Nov. 21, 1967 E. A. TAYLOR, JR 3,353,381

HIGH VELOCITY TOW WASHING CASCADE

Filed Nov. 26, 1965 3 Sheets-Sheet 1

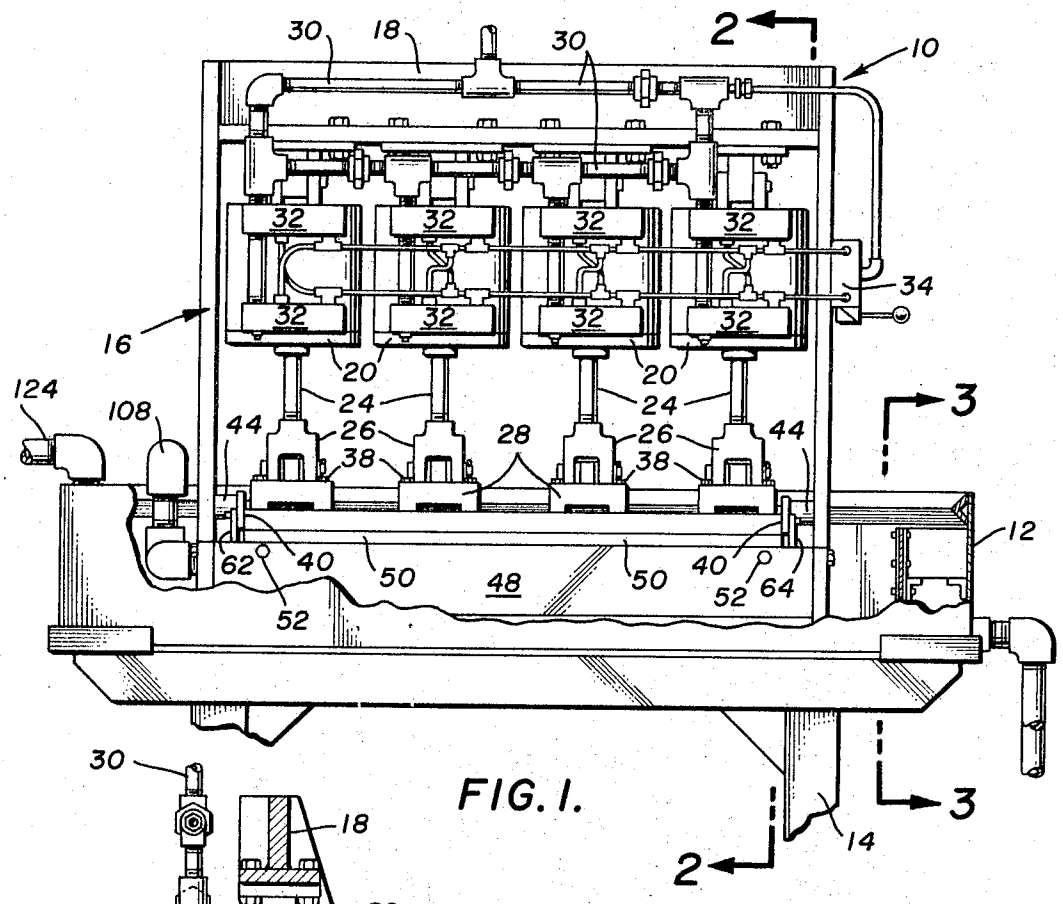


FIG. 1.

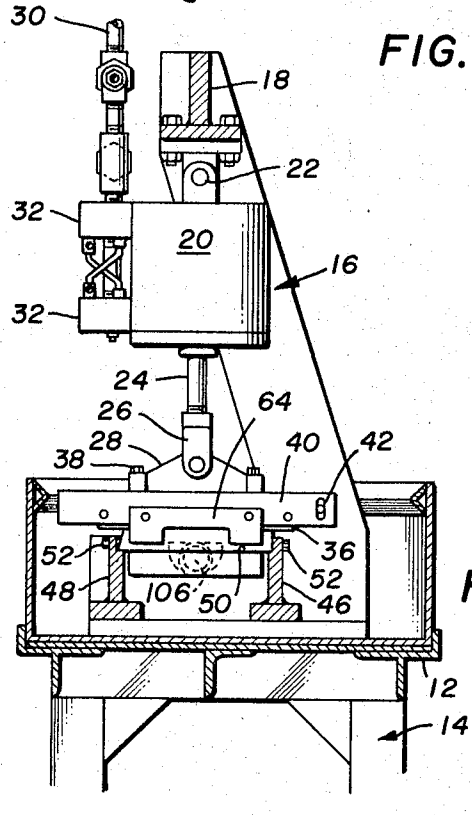


FIG. 2.

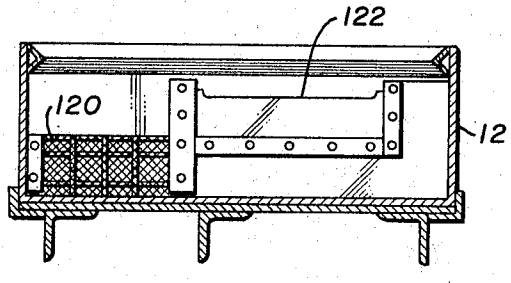


FIG. 3.

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HIGH VELOCITY TOW WASHING CASCADE

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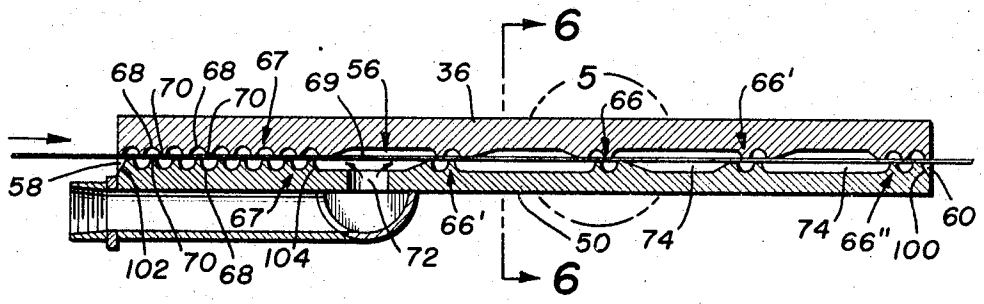


FIG. 4.

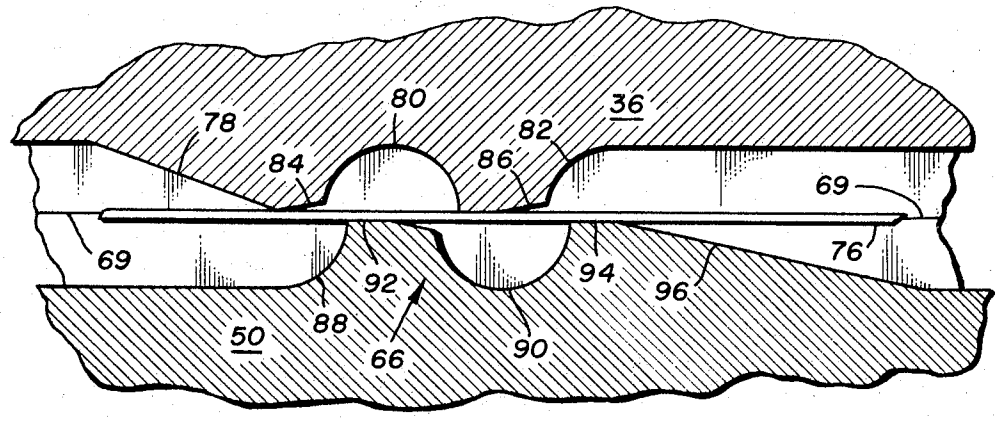


FIG. 5.

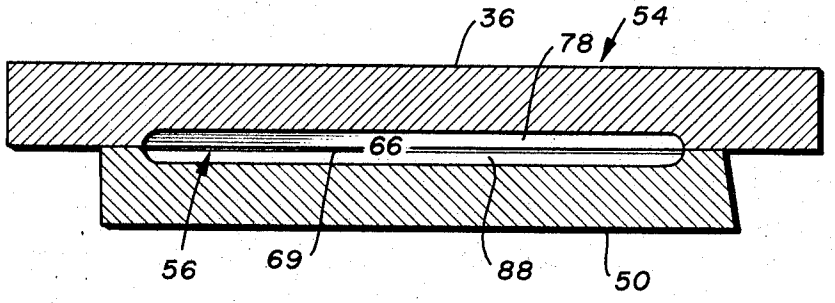


FIG. 6.

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HIGH VELOCITY TOW WASHING CASCADE

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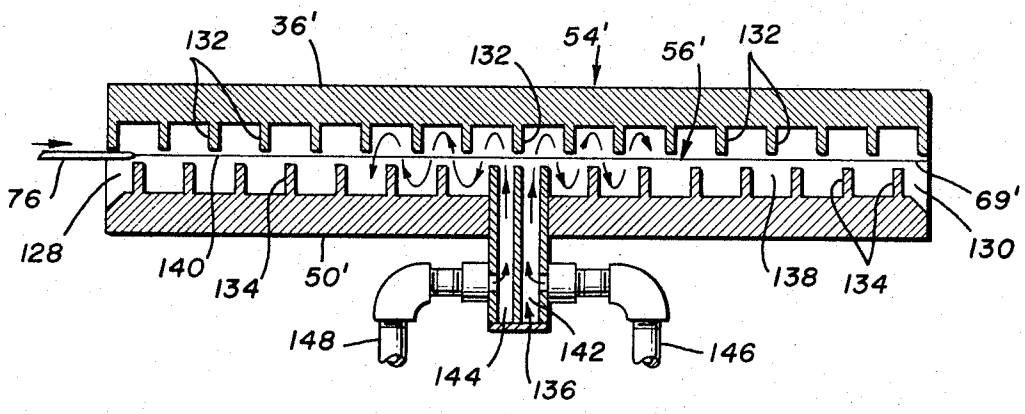


FIG. 7.

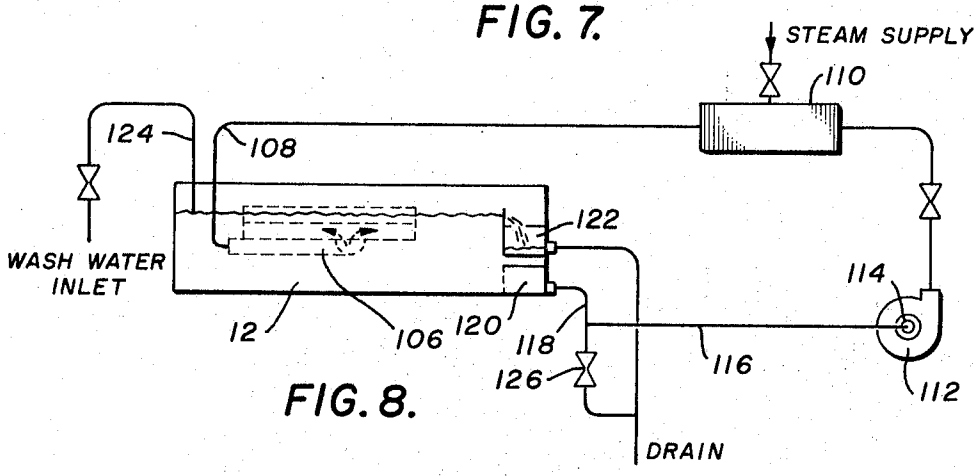


FIG. 8.

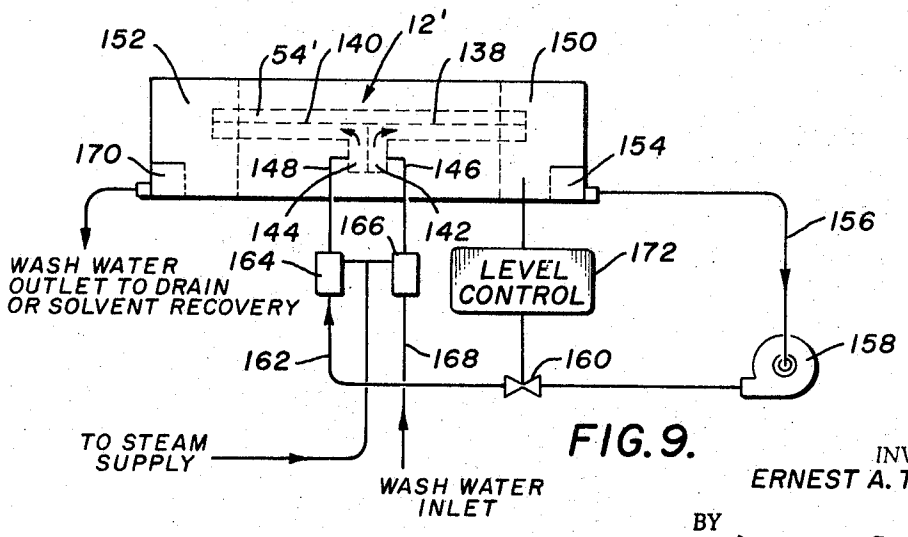


FIG. 9.

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3,353,381

HIGH VELOCITY TOW WASHING CASCADE

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Filed Nov. 26, 1965, Ser. No. 509,749
26 Claims. (Cl. 68—184)

ABSTRACT OF THE DISCLOSURE

This invention provides an apparatus for continuously washing a moving tow of synthetic fibers, the tow being spread into ribbon form. The apparatus is provided with an elongated chamber through which the tow and water are passed. The chamber is provided with a plurality of curved deflecting surfaces which force the water to sweep back and forth through the tow from one side of the chamber to the other.

This invention relates to an apparatus for washing synthetic fibers and more particularly relates to an apparatus for washing synthetic fibers in which washing fluid is directed substantially perpendicularly to the plane in which the synthetic fibers move while at the same time, the washing fluid is directed both countercurrent and with the direction of filament flow.

In the wet spinning process of making synthetic fibers, a dope which consists of a polymer or copolymer and a solvent is extruded through spinnerettes into a coagulating bath. Filaments are formed as the coagulating fluid comes in contact with the extruded dope. These are gathered into a group, the aggregation of which comprises the tow. In order to produce a filamentary tow having good textile processing characteristics, the residual solvent existing therein must be removed. This operation is presently performed by passing the tow along what is known as a cascade in which the tow is drawn upward along a countercurrent flow of washing fluid, generally water.

Difficulty has been experienced in removing the solvent from the tow as it travels along the cascade because it carries therewith an amount of washing fluid which forms a boundary layer around each filament. This boundary layer impedes the rinsing process for the wash fluid cannot effectively circulate through the tow and contact the fibers due to the affinity of the fibers for the fluid.

Heretofore attempts have been made to remove this boundary layer by utilizing a stripping process performed either by sharply bending the tow or by nipping it. Since the tow is generally drawn up the cascade along a straight path under tension, it cannot be bent with any effectivenes. Stripper bars and rollers have been employed to squeeze the tow as it passes along the cascade and hence attempt to remove the boundary layer therefrom. This method is often times ineffective unless great pressure is utilized especially where tows of a large denier are being washed. The disadvantages of applying great pressure to a synthetic filament still partly imbued with solvent are self-evident. Furthermore, an increase in pressure causes an increase in friction between the outer fibers and the stripping means resulting in breakage and further damage.

According to the present invention it has been found that these difficulties may be overcome by utilizing an elongated washing compartment having a plurality of baffles extending thereacross. The washing compartment is formed by a pair of troughs removably secured or hinged together, each including deflectors extending across their bottom. The deflectors on the troughs are arranged to form the compartment baffles and result in a tortuous

path for a flow of washing fluid, such as water, through the compartment. The deflectors are arranged to alternately direct the fluid toward and through the tow from above at substantially a perpendicular angle and then at the tow from below at substantially a perpendicular angle as it flows thereby.

Fluid flow commences at an inlet located intermediate the ends of the trough and is divided and directed outwardly in opposite directions. In this manner the tow passing through the washing device, which is the subject of this invention, is subjected partly to a countercurrent fluid flow and partly to a flow in the direction in which the tow is moving. At the ends of the trough the washing fluid overflows into a receptacle or receptacles where it is collected.

In one embodiment of the invention the deflectors on the troughs are shaped and related to form a baffle in an S-shaped curve. The curve is dimensioned so that the tow may pass through the center section thereof while the washing fluid is directed at a relatively high velocity along a curved path. Along one portion of the washing compartment the baffles are spaced apart to form low velocity areas or chambers by means of which the compartment length can be extended without increasing the pressure drop due to fluid flow. The increased length of the washer compartment is necessary to permit solvent in each fiber to diffuse outwardly after the solvent containing boundary layer of fluid has been removed by passage of the tow through the baffle. The washer can be divided into any number of high velocity washing areas and intermediate diffusion areas as required by the tow thickness, speed and difficulty of washing. Along another portion, the washing compartment consists of a plurality of baffles located side by side to form an area of intense solvent removal.

In this first embodiment the washing fluid from both portions of the washing compartment discharges into a common reservoir from which it is recirculated by a pump to the compartment. To prevent an undue accumulation of solvent in the wash water, a supply conduit opens into the reservoir on the pump inlet and introduces fresh water while an equal amount of solvent containing fluid is overflowed from the reservoir to a drain or to a solvent recovery area.

In another embodiment of the invention the baffles in the washing compartment are formed by planar deflectors on each trough. The washing fluid may exit into a common reservoir from each end of the washing compartment as described above, or alternatively, the fluid from each end may be received in separate reservoirs. In the latter instance the fluid flowing through a first portion of the compartment is recirculated through the other portion of the compartment while fresh washing fluid is introduced into the first portion. In both embodiments it has been found desirable to heat the washing fluid in a suitable manner before it is introduced into the washing compartment.

Accordingly, it is an object of this invention to provide an apparatus for washing a tow of synthetic filaments in which the boundary layer is stripped therefrom by the force of the washing fluid acting at an angle thereto.

A further object of the invention is to provide apparatus for washing a filamentary tow of synthetic material in which the usual boundary layer stripping rolls or bars are replaced by a plurality of baffles which direct a high velocity stream of washing fluid through the tow at an angle.

Another object of this invention is to provide an apparatus for removing a solvent from a filamentary tow of synthetic material in which no mechanical elements are placed in contact therewith.

Still another object of this invention is to provide an apparatus for removing solvent from a filamentary tow of synthetic material in which a flow of washing fluid is established both countercurrent to and with the flow of filaments.

Yet another object of this invention is to provide an apparatus for removing solvent from a filamentary tow of synthetic material in which the washing fluid may be recirculated through a portion of the apparatus.

A still further object of this invention is to provide apparatus which effectively penetrates and removes the boundary layer of washing fluid from all the filaments comprising a tow.

And still another object of this invention is to provide a series of spaced apart baffled sections to allow sufficient time for solvent diffusion from each filament.

These and other objects and advantages of this invention will be more apparent upon reference to the following specification, appended claims and drawings wherein:

FIGURE 1 is a partly broken side view of one embodiment of the washing apparatus according to the instant invention showing the interrelationship between the reservoir, troughs, washing fluid supply and draining conduits, and the mechanism for moving the troughs relative to one another;

FIGURE 2 is a cross-sectional view taken along lines 2—2 of FIGURE 1;

FIGURE 3 is a cross-sectional view taken along lines 3—3 of FIGURE 1 showing a portion of the washing fluid supply and drain system;

FIGURE 4 is a cross-sectional view of the washing compartment according to the embodiment illustrated in FIGURE 1 showing the interrelationship of the baffles and the washing fluid inlet;

FIGURE 5 is an enlarged fragmentary view showing in detail the configuration of a baffle according to the embodiment illustrated in FIGURE 4;

FIGURE 6 is a cross-sectional view taken along line 6—6 of the washing compartment illustrated in FIGURE 4;

FIGURE 7 is a partly cross-sectional view of a washing compartment having planar baffle forming deflectors according to another embodiment of the invention;

FIGURE 8 is a diagrammatic illustration of the fluid flow system according to one embodiment of the invention; and

FIGURE 9 is a diagrammatic view similar to FIGURE 8 but illustrating the fluid supply system according to another embodiment of the invention.

In order to better understand the construction and use of this novel method and apparatus for washing, it will be described in relation to removal of solvent from a filamentary tow of synthetic materials. It is to be understood, however, that various other uses may be found for this novel method and device. For example, it can be utilized for removing excess of unwanted materials or fluids from a finished or partly finished fabric or for dyeing a fabric or tow.

It can also be used to assure penetration of materials or fluids such as a dye-bath, finish additives, delustrants, or various other chemicals wherein it is desired to treat either a tow or a finished cloth uniformly from fiber to fiber and from outside to inside. Other uses will be readily apparent to those skilled in the art.

With continued reference to the accompanying figures wherein like numerals designate similar parts throughout the various views and with initial attention directed to FIGURE 1, reference numeral **10** designates generally a tow washing device according to the instant invention. This device includes a reservoir **12** capable of containing a quantity of washing fluid such as, for example, water supported on a framework **14**. A second framework **16** extends above reservoir **12** and, as most clearly shown in FIGURE 2, includes at its uppermost extent an inverted T-bar **18** to which a plurality of pneumatic cylinders **20** are secured through a pivot **22**. Actuating rods **24** movable within the cylinder **20** in response to the introduction of a compressible fluid such as air extend below cylinders **20** and are pivotably secured through rod clevises **26** to brackets **28**.

The compressed fluid is furnished to the cylinders **20** through air lines **30** connected to a plurality of control valves **32**. Impelling air is introduced into the cylinders **20** by manipulation of the lever operated control valve **34** which simultaneously opens or closes the control valves **32** according to the result desired. This system is not considered an essential feature of the invention and could be modified in various ways to obtain the same end result. For example, an electrical-electronic system featuring servo-motors and controls could be utilized just as well.

As most clearly shown in FIGURE 1, the brackets **28** are secured to an inverted trough **36** through bolts **38**. The trough **36** is in turn secured to hinge plate **40** which, as shown in FIGURE 2, are pivotally connected at point **42** to an extension **44** of the frame **16**. Thus, as actuating rods **24** are drawn into the cylinders **20** under the influence of a compressed fluid supplied through lines **30**, the inverted trough **36** pivots upwardly about point **42** to an angular open position. Conversely, the trough is held in its closed position as compressed fluid is utilized to force rods **24** to an outwardly extended position.

A pair of inverted T-bars **46** and **48** also secured to and forming a portion of the frame **16** are disposed within the reservoir **12** as shown most clearly in FIGURE 2. Mounted between these bars is another trough **50** secured thereto by bolts **52**. As most clearly shown in FIGURES 2, 4, 5, and 6 troughs **36** and **50** form, in combination, a washing compartment **54** having a hollow interior or passageway **56** communicating with entrance **58** and exit **60** apertures through which a filamentary tow or other material to be treated can be passed. As shown in FIGURES 1 and 2, tow guides **62** and **64** are provided at apertures **58** and **60** to maintain the tow along a desired path.

As most clearly illustrated in FIGURES 4, 5, and 6 the hollow interior or passageway **56** of the washing compartment **54** is formed into a tortuous conduit for fluid by a plurality of baffles **66** and **67** disposed therein. Immediately adjacent the inlet aperture **58** the baffles **67** are defined by a plurality of deflecting surfaces placed side by side on troughs **36** and **50**. Each deflector includes a cylindrical surface **68** having as its directrix an arc of a circle the center of which is located to one side of the dividing line **69** between troughs **36** and **50** as will be hereinafter more fully explained. Cylindrical surfaces **68** are joined by connecting surfaces **70** which extend along, and are at least partly parallel to the dividing line **69**.

A washing fluid inlet **72** is provided in the washing compartment **54** intermediate its ends. Between washing fluid inlet **72** and aperture **60** the hollow interior or passageway **56** is divided into a tortuous path by baffles **66** which are spaced from one another to provide chambers **74** in which the tow has an opportunity for additional solvent diffusion therefrom before again being subjected to washing fluid moving at a high velocity through the constriction formed by baffles **66**. As representative of all baffles **66** and to some extent baffles **67** the circled baffle is shown in detail in FIGURE 5.

As shown in FIGURE 5 a tow **76** of synthetic filamentary material moves along a path in the interior passageway **56** which is substantially midway between the bottoms of troughs **36** and **50** and approximately along the dividing line **69**. Each baffle includes a planar surface **78** sloping away from the inlet **72** toward, but terminating at one outermost extent of the path which tow **76** follows. Longitudinally spaced from the planar surface **78** is a cylindrical surface **80** the directrix of which is an arc of a circle centered along one side of the tow **76** path. The directrix of this first cylindrical surface **80** forms substantially a semi-circle having a radius equal to the distance from the path for tow **76** to the bottom of the

trough **36**. Thus, the first cylindrical surface **80** extends from substantially the tow path to the bottom of the trough and back to the tow path.

Longitudinally spaced from the first cylindrical surface **80** and the planar surface **78** is a second cylindrical surface **82**. Again, the directrix of the second cylindrical surface is an arc of a circle centered along the other side of the said tow path and having a radius equal to the distance between said tow path and the associated bottom of the trough **36**. This surface, however, extends only from a point substantially at said path for tow **76** to the bottom of the trough where it terminates as clearly shown in FIGURE 5.

Joining the first cylindrical surface **80** and the planar surface **78** is a first connecting surface **84**. Likewise, a second connecting surface **86** joins the first and second cylindrical surfaces **80** and **82** respectively. In order to provide a rapid but smooth flow of fluid through the baffle **66** with minimum fluid energy loss, the planar surface **78** slopes at a relatively mild angle of 20 degrees to a point adjacent the tow path. Since the flow of fluid (as indicated by arrows) tends to displace the tow from the level path illustrated, the first and second connecting surfaces **84** and **86** are sloped downwardly at approximately 10 degrees to avoid contact with the tow **76** to the greatest extent possible and to provide a snag-free path through the baffle. Otherwise, connecting surfaces **84** and **86** extend generally parallel to the path along which tow **76** is moved.

The deflecting surfaces formed on the trough **50** as part of the baffle **66** are much like those described above placed, however, in substantially a reversed relationship. Thus, this deflector includes a first cylindrical surface **88** and a second cylindrical surface **90** each of which have a directrix that is an arc of a circle with its center located along the path for tow **76**. Again, the radius of the circle is equal to the distance to the path for tow **76** to the bottom of its associated trough **50**. The first cylindrical surface **88** extends from a point substantially at the path for tow **76** to the bottom of trough **50** where it terminates while the directrix of the second cylindrical surface is substantially a semi-circle so that it extends from the path for tow to the bottom of the trough **50** and back to the path for tow.

A first connecting surface **92** extends substantially along the paths for tow **76** and joins first and second cylindrical surfaces **88** and **90** respectively. A second connecting surface **94** joins the second cylindrical surface **90** to a planar surface **96** which slopes downward from a point substantially at one outermost extent of the paths for tow to the bottom of its associated trough **50**. The planar surface **96** is inclined at an angle of approximately 20 degrees to the path for tow **76** while the first connecting surface **92** has a partly sloping surface which, again, is at an angle of approximately 10 degrees with respect to the path for tow to provide a smooth, snag-free passageway for the tow **76**. The small angle of surface **96** allows the moving fluid to expand into the diffusion chamber with a minimum loss of fluid energy, according to well established fluid flow principles.

The deflecting surfaces on trough **50** and trough **36** are related so that when combined a baffle is produced constricting the passageway **56** into a substantially S-shaped curve. Thus, the radii of the various directrix of the cylindrical surfaces, all of which are equal in length as explained above, are spaced along said path for tow **76** such that they overlap to an extent sufficient to provide a constricted, and hence high velocity, fluid passageway along the deflecting surface formed by cylindrical surface **80** and the deflecting surface formed by cylindrical surface **90**. For example, where the radii of these directrix measure one-fourth inch, the directrix centers will be spaced apart 0.406 inch, an amount equal to approximately the sum of two radii minus approximately one-fifth the sum.

In order to provide a clear path for tow through the baffles **66**, the centers of the directrix of the cylindrical surfaces **80** and **82** formed in trough **36** and the outermost extent of first and second connecting surfaces **84** and **86** and planar surface **78** lie in a plane which is disposed slightly to the trough **36** side of the path for tow **76**. Likewise, the centers of the directrix for first **88** and second **90** cylindrical surfaces and the outermost extent of planar surface **96** and connecting surfaces **92** and **94** formed on trough **50** lie in a plane disposed to the trough **50** side of the path for tow **76**. Thus, all deflector surfaces formed on trough **36** and trough **50** are spaced from one another a distance equal to at least the thickness of the path for tow **76**.

As clearly shown in FIGURE 4 alternate baffles **66'** are formed by reversing the position of the deflector surfaces on troughs **36** and **50**. In this manner, the planar and first and second cylindrical surfaces **80** and **82** and their associated connecting surfaces **84** and **86** are inverted and formed on trough **50**. In a like manner planar surface **96**, first and second cylindrical surfaces **88** and **90** and their associated connecting surfaces **92** and **94** are inverted and formed on trough **36**. While not absolutely necessary, this reversal does result in smoother fluid flow and minimum fluid energy losses, and hence, additional efficiency in the utilization of washing fluid.

The outermost baffle **66''** at aperture **60** is very similar to baffle **66** except that the second cylindrical surface corresponding to second cylindrical surface **82** has, like cylindrical surface **80**, as its directrix an arc which is substantially a semi-circle. This, in conjunction with the angular planar surface **100** extending at approximately a 60 degree angle to the path for tow, directs the flow of washing fluid downwardly into the reservoir **12** to prevent excessive splattering.

The baffles **66** are not illustrated in detail since they are substantially identical in their formation and relationship as the deflector surfaces formed by cylindrical surface **80** and cylindrical surface **90** illustrated in FIGURE 5. Again, the radii of the directrix of these two surfaces overlap as described above and their centers are located relatively to the tow path in the same position. Furthermore, the length of these radii is, again, equal to the distance from the trough side of the tow path with which it is associated to the bottom of that trough. Connecting surfaces **70** are substantially identical to connecting surfaces **86** and **92** as shown in FIGURE 5 except that they slope oppositely, as shown, to compensate for the fact that washing fluid flows through these baffles in a different direction as shown by the arrows. As shown, the planar surfaces **78** and **96** as well as the half cylindrical surfaces **82** and **88** are eliminated and a series of cylindrical surfaces similar to those shown at **80** and **90** in FIGURE 5 are placed side by side to form an undulating, tortuous passageway for fluid. At the entrance aperture **58**, a planar surface is provided again to, in combination with the last cylindrical surface, direct washing fluid downwardly into the reservoir **12**. Another curved surface **104** is provided at the inlet side of this tortuous passageway formed by baffles **67** to direct the washing fluid along the desired course.

As shown in FIGURES 2 and 8, the washing water inlet **72** is connected through a conduit **106** to a pipe **108** extending through a heat exchanger **110** to a pump **112**. The inlet **114** of pump **112** is connected through pipes **116** and **118** to a screened drain **120** in reservoir **12**. By this arrangement wash water is recirculated from the reservoir **12** as a conservation measure. To prevent solvent concentration from becoming excessive, a continuous overflow is maintained through the screened drain **122** at the same time a continuous supply of fresh, relatively solvent-free washing fluid is supplied through a pipe **124**. The amount of solvent concentration can, therefore, be regulated merely by increasing or decreasing the amount of solvent-free fluid introduced through pipe **124**. Complete drain-

age of reservoir **12** is effected by opening valve **126** and ceasing operation of the pump **112**.

In operation, a filamentary tow is threaded through the washing compartment **54** by raising the trough **36** under influence of the action of pneumatic cylinders **20** acting through actuating rods **24**. After threading, the trough **36** is returned to its closed position and operation of the pump **112** commenced to force washing fluid through the inlet **72**. Upon reaching the interior passageway **56** of the washing compartment **54**, the washing fluid divides with part flowing through the baffles **66** and part through the baffles **67**. Tow entering through aperture **58** and exiting through aperture **60** is subjected to a countercurrent flow of fluid as it passed along baffles **67** and at the same time a high velocity flow alternately from above and below its path. This action tends to spread the tow and force water therethrough, breaking the boundary layer and achieving good penetration and hence a thorough washing.

As the tow continues through the hollow interior **56** across baffles **66**, **66'** and **66''** it is subjected to a flow of washing water moving in the same direction but, usually, at a greater velocity. Thus, in this section the washing action is more gentle while at the same time maintaining good penetration of the tow to remove the desired amount of residual solvent or other unwanted ingredients. Again, penetrating from above and below is achieved by flow of fluid from these directions.

In the embodiment of the invention illustrated in FIGURE 7, the washing compartment **54'** is formed by a pair of troughs **36'** and **50'** fitted together and relatively hinged as illustrated in FIGURE 1. When in operative position as shown, a hollow interior passageway **56'** is formed similarly to the embodiment illustrated specifically in FIGURES 4 and 5. This hollow interior passageway **56'** communicates with an inlet aperture **128** and an outlet aperture **130** through which tow **76** may be passed as indicated by the arrow. The interior of this passageway is formed into a tortuous, undulating conduit for washing fluid by a plurality of baffles, each of which is formed by a deflector **132** on trough **36'** alternately spaced with a deflector **134** on trough **50'**. As illustrated these deflectors **132** and **134** are planar and extend substantially perpendicular to the bottom of its associated trough bottom and terminate in closely spaced relationship to one another to form a relatively obstacle free path through which tow **76** may pass. The arrangement of deflectors **132** and **134** is such, however, as to form a tortuous, undulating path for fluid as shown by the arrows so that the tow is alternately subjected to a high velocity flow directed therethrough at a substantially right angle from above and then from below.

Washing fluid is introduced into the interior passageway **56'** of the washing compartment **54'** at a point substantially equidistant from inlet and outlet apertures **128** and **130**. Washing fluid passes through an inlet distribution head **136** which projects into the hollow interior **56'** and divides it into a first portion **138** between the head **136** and the outlet aperture **130** and a second portion **140** between the head **136** and the inlet aperture **128**. The inlet head **136** is divided into first and second chambers **142** and **144** respectively and is arranged so that the dividing line therebetween is located exactly opposite a deflector **132** on the trough **36'**. Washing fluid is introduced into the first chamber **142** through a pipe **146**, and similarly, washing fluid is introduced into the second chamber **144** through a pipe **148**. Fluid flow is maintained at a constant rate through both first and second chambers **142** and **144** in a manner hereinafter described so that the volumes of fluid passing through the washing compartment portions **138** and **140** are equal. As shown by the arrows, the washing fluid passing through each portion is directed by the various deflectors along a tortuous and undulating course.

While it is obvious that the embodiment of the invention illustrated in FIGURE 7 can be utilized with the fluid supply system illustrated in FIGURE 8 and described above, an alternate supply system is illustrated in FIGURE 9. As shown in FIGURE 9, the reservoir **12'** is divided in such a manner as to provide a first receptacle **150** at the outlet end of washing compartment **54'**. A screened drain **154** is provided in the bottom of receptacle **150** and is connected through tubing **156** to the inlet of a pump **158**. As shown in FIGURE 9 the pump **158** is connected through a throttling valve **160**, pipe **162**, and heat exchanger **164** to pipe **148** which exits into the second chamber **144** of the inlet head **136**. The first chamber **142** of inlet head **136** is connected through pipe **146** to a heat exchanger **166** and thence through a pipe **168** to a supply of fresh washing fluid. A regulated supply of steam is provided to heat exchangers **164** and **166** from a steam supply to maintain the washing fluid at the desired temperature.

In operation, fresh washing fluid passes through heat exchanger **166** where its temperature is elevated, through the first inlet head chamber **142**, through first washing compartment portion **138** and thence into receptacle **150** where it is collected. This fluid is then conducted through drain **154** and pipe **156** to pump **158** and thence through heat exchanger **164** into the second chamber **144**. From chamber **144** the fluid passes into the second portion **140** of washing compartment **54'** and into receptacle **152**. The washing fluid is then either disposed of through a screened drain **170** or directed to a solvent recovery device. The amount of fluid in receptacle **150** is maintained at a preselected level by control **172** which operates throttle valve **160** in a well known manner. Thus, the volume of fluid passing through portions **138** and **140** is maintained equally in the following manner. If the amount of fluid passing through portion **138** increases, the level in receptacle **150** will also increase and such is sensed by level control **172**. After a slight rise in level the throttling valve **160** is adjusted to allow passage of more fluid into the second compartment portion **140**. Obviously, if the level of fluid in receptacle **150** falls, the throttle **160** will be adjusted to lessen the volume passed through second portion **140**.

As tow **76** passes through aperture **128**, and along second washing compartment portion **140** it is subjected to a countercurrent flow of washing fluid alternately forced therethrough from above and below at high velocity. Passing on into first trough portion **138** the tow **76** is subjected to a concurrent flow of fluid which is again alternately forced therethrough from above and below. In this manner, the tow which comprises a plurality of synthetic filaments is repeatedly penetrated to remove unwanted residual ingredients.

It will be apparent that by utilizing the apparatus and method for washing filamentary tows which is the subject of this invention, a much more efficient and effective removal of solvent is accomplished. This result is obtained without utilizing boundary layers, stripper bars, or rolls as has heretofore been the practice. In addition to improving the effectiveness of tow washing, this novel apparatus and method enables the washing of larger tows in a relatively small floor space due to the more efficient use of the washing fluid. Thus, more efficient utilization of both floor area and washing fluid can be accomplished resulting in the saving of both time and capital to a significant degree.

The same principles of high velocity washing that assures intimate contact of the washing fluid with every fiber of a tow can be applied when it is desired to contact every fiber of a tow or fabric with a chemical or other substance in a fluid vehicle. In the first case, intimate contact of solvent containing fiber with relatively solvent free fluid allows diffusion of solvent from the fiber to the fluid. In the opposite case, intimate contact of a chemical poor fiber arrangement with a chemical rich fluid will encourage uniform diffusion, if such can occur, of the chemical from the fluid into the fibers.

It may be further noted that, since the fluid is introduced into the intermediate portion of the apparatus and fluid flow is towards opposite ends which are open to the atmosphere, it is obvious that the fluid pressure at the point of introduction is higher than atmospheric. This means that a fluid may be introduced into the apparatus at a temperature higher than its atmospheric boiling point. The apparatus may thus be considered a pressure vessel wherein a fluid of a higher than normal temperature may be used. For instance, if water is introduced into the washer at an inlet pressure of 25 p.s.i.g. (39.7 p.s.i.a.), it can be introduced at a temperature up to 265° F. rather than a temperature of 212° F. This does result in considerable flashing off of steam as the water drops in pressure in passing through the washer. Generally, it is more practical to utilize some maximum temperature intermediate the atmospheric boiling point and the boiling point at the pressure indicated. Otherwise, the percent of vapor to fluid impairs the efficiency of the fluid action.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

I claim:

1. Apparatus for treating a filamentary tow comprising:
- (a) a first elongated trough having a channel extending from end to end thereof;
- (b) a second elongated trough having a channel extending from end to end thereof;
- (c) said first and second troughs movably secured together to form an elongated compartment defined by said channels and including a passageway extending therethrough adapted to receive a filamentary tow;
- (d) an inlet opening into said compartment intermediate said ends and adapted to supply a treating fluid to said passageway;
- (e) at least one deflector means on each of said first and second troughs disposed across said channels and extending into said passageway to form in combination a passageway baffle;
- (f) said deflectors closely, spacedly terminating at their outermost extent to define a path through said compartment for passing tow and a tortuous conduit through said compartment for said fluid whereby said fluid will be repeatedly directed toward and through filamentary tow in said passageway at substantially right angles.

2. Apparatus according to claim 1 wherein a plurality of said passageway baffles are formed by a plurality of planar deflectors extending outwardly from the bottom of each of said channels with the deflectors of one channel spaced intermediate the deflectors of the other channel.

3. Apparatus according to claim 2 in which each end of said passageway terminates in a separate receptacle adapted to contain said fluid and wherein:
- (a) said inlet comprises first and second fluid inlets disposed in contiguous relationship and dividing said compartment into first and second portions;
- (b) one of said deflectors disposed intermediate said first and second inlets and arranged to direct treating fluid from said first inlet into said first compartment portion and from said second inlet into said second compartment porton whereby both a flow of fluid countercurrent to tow movement and with tow movement will be established.
- (c) said receptacle at the end of said first compartment portion connected through a pump to said second inlet whereby fluid from said first portion is circulated through said second portion; and
- (d) means for determining the fluid level in said receptacle at the end of said first compartment portion and changing the fluid flow rate from said receptacle to said second inlet to mainttain said fluid level constant and thereby the volume of said fluid in said first and second compartment portions equal.

4. Apparatus according to claim 1 wherein said deflectors are shaped to form a baffle constricting said passageway into a substantially S-shaped curve.

5. Apparatus according to claim 1 wherein said deflector on said first trough is defined by:
- (a) a planar surface sloping outwardly from the bottom of said channel away from said outlet toward said path;
- (b) a first cylindrical surface, the directrix of which is an arc of a circle centered along said path for tow at a point spaced from said planar surface, said first cylindrical surface extending from said path to substantially the bottom of said channel and outwardly from said channel bottom to said path;
- (c) a second cylindrical surface, the directrix of which is an arc of a circle centered along said path for tow at a point spaced from said cylindrical surface directrix center, said second cylindrical surface extending from said path to substantially the bottom of said channel; and
- (d) first and second connecting surfaces extending along said paths and joining said planar surface and said first cylindrical surface and said first cylindrical surface and said second cylindrical surface respectively.

6. Apparatus according to claim 5 wherein said deflector on said second trough is defined by:
- (a) a first cylindrical surface, the directrix of which is an arc of a circle centered along said path for tow, said first cylindrical surface facing said inlet and extending from the bottom of said channel to said path;
- (b) a second cylindrical surface the directrix of which is an arc of a circle centered along said path for tow at a point spaced from said cylindrical surface directrix center, said second cylindrical surface extending from said path to substantially the bottom of said channel and outwardly from said channel bottom to said path;
- (c) a planar surface sloping outwardly from said paths and intercepting said channel bottom on said second trough; and
- (d) first and second connecting surfaces extending along said path and joining and intersecting said first and second cylindrical surfaces, and said second cylindrical surfaces and said planar surface respectively.

7. Apparatus according to claim 6 wherein:
- (a) said directrix centers for said cylindrical surfaces defining a portion of said deflector on said first of said troughs lie in a plane extending parallel to said path for tow located between said path for tow and said bottom of said channel in said first trough; and
- (b) said directrix centers for said cylindrical surfaces defining a portion of said deflector on said second of said troughs lie in a plane extending parallel to said path for tow and located between said paths for tow and the bottom of said channel in said second trough.

8. Apparatus according to claim 7 wherein said path for tow lies midway between the bottoms of said channels whereby said passageway is symmetrical about said path.

9. Apparatus according to claim 8 wherein the radii of said directrix circles are the same length and are equal to substantially one-half the depth of said passageways less the thickness of said path for tow.

10. Apparatus according to claim 9 wherein said baffle is defined by said deflector on said first trough and said deflector on said trough related to a point in said passage-

way such that the directrix radii defining said first trough deflector overlap directrix radii defining said second trough deflector.

11. Apparatus according to claim 9 wherein:

(a) said directrix radius of said first cylindrical surface of said deflector on said first trough overlaps said directrix radius of said first cylindrical surface of said deflector on said second trough;

(b) said directrix radius of said second cylindrical surface of said deflector on said second trough overlaps both the directrix radii of said first and second cylindrical surfaces of said deflector on said first trough.

12. Apparatus according to claim 11 wherein said directrix centers are equally spaced from one another along said path for tow at a distance substantially equal to the sum of their radii less substantially one-fifth said sum.

13. Apparatus according to claim 12 wherein:

(a) said first connecting surface of said deflector on said first trough slopes away from said path for tow toward the bottom of said first trough;

(b) a portion of said second connecting surface of said deflector on said first trough slopes away from said path for tow toward the bottom of said first trough and intercepts said second cylindrical surface; and

(c) a portion of said first connecting surface of said deflector on said second trough slopes away from said path for tow toward the bottom of said second trough intercepting said second cylindrical surface on said second trough.

14. Apparatus according to claim 12 wherein:

(a) the slope of said first and second connecting surfaces of said deflector on said first trough and the slope of said first connecting surface and said planar surface of said deflector on said second trough is substantially ten degrees from said path for tow; and

(b) the slope of said planar surface of said deflector on said first trough is substantially twenty degrees from the path for tow.

15. Apparatus according to claim 14 wherein a plurality of baffles are spacedly disposed along said passageway and are constructed and arranged such that alternate ones are formed by reversing said deflectors so that said surfaces of said deflector on said first trough are on said second trough and said surfaces of said deflector on said second trough are on said first trough.

16. Apparatus according to claim 15 wherein low fluid velocity chambers are disposed between said baffles.

17. Apparatus according to claim 16 wherein said baffles are disposed between one end of said passageway and said inlet.

18. Apparatus according to claim 17 wherein baffles are disposed between the other end of said passageway and said inlet and comprise:

(a) deflectors formed alternately on said first trough and on said second trough;

(b) each deflector including a cylindrical surface the directrix of which is an arc of a circle centered along said path for tow and extending from said path for tow to substantially the bottom of said channel and outwardly from said channel bottom to said path, and a connecting surface extending along said path and joining and intersecting the cylindrical surface of the adjacent deflector;

(c) said directrix centers disposed in planes parallel to said path for tow and located between said path for tow and the bottom of the channel on which its associated cylindrical surface is disposed;

(d) said path for tow lying midway between the bottoms of said channels whereby said compartment is symmetrical about said path;

(e) said radii of said directrix circles being the same length and equal to one-half the depth of said compartment less the thickness of said path for tow;

(f) said directrix radii of said deflectors on said first trough overlapping said directrix radii of said deflectors on said second trough; and

(g) said directrix centers equally spaced from one another along said path for tow at a distance equal to substantially the sum of their radii less substantially one-fifth that sum.

19. Apparatus according to claim 18 wherein said passageway terminates in a receptacle adapted to contain said treating fluid and including means for supplying heated treating fluid thereto.

20. Apparatus according to claim 1 wherein said baffles comprise:

(a) said deflectors formed alternately on said first trough and on said second trough;

(b) each deflector including a cylindrical surface the directrix of which is an arc of a circle centered along said path for tow and extending from said path to substantially the bottom of said channel and outwardly from said channel bottom to said path, and a connecting surface extending along said path and joining and intersecting the cylindrical surface of an adjacent deflector.

21. Apparatus according to claim 20 wherein said directrix centers are disosed in planes parallel to said path for tow and located between said path for tow and the bottom of the channel on which its associated cylindrical surface is formed.

22. Apparatus according to claim 21 wherein said path for tow lies midway between the bottoms of said channels whereby said passageway is symmetrical about said path.

23. Apparatus according to claim 22 wherein the radii of said directrix circles are the same length and are equal to one-half the depth of said compartment less the thickness of said paths for tow.

24. Apparatus according to claim 23 wherein said directrix radii of said deflectors on said first trough overlap said directrix radii of said deflectors on said second trough.

25. Apparatus according to claim 23 wherein said directrix centers are equally spaced from one another along said path for tow at a distance equal to substantially the sum of their radii, less substantially one-fifth said sum.

26. Apparatus according to claim 25 wherein said connecting surface extending along said paths and joining and intersecting the cylindrical surface of an adjacent deflector slopes away from said path for tow toward the bottom of the channel on which it is disposed at substantially an angle of 10 degrees to said path for tow.

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