United States Patent

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[54] **PROCESS AND APPARATUS FOR TREATING FIBRES WITH FLUIDS**

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[52] **U.S. Cl.** 68/44
[51] **Int. Cl.** **B05c 3/136**
[58] **Field of Search** 68/44

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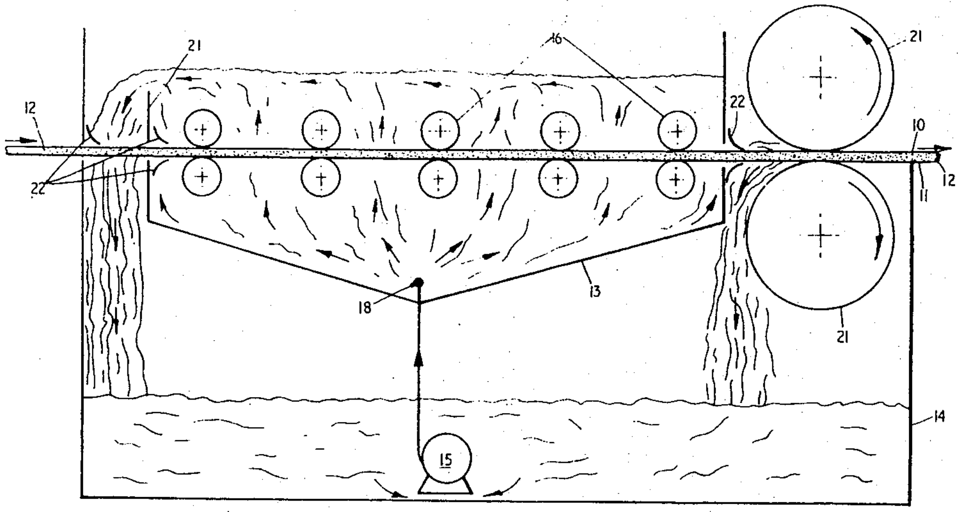
[57] **ABSTRACT**

A method and apparatus for treating a layer of fibrous material with a liquid in operations such as the scouring of wool fibers, the fibers being arranged into a thin layer between porous conveyors and conveyed by them through a body of treating liquid, the layer being subjected to a series of nipping actions which cause liquid to flow along the layer of fibers, the flow of liquid through the layer in a direction normal to the plane of the layer being maintained. It is preferred that the nipping devices should be in the form of nipping members which have a surface arranged at an acute angle to the surface of one of the conveying members so as to define a wedge-shaped space, the arrangements of these members being such as to maintain a hydrodynamic pressure gradient across the layer of fibers thus promoting a uniform unidirectional flow of liquid through the fibers.

9 Claims, 5 Drawing Figures



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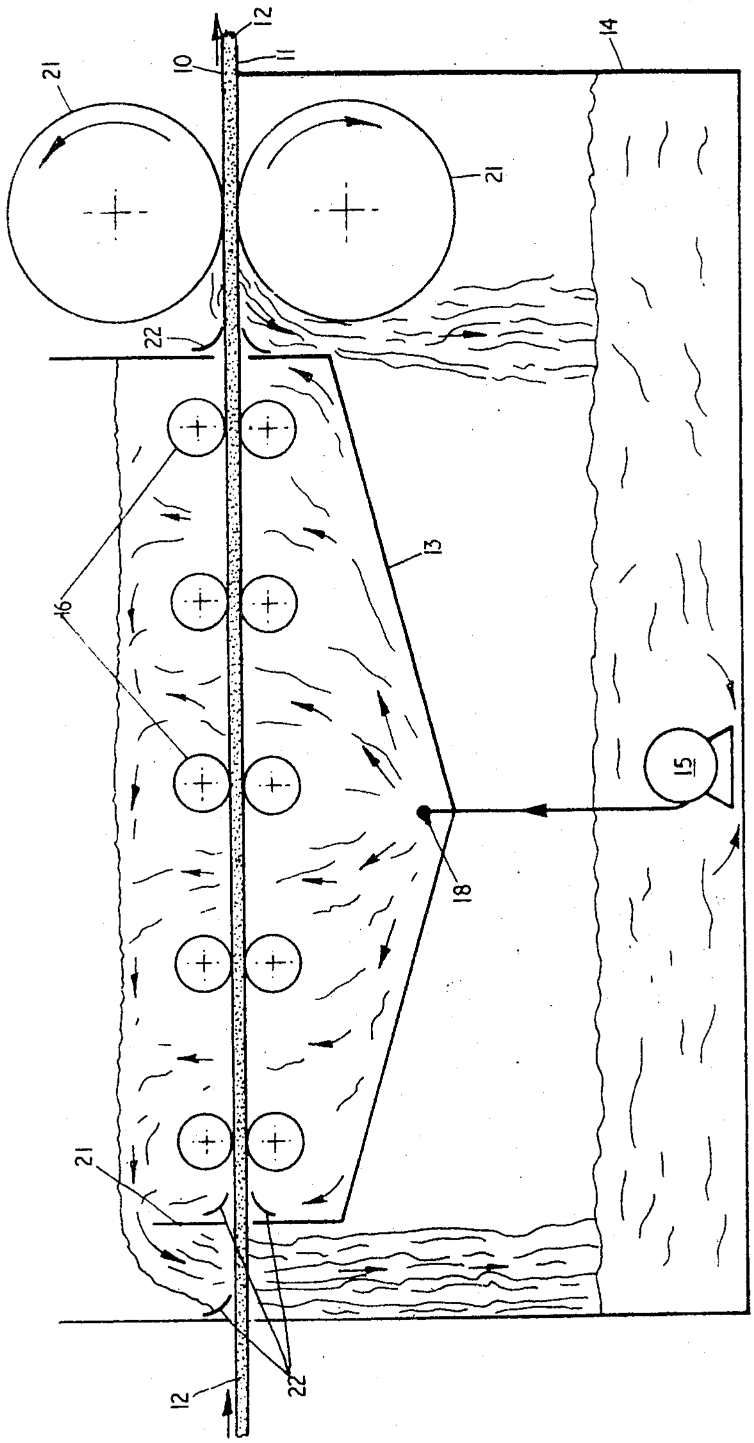

FIG. 1

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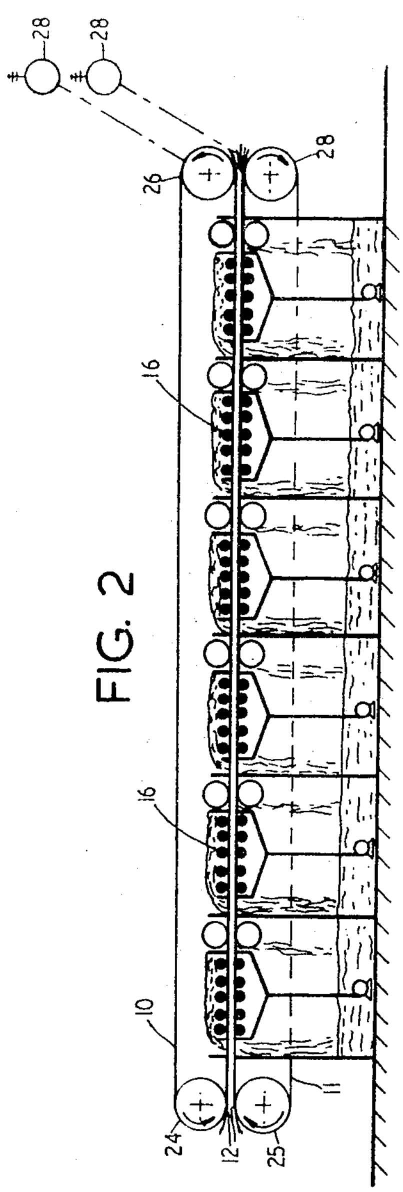

FIG. 2

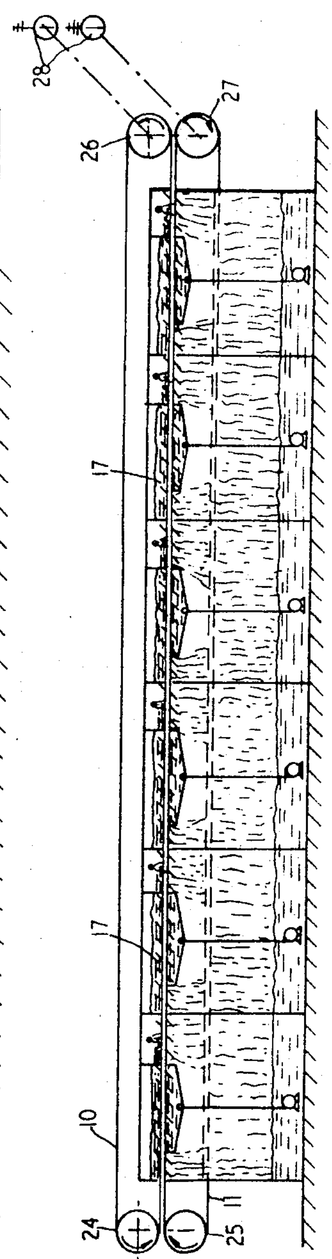

FIG. 4

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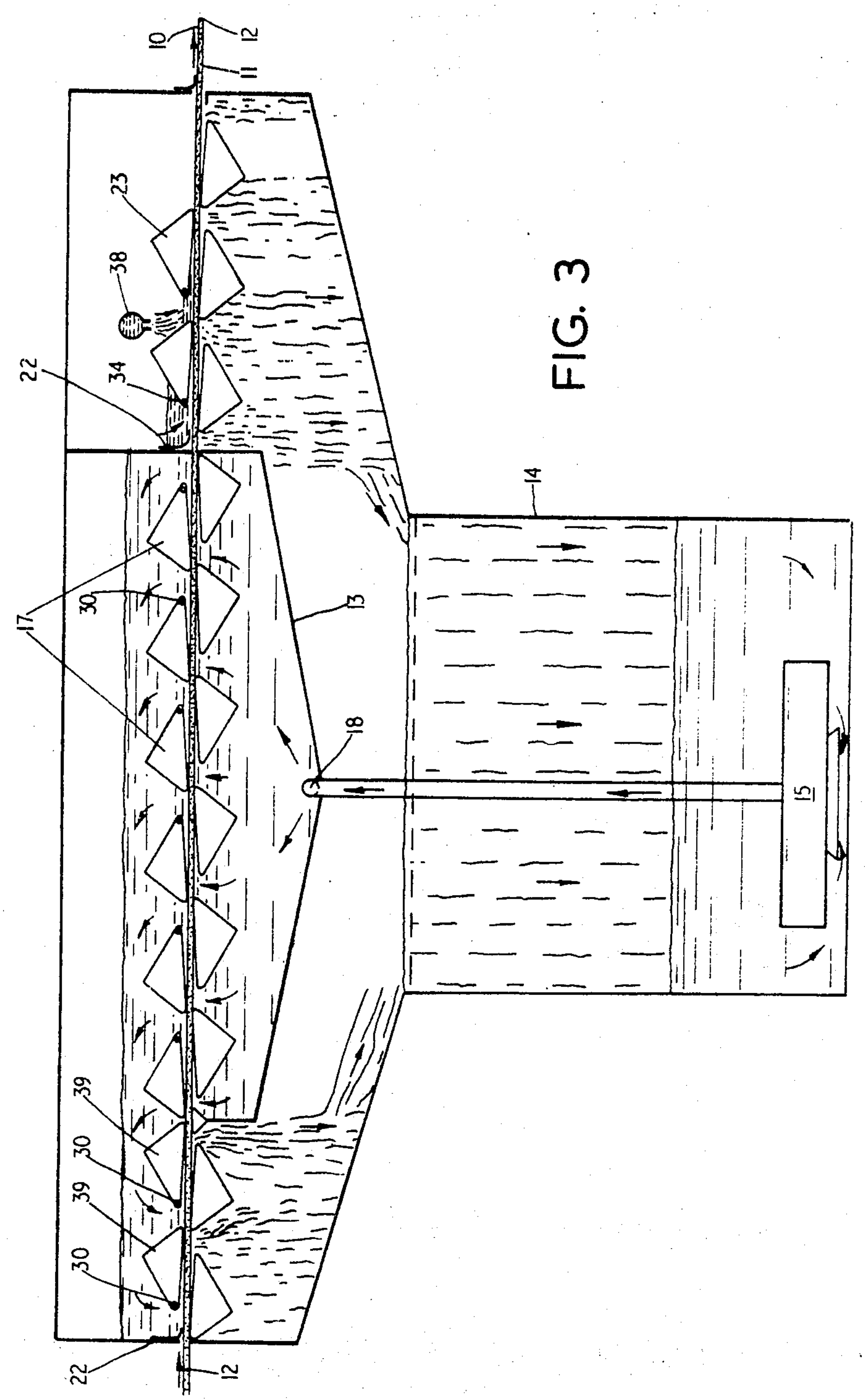

FIG. 3

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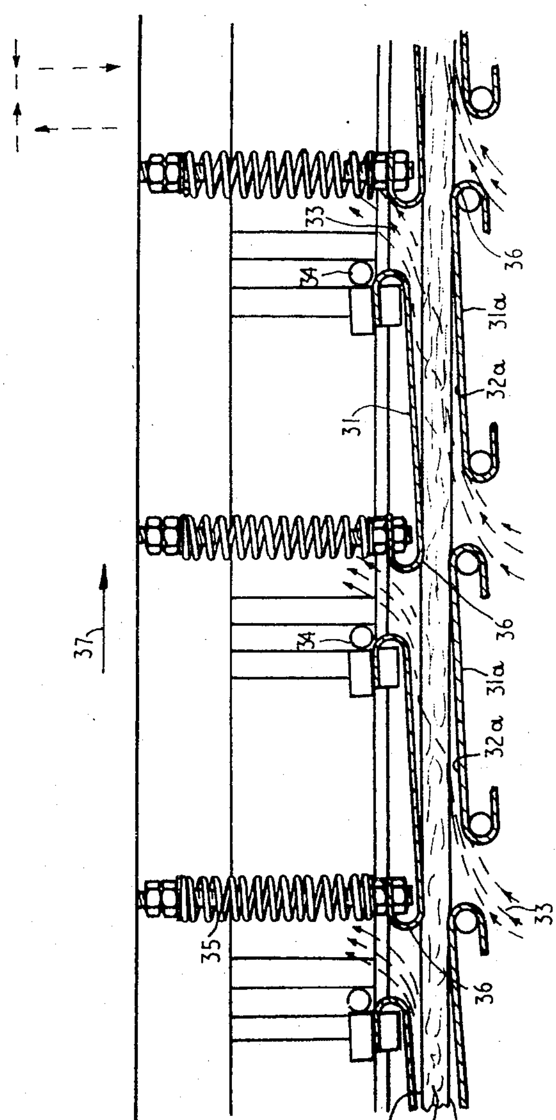

FIG.5

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PROCESS AND APPARATUS FOR TREATING FIBRES WITH FLUIDS

This invention relates to a process and apparatus for treating fibrous material with a liquid and particularly but not exclusively for the removal of impurities, and for scouring, steeping, carbonizing and bleaching operations on wool. The term "fibrous material" is used to include not only natural fibers such as wool and cotton but assemblies of metal or non-metal filaments, man-made fibers and straws.

One object of the invention is to provide a process and apparatus of high efficiency in which a high rate of production may be achieved using short treatment times thus minimizing any adverse effects that the treatment might otherwise have on the fibers. Further objects are to avoid entanglement of the fibers during treatment by reason of relative motion between them and to provide an apparatus of reduced capital cost.

The present invention may be utilized to great advantage in the scouring of raw greasy wool where it is required to remove from the mass and the individual fibers, quantities of wool grease, suint (mainly sheep perspiration) and animal and vegetable and mineral matter, and at the same time to prevent fiber movement and to keep chemical damage to the fibers at a minimum and to be able to operate continuously. Other applications of this invention are in the washing, scouring, extraction, pickling, dyeing, coating, carbonizing and neutralizing, etc. of any fibrous or straw-like materials including natural fibers or straws and man-made filaments (metallic and non-metallic) capable of existing as a thin permeable layer either woven, knitted or felted, or as a loose fibrous assembly, in which it is desirable to minimize movement and to have effective uniform treatment while being able to process large quantities of the material.

However, for illustrative and explanatory purposes, the scouring of raw greasy wool is discussed, as in this case, fiber movement is energized by surface friction and internal sources as well as by external mechanical forces.

In present day textile processing, this procedure is commonly known as raw (greasy) wool scouring and may be carried out using an aqueous scour solution of soap and soda or synthetic detergent which is caused to act on the loose wool. By "loose wool" is meant wool fibers whose general configuration is such that some are and some are not considered to be in a parallel position relative to each other. In this conventional system, loose wool is usually scoured by passing it through a succession of tanks (bowls) containing the scour liquors, the last tank being a rinsing bowl containing mains water only. The temperatures of the liquors are such as to effect optimum scouring of the loose wool, and usually range from 100° to 160°F. In the bowls the loose wool is moved along by a mechanized raking action and by fluid friction forces and, although floating, is mainly submerged in the liquors, except between bowls when it is elevated out and passed through squeeze rollers, and into the next bowl.

While the method is effective in scouring the loose wool to remove the undesired matter from it to a degree sufficient for the efficient subsequent processing of the scoured wool, it has a number of drawbacks, the major one being the entanglement or intertwining or coiling of the loose wool fibers relative to each other resulting in fiber breakage during subsequent processing. The next process after the scouring of raw greasy wool is carding, where the loose scoured wool is disentangled in order to arrange the individual fibers in a sliver in substantially parallel relationship. During this carding operation, wool fibers break due to the method of disentanglement, and the extent of fiber breakage is a function of (proportional to) the degree of entanglement of the scoured wool. In wool processing, the longer fibers are considerably more valuable than the shorter ones, most of the short ones being obtained by fiber breakage, and therefore it is highly desirable that during the scouring process of the loose wool entanglement of the wool be kept to a minimum, this being one of the most important advantages of the present invention when applied to the scouring of wool. Other drawbacks in the conventional method is that prolonged contact of the wool with the alkaline liquors tends to promote yellowing in wool and may even reduce the strength of the fibers. Also the machinery used is not easily adaptable to continuous operation since dirt accumulation necessitates frequent shut-downs for cleaning.

There have been other attempts to overcome these drawbacks by using liquid jets on submerged compressed loose wool layers or by using liquid sprays on non-submerged non-compressed loose wool layers. However, these have not yet shown to be competitive and also the machines are relatively more complex and can have problems when transferring the wool from one transporting element to another.

In the application of the present invention to the scouring of wool, the loose wool layer is constrained from movement between two porous conveyors through which liquors continuously permeate and which are compressed sufficiently together by a series of regularly displaced nipping devices. The speed of these conveyors and the length of the scour is such that the contact time of the wool with the liquor is very short and sufficiently short to avoid any chemical damage that may be caused by dissolved alkali. The only relevant mechanical movement in the transfer of the layer of wool through the scouring machine is that of the two conveyors sliding through the series of nipping devices, each pair preferably having one element stationary and the other free to move perpendicularly to the layer of wool. There are no transfer points between the bowls of the scour and so the machine is very simple mechanically. The continuous removal of dirt is greatly facilitated by appropriate tank and process flow design thereby permitting continuous scouring operation.

The invention consists in a method of treating fibrous material with a liquid wherein fibers to be treated are formed into a thin layer between porous conveying members and conveyed by said conveying members through a body of treating liquid, the conveying members passing through a series of nipping devices each arranged to squeeze said conveying members together in passing, to constrain the fibers against relative movement and to produce an impulse causing relative movement between the treating liquid and the conveyed fibers along the layer of fibers and simultaneously causing liquid to flow through said layer in a direction substantially normal to the plane of the layer.

The invention further consists in apparatus for treating fibrous material with a liquid comprising at least one tank containing the treating liquid, a pair of closely spaced conveyor belts passing through the liquid in the tanks, the conveyor belts being constructed and arranged to apply pressure to and convey between them a thin layer of fibrous material to be treated, a series of nipping devices arranged on either side of and along the length of the conveyor members within the tank, each nipping device being arranged to squeeze said conveyor belts together in passing to constrain the fibers against relative movement and to produce an impulse causing relative movement between the treating liquid and the conveyed fibers along the layer of fibers and means to produce a flow of liquid through said layer in a direction substantially normal to the plane of the layer.

With a method according to the invention, a thin layer of fibers is required so that treating fluid can easily gain access to and effect uniform treatment of the fibers and/or remove impurities. It is furthermore advantageous for this process to transport the thin layer of fibers held between the porous conveying members at a high speed.

The invention is most advantageously applied by the use of nipping devices in the form of nipping members, pressing on opposite sides of the porous conveying members, through which the conveying members pass each nipping member having a surface arranged to define a wedge-shaped space between it and one conveying member, the surfaces acting hydrodynamically to promote a uniform unidirectional flow of liquid through the layer of fibers as the conveying members move between them. Nipping devices of this form are referred to, for want of a better term as "wedge nips."

While nipping members of the form described above are to be preferred other forms of nipping member may be used such as pairs of rollers which rotate relative to the layer of fibers being treated or alternatively fixed members such as stationary rods.

In order that the nature of the invention may be better understood preferred embodiments thereof are hereinafter described by way of example, with reference to the accompanying diagrammatic drawings in which:

FIG. 1 is a sectional view of one treatment unit,

FIG. 2 is a similar view, to a reduced scale showing a complete installation of six units,

FIG. 3 is a similar view to FIG. 1 but showing an embodiment in which rollers are replaced by wedge nips, and

FIG. 4 shows a complete installation of six units as shown in FIG. 3,

FIG. 5 illustrates the manner in which the wedge nips operate.

In the apparatus shown in FIGS. 1 and 3, two porous conveyor belts **10** and **11** hold between them a thin layer of wool **12** which may be, for example, 2 to 3mm thick and which is conveyed through the apparatus at a speed of, for example, 150 feet per minute. One treatment unit of the apparatus consists of two tanks **13** and **14** one of which **14** is used for collection and storage of the treating liquor which is delivered by a circulating pump **15** to the processing tank **13**. In the processing tank **13** a number of pairs of nipping devices, rollers **16** are shown in FIG. 1 and wedge nips **17** are shown in FIG. 3, which are lightly loaded so as to press on the conveyors **10** and **11** in passing and produce a relative velocity between liquor and fibers in the same plane as the wool layer **12**. The liquor delivered by the circulating pump **15** enters the processing tank **13** at the point **18** from where it then proceeds to percolate through the moving layer of wool thereby impregnating and providing a continuum of liquor displacement normal to the wool layer. This liquor then flows over a weir **21** (as shown in FIG. **1**) or maintains a level (as shown in FIG. **3**) on the moving wool layer before the latter enters the processing tank **13**, and then passes back into storage tank **14**, passing through the layer **12** before it does so.

Seals **22** are provided at the points of entry and exit of the conveyor belts **10** and **11** to the tanks **13** and **14**. Excess treating fluid retained by the wool layer leaving the processing tank **13** is removed by a pair of squeeze rollers **21** (as shown in FIG. **1**) or is partially displaced by backflow liquor pumped from the next processing stage (as shown in FIG. **3**) by the employment of at least two pairs of lightly loaded nipping devices (such as the small rollers **16** shown in FIG. **1** or by wedge nips **23** as shown in FIG. 3).

A complete set of six such treatment units is illustrated in FIG. **2** and FIG. **4**. This includes conveyor belt drive pulleys **24, 25, 26, 27** of which **26** and **27** are driven by geared electric motors **28**. The belts **10** and **11** are maintained in tension by conventional tensioning means (not shown) and thus exert a certain pressure on the layer of fibers between them.

It will be seen that the conveyor belts **10** and **11** extend through the full length of the apparatus and no transfer of the wool fibers is required within or between stages.

In the apparatus of FIG. **2** a small countercurrent flow of treatment liquor is provided by pumps and piping (not shown) through the tanks of the separate units.

In both forms of apparatus the very thin layer of wool is transported rapidly through the apparatus, being subjected to a series of impulses as it passes the nipping devices and these produce vigorous relative movement between the fluid and the fibers.

The wedge nips **17** of FIGS. **3** and **4** are to be preferred to the rollers **16** of FIGS. **1** and **2** as a hypothetical study of nip actions revealed that squeeze rollers require high inertia reversals to remove viscous fluids dragged into the nip at the roller surfaces, and along, and some of that within, the solid medium passing through the nip.

To eliminate the problems of inertia reversal and high pressure build up in the nip area (which results in an excessive bearing surface requiring a higher loading to maintain the necessary bearing pressure) a nip design was proposed using a pair of wedges directed against the direction of motion, one above and one below the conveyors and pressing them together.

However in a scouring or similar process a cross-flow is desirable and so the wedge nip design shown in FIG. **2** was adopted which incorporated a secondary effect as predicted by the hydrodynamic theory of flow of viscous fluids in wedges.

Wedge nips have been found effective in promoting a uniform unidirectional flow of liquid through the layer in contrast to the rollers shown in FIG. **1** with which the flow through the layer varies considerably from place to place being a maximum between rollers.

A complex of such nipping members are used in which practical considerations have been borne in mind. These include rounded extremities such that the material passing through them is not damaged, smooth faces on the nipping member to reduce the viscous drag to a minimum, small bearing surface such that only small loadings will provide relatively high bearing pressures with a low drag force required through the nips, and uniformity of crossflow throughout the travel of material by the maintenance of a reasonably constant hydrodynamic pressure gradient.

The nipping members can be made of formed sheet material such as stainless steel, a spring force acting on the nipping members providing the bearing load at the nip. The upper nipping members are pivoted at the points **30** in FIG. **1** and the only movement at the nip itself is in a vertical direction — a result of non-uniformities in the wool layer.The lower nipping members are fixed.

The spacing of the wedge nips and for that matter between any forms of nipping device is preferably such that each fiber being treated is held by one nipping device at any one time. Thus the spacing between nipping devices is preferably about equal to the average length of the individual fibers being treated.

The action of the wedge nips is illustrated in FIG. **5** in which two complete sets are shown. Above and below the conveyor belts **10** and **11** between which lies the layer of fibers **12** are arranged nipping members **31** and **31**a which although of a different shape and construction from the members constituting the wedge nips of FIG. **1** are their functional equivalent. Each is made of a strip of sheet metal bent over along each edge as shown and presenting a surface **32** or **32*a*** to the conveyor belts **12** and **13**, respectively, which surfaces are arranged so as to define a wedge-shaped space **33** with the adjacent conveyor belt.

The members **31*a*** are fixed whereas the members **31** are arranged to be movable in a vertical direction being either pivoted at the point **34** or attached to a rod free to move vertically. Members **31** are spring-loaded downwardly by coil springs **35**. A portion of each member **31** or **31**a near the tip **36** makes contact with the adjacent conveyor belt and the layer of fibers **12** is thus nipped between those portions of adjacent members **31** and **31*a***.

The arrowed broken lines indicate the direction of flow of liquid through the layer of fibers due to the hydrodynamic effect of the surfaces **32** and **32*a*** assuming the conveyor belts **10** and **11** are moving in the direction of the arrow **37**. Thus movement of the conveyor belts causes impulses to be produced in the layer of fibers resulting in relative movement between the fibers and the liquid along the layer and also a unidirectional flow of liquid across the layer as indicated by the arrowed broken lines.

It will be appreciated that the shape of the members **31** and **31*a*** apart from those parts forming the surfaces **32** and **32*a*** and the extremities of those surfaces is to a large extent arbitrary.

The wedge nips are utilized in an additional manner in the unit of FIG. 3. It consists of a displacement of the liquor in the wool layer with the liquor from the following less contaminated processing unit.

Liquor from the next succeeding unit is pumped into the tank **14** through the inlet **38** and by the hydrodynamic action of the wedge nips **23** in that section of the tank displaces the liquor in the wool layer by less contaminated liquor from the next unit, thus avoiding the necessity for using squeeze rollers such as **21** of FIG. **1**. The volume of liquor supplied is in excess of the liquor displaced from the layer by thus providing a countercurrent flow of liquor through the system.

In the construction of FIG. **3** additional wedge nips **39** are provided and these like wedge nips **23** are arranged to promote a downward flow of liquid through the layer of fibers **12**, unlike the wedge nips **17**, which promote an upward flow of liquid. Liquid flows from the tank **13** into the tank **14** through the layer **12** under the action of wedge nips **39** thus giving the fibers a preliminary treatment with more contaminated liquid that has already passed through the layer **12**.

Experimental results obtained by the use of a single apparatus substantially the same as that shown in FIG. **3** are set out below.

EXAMPLE I

Merino wool of grade 60^s–64^s containing **18** percent grease was formed into a layer of a density of one-tenth pound per square foot and was passed between the conveyor belts at a speed of 150 feet per minute through a scouring liquor containing 0.3 percent soap and 0.1 percent soda maintained at 200°F. A flow rate of liquor in the tank of 30 gallons per minute per square foot through the layer of wool was maintained. The time taken to pass the wool through the apparatus was 2 seconds and the pressure exerted by each nipping member was one-half pound per linear inch of the extension of the nipping member across the conveyor belts. As a result of a single pass the grease content of the wool was reduced to 6 percent.

EXAMPLE II

Crossbred wool of grade 46^s was treated under the same conditions as set out in Example I above and its initial content of 7 percent grease was reduced to 0.75 percent.

In the scouring of wool it is considered that the method of the invention is most advantageously carried out by utilizing a conveyor speed of between **50** feet per minute and 300 feet per minute and a density of wool in the layer of up to one-half pound per square foot of area. It is impossible to give any definite guide as to the thickness of the layer of fibers and the speed at which the conveying members are to be moved as these will vary to a considerable extent according to the nature of the wool and even more so when other fibers are being dealt with. In general, however, it may be said that the fewer solids present in the layer of fibers, the thicker may be the layer and the slower the movement of the conveying members, whereas where more solids are present, the contrary is the case.

While the invention has been described as being applied to the scouring of wool, it should be emphasized that it may be used for carrying out a variety of other treatments and may be used for treating other fibers.

We claim:

1. Apparatus for treating fibrous material with a liquid comprising at least one tank containing the treating liquid, a pair of closely spaced conveyor belts

passing through the liquid in each of the tanks, the conveyor belts being constructed and arranged to apply pressure to and convey between them a thin layer of fibrous material to be treated, a series of spaced nipping devices arranged on either side of and along the length of the conveyor members within the tank and below the level of the liquid therein, each nipping device being arranged to squeeze said conveyor belts together in passing to constrain the fibers against relative movement and to produce an impulse causing relative movement between the treating liquid and the conveyed fibers along the layer of fibers and means to produce a flow of liquid through said layer in a direction substantially normal to the plane of the layer.

2. Apparatus as claimed in claim 1, wherein each nipping device is a pair of rollers arranged one on each side of the conveyor belts.

3. Apparatus for treating fibrous material with a liquid comprising at least one tank containing the treating liquid, a pair of closely spaced conveyor belts passing through the liquid in the tanks, the conveyor belts being constructed and arranged to apply pressure to and convey between them a thin layer of fibrous material to be treated, a series of nipping devices arranged on either side of and along the length of the conveyor members within the tank, each nipping device being arranged to squeeze said conveyor belts together in passing to constrain the fibers against relative movement and to produce an impulse causing relative movement between the treating liquid and the conveyed fibers along the layer of fibers and means to produce a flow of liquid through said layer in a direction substantially normal to the plane of the layer, each said nipping device is a pair of nipping members placed on opposite sides of the conveying members, each said nipping member having a surface arranged at an acute angle to the surface of one of said conveying members to define a wedge-shaped space therewith, a portion at one end of said surface being in contact with the one conveying member, said portions of the two nipping members acting between them to squeeze the conveying members together in passing the surfaces being arranged to maintain a hydrodynamic pressure gradient across the layer of fibers and thus promote a uniform unidirectional flow of treating liquid through the fibers.

4. Apparatus as claimed in claim 3, wherein the run of said conveyor belts is substantially horizontal and nipping members arranged below the layer of fibers and in contact with the lower conveying member are fixed whereas the nipping members in contact with the upper conveying member are capable of movement in response to irregularities in the layer of fibers and are subject to a force pressing their said portions against the upper conveying member.

5. Apparatus as claimed in claim 4, wherein the nipping members are arranged to promote a flow of liquid through the layer of fibers in an upward direction.

6. Apparatus as claimed in claim 5, wherein a series of similar nipping members are provided in the tank through which the conveyor belts pass at a position before the conveyor belts pass through the first mentioned nip members, the second mentioned nipping members being arranged to promote a flow of liquid through the fibers in a downward direction whereby the fibers are subjected to a preliminary action by said liquid and whereby treating liquid is circulated in the tank.

7. Apparatus as claimed in claim 3, comprising a plurality of tanks each containing a group of said nipping devices, the conveyor belts passing continuously from tank to tank through all said groups, there being associated with each tank means to displace from the layer of fibers, liquid remaining in the layer after treatment with the liquid in that tank, means being provided to produce a countercurrent flow of treating liquid through the said tanks whereby liquid is fed back from each tank to the preceding tank.

8. Apparatus as claimed in claim 7, wherein the means to displace liquid from the layer of fibers are squeeze rolls.

9. Apparatus as claimed in claim 7, wherein the means to displace liquid from the layer of fibers consists in that each said nipping device comprises a pair of nipping members arranged one on each side of the conveyor belts arranged along the conveyor belts at a position in each tank after the conveyor belts have passed through the liquid in that tank, means being provided to produce a flow of less contaminated liquid from the succeeding tank over the last mentioned nipping devices, the last mentioned nipping devices being arranged to promote a flow of that liquid through the layer of fibers to displace the liquid therein and means being provided to return the displaced liquid to that tank.

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