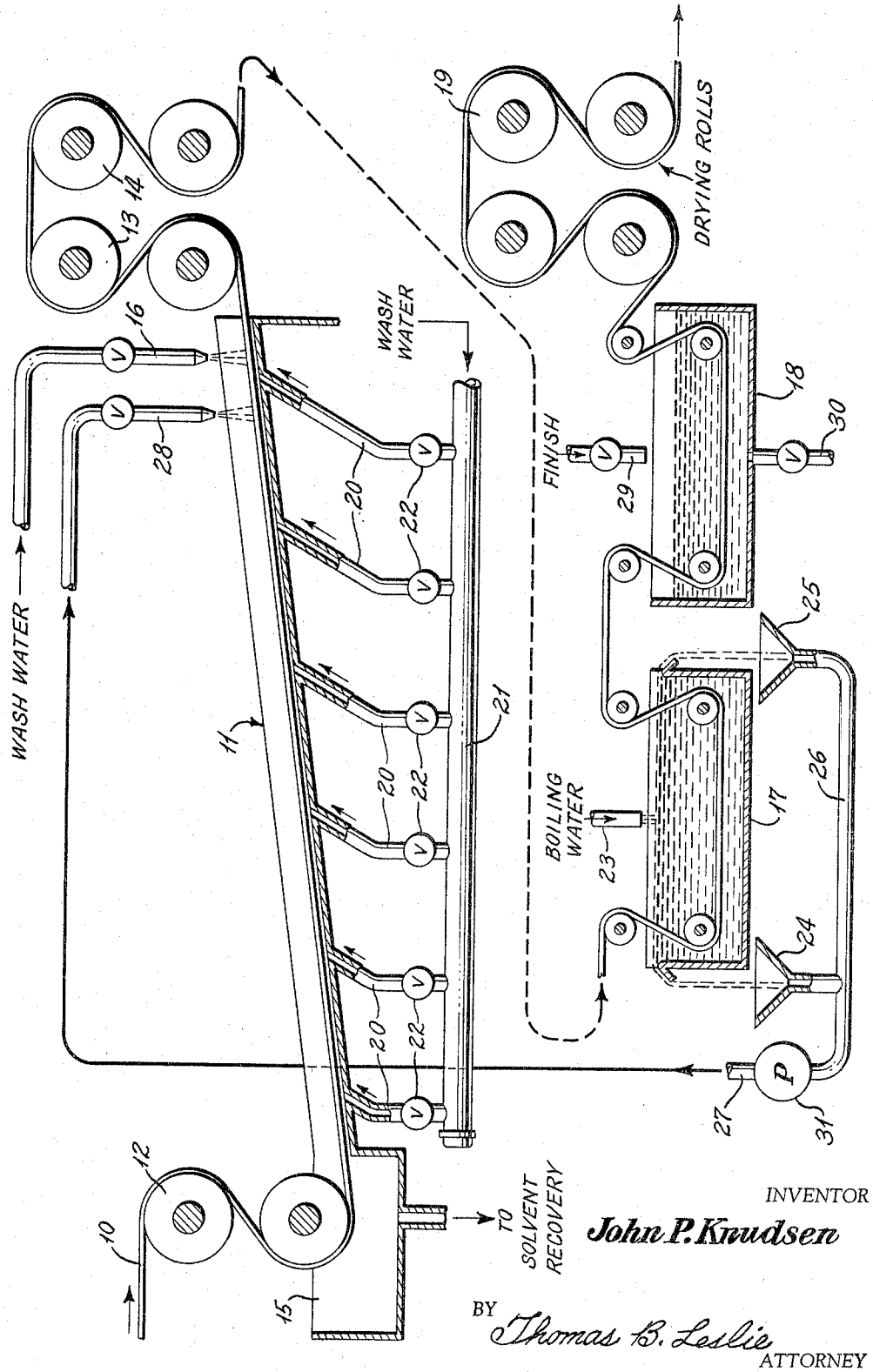
Oct. 18, 1966 J. P. KNUDSEN 3,279,225

APPARATUS FOR WET SPINNING

Filed April 2, 1964



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3,279,225

Patented Oct. 18, 1966

3,279,225

APPARATUS FOR WET SPINNING

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Filed Apr. 2, 1964, Ser. No. 358,143
4 Claims. (Cl. 68—181)

This application is a continuation-in-part of now abandoned application Serial No. 33,326, filed on June 1, 1960.

The present invention relates to apparatus for wet spinning shaped articles such as fibers, filaments, threads, yarns, ribbons and the like of synthetic polymers. More particularly, the invention relates to new wet spinning apparatus for washing shaped articles of synthetic polymers.

In the wet spinning process for making synthetic fibers, filaments and the like from synthetic polymers as polyacrylonitrile, acrylonitrile copolymers and blends of same, vinylchloride copolymers, polyolefins, polyamides, polyesters and cellulosic polymers such as cellulose acetate, secondary acetate and triacetate, a dope which consists of a solution of the polymer in a solvent is extruded through one or more spinnerets into a coagulation bath to form a filamentary tow. With acrylonitrile polymers and copolymers, in which process the invention will be illustrated as to its use, the dope is comprised of an acrylonitrile polymer dissolved in such solvents as N,N-di-methylformamide, N,N-dimethylacetamide, ethylene carbonate, sulfolane and the like and the dope is extruded through a spinneret into a coagulation bath comprising a dilute solution of the same solvent and a coagulant for the polymer, normally water, which bath extracts a large portion of the solvent from the filaments formed. Thereafter, the tow is flattened somewhat to ribbon form and the remainder of the solvent is removed by countercurrent washing with water. In order for the tow to be of an acceptable quality, it must be washed until it is almost completely free of solvent. The wash water clings to the tow forming a boundary layer of water which impedes the washing process. During the countercurrent washing, it is customary to subject the yarn to high stretching. Synthetic fibers, and particularly acrylonitrile polymer fibers, so formed are capable of being produced in very high denier tows at high spinning speeds but, in order to take practical advantage of this property, it is necessary that the washing capacity keep pace with the spinning. An ordinary cascade washer, while effective at lower speeds and with lower denier tows, is inadequate to take full advantage of the spinning capabilities in the wet spinning systems now presently employed to form shaped articles from such polymeric compositions. In large measure the inadequacy of the present cascade washers is due to the above noted formation of a boundary layer or laminar flow of saturated wash water in direct contact with the filamentary tow.

Therefore, it is the primary object of this invention to provide improved apparatus for washing tows formed from synthetic polymeric compositions, and particularly acrylonitrile polymers, which is characterized by the capability of effecting thorough washing of high denier tows at high speeds. A further object of the present invention is to provide improved apparatus for washing tows of synthetic fibers which is capable of effecting thorough washing at high speeds and to accomplish such washing concurrently with a stretching operation. A still further object is to provide apparatus for washing a multifilament tow which permits an increase in production. A still further object of the invention is to provide

apparatus capable of washing a multifilament tow in which the washing liquid flows countercurrent to the direction of movement of the tow while at the same time introducing wash liquid at positions spaced along the length of the tow in a direction transverse the path of tow movement and at velocities sufficient to cause areas of local agitation and consequent destruction of boundary layers of saturated wash liquid. Other objects and advantages of the present invention will be apparent from the description below.

The single figure of the drawing is a schematic view in side elevation of the washing apparatus of the present invention employed in a washing and stretching arrangement.

Referring to the drawing, the tow, designated by numeral **10**, has been extruded into a dilute solvent bath, withdrawn therefrom and flattened into ribbon form by apparatus not shown. This tow is delivered to the lower end of a cascade washer **11** by a pair of draw rollers **12** and it is withdrawn from the upper end of the cascade by pairs of draw rollers **13** and **14**. The cascade **11** comprises a sloping trough with sides high enough to confine a flowing body of water. At the lower end of the trough **11** there is a solvent recovery trough **15**. The main supply of water to the upper end of the cascade comes from a source, not shown, through outlet **16**. The tow leaving the pair of draw rollers **14** is suitably guided through baths **17** and **18**, is then dried on heated draw rollers **19** and thereafter passed to a point of collection, not shown.

It is to be understood that the outlet **16** is diagrammatically shown and that in practice it is so shaped and located as to provide a flowing stream of water the full width of the tow ribbon **10** and the cascade **11**. This water flows by gravity in a direction counter to the direction of tow travel and is recovered in recovery trough **15**. Additional wash water is supplied at spaced points along the bottom of the cascade **11** and, to this end, conduits **20** are provided. These are fed from a header **21** and each has a valve **22** so that all or only some of the conduits **20** may be used and flow of each may be regulated. Wash water for the header **21** may come from the same source as that which provides outlet **16** or wash water may be recycled by drawing off water at some point along the cascade and returning it through the header **21**.

The apparatus shown in the drawing may be used in several ways according to the teachings of the present invention to improve washing capacity. With the valves **22** open and either fresh or recycled water supplied to the manifold **21** and fresh water supplied to outlet **16**, the washing and stretching can be accomplished between draw rollers **12** and **13**, the tow thereafter bypassing hot water bath **17** and going to the drying rolls **19** through a finish bath **18**. When this is done the water from outlet **16** and that supplied to header **21** must be at about 95° C. when spinning acrylonitrile polymer filaments. Rolls **13** are driven enough faster than rolls **12** so that the tow leaving the trough **11** is about five times as long as the entering tow, by which a 500% stretch is effected. Since the tow enters at 20–50 feet per minute and since the cascade **11** is usually about 25 feet long, the washing problem is considerable. With a 500% stretch in cascade **11**, it is found that as soon as the filaments reach 95° C. they are stretched and the elongated tow is thereafter moved through the cascade very rapidly. In practice the stretch is found to occur in the first 3 feet of a 25 foot cascade with the tow travel through the remaining 22 feet being

very rapid. Thus any given length of tow moves through most of the cascade at speeds generally ranging from about 100 to 300 feet per minute and up to 500 feet per minute.

These tensioned filaments being strenched are the very ones which must also be washed. Some boundary layer of laminar flow adjacent the tow is found to exist despite the countercurrent arrangement but the turbulence resulting from the introduction of wash water from the pipes **20** has been found to produce sufficient alteration of the water-tow contact pattern as greatly to improve the washing efficiency with resulting increase in the capacity of the washer.

The conduits **20** define with the bottom of cascade **11** an acute angle preferably of about 15 to 75 degrees, such that the entering wash water flows partly tangent to the tow and partly across its component filaments, thus tending to flow between adjacent filaments and thereby accomplish the desired washing operation. While only six conduits **20** are shown in the drawing, it is understood that the number of these conduits and the cross section of the apertures in the bottom of the cascade **11** will be such as fully to cover the width of the tow. The wash liquid is introduced from the conduits **20** at a velocity in excess of the gravity flow velocity of the liquid in the cascade **11** so as to cause areas of local turbulence and promote better washing through destruction of the boundary layer of laminar flow.

While the foregoing arrangement greatly increases the capacity of a cascade washer for handling tows, another arrangement of the apparatus affords even greater advantages. In this case the tow is stretched between the draw rollers **14** and **19**, the required speed differential being maintained between the draw rollers **14** and the set of drying rollers **19**. A short hot water bath **17** is maintained at at least 90° C. To this end the container is continuously replenished from a spout **23** and the overflow from the container enters funnels **24** and **25** which connect with a header **26** which leads through conduit **27** to an outlet **28** at the upper end of cascade **11**. Appropriate finish solution is supplied to the bath **18** through outlet **29** and is drained off for recycle through conduit **30**.

In this arrangement the tow in the cascade **11** is not under stretching tension and its component filaments are therefore more readily accessible to the wash water and enjoy a considerably longer residence time in the wash water by reason of the absence of stretch. Very much superior washing occurs. For processing acrylonitrile polymer filamentary tows the temperature of the water in the cascade can be any temperature greater than 20° C., and is preferably from about 20° to 60° C. The bath in the container **17** need be only about 2 feet long, though any desired length is suitable so long as all filaments in the tow reach at least 90° C. The recycle of hot water to the cascade from the container **17** is optional and may be used as a temperature control device if desired. In the drawing the liquid is shown as being delivered by a pump **31**. Where possible, it is better to use a gravity arrangement if plant space conditions permit.

Where stretching is accomplished in the bath **17**, the use of the novel apparatus of this invention embodying the conduits **20** and the header **21** still further increases the capacity of the system to handle higher deniers. When desired, as, for example, when there is no stretch in the cascade **11**, the valves **22** may be closed.

The apparatus of the instant invention presents many advantages. Filamentary tows of synthetic polymers can be prepared and washed with greater efficiency and increased production per spinning operation. Furthermore the apparatus of this invention is relatively simple and, therefore, does not necessitate any great structural and design changes in existing equipment. Accordingly, greatly increased productivity is derived without a corresponding increase in cost of production equipment. Use of the apparatus of the present invention at the same production speeds ordinarily results in more efficient and more thorough washing of such synthetic filamentary tows.

While a preferred embodiment of the invention has been disclosed, it is to be understood the changes and variations therein may be made without departing from the spirit and scope of the invention as defined in the appended claims.

I claim:

1. Cascade washing apparatus comprising:
(a) an inclined trough,
(b) means for advancing a tow through the trough toward the higher end thereof,
(c) means to introduce liquid to said trough for gravity flow therethrough in a direction countercurrent to the path of said tow,
(d) said trough having apertures spaced across the breadth of the bottom thereof at spaced points along its length, and
(e) means to introduce liquid under pressure through said apertures in a direction intersecting the path of said tow and counter to the main flow of liquid down said trough to cause turbulence in said main flow of liquid.

2. Cascade washing apparatus comprising:
(a) an inclined trough,
(b) means for advancing a tow through the trough toward the higher end thereof,
(c) means to introduce liquid into the higher end of the trough to provide a flow of liquid downward through the trough for washing the tow,
(d) a header for carrying liquid,
(e) a plurality of pipes connected to the header and leading at an acute angle to inlets spaced across the breadth of the bottom of the trough, and
(f) a plurality of valves in said pipes for adjusting the flow of liquid therethrough such that the flow of liquid from said inlets causes turbulence in the flow of liquid downwardly through the trough.

3. Cascade washing apparatus comprising:
(a) an inclined trough having a plurality of apertures spaced across the breadth of the bottom thereof,
(b) means for advancing a tow through the trough toward the higher end thereof,
(c) means to introduce washing liquid into the higher end of the trough to provide a main flow of liquid downward through the trough for washing the tow,
(d) a header for carrying washing liquid under pressure, and
(e) a plurality of pipes connected to the header and leading to the spaced apertures in the trough to introduce washing liquid under pressure into the trough, said pipes engaging the trough at acute angles so that liquid flowing through said pipes and apertures is directed so as to intersect the path of the tow and counter to the main flow of liquid down said trough to cause turbulence in said main flow of liquid.

4. Cascade washing apparatus comprising:
(a) an inclined trough having a plurality of apertures spaced across the breadth of the bottom thereof,
(b) means for advancing a tow through the trough toward the higher end thereof,
(c) means to introduce washing liquid into the higher end of the trough to provide a main flow of liquid downward through the trough for washing the tow,
(d) means for recovering the washing liquid exiting the lower end of the trough,
(e) a header for carrying washing liquid under pressure, and
(f) a plurality of pipes connected to the header and leading to the spaced apertures in the trough to introduce washing liquid under pressure, said pipes engaging the trough at an angle of from 15 to 75 degrees so that liquid flowing therethrough is introduced into the trough in a direction intersecting the path of said tow and counter to the main flow of

liquid down said trough to cause turbulence in said main flow of liquid.

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