby said upper roll means slips forwardly relative to said web.

6. Apparatus as defined in claim 5 in which the upper and lower roll means consist of single rolls whose axes lie in the same vertical plane and in which the web passes over the upper roll and under the lower roll helically along said rolls.

7. Apparatus as defined in claim 6 in which one roll is inclined toward the other in the direction of the pulling means.

8. A method for moving a continuous fabric web through a liquid bath at high speed, which web may change in length during its passage through said bath, comprising the steps of introducing said web into said bath, removing said web from said bath at a predetermined linear speed, supporting said web in a series of downwardly concave loops over said bath with depending portions of said web immersed in said bath, and advancing said web by contacting the inside of said loops above said bath with a member moving at a peripheral speed materially exceeding the maximum linear speed of the web of the loop which it contacts to create a sliding frictional drive between said loop and said member, the peripheral speed of said member exceeding any linear speed imparted to said web by change in length.

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