Jan. 22, 1963 C. F. OLDERSHAW 3,074,775

METHOD AND APPARATUS FOR THE LIQUID TREATING OF FIBER TOW BUNDLES

Filed Sept. 13, 1957 2 Sheets-Sheet 1

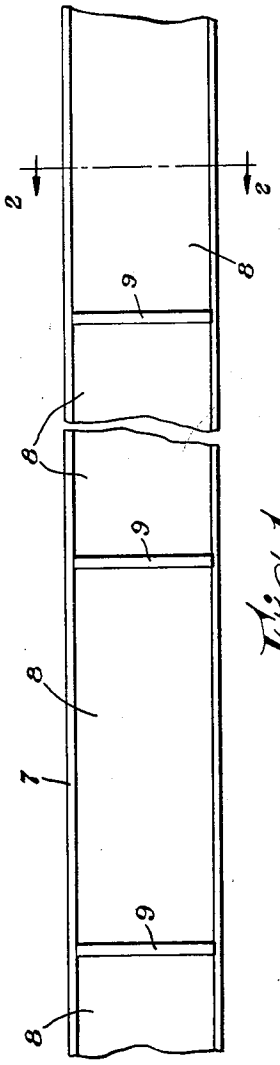

Fig. 1

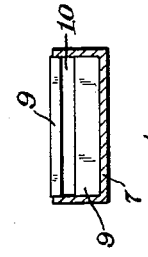

Fig. 2

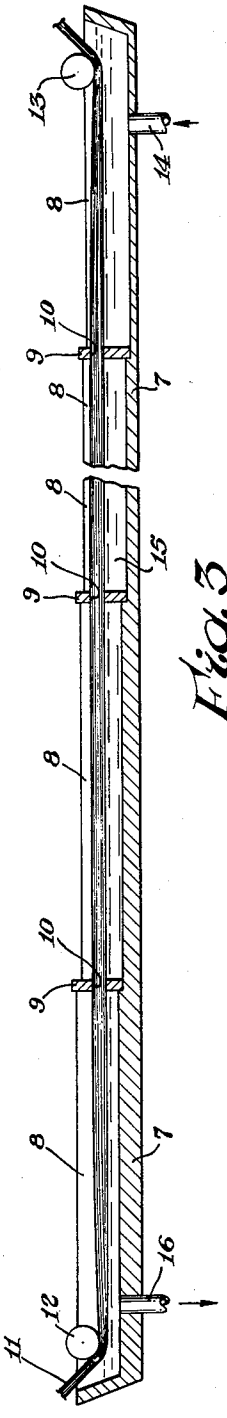

Fig. 3

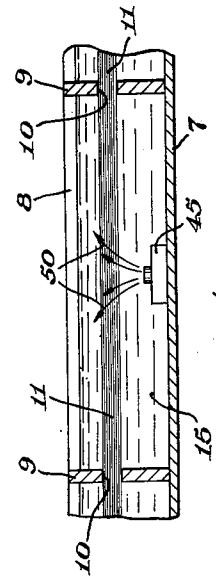

Fig. 8

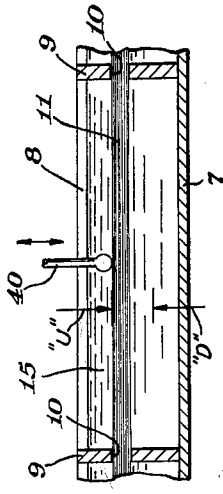

Fig. 7

INVENTOR.
Charles F. Oldershaw
BY
Griswold & Burdick
ATTORNEYS

Jan. 22, 1963 C. F. OLDERSHAW 3,074,775

METHOD AND APPARATUS FOR THE LIQUID TREATING OF FIBER TOW BUNDLES

Filed Sept. 13, 1957 2 Sheets-Sheet 2

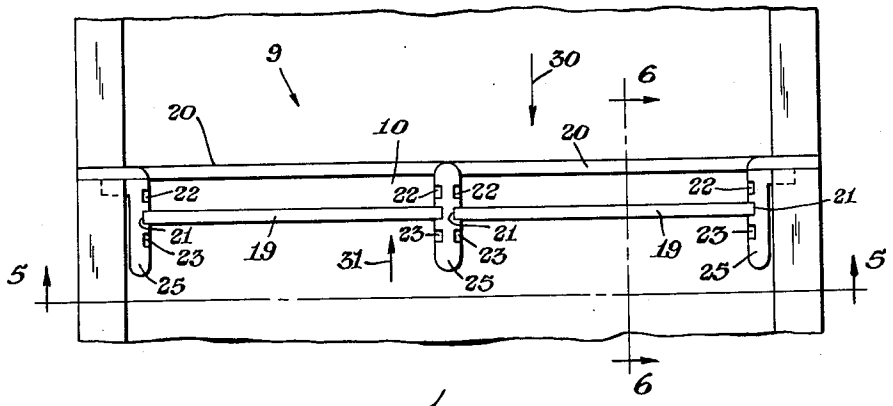

Fig. 4

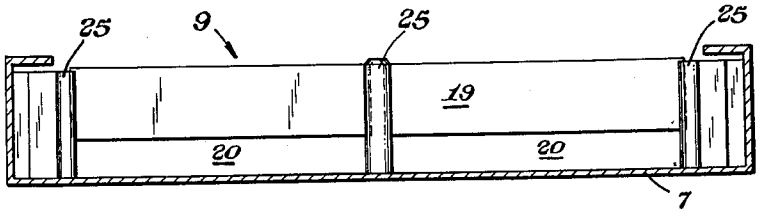

Fig. 5

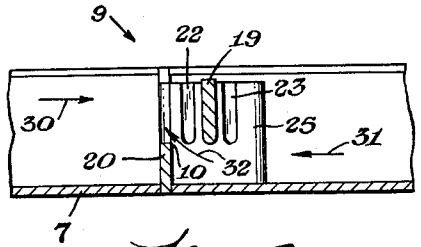

Fig. 6

INVENTOR.
Charles F. Oldershaw
BY
Griswold & Burdick
ATTORNEYS

United States Patent Office 3,074,775 Patented Jan. 22, 1963

3,074,775

METHOD AND APPARATUS FOR THE LIQUID TREATING OF FIBER TOW BUNDLES

Charles F. Oldershaw, Concord, Calif., assignor to The Dow Chemical Company, Midland, Mich., a corporation of Delaware

Filed Sept. 13, 1957, Ser. No. 683,757
12 Claims. (Cl. 8—151.2)

In the manufacture of many of the so-called artificial silks and textile and other fibers from other manmade, synthetic, fiber-forming materials, it is oftentimes required to wash out or extract certain undesired constituents and impurities from the freshly spun filamentary products in order to provide them in a satisfactorily useful and commercially acceptable form. Wet spun yarns and filaments, for example, must generally be washed in a suitable extractant medium or washing liquid (that frequently may be water or an aqueous liquid) in order to remove residual quantities of the spinning solution solvent that was employed to furnish the fiber-forming material in extrudable form, as well as any coagulant that may persist in the freshly spun and newly formed fiber by entrapment or entrainment after its withdrawal from the coagulating spin bath. Certain of the artificial and synthetic textile fibers that are prepared by dry or evaporative spinning techniques may also require washing for similar purposes subsequent to their extrusion. Likewise, some of the melt spun synthetic filamentary materials may need to be washed after being spun. Thus, certain of the superpolyamide fibers, particularly, by way of illustration, those that are derived from the epsilon-caprolactam (which are sometimes popularly known as being nylon "6"-type materials), must usually be washed after spinning in order to be rid of intolerably high contents of monomer and undesirably low molecular weight polymer, including dimer and trimer, that invariably obtains in the freshly extruded material.

For purposes of washing and otherwise processing many synthetic and artificial textile fiber materials subsequent to spinning, it is usually convenient and expedient to form the fibers in continuous or endless filamentary lengths that, during or subsequent to spinning, are assembled in multiple filament tow bundle arrays or gathered arrangements in which a plurality of individual, component continuous filaments are handled in a closely associated, substantially parallel relationship. This is particularly the case for many of the wet spun synthetic textile materials, including those that are derived from fiber-forming acrylonitrile polymer compositions, particularly polyacrylonitrile and copolymers that contain in the polymer molecule at least 80 percent or so by weight of acrylonitrile. In many such operations, notably those in which relatively fine denier textile fiber products are being manufactured for ultimate conversion into staple fiber commodities, it is desirable for such multiple filament tow bundles to be of considerable magnitude. Often, for example, in the manufacture of say, 1 to 10 denier products, it may be preferred to operate with tow bundles that, quite commonly, are comprised of from 10,000 to 50,000 or more individual, filaments. As a practical matter, it is frequently preferred to form and handle such ponderous tow bundles as relatively flat and wide, ribbon-like arrays that have characteristically rectangular cross-sections with an average depth or thickness which, as a practical matter, is usually at least about 40 or so filaments and seldom in excess of 125 or so filaments. Of course, if desired, much thinner tow bundles can also be utilized such as those whose average thickness is on the order of, say, only 5 to 10 filaments. Physical arrangements of such nature for the tow bundle provide for greater facility in its manipulation during processing. And, in connection with

the washing and liquid treatment of such tow bundles, it is usually preferred to employ countercurrent liquid contacting techniques and processing schemes in which the direction of travel of the tow through one or more stages is opposite the path of flow of the washing or treating liquid that is being employed. This, as is widely recognized, generally secures optimum efficiency in the operation. In this connection, maximum benefit is usually obtained in such liquid treatments when plural, separate stage washing or other liquid treating appliances are employed and the tow bundle being passed through the stages is actually physically lifted out of one stage (or container therefor) for transfer into the next by means of guide bars, rollers and the like devices well known to the art.

The main purpose and chief concern of the present invention is to provide an improved method and highly effective apparatus for use in conjunction therewith for washing or leaching extractable constituents from various artificial and synthetic textile fiber materials during their processing in the form of multiple continuous filament tow bundles subsequent to spinning, especially tow bundles that have a relatively flat, ribbon-like form and are filamentary gatherings of considerable magnitude. It is a particular object and specific relationship of the invention to deal with the washing of wet spun synthetic textile materials, especially fibers from acrylonitrile polymer compositions that are obtained and handled in an aquagel form upon their spinning and during their immediately subsequent handling which occurs prior to drying. As is well known, such aquagel materials are the water-swollen or hydrated filamentary structures that may be derived by wet spinning extrudable solutions of acrylonitrile polymers in polyacrylonitrile-dissolving aqueous saline solvents (that beneficially may be zinc chloride and its saline equivalents for such purpose) into aqueous, non-polymer-dissolving coagulating spin bath solutions of the same salt or salts. A highly important purpose of the invention, one of particular significance and which is calculated to provide exceptional advantage, is to furnish a method and means of the indicated variety for use in plural stage liquid treatments that would secure improved separation of the stages and permit plural stages to be built more economically, operated with relatively less expense and maintained with minimized requirements for physical space. And, as can readily be comprehended by those who are gifted with the skill of their calling, the broader aspects of the present invention include an improved process and apparatus for any liquid treatment upon any filamentary textile material, including those of natural origin, wherein it may be desired to handle the filaments in a tow-like form (including roving and sliver-like assemblies), especially as a large, ribbon-like tow bundle, for countercurrent passage through a particular desired beneficial treating liquid.

According to the present invention, wherein the above-stated ends and the indicated and corollary benefits may most advantageously be achieved, a tow-bundle or like arrangement of continuous filament fibers, especially a relatively large array of considerable magnitude in a flat, ribbon-like assembly, may be washed free or substantially free from undesired, liquid extractable, constituent impurities or otherwise treated in and with a beneficial treating liquid by a method which, on a continuously operating basis, comprises introducing said multiple continuous filament tow bundle into a countercurrently flowing treating liquid in a first liquid treating stage at one end of a bath of desired treating liquid that consists of a plurality of at least two physically separated but intercommunicating stages; passing said tow bundle in a sequential fashion through said counter-currently flowing treating liquid in each of said stages; withdrawing the liquid treated tow bundle from said treating liquid in the

last of said stages at the opposite end of said bath; introducing or admitting at least a portion of fresh treating liquid in the last of said stages; withdrawing at least a portion of the spent or used treating liquid from the first of said stages; and passing said treating liquid from the last of said stages to the first thereof through each of said stages countercurrent to said tow bundle in such a manner that, at (or about at) each point of physical separation or compartmentation between each of said stages, said countercurrently flowing treating liquid is caused to pass and flow through and between the integrant filaments in said tow bundle that is traversing (and while it is traversing) said point of separation.

Advantageously, as has been indicated, the tow bundle may be a ribbon-like array of considerable magnitude that contains a large plurality of the individual filaments that are desired to be treated. Desirably, the filaments may be freshly spun, especially freshly wet spun filaments, of synthetic or artificial textile fibers that are being washed for their purification from solvents, coagulants and other liquid extractable contaminants subsequent to their formation. It is highly beneficial to water wash freshly wet spun tow bundles of acrylonitrile polymer aquagel filaments that contain solvent (and possibly coagulant) residues of an aqueous saline nature which persist in the filaments after their withdrawal from the spin bath. It is usually preferable to practice the invention with a bath of the beneficial treating liquid that is compartmentalized or physically separated into at least 2 and, more advantageously, at least 4 or even 10, individual stages wherein all or substantially all of the fresh treating liquid is admitted to the last stage for counter-current flow through the bath and wherein substantially all of the spent or used treating liquid is withdrawn or emptied through and from the first stage. Of course, the precise number of stages that may be best to employ in any particular situation depends to a great extent on the particular operation and liquid treatment involved and the efficiency or results desired in its performance. Almost inevitably, regardless of the number of stages used, some of the treating liquid will be entrained in the tow bundle and carried off therewith upon its withdrawal from the baths. Preferably the bath is contained in an open, horizontally disposed pan or trough although, if desired, totally enclosed chambers in other than horizontal disposition may be employed. As is apparent, any desired portion of the treating liquid can be admitted or withdrawn, if so desired, at one or more of the intermediate stages of the bath when more than two are involved. Such procedure, however, is ordinarily of lesser attractiveness than that which involves admission of all the treating liquid in the last stage and withdrawal of substantially all of it in the first.

The particular rates of passage of the tow bundle through the bath and of the liquid into and out of the bath and the relative ratios of treating liquids to tow that are being employed depend largely upon and may vary with individual circumstances. Greater volumes of treating liquid, especially for washing, generally bring about most efficacious treatments. However, an economic balance must be struck so that employment of excessive quantities of liquid are avoided. Likewise, the flushing and contacting action of the liquid on the tow must not be so vigorous as to cause damage to the individual filaments therein, especially when freshly wet spun filaments are involved. Such filaments, particularly aquagel structures of acrylonitrile polymers, may be quite tender and easily susceptible to damage. As is ordinarily considered desirable, particularly in washing and liquid extraction operations, the treating liquid upon withdrawal from the bath has generally most effectively been employed when it is in a completely utilized condition in which it retains little if any beneficial treating potency for the particular purpose at hand. In washing operations, this condition is generally brought about for the reason that the used treating liquid is substantially at equilibrium with respect to its solute-attracting potency with the untreated fibers. It is deemed that the most satisfactory arrangements and mode of operation for practice of the invention in particular instances and for particular purposes can be easily determined and arrived at by those who are skilled in the art and that, in general, no more than routine experimentation in the light and direction of the present contribution need be resorted to to attain such end.

The apparatus of the invention in its most basic and generic concept comprises a means for containing a bath of treating liquid; partition means in said bath containing means for subdividing it into a sequential plurality of at least two stages; each of said partition means being provided with a tow-bundle-accommodating opening or aperture that is adapted to fit closely about and permit the passage of a multiple continuous filament tow bundle in submersion in said bath (when said tow bundle and said bath are present in and being passed through said containing means for said bath) from stage to stage, said opening being further adapted to provide liquid communication between said stages; means for passing a tow bundle sequentially through each of the said stages from the first to the last thereof through said partition openings; and means for circulating treating liquid for said tow bundle through said partition openings and, coincident thereto, through each of said stages in said bath countercurrent to the path of travel of said tow bundle. The most advantageous embodiment of the apparatus that is to be used for any particular purpose may be collated to and based upon the most desirable manner for performing the particular method or treatment whose practice it is designed to afford. Thus, as will hereinafter appear, the apparatus may quite beneficially be a horizontally disposed, relatively flat or shallow pan or trough having a plurality of wall-like partitions spaced at about regular longitudinal intervals, each of which partitions has a substantially rectangular, slit-like opening below the intended liquid level of the bath to accommodate passage of the preferred form of ribbon-like tow bundle. Of course, apertures having other configurations, such as circular or elliptic shapes, may be provided in the partitions to conform to tow-bundles having other than substantially rectangular cross-sections. In addition, it is of exceptional benefit for the upper portion of the partition to be offset from its lower section surrounding the tow-accommodating aperture so as to cause a substantially vertical interpassage of the treating liquid through the tow bundle at each of the points of physical stage separation. Furthermore, it is highly desirable for the upper portion of each partition to be removably provided in the apparatus and for each of them to be movably mounted therein so as, under the influence of gravity, to ride upon and firmly enclose or confine the tow bundle passing through the opening in the partition. Preferably, the entire plural stage unit is longitudinally tilted, inclined, sequentially stepped or otherwise provided so as to permit gravity flow of the treating liquid through the apparatus. To this end, especially when aqueous treating liquids are involved, it is desirable for the gravity flow to be caused by the pressure effect of about a half-inch of water head differential between each of the successive, interconnected stages in the assembly.

It is highly advantageous, especially if maximum washing efficiency is desired, to include in some and preferably all of the stages some means for physically agitating the tow bundle in the treating liquid or of transversely flushing the tow bundle with some portion of the countercurrently passing liquid.

Practice of the present invention intrinsically provides for and accomplishes many real and very worthwhile advantages and benefits. As is apparent, it neatly achieves a basic requirement for optimum results in countercurrent

liquid treating processes of separating the treating bath into consecutive, individual stages. This is done with utmost economy in requirements for materials, apparatus and space. At the same time, it secures a unique and most effective flushing or intimate contacting action of the treating liquid passing through the tow bundle at each of the stage separating partitions. This is effected by means of an extremely simple apparatus with minimized propensity for back mixing to occur between the liquid constituents of the various stages while simultaneously avoiding and eliminating any necessity for using rollers, guides or other means to physically withdraw the tow out of a first stage for transfer to and reintroduction in the liquid of a subsequent countercurrent stage. Great economies in tow handling apparatus are, of course, thereby made possible, as well as in requirements for plural, individual installments of liquid containing devices. Likewise, performance of the liquid treatment may be accomplished on a basis of minimum operating cost. Furthermore, the present invention permits substantial reductions in the length of a given treating bath to be made when it is practiced in conjunction with tow agitating or transverse flushing means in the stages, due to the greater liquid treating efficiency that it involves as compared with continuous undivided baths or even plural stage baths of sequential, individually contained liquid volumes. Frequently as much as 25–50 percent and even much greater reduction in length of a liquid treating bath may be achieved when the present invention is utilized in the last mentioned way so as to agitate or flush the tow being treated in preference to conventional liquid treating or wash bath installations.

In the several views of the accompanying drawing wherein, insofar as may be possible, like reference numerals refer to like parts or components, there are illustrated certain of the preferred embodiments of the invention that are not intended to be limiting or restrictive thereof but which are included herewith for purposes of convenient illustration. As shown;

FIGURE 1 is a fragmentarly plan view of an apparatus according to the invention;

FIGURE 2 is a side elevation in section taken along the line **2—2** in FIGURE 1;

FIGURE 3 is a simplified schematic representation presented in cross section which shows a four stage liquid treating bath according to the invention in operation with a tow bundle passing therethrough;

FIGURE 4 is a fragmentary plan view of a preferred form of stage-separating partition means for use in the practice of the invention;

FIGURE 5 is a front elevation of the partition, partly in section, taken along the line **5—5** in FIGURE 4;

FIGURE 6 is a side elevation in section taken along the line **6—6** in FIGURE 4; and

FIGURES 7 and 8, which are both fragmentary front elevations in section, schematically depict tow bundle agitating and transverse liquid flushing arrangements, respectively, which may be used in conjunction with the stage separating means in the practice of the present invention.

With initial reference to FIGURES 1 and 2 of the drawing, there is shown a pan or trough **7** for containing a bath of beneficial treating liquid for a tow bundle of fibers (neither of which are shown in the first two figures) to be passed through the bath when it is contained in the trough and caused to flow countercurrent to the tow bundle. The trough **7**, which may be of any desired or necessary length, width and depth, is divided into a plurality of intercommunicating liquid-containing stages **8** by a plurality of partitions or aperture-containing wall members **9**. As indicated, and as is shown in FIGURE 2, each of the partition members **9** is provided with an opening or aperture **10** that is adapted to fit closely about a tow bundle being passed through the multiple stage bath while providing means for permitting the countercurrent

flow of treating liquid through the stages **8** in the trough **7**. As has been mentioned, the openings **10** in the partition **9** may have any configuration capable of best accommodating the shape of a particular tow bundle being handled. Quite advantageously, the openings **10** may be substantially rectangular to match a flat, ribbon-like tow bundle of continuous filament fibers so as to facilitate the handling of the tow bundle in such form. The openings **10** are formed or provided in the partitions **9** at a level beneath the intended liquid level of the treating bath so that the tow bundle can be passed completely through all of the stages in the bath while remaining in complete submersion therein during such manipulation.

An embodiment of the method of the present invention with an apparatus in accordance therewith is schematically portrayed in FIGURE 3. The treating bath is divided into four equal stages **8** that are separated by the partitions **9**. Advantageously the treating bath may be a bath of aqueous wash liquid **15** for a multiple continuous filament tow bundle **11** of freshly wet spun polyacrylonitrile filaments in aquagel form that have been withdrawn from a coagulating bath therefor (not shown) and which contain residual quantities of an aqueous saline solution that remains primarily from the solvent and which must be washed out of the filaments to provide them in a suitable physical form and commercially acceptable condition. The tow bundle **11** is introduced into the treating liquid **15** in the first stage of the bath by being passed under a roller guide **12** or equivalent tow-handling and forwarding means for the purpose. The tow bundle **11**, as has been indicated, is advantageously assembled as a relatively flat, ribbon-like array of individual continuous filaments having a substantially rectangular cross-section. The tow bundle **11** is sequentially passed through all of the stages in the bath; traversing each of the stage-separating partition members **9** through the tow-accommodating apertures **10** therein. The tow bundle **11** is withdrawn from the last stage of the treating bath around the roller guide **13** after having been thoroughly washed or otherwise treated. The treating liquid **15** which, as indicated, may advantageously be an aqueous liquid for washing purposes, is passed countercurrently through each of the stages of the bath against the tow bundle. Preferably, this is done by gravity flow, as has been indicated, through stepped or inclined stages. If desired, however, the liquid can actually be pumped through the stages by any suitable fluid-impelling means. The treating liquid **15** is admitted in the last stage of the bath through the liquid inlet **14** and is withdrawn in a spent or used condition after its countercurrent flow from the first stage of the bath through the liquid outlet **16**.

In passing from stage to stage in the bath, the treating liquid passes through the apertures or openings **10** in the partition members **9** directly through and between the individual filaments in the tow bundle **11** while the filaments are traversing each of the partitions in their movement from stage to stage. This, as has been indicated, secures a highly efficient flushing and washing action or other liquid treating contact of the liquid **15** on the tow bundle **11**. It is possible, incidentally, to operate in such a manner that some of the liquid overflows the partitions. Preferably, however, all or substantially all of the liquid is passed through the openings **10** in the partitions **9** so as to actually traverse the tow bundle in its interstage movement.

When acrylonitrile polymer aquagel filament tow bundles are being washed from residual quantities of the spinning solution solvent after having been withdrawn from the coagulating spin bath, it is generally desirable to countercurrently pass at least about 7 parts by weight of the wash liquid, that preferably is introduced as fresh water in the last stage, for each part by weight of the polymer (on a dry weight basis) that is contained in the aquagel filaments. Frequently, it may be preferable to employ from 8 to 40 parts by weight of aqueous wash liquid for each part by weight of polymer in the tow bundle. In

connection with this, when acrylonitrile polymer filaments are wet spun in aqueous saline solvents using aqueous saline coagulants, the freshly spun filaments generally contain at least about 10 parts by weight of salt solution to each part by weight of polymer therein, which solution usually has at least about 45 percent by weight of zinc chloride or its saline equivalents. Such filaments must ordinarily be washed to a condition in which they contain not more than about 0.5 percent by weight of salt, preferably less than about 0.1 percent by weight, based on the dry weight of the polymer in the filaments. A thoroughly washed tow of aquagel filaments generally contains about 4 parts of water per part by weight of dry polymer. In the wash liquid that is employed in countercurrent washing processes for such aquagel filaments, it is usually desirable to employ the liquid to such an extent in the washing process that the spent or used liquid that is withdrawn from the first stage of the treating bath contains at least about 20 percent by weight of salt that has been extracted from the aquagel filaments and preferably at least about 30 or 50 percent by weight of salt, especially when it is zinc chloride.

One possible embodiment of a preferred form of partition member or weir-like stage separator is shown in FIGURES 4, 5, and 6 of the drawing. The partition **9** is comprised of upper and lower sections or members **19** and **20**, respectively. The lower member **20** may be securely fixed or mounted at the bottom of the trough **7**. The upper member **19** may advantageously be removably installed in the trough in such a manner that it is slidably disposed across the width of the trough so as to press closely on and fit accurately with the tow bundle that is passing through the opening **10** in the separator or partition **9**. This may be readily accomplished, as is shown, by mounting the upper partition member **19** in a groove, permitting it to be easily removable and achieving the desired slidable disposition in the assembly. Thus, as is shown in FIGURES 4 and 6, the upper partition member is held between the grooves **21** in the trough. Advantageously the grooves may be provided in mounting elements **25** that are arranged in a suitable disposition. As shown, the upper partition member may actually consist of two slit-like sections which each extend inwardly from the sides of the trough to a centrally provided mounting element **25** that is grooved on each side to match the grooves in the mounting elements near the side walls of the trough. The central mounting element, of course, temporarily divides the tow bundle in its passage through the partition. Such an arrangement facilitates transverse division or separation of very wide tow bundles for ease in handling through certain arrangements. Use of centrally dividing mounting elements is not at all necessary and, quite frequently, can be avoided with complete satisfaction.

In addition, as shown, several matched grooves may be provided in each of the mounting elements to facilitate changes in the spacing between the upper and lower members of the partition. These are shown as the grooves **22** and **23** which are provided adjacent to the grooves **21** in which the upper partition member is mounted. As has been indicated, it is beneficial for the upper portion of the partition to be longitudinally offset from the lower section surrounding the tow accommodating aperture. Such an arrangement is apt to secure the desirable substantially vertical interpassage of the treating liquid through the tow bundle at each of the points of physical stage separation. The offset arrangement between the upper and lower partition members may advantageously be such that the upper member **19** is spaced from the lower member **20** in the same direction as the direction of travel of tow bundle that is passing through the assembly in the bath, as is indicated by the arrow **30**. This, of course, is opposite to the path of the countercurrently flowing treating liquid, as is indicated by the directional arrow **31**. In such an assembly a countercurrent treating liquid passes through the tow bundle in the opening **10** of the partition substantially in the direction of the arrow **32** that is drawn in FIGURE 6.

Of course, if it should be desired, the upper partition member or members **19** may be spaced and offset from the lower member **20** on the upstream side of the partition with respect to the flow of treating liquid. When such an arrangement is made, the treating liquid passes down through the tow bundle in a generally downward manner rather than up through the assembled filaments in the manner of flow that is illustrated in FIGURE 6.

In FIGURE 7, there is schematically illustrated a means for agitating the tow bundle **11** during its passage through one of the stages in order to increase the liquid treating efficiency of the operation being performed and to secure maximum benefit in the practice of the present invention. To this end and pursuant to such practice, any suitable means for vertically reciprocating or agitating the tow bundle **11**, such as the reciprocating element **40** which is vertically operable (as indicated by the bidirectional arrow), may be employed in order to reciprocate the tow bundle and move it back and forth between spaced upper and lower limits, such as the points designated by the arrows "U" and "D," respectively. Advantageously, the means that is employed for such purpose may be in essential accordance with that which has been disclosed in the copending application for United States Letters Patent having Serial No. 663,694, which was filed on June 5, 1957, by Thomas C. Spence, Rex E. Thomas, and Arthur B. Greenwood for a "Method and Apparatus for Washing Tow Bundles of Wet Spun Fibers."

Another advantageous means for greatly increasing the efficiency of the liquid treatment on the tow bundle which may be achieved in any or all of the stages in the practice of the present invention is in keeping with the manner that is schematically illustrated in FIGURE 8, wherein a means is utilized for transversely flushing the tow bundle with a portion of the treating liquid being passed through the stage. Preferably, the portion of the liquid that is employed for the transverse flushing is internally circulated from the volume of the treating bath that is contained within each stage. The recirculated liquid is passed through a liquid distributor or ejecting element adjacent to the tow bundle **11**, such as the element **45**, which is schematically depicted in FIGURE 8. Most advantageously, the distributor element **45** is adapted to pass a sheet-like stream of the recirculated treating liquid transversely through the passing tow bundle so as to secure an effective flushing action therethrough in the general direction indicated by the arrows **50**. Most advantageously, the flushing or transverse washing means that is utilized is embodied and employed in accordance with the disclosure of the copending application for United States Letters Patent having Serial No. 683,653, which was filed on September 12, 1957, by Charles F. Oldershaw for an improvement in "Treating Tow Bundles With Beneficial Liquids."

As has been mentioned, the treating liquid **15** that is employed may be of any desired variety that may be utilized for accomplishing a beneficial effect upon the fibers. While it is of great advantage, as is apparent, to wash freshly spun articles and synthetic fibers in the practice of the technique and with physical means according to the invention, other beneficial liquid treatments on textile fibers of practically any desired origin may also be achieved. Thus the fibers may be bleached, scoured, dyed, lubricated, conditioned or provided with coatings or finsh deposits of various sorts from diverse types of liquid applicating compositions in the practice of the invention. Other suitable liquid treatments may also be done in this manner.

By way of further illustration, an apparatus patterned after that shown in FIGURE 3, but having stage separating partition elements similar to those shown in FIGURES 4, 5 and 6, is employed to wash a freshly wet spun tow

bundle of polyacrylonitrile aquagel filaments that consists of about sixty thousand individual continuous filaments, each of which has an ultimate denier, as a finally finished textile fiber product, of about three. Upon their introduction into the treating liquid, the aquagel filaments contain about 10 parts by weight of 45 percent by weight aqueous zinc chloride solution to each part by weight of polymer (on a dry basis) therein.

The wash bath has a total length of about 70 feet, a width of about 1.5 feet and is adapted to contain the wash liquid at an average depth of about 3 inches. The stage separating partition elements in the bath are separated at about 3.5 feet intervals. The upper partition members surrounding the openings in each of the stage separators have an effective vertical width of about 1.25 inches in the treating bath and are offset, or are spaced downstream with respect to the wash liquid from the lower partition members, by a distance of about 1.5 inches. The lower partition members in each of the separators are rectangular walls that extend upwardly about 1.75 inches from the bottom of the trough. This, in effect, provides a substantially rectangular opening in each of the partition members that lies disposed in a horizontal plane so as to accommodate passage of the tow through the partition in a sort of zig-zag manner of progression. The tow width-accommodating length of each opening in each partition member is about 12 inches. The apparent cross-section dimensions of the tow are about 0.22 by 12 inches, so that it closely conforms to the openings in the partition members during its zig-zag passage between the stages.

The tow is passed through the bath at a linear rate of about 15 feet per minute. Fresh water is introduced in the last stage of the bath at a rate of about 1.7 gallons per minute and passed countercurrent to the tow bundle through each of the stages to be withdrawn from the first stage containing about 31 percent by weight of zinc chloride. The washed tow contains about 4 parts by weight of water to each part by weight of polymer. It has an excellently low salt content, based on the weight of the polymer therein, of about 0.1 percent. The washed tow, upon withdrawal from the bath, is subsequently dried. It provides premium quality, polyacrylonitrile textile fiber products.

The efficiency of the above-described washing operation can be greatly increased and the requisite length of the wash bath considerably reduced by employing in each stage either physical tow agitating means such as is illustrated in FIGURE 7 of the drawing (especially when they are in accordance with those described in the referred-to copending application of Spence, Thomas and Greenwood) or transverse liquid flushing means (particularly of the type comprehended in the referred-to copending application of Oldershaw), or both, if such a dual installation is so desired.

What is claimed is:

1. A method for treating a tow bundle of a plurality of continuous filament fibers which comprises, on a continuously operating basis, introducing said multiple continuous filament tow bundle into a countercurrently flowing treating liquid in a first liquid treating stage at one end of a bath of said treating liquid that consists of a plurality of at least two physically separated stages each sequentially intercommunicating through an opening at the point of physical separation between each stage which opening is adapted to fit closely about and permit the substantially squeezeless passage therethrough of said tow bundle while permitting liquid communication between adjacent stages through said opening and the tow bundle therein; passing said tow bundle in a sequential fashion through each of said openings and through said countercurrently flowing treating liquid in each of said stages so that said tow bundle, without being substantially squeezed therein, fills each opening through which sequential stages intercommunicate at each point of physical separation between stages; withdrawing the liquid treated tow bundle from said treating liquid in the last of said stages at the opposite end of said bath; admitting at least a portion of fresh treating liquid in the last of said stages; withdrawing at least a portion of the used treating liquid from the first of said stages; and passing said treating liquid from the last of said stages to the first thereof through each of said stages, countercurrent to said tow bundle, in such a manner that at each point of physical separation between each of said stages, all of said countercurrently flowing treating liquid flowing through the opening from stage to stage is caused to pass and flow through and between the integrant filaments in said tow bundle, as aforesaid, filling said opening in a substantially squeezeless manner while said tow bundle is transversing said point of separation.

2. The method of claim 1, wherein the tow bundle is comprised of freshly wet spun filaments containing residual impurities and said treating liquid is a washing liquid for extracting said impurities.

3. A method in accordance with the method that is set forth in claim 1, and including the additional step in integral combination therewith of physically agitating said tow bundle in a relatively vertical up and down manner within said treating liquid while it is passing through one or more of said stages.

4. A method in accordance with the method that is set forth in claim 1, and including the additional step in integral combination therewith of transversely flushing said tow bundle with said treating liquid while it is intermediate between and passing through one or more of said stages.

5. The method of claim 1, wherein said treating liquid is passed through said stages by gravity flow.

6. The method of claim 1, wherein said tow bundle is comprised of at least ten thousand individual filaments and is assembled in a substantially flat, ribbon-like form.

7. A method in accordance with the method that is set forth in claim 6, wherein the average thickness of said tow bundle is between about 5 and 125 filaments.

8. A method in accordance with the method that is set forth in claim 7, wherein the average thickness of said tow bundle is at least about 40 filaments.

9. The method of claim 1, wherein the tow bundle is comprised of freshly wet spun acrylonitrile polymer aquagel fibers and wherein said treating liquid is water.

10. A method in accordance with the method that is set forth in claim 9, wherein between about 8 and 40 parts by weight of water are employed for washing each part by weight of polymer on a dry basis and said tow bundle.

11. A method in accordance with the method that is set forth in claim 10, wherein at least 4 individual stages are employed in said wash bath.

12. A method in accordance with the method that is set forth in claim 10, wherein all of the water is admitted in the last of said stages and substantially all of the used washed liquid is withdrawn from the first of said stages.

References Cited in the file of this patent

UNITED STATES PATENTS

1,175,538	Matos	Mar. 14, 1916
2,131,409	Nai	Sept. 27, 1938
2,133,535	Campolunghi	Oct. 18, 1938
2,149,708	Von Recklinghausen	Mar. 7, 1939
2,772,552	Nikles	Dec. 4, 1956
2,782,623	Coe	Feb. 26, 1957
2,949,337	Oldershaw	Aug. 16, 1960

FOREIGN PATENTS

460,079	Great Britain	Jan. 20, 1937