

Oct. 2, 1962

S. H. WILLIAMS

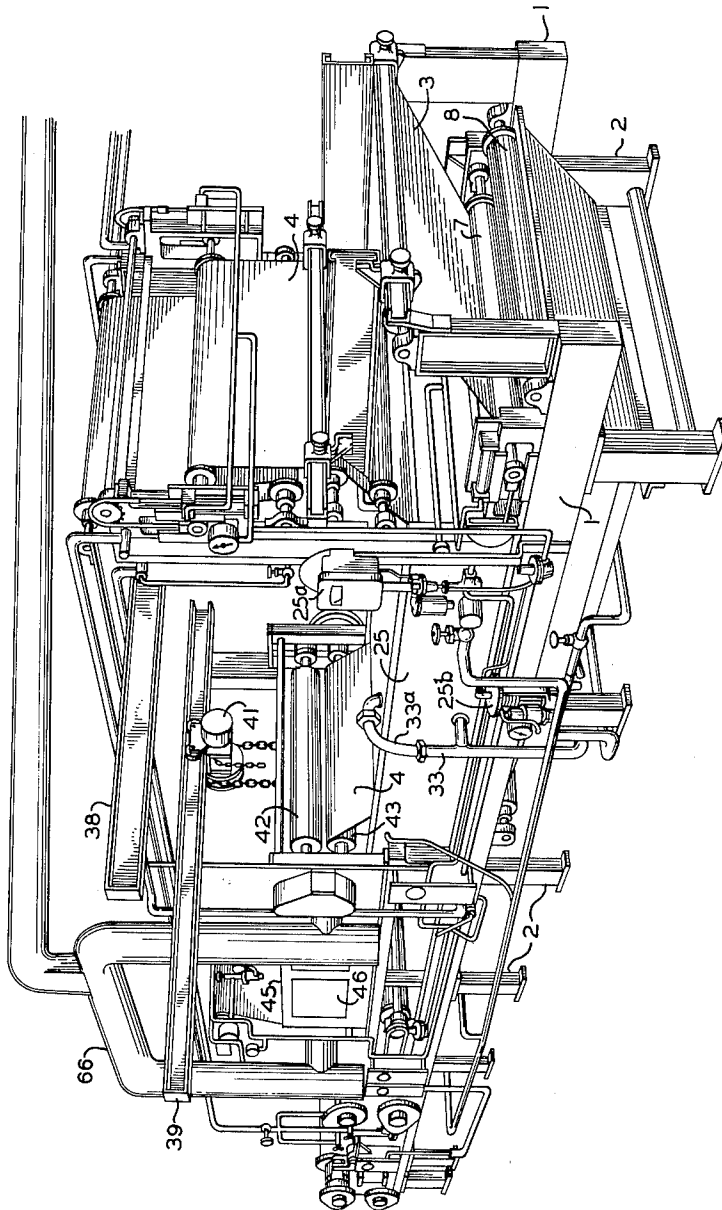
3,056,275

FIBER PROCESSING MACHINE

Filed Dec. 23, 1957

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Fig. 1



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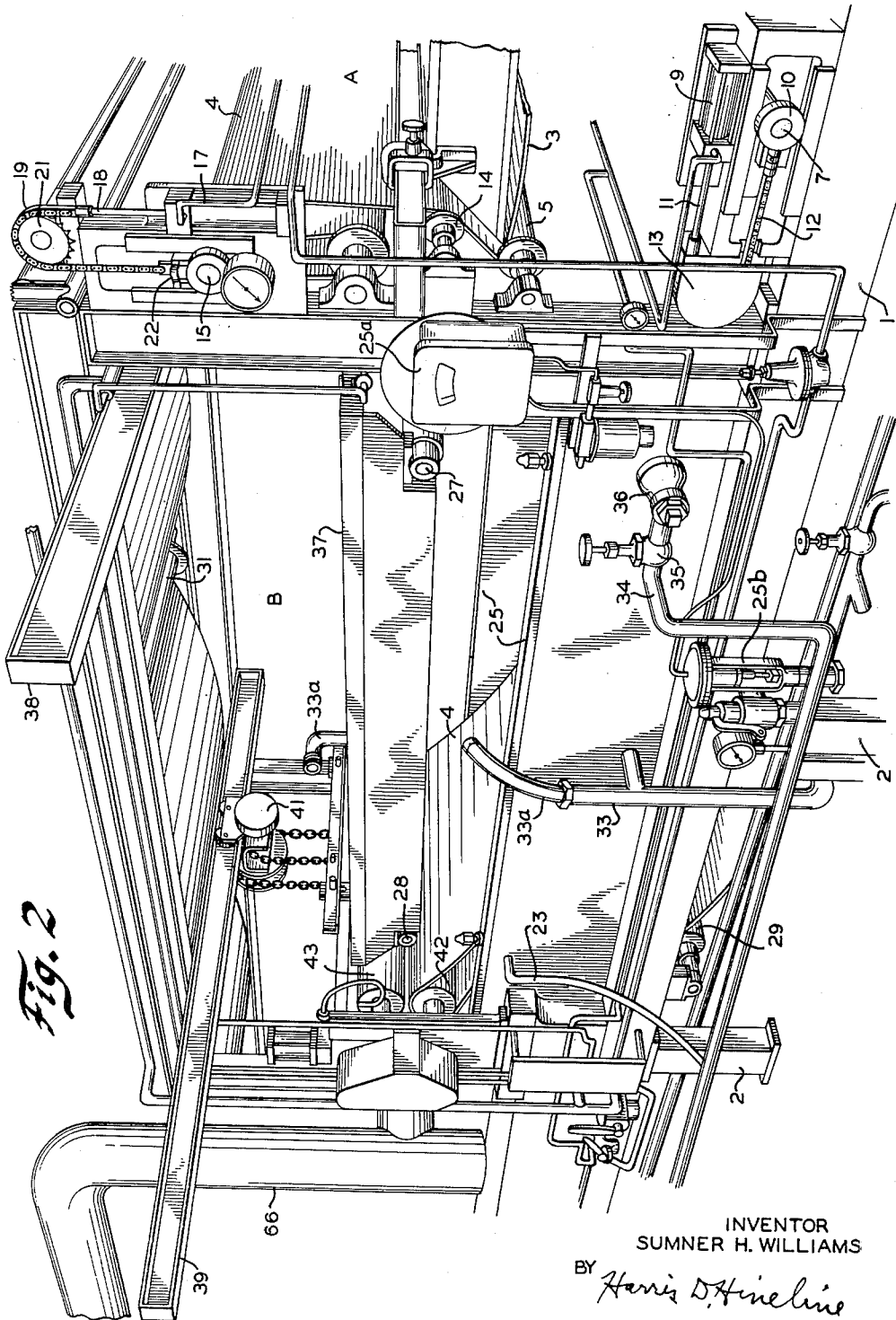
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FIBER PROCESSING MACHINE

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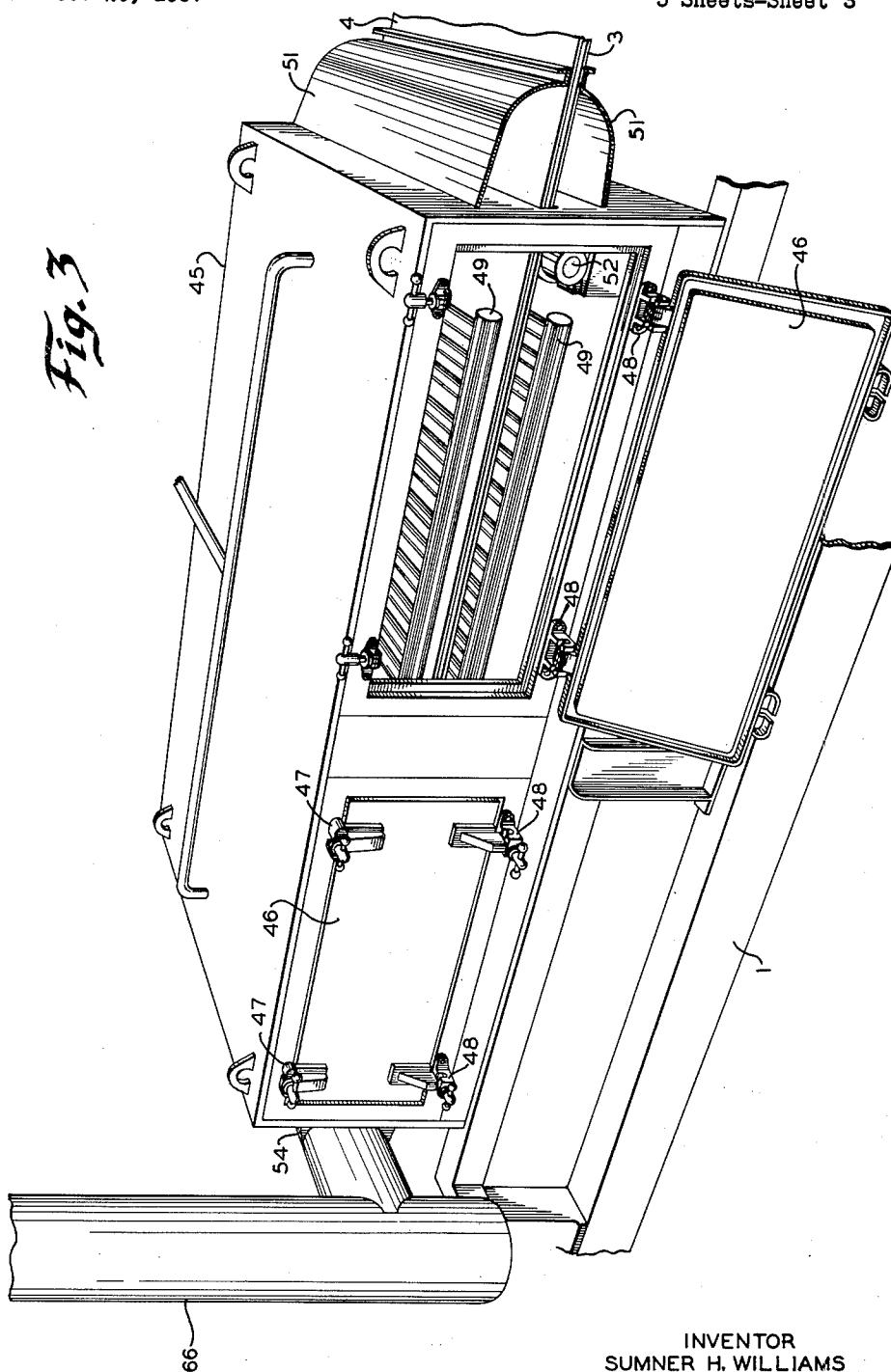
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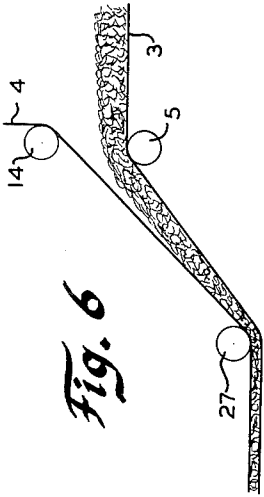


Fig. 6



Fig. 5

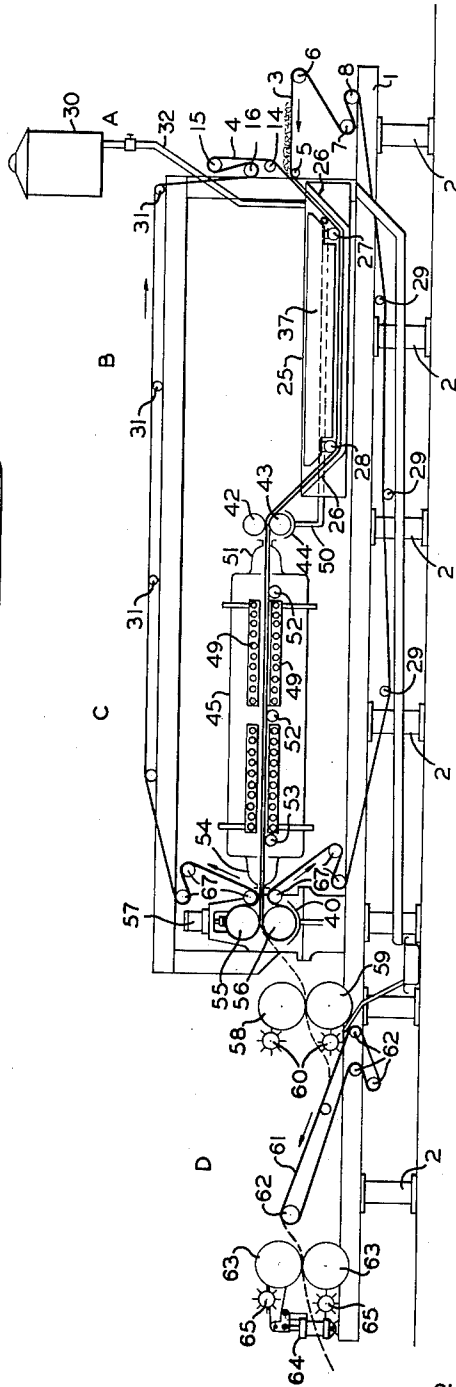


Fig. 4

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Fig. 8

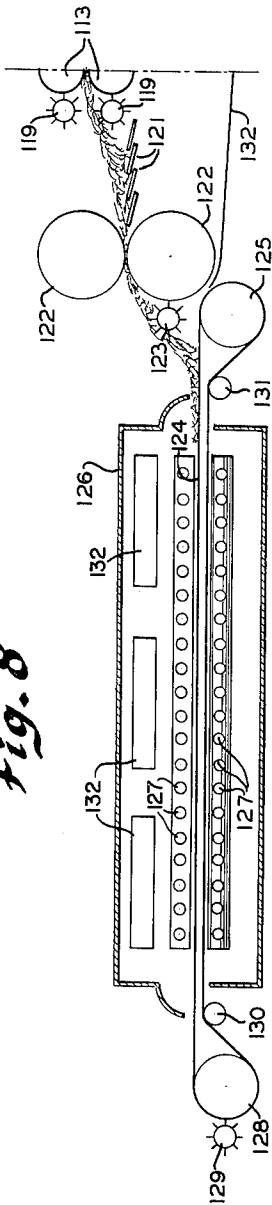
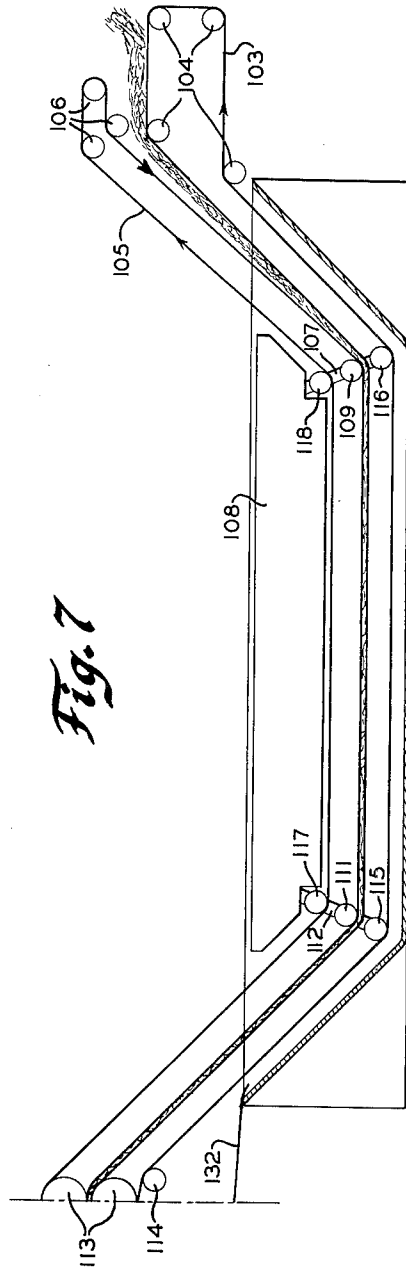


Fig. 7



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3,056,275

FIBER PROCESSING MACHINE

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3 Claims. (Cl. 68-15)

The invention here presented is a new and useful machine for the treating of materials, which is especially useful for the treating and processing of loose fibres in the form of loosely matted sheets or bats, or sliver, but is equally applicable to fibres in any other form, whether felted, spun, woven, knitted, or the like; and the device is particularly useful for dyeing, bleaching, chemical treating or otherwise processing such materials in any appropriate form.

Almost all commercially utilized fibres are given a dye, or chemical, or bleach treatment, or the like at some stage between the production of the raw fibres, and the delivery of the finished materials in the form of a fabric, and this treatment may be applied at almost any stage of the manufacture of materials into fabrics or cloths. For many purposes, it is particularly desirable that the fibers be given a dye, chemical, or bleach treatment prior to spinning, while the fibres are in a loose, free state, such as for example, baled cotton from the gin or at other such times as at the time of delivery from the carding or other steps prior to or after the fibres are made into cloth, in the case of cotton or wool particularly. The device of the present invention is particularly adapted to the processing of materials at any stage prior to the spinning operation and it includes means for holding the materials in a lightly matted sheet of uniform thickness and applying the dye solution, chemicals or bleach solution, or the like to the materials while held in sheet form. However, the device is equally well adapted to the dyeing, starching, bleaching, chemical treatment or processing at any stage such as after spinning, after weaving or knitting, after felting or the like. Many fabrics, whether woven or knitted, because of their construction, require processing under no tension. Such fabrics can be processed through this machine without difficulty.

In the past, loose fibres have been dyed almost entirely by one or the other of two procedures, one of these consists in the step of packing the loose fibres into a container provided with a tight top, through which dye solution can be forced under pressure. This procedure has however, been found to be unsatisfactory in many cases because of the tendency of the dye solution to find channels through the packed fibres, when it is forced through under pressure, with the result that the fibres adjacent to the channels are fully dyed, but others at a distance from the channels are poorly dyed, resulting in very uneven coloring. In many forms of dyeing, color lakes and precipitates are produced on the fibre. When dye processes of this type are conducted in a pressure process, particles of the color lakes and precipitates are formed elsewhere than on the fibres, and the resulting particles are filtered out onto the fibres either at the top or bottom of the tank, according to the direction of flow of the dye solutions. The presence of such particles causes trouble in the subsequent spinning and carding processes since there are strongly adherent precipitates on the fibres which cannot be easily washed out of the stock.

The alternate procedure has been to throw the loose fibres in bulk into a tank of dye, transferring the loose fibres from tank to tank of dyestuff until they are fully dyed. This procedure however, is objectionable because of its dirtiness and the almost unavoidable irregularities in depth and coloring in the resulting dyeing; as well as the unavoidable loss of quantities of valuable dyestuffs.

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In addition, with both of the prior procedures, particularly when the sulphur dyes are used, the dye solutions are not exhausted by either process and approximately one-third of the valuable coloring material is discarded. That is, a sulphur dye by its nature, permits of the use of only about two-thirds of the dye in a given solution; perhaps an equilibrium action occurs. Accordingly, if a sulphur dye is used for pot dyeing, one-third of this rather expensive dye must be discarded. Some mills put these residues of dye solution into storage tanks with the thought of adding additional dye to the solution, strengthening it; but such procedure requires a storage tank for each color and since the quantity frequently is large, and the variety of colors substantial, an excessive amount of space is required for storage of sulphur dye and there is a strong tendency for the solution to become contaminated and spoiled, whereupon the residual dye solution must be discarded anyway.

The process and apparatus of my invention provides a continuous material treating machine suitable for use on materials in any form, whether the loose raw fibers or lightly felted sheets, or bats, or sliver, or spun, woven, knitted, or felted; whereby the materials in any form are held between tensioned woven wire belts which are permeable to the processing solution, but provide sufficient pressure, throughout the processing, upon the fibres to prevent lumping, wrinkling, or displacement of the fibres in any way whatever in the entire sheet whereby the materials in any form are held in a uniform thickness or layer suitable for very even processing.

Furthermore, the dyeing vat of the present invention is presented in the form of a narrow channel through which the material is carried, while the channel is filled with dye solution. This dye solution is circulated through the channel and from a small storage tank in which additional fresh dye may be dissolved so that a relatively very small amount of dye solution is needed and the dye solution is, in effect, used over and over with the result that the loss of dye is small. That is, in the embodiment here described the amount of dye solution required is approximately 70 gallons, which is sufficient for the dyeing of a practically unlimited amount of fibres since this circulating solution is strengthened by the addition of more solid dye material as the dye is used up with the result, if a given run is of any reasonable length, the amount of dye discarded with the rejected solution is negligible, thereby effecting an important saving in the cost of dye, and an outstanding economy of operation.

By the device of the invention, a plurality of treatments can be applied to the materials in succession by passing the materials sandwiched between tensioned permeable wire belts, through whatever baths and treatments may be required. In the present embodiment there is shown a single bath treatment followed by a single steam treatment. However, the machine and processes are not limited to this particular procedure, since it is convenient to supply more than one bath step, and if desirable, more than one heating, steaming or vapor treating step, according to the requirements of the dye or fabric.

When the desired dye can be applied from a single solution, only one vat, tank, or tray, need be used for the dye solution; the materials being submerged in the dye solution between permeable wire belts passing through the dye container. The fibres are gripped between the belts at a convenient point at or in the vat and carried, under pressure, through the dye solution to the exit end, entrance and exit being made at an easy angle, not over 45° from the horizontal. At the exit end, the belts with the contained fibres are passed between squeeze rolls under pressure depending upon the amount of dye solution to be carried along with the fibres which then pass through a steam oven, the depth of dyeing being

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determined in part by the amount of dye solution left in the fibres after this first squeeze treatment. The excess dye solution is caught in a trough under the squeeze rolls and drained to a sump from which it may be returned to the tray or vat, or may be delivered in whole or part to a storage tank in which the dye content is reinforced and increased for return at full strength to the vat. It will be noted that there is sufficient stirring of the dye solution in the vat so that the concentration remains nearly constant throughout the vat and the total amount of dye incorporated into fibre depends in part upon the dye concentration as delivered to the vat and in part on the amount of dye solution carried out in the fibres from the first squeeze roll treatment.

It may be noted that as the materials enter the tank, they meet two things, to wit, a fresh portion of dye solution from the dye tank sufficient to make up for the amount of dye liquor carried out of the vat in the fibres after passage through the squeeze rolls, and the returned dye solution drained from the squeeze roll operation. It may be noted that with most dyes there is not too much difference in dye concentration between the makeup solution and the return solution.

After the unit treatment in solution, the materials are drawn out of the dye bath at an easy angle, and may be passed, while between the woven wire belts, through mangles or squeeze rolls, or pressure rolls to squeeze out part of the solution, it being possible to bring the moisture content of the materials which leave the bath with several thousand percent of excess moisture, down to a uniform moisture content of about several hundred percent.

It may be noted that in the dye vat the materials, whatever their form, must be held between two permeable belts under sufficient compression to insure the absence of movement; and the two belts may be continued not only through the squeeze rolls at the vat exit, but also through the following steam chest. However, it is not essential to the invention that the top belt be carried through the steam chest. It may be stripped away from the material sheet immediately after passage through the first squeeze rolls and returned over appropriate guides to the input end of the machine for recycling, and this is the preferred form, since it very materially shortens the length of the upper belt reducing the power needed for driving and reducing the cost of the belt. This is particularly the case with cotton materials and other materials may in some instances require that the belt be continued through the steam chest.

The materials, in whatever form, while still between or on one of the woven wire belts then may be passed into a steam chest in which they may be treated by moist or superheated steam at atmospheric or superatmospheric pressure, by the simple expedient of heating the steam chamber with high pressure steam in pipe coils. The heating may be accomplished by steam at low pressure or high pressure in hollow plates above and below the line of travel of the belt and material. As another alternative, substantial size chests containing steam under any desired pressure may be positioned above and below the line of travel of the material. In some instances, it is desired to use direct steam which may be superheated steam if desired in order to provide extra heat for setting the dye and evaporating some at least of the dye solution carried from the vat. In such a case it is usually desired that steam jets be provided impinging upon both sides of the material through the permeable belts.

The steam oven serves primarily to set the dye and may serve secondarily, to reduce somewhat the moisture content in the material. That is, the moisture left in the material after passage through the first set squeeze rolls remains in large part in the material during its passage through the steam chest. The heat from the steam in the chest whether in the coils or live steam serves to raise the temperature of the dye solution in the material, thereby accelerating the chemical reaction in the dyeing

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during the passage of the materials through the steam chest.

After the materials leave the steam chest, the excess moisture or in some instances excess dye solution is squeezed out to as large an extent as possible by passage through a second pair of squeeze rolls under a relatively much higher pressure than with the first rolls.

For most purposes a single unit or tank of solution is sufficient, but it is within the scope of the present invention to provide a plurality of solution tanks or units through which the materials may be carried while held between the woven wire belts, the belts and the contained fibres being lead directly from one tank of solution to the next, if desired, or if the process calls for it, they may be passed between pressure rolls, interposed between successive tanks or units to limit to a minimum the carry-over of solution from one tank or unit to the next.

The woven wire belts are kept under considerable uniform tension at all times during travel through the machine with the result that the materials are always held with sufficient firmness to prevent bunching or wrinkling of loose fibres or of woven, knitted, or felted sheets, and this fact of substantial tension upon the belts at all times gives a particularly advantageous handling of all materials including loose fibres which are, thereby, prevented from bunching between the carrying belts as is inevitable with any other form of conveyor. In addition, the belts enter and leave the successive processing units or stages at easy angles, less than 45°, and where possible, in a horizontal direction to minimize the tendency otherwise present of gravitation influence leading to bunching or wrinkling of the materials. Instead, the combination of pressure from the belt, plus the character of the belt, including the small openings, the transmission wires and the protruding humps where the wires cross each other, together with an easy angle of entrance and exit, results in a grip upon even the loosest mat of fibres sufficient to prevent any troublesome displacement; whereby these fibres are carried at all times in a uniform manner, such that complete uniformity of penetration of dye solution is obtained and an outstandingly superior uniformity of dyeing is produced.

The device is of general application to textiles or materials in any form or condition. It is particularly applicable to loose fibres such as cotton, wool, silk, nylon, Orlon, linen, hemp, viscose, rayon acetate, Acrilan, and both the natural and synthetic fibres of any form; and it is applicable to these fibres in any type of fabric not only loose fibres, but spun thread, woven or knitted materials, felted fibres and fibres in any form whether as finished fabric, warps and the like including tow, sliver, wood pulp either in the form of pulp or laid as paper from any paper fiber process.

The machine of the present invention treats the material without tension on the materials, but under sufficient pressure to prevent the development of tension in the material by slippage or non-synchronous movements during the processing; whereby all danger of bunching of fibres, or material, irregular laying of fibres or materials, bunching or wrinkling of fabrics in general are avoided.

A major object of the invention is to provide a machine, whereby a sheet of fibres are gripped between woven wire belts and held against relative movement while carried therebetween by the combination of the physical texture of the woven wire belts, and the tension on the belts, during which holding, the fibres or materials in any desired form may be processed through solutions, through which they are carried either in a horizontal direction or in and out under conditions of slight slope; whereby the fibres may be subjected to squeeze pressure between rolls without danger of lumping or shifting between the belts, and whereby the materials while fully relaxed are firmly held between the woven wire belts, and may be further processed through either moist or dry heat treatments.

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Thus the invention provides a machine by which materials are held between woven wire belts in a relaxed, untensioned state but gripped firmly between the belts and while so held are passed in an approximately horizontal direction through a plurality of treating processes, either hot or cold, wet or dry, which may include roll squeezing to remove surplus moisture, steaming and drying. Other objects and details will be apparent from the following description when read in connection with the accompanying drawings in which

FIGURE 1 is a side view in perspective of the machine of the invention.

FIGURE 2 is a side view in perspective of the vat portion of the machine of the invention.

FIGURE 3 is a side view in perspective of the steaming oven.

FIGURE 4 is a vertical view in section of the device.

FIGURE 5 is a view in perspective of a fragment of a desirable form of conveyor belt.

FIGURE 6 is a view in section of an alternative arrangement of the belts at the point of entrance to the dye vat.

FIGURE 7 is a view in vertical section of an alternative embodiment and

FIGURE 8 is a view in vertical section of still another embodiment.

Referring to the figures, there is provided a frame 1 supported upon columns 2. These structures provide means for holding the various sections of the machine in operative relationship. Upon the frame members 1 there are then mounted the various components of the machine which may be listed as a feed member A, a tank member B, an oven member C, and a delivery member D. There are then provided two continuous woven wire belts 3 and 4, which pass through the machine under the guidance of rollers as is particularly well shown in FIGURE 4.

The feeding section consists of a roll member 5 and a second roll member 6 between which the belt 3 passes to form a moving table upon which the fibres in any form may be placed. Below the roller 6 there is then provided a movable roller 7 and a stretcher roller 8, the belt passing around both rollers. The movable roller 7 is then pressured by a pressure cylinder 9 working through a piston rod 11 connected to a chain 12 passing over a pulley (not shown in housing 13) to a carrier 10 for the end of the roller 7 thus pulling the roller 7 in the direction of the arrow shown on FIGURE 4, taking up slack in the form of a loop as is particularly well shown in FIGURE 4. This mechanism provides means for keeping the belt 3 under controllable tension at all times by varying the air pressure in the tension cylinders 9.

Above the roller 5 there is then positioned another roller 14 over which the second belt 4 passes. A movable roller 15 and a stretcher roller 16 positioned above the roller 14 then provide a second tensioning loop, the roller 15 being moved by a cylinder 17, piston rod 18, and chain 19, passing over a pulley 21 to a carrier 22 for the end of the roller 15. It will be observed from FIGURE 1 that these tensioning members are provided in duplicate upon opposite sides of the section A.

Thus as it is particularly well shown in FIGURE 4, the input portion of the belt 3 in section A provides a flat table upon which the material to be processed can be placed. This table is particularly advantageous for the placing thereon of raw fibres, or any other form of materials which may be merely scattered or plaited in a moderately uniform layer by hand, or other mechanical feeding devices, or may be delivered thereto in the form of a bat, from baskets or convenient containers. Alternatively, the material to be processed may be fibres directly from the bale. For this procedure a standard bale breaker of well-known pattern may be positioned in front of the table portion 3, the bales dropped into the breaker and the resulting loose fibres are then delivered from the breaker onto the belt 3 at the feed position. Alternatively, the input may be

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made in the form of bats, already prepared and stored, prior to dyeing. Similarly, sliver, stored in baskets in the usual way, may be delivered to the input table of the machine, in which case of course a considerable number may be fed, each basket being replaced with a fresh basket as it is emptied. Likewise, a tow may be dyed by feeding the tow through the machine in which it is of course held strictly in its original relationship, and may be re-reeled at the discharge end as desired.

As another alternative, a felted or knitted or woven fabric is equally clearly placed upon this receiving table and in such instances they are usually conveniently drawn from a roll mounted upon a movable carrier (not shown) or convenient roll stand.

Section A thus provides a convenient feeding means for the fibres in any desired form; and appropriate tensioning means for the woven wire belts.

Section B then is built around a dye vat 25. The dye vat 25 may be an integral part of the machine, but for convenience in cleaning, it may be made removable and carried on the frame members 1. The ends 26 of the tank are desirably set at an angle which may conveniently range from 20° to 45° from the horizontal. This angle may conveniently correspond with the angle at which the wire belts enter the dye vat 25 and this angle is provided to permit the wire belts and contained fibres to enter the dye solution at any easy angle so that the weight of the contained fibres is not exerted in a direction parallel to the belts; thereby bringing the weight and gravitational forces inherent in the fibres to such a position that the pressure upon the belts and the rough surface of the wire belts has a grip upon the fibres which is greater than the gravitational forces. This is done to prevent bunching and wrinkling of the fibres as they enter the dye bath.

It will be observed that there are alternating forces involved at this point. Before the fibres are submerged in the dye solution, they have a substantial weight which tends to carry them downwards and force them to slide down the surface of the lower belt. The angle of slope must be such that the friction inherent in the combination of tension, pressure, and roughness of wire is greater than the gravitational forces tending to slide the fibres downward on the lower belt. When the fibres are submerged, the forces are reversed because of the fact that the fibres both directly, and because of occluded air, have a density considerably less than that of the dye solution, and accordingly they tend to float and slide upward along the surface of the upper belt. Thus there are opposing forces at the surface of the dye solution exerting a strong tendency to bunch the fibres and produce transverse wrinkles in the layer of fibres.

It is unexpectedly found that these forces can be overcome by the triple combination of rough woven wire belt, strong tension on the belt and a slope on the belt within an angle between 20° and 45° from the horizontal, the exact angle being dependent in part upon the nature of the fibres, in part on the density of the dye solution, in part upon the roughness of the belt, and in part upon the tension of the belts. For cotton and wool, an angle of 45° is not too steep, although a somewhat smaller angle may be sometimes preferred. For the slippery fibres such as rayon staple a smaller angle may be found necessary, again depending upon the roughness of the belts and the belt tension.

The exact position of roll 14 with respect to the roll 5 depends to a considerable extent upon the character of the material and the nature of the dye bath; and in addition, the character of interaction between the material and the dye solution. That is, with cotton fibres and the simpler dyes the roller 14 is desirably positioned so that the belt 4 makes fairly strong contact with the fibres on the belt 3 against the roller 5, as shown in FIGURE 4. This arrangement permits of maximum speed of travel of the belt but is contingent upon a rapid and easy wetting of the fibres by the dye solution. The speed of wetting

may be increased by the presence of wetting agents in the dye solution and excellent results are obtained.

However, in some instances the dye solution shows an insufficient speed of wetting of the cotton fibres to obtain full penetration of the dye solution into and completely through the layer of fibres, even when a wetting agent is included. When this situation occurs, the roll 14 may be elevated so that the belt 4 does not touch the belt 3 while it is in contact with the roller 5, but forms a "funnel" as shown in FIGURE 6. By this arrangement the fibres enter the dye solution through a condition of low pressure thereby permitting the dye to flow into the body of fibres which in some instances is sufficient to give complete penetration through the body of fibres. In other instances, penetration is not complete, but when the two belts reach the roller 27, the application of heavy pressure at that point squeezes the dye solution out of the surface layers of the fibres, forcing part of it inward into the core of the layer and part of it outward towards the surface. This effect results in very thorough penetration under conditions of high liquid pressure into the entire layer of fibres, without recourse to the use of wetting agents or surface active agents in the dye solution.

It may be noted that at the beginning of the movement of the fibres down the slope from the roll 5 to the roll 27, they are not initially held by pressure between the wire belts. Instead, the easy angle of slope of the belt 3 in combination with the roughness of the belt is sufficient to prevent relative movement during the small number of inches of travel before the upper belt takes hold.

The belts with the interposed fibres are carried under a roll 27, preferably pressed close to the bottom of the dye tank 26 and preferably close to the vertex of the angle between the end and the bottom of the tank. Another roll 28 is positioned at the other end of the tank 29 and the wire belts and interposed fibres are carried under this roll also. It will be observed that the rolls 27 and 28 are submerged in the dye solution and they are conveniently held in position by bearing boxes at opposite sides of the tank 25.

It will be noted that the ends of the tank are shown as having a slope which is followed by the belts and the interposed fabric. It is not, however, essential that the ends of the tank have the slope shown, but merely that the rollers 5, 14 and 27 be so positioned as to carry the belts and contained fibres into the tank at the specified angle, but the slope is desirable because of the saving in dye solution required to fill the tank.

The bottom belt 3 is returned to the roller 8 and carried by rollers 29, positioned underneath the tank 25, and the upper belt 4 is returned to the roll 16 in a path above the tank 25, where it is supported on rollers 31 as shown. The dye solution is supplied to the tank 25 from a mixing tank 30 as shown in FIGURE 4, through an input duct 32, and an overflow pipe 23, connected to the top of the dye vat, is also provided, and a drain 34, controlled by valve 35 and fitting 36, by which the dye tank may be drained as desired.

It is shown in FIGURE 2 that the rollers 28 and 27 are carried on the under side of a removable steam chest 37, which is shown in FIGURE 2 in raised position to permit of easy threading of the belts 3 and 4 through the tank 25. The chest 37 then is lowered into the tank 25, on top of the belts 3 and 4 after they are properly threaded. This is an operating convenience which also simplifies the cleaning of the tank. It will be observed that trolley rails 38 and 39 carrying hoist members 41 are provided for raising the chest 37 and sliding it side-wise out of the way.

The chest 37 carrying the rolls 27 and 28 is made in the form of a closed steam chest into which the dye solution does not enter. The result is that the amount of dye required for operation is only the small amount required to fill the channel through which the belts and material travel. This quantity is readily made considerably less

than 100 gallons in any size of machine, thereby effecting a very conspicuous saving in the quantity of dye solution required. The member 37 also serves for heating the dye solution. A flexible lead 33a is provided connected to the steam input pipe 33 and connected to the member 37 when it is in operating position, thereby providing ample heat for maintenance of the temperature of the dye bath which is usually somewhat below the boiling temperature at atmospheric temperature. An appropriate drain for condensate is provided, (not shown) although it is immaterial whether the member 37 is filled with live steam or with water at nearly the boiling point. In either event, a drain leading from the top surface towards the bottom of the tank is provided and connected through another, similar, flexible lead to a steam trap for discharge of condensate.

The tank member 25 also is desirably steam jacketed and a thermo regulator 25a is desirably provided coupled to a temperature sensitive member, (not shown) positioned within the tank 25 in contact with the dye solution. The regulator 25a controls a steam valve 25b which in turn admits steam to the jacket and frame member as needed to maintain the dye bath temperature.

There is also provided a liquid level controller which may be included in the case of the temperature regulator 25, or may be a separate device whereby the rate of flow of fresh dye solution to the dye member 25 is regulated in accordance with the height of the dye solution in the tank.

It will be observed that this structure provides a dye tank and means for the supply to and discharge from the tank of dye solution, as desired. There are also provided guide rollers and a frame for the support thereof which keep the woven wire belts submerged in the dye solution and carry the belts in and out at easy angles, the roller frame being readily removable from the tank.

At the output end of tank 25, there are provided wringer rolls 42 and 43 between which the belts 3 and 4 with the interposed material passes. Underneath these rolls there is then provided a trough member 44 having an outlet leading back to the dye tank into which the squeezed-out dye solution is entered. The trough member 44 may discharge directly back into the dye vat 25, as desired. However, experience shows that better results are obtained if this returned solution is delivered through pipe 50 to the entrance end of the vat along with the stream of replenishment solution of fresh dye.

The pressure applied between the rolls 42 and 43 may be adjusted according to the requirements of the materials in use; the criterion being that sufficient dye solution be left in the materials to give the desired depth of color, but no excess over that amount. Accordingly, the pressure on the rolls 42 and 43 varies according to the types of materials in use. It will be obvious that any dye solution squeezed out at this point is a worthwhile saving of expensive material, and only enough should be left in to complete the dyeing. It will be observed that as the fibres leave the dye solution they carry with them many times their weight of solution, the amount of solution being, by weight, from several hundred to several thousand percent of the weight of fibres. It is usually desirable to reduce this amount to such a value that the weight of solution carried is not more than an amount equal to the weight of the materials; up to an amount several times as much, depending, as before pointed out, upon the character of the treatment. The actual pressure upon the rolls then varies according to many factors and to the additional factor of the thickness of the layer of materials. The limitation upon the amount of pressure is of course the strength of the belts, and the pressure must be kept below an amount sufficient to damage the belt. On 48-inch rolls, the pressure may vary from about 50 pounds, or a little under, to as much as several hundred pounds for the total roll length.

From the dye bath section B, the fibres are delivered to the oven section C.

There is also provided an oven member 45. The oven section is provided with doors 46, held closed by latches 47 and hinges 48, insulating material being provided in the doors and walls to minimize the loss of heat. Within the oven there are then provided steam coils 49 for open steam and steam plates for elevating temperature. The woven wire belts 3 and 4 then pass from the wringer rolls 42 and 43 to the oven 45, through entrance members 51 which form a slot which is particularly well shown in FIGURE 3 for the entrance of the wire belts and fibres. An entrance roll 52 is provided just inside of the oven 45 to support the weight of belts and fibres. The belts then pass horizontally through the oven between the upper and lower heating coils 49 to an output roll 53, which is particularly well shown in FIGURE 4. The belts then pass out of the oven 45 after riding on roll 53 through a similar exit slot through members 54. After having passed through the slot, the belts and fibres pass between another set of squeeze roll members 55 and 56. As shown, provision is made for the application of pressure by pressure cylinders 57, operating on each end of the upper roll 55. The wire belts then pass respectively upward and downward around the respective rolls 55 and 56 to auxiliary rolls 67, as shown in FIGURE 4. By this procedure the belts are drawn away from the fibres which follow a path indicated by dotted lines on FIGURE 4 to another pair of rolls 58 and 59, by which they are transferred to a carrier belt 61 running over rolls 62.

Cleaning brushes 60 are provided in conjunction with each of the rolls 58 and 59 to insure discharge of the fibres onto the belt 61, by which they are carried up over the output roll of 62 and delivered to still another pair of rolls 63 in which pressure is also applied by a pressure cylinder 64. Cleaning brushes 65 are also supplied for the rolls 63 as shown in FIGURE 4.

From the rolls 63, the fibres may be taken and handled in any desired fashion. If the raw fibres are fed to the machine on the table portion of belt 3, they are discharged from the rolls 63 in a mildly felted condition, sufficient to permit them to be folded into a basket or wound on a roll as desired. Alternatively of course, if a woven or knitted fabric is processed, the fabric is delivered as woven or knitted from the rolls 63 and wound up on any convenient reel. Similarly, if a tow is processed it appears as parallel threads at the rolls 63 and may be wound up on a suitable reel as desired.

Almost any desired permeable belt may be used, including flat woven wire mesh of the order of sieve wire or the like, but it is found that a particular type of belt has worthwhile advantages. This belt is made of a considerable number of transverse wire spirals linked together by a transverse straight wire passing through the coils of adjacent spirals as is well shown in FIGURE 5. It is highly desirable that the belt wires be made of a corrosion resistant wire. Stainless steel is satisfactory, Monel metal and Nichrome are both fully satisfactory; bronze is also satisfactory for some uses. Stainless steel is however preferred because of its greater strength and stiffness and its high resistance to corrosion. It is of course desirable that the ends of the several wires be welded so that the straight locking wires, are held in position against transverse movement since otherwise the wires tend to work out of position whereupon the belt parts and the machine is out of operation. Since this structure also has the very great advantage that portions of the belt may be inserted and removed as desired and repairs may be effected without replacement of the entire belt.

In the operation of the machine of the present invention, the first step is the threading and splicing into it of the woven wire belts. These may conveniently be of any desired width from a foot or less to the maximum width needed for the processing of the desired fibres, which may be as great as 8 or 10 feet, or even more. When the wire belts are in place, a suitable dye solution is delivered

to the vat 25, and the frame 37 carrying the rollers 27 and 28 may be lowered into the vat and onto the upper wire belt. The weight of frame and rollers is usually sufficient to hold it in place, but it may if desired be fastened down in any convenient way. Tension is then applied to the belts, by the tensioning device shown in FIGURES 1 and 2. During this time, steam is turned into the heater coils to bring the dye vat and the oven 45 up to the desired temperature. When this is reached, the driving motor (not shown) is started and travel of the belts begun. When the belts are moving, the materials may be delivered to the table portion of belt 3 as shown in FIGURES 1 and 4. The preferred method of delivering loose fibres is in the form of a bat, which may be prepared directly from the bale of materials such as cotton or wool or other fibres, or may be derived from an intermediate step of the processing of the material.

Travel of the belts 3 and 4 then draws the material between them and puts the materials under substantial pressure, sufficient, as above pointed out, to prevent slipping or movement of the materials between the belts. The materials are carried onward and downward at an easy angle into the dye solution in the vat 25, through which they travel at a leisurely pace, sufficient to permit of proper absorption of the dye from the solution. In due course, the belts and the contained materials are carried outward from the vat 25, again at an easy angle, and allowed a brief interval to drain. The bolts and materials are then carried through squeeze rolls which press out the major portion of the dye solution. The belts and contained materials then pass into the oven which may be heated by steam under substantial pressure ranging from 5 to 150 pounds per square inch.

The dye solution is conveniently prepared in a tank which will hold substantially more than is required to fill the channel in the vat 25 and the dye solution is delivered, preferably by gravity through an appropriate conduit to the vat 25 where it is heated by steam in the jacket and in the inner frame 25. The surplus dye solution squeezed out from the fibres by the rolls 42 and 43 is collected, returned to the input end of the vat, and simultaneously a small stream of fresh dye solution is added, under the control of an automatic fluid level controlling device so that the channel through the tank 25 is kept full, but prevented from overflowing. If a large quantity of material is to be dyed, requiring more dye solution than can conveniently be prepared in the associated dye tank, an auxiliary mixing tank may be provided in which the dye solution is made up in proper concentration and delivered to the first supply and storage tank. By this procedure, a constant supply of fresh, full-strength dye solution is available for the dyeing operation, but no large quantity of dyestuff need be prepared in advance, and no difficulty is encountered in so scheduling the preparation of the dye solution as to permit the utilization of substantially all of the solution when the end of the run is reached. By this procedure the only discard of dye solution which need be made in the relatively small quantity required to fill the channel in the dye vat and even this quantity is readily exhausted to the point where the concentration may be one third or less than the original concentration. This procedure effects an outstanding economy in the utilization of the expensive dyes or other chemicals.

The oven 45 is at atmospheric pressure, and even though the heating coils contain steam at a substantially elevated pressure, that temperature does not, usually, provide sufficient heat to evaporate all of the moisture in the fibres, but it does bring the temperature well up towards the boiling point of water and accordingly the final dyeing stages and setting of the dye are readily accomplished. However, some of the moisture is usually evaporated and accordingly an exhaust pipe 66 is desirably provided for conveying the resulting steam away from the machine, as is well shown in FIGURE 2. The length of the oven

is such as to give a satisfactory baking of the fibres and setting of the dye. The belts and contained fibres then pass out of the oven 45 through squeeze rolls 55 and 56, where further pressure is applied and the fibres and belts cooled. The fibres then pass out in a lightly matted state through a second pair of rolls to a conveyor belt, and third pair of rolls to a collector which may be a reeling stand or basket or other receiver.

It will be observed that a major portion of the invention is the use of rough, permeable, carrying belts which apply substantial pressure to the contained fibres, plus entrance and exit into the dye bath at easy angles to minimize the effect of forces tending to bunch or wrinkle the materials.

In the above described embodiment, the bottom belt was shown as having been carried from the loading station A to the delivery station D with the materials, in whatever form they were treated, held in place on the bottom belt; with the upper belt carried along with the bottom belt, for the full length of the machine, or separated from the bottom belt before the fibres entered the steaming oven. For some uses these two arrangements are very much preferred. However, the fact that the bottom belt is drawn under the rest of the structure, leaves it out in the open air, where it cools off, wasting the sensible heat stored therein by the dye tank and steam oven, and requiring rewarming in the dye tank as it is returned thereto. Similarly, the upper belt is carried overhead, and allowed to cool in the same way thereby again requiring rewarming in the dye bath. In addition, a certain amount of dye solution is necessarily carried out of the dye bath by surface tension on the wire belt, and the transfer from delivery end to loading end in the open air, on the initially warm wire tends to cause an evaporation of water from the adherent dye, leaving flakes of dried dyestuff on the wire thereby returned to the dye bath. With many dyes, such dry particles dissolve promptly and cause no difficulty, and with many dyes, where a relatively low dye or chemical bath temperature is used, the loss of heat is immaterial, and the gain obtainable by carrying the fibres between the belts all the way through, to the final doffing roll, much more than counterbalances the minor loss of heat and the introduction of minor particles of dried dyestuff into the dye bath. However, in other instances, especially where a very hot dye bath is used, and one in which the dye particles are soluble with difficulty, it is highly desirable that the loss of heat and the production of such dye particles be avoided. This is easily accomplished by the procedure shown in FIGURES 7 and 8.

It is found, rather unexpectedly, that no difficulty is encountered in doffing the fibres from the wire belt immediately after emergence from the dye bath, and the fibres are easily transferred to another belt upon which they can be carried through the steam oven to the final doffing roll.

Referring to FIGURES 7 and 8, in this construction a short belt 103 is provided passing over rollers 104 at a loading station similar to that previously described. The fibres are placed upon the belt 103 at this point and transferred over a feeding roll into the vat, at which time a second wire belt 105 carried on rollers 106 is superposed upon the belt 103 under substantial pressure as above pointed out, and the belt with the interpositioned fibres passes at an easy angle into the dye bath, as previously described. A roller carrying support member 107 is provided and attached to a steam chamber 108, as before and the belts with interposed fibres are carried under a roller 109, supported by the frame 107, along the bottom of the vat to another roller 111, similarly mounted upon a frame 112 which in turn is carried upon the member 108. The belts and interposed fibres are then carried upward at an easy angle to another pair of rolls 113 which may serve as squeeze rolls to remove at least a portion of the dye solution, or may be merely support rolls. From the lower roll 113 the wire belt is then carried over a roller 114

underneath the roll 113, down to another roller 115 mounted on the frame 112, below the roller 111; and thence, along the bottom of the vat to another roller 116 similarly mounted in the frame 107, and upward, again preferably at an easy angle, back to the rollers 104 for reloading. By this procedure the bottom belt is out of the dye solution only long enough to discharge the fibres and later to be reloaded on the rollers 104 thereby limiting the time of exposure to the air to an interval short enough so that no significant cooling occurs and no troublesome drying of dye solution occurs. Simultaneously the upper belt 105 is drawn back from the roll 113 to a roll 117, also mounted on the frame 112 and thence along the bottom side of the member 108 to a second roller 118 and thence upward at an easy angle to the rolls 106 at the loading station. By this procedure, both of these belts are kept warm and moist with dye solution and the difficulties involved in cooling and drying are avoided.

In this embodiment doffing rolls 119 are desirable to insure complete removal of the fibres from both of the wire belts 103 and 105, although, as a rule, no serious difficulty occurs if small portions of fibres are carried backward through the vat and dye solution. From the doffing rolls 119, the fibres may be conveyed by any conventional means (schematically indicated as pusher bars by element 121 in FIG. 8 of the drawing) to another pair of rolls 122, which are preferably squeeze rolls. It may be noted that the type of wire belt shown in the figure does not permit of an intensive squeezing action and its presence, while necessary, limits the amount of squeeze which can be applied to the fibres and correspondingly limits the reduction in water content. In contrast, the rolls 122, having no wire belt associated therewith, can give a much more thorough wringer effect, thereby reducing the water content to the best value for use in the steaming oven. The lower roll 122 is desirably provided with a doffing roll 123 to transfer the fibres to another belt 124 carried upon a roll 125 permitting entry into a steam oven 126 which is desirably heated by steam coils 127, steam plates 132 or by live steam and pressure heated plates, as previously described. The belt 124 after conveyance through the steam oven 126 then is passed over another roll 128 at which the fibres are removed by still another doffing roll 129, whereafter the belt is returned, supported by rolls 130 and 131, through the oven to the roll 125 for reloading. By this structure, this belt also is prevented from cooling unduly, and from collecting dried dye particles.

The preferred embodiment uses but a single belt through the steaming oven, but since in some instances fibres may prove to be fluffy and curly to an undesirable extent, a second belt may be used to hold them in place on the first belt; in which case duplicate rolls 125 and 128 are provided and duplicate carrying rolls above the return portion of the upper belt.

As before, dye or chemical solutions squeezed out of the fibres by rolls 122 may be caught in a trough, transferred to a sump and returned by a pump to the vat, or a pan 132 may be provided over which the squeezed-out dye or chemical solutions may flow back to the vat.

The availability of this alternative embodiment, and the possibility of separating the belt at any desired time, either for the insertion or removal of additional lengths, permits the conversion of the first embodiment shown into this embodiment merely by making provision for three sets of rollers in the dye vat, and doffing rollers at the exit rolls from the dye vat.

It may be observed also that while the device is primarily intended for the processing of loose fibres, it is equally useful for fibers in any form, whether as batting or sliver, or spun threads or tow, or knitted or woven or felted fabric, thereby making a highly versatile machine capable of many diversified uses.

Thus the device and process of the invention provides wire belts placed close together with materials held be-

tween by tension on the belts and roughness of the belts, in combination with easy angles for entrance and exit into a dye bath to avoid bunching or wrinkling of the materials and obtain a very uniform, even, level dyeing of the materials in whatever form they are presented.

While there are above disclosed but a limited number of embodiments of the device and process of the present invention, it is possible to produce still other embodiments of the invention without departing from the inventive concept herein disclosed and it is therefore requested that only such limitations be imposed upon the appended claims as are stated therein or required by the prior art.

The invention claimed is:

1. In a fiber processing machine comprising a frame member, a tank adapted to contain a fiber processing liquid supported within said frame member and a plurality of belt carrying roll means, including adjacent paired rollers, supported by said frame member, a pair of endless wire mesh belts disposed, one above the other in said machine, each of said belts being supported upon and traversing said roll means; a plurality of roll means for supporting the upper surface of the lower of said belts at the start of its inward travel into said machine, said last mentioned roll means being spaced apart on a substantially horizontal plane and positioned in advance of the upper of said belts, whereby the upper inwardly traveling portion of said lower belt at the start of its travel into said machine forms a receiving table for the reception of fibers upon said lower belt, roll means for guiding the lower surface of said upper belt located adjacently above the innermost roll means supporting the portion of the lower belt forming said receiving table whereby said lower belt and the fibers thereon are covered by said upper belt and the fibers are gripped between said belts and conveyed between said belts through said tank, said tank being characterized in that the length thereof is substantially greater than its depth, supporting means adapted to be positioned within said tank and roll means carried thereby to control the vertical position of the lower surface of said upper belt in its travel through said tank, said last-mentioned roll means being adapted to be positioned below the liquid level in said tank and being spaced at such a horizontal distance from roll means supporting the upper surface of the said lower belts immediately prior to its entrance into and immediately after its exit from said tank as to cause said belts and the fibers gripped therebetween to be

conveyed into and out of said tank at an angle not exceeding 45° from the horizontal, and a closed steam chest disposed above said tank over a substantial portion thereof and adapted to be raised and lowered into said tank, means for vertically raising and lowering said steam chest out of and into said tank, so that when said steam chest is lowered into the tank there is provided a narrow channel of liquid within said tank between the bottom of said steam chest and the bottom of said tank through which channel said belts and interposed fibers pass.

2. A machine as defined in claim 1, wherein there is provided a pair of squeeze rollers at the exit end of said tank, one of said squeeze rolls being positioned above the lower outwardly traveling portion of said upper belt and the other of said squeeze rolls being positioned below the upper outwardly traveling portion of said lower belt for expressing a portion of the processing solution from the fibers while between said belts and a receiver underneath said squeeze rollers, and means for transferring process liquid collected therein from said squeeze rollers to the entrance end of said tank.

3. A machine as defined in claim 1 and having means for moving at least one of the rollers cooperating with the lower belt and means for moving at least one of the rollers cooperating with the upper belt into and out of engagement with their respective belts to thereby adjust the tension on said belts.

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