In the manufacture of many of the so-called artificial silks and other man-made synthetic textile fiber com-
modities from various fiber-forming materials, it is often-
times required to wash out or extract various impure
substances and undesired constituents 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 gener-
ally be washed in a suitable extractament medium or wash-
ing liquid (that frequently may be an aqueous liquid) in order to remove residual quantities of the spin-
ing solution solvent that was employed to obtain the
fiber-forming material in extrudable form, as well as any
coagulant that may persist in the freshly spun fiber by
impregnation or entrapment after its withdrawal from
the coagulating spin bath. Of course, the washing liq-
uid must be one that is miscible with and have unsat-
fied capacity for the spinning solution solvent or any
other impurities, or both, that are being removed. Cer-
tain 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 syn-
thetic filamentary materials may need to be washed after
being spun. Thus, by way of illustration, certain of the
superpolyamide fibers, particularly those that are derived
from epsilon-caprolactam (which are sometimes popu-
larly known as being nylon "G"-type materials), must
usually be washed after spinning in order to be rid of
intolerably high contents of monomer and undesirably
to low molecular weight polymer that invariably obtains in
the freshly extruded material.

For purposes of washing and otherwise processing
many synthetic and artificial textile fiber materials sub-
sequent to spinning, it is usually convenient and expedi-
et to form the fibers in continuous or endless filament-
ary lengths that, during or subsequent to spinning, are
assembled in multiple filament tow bundle arrays or
gathered arrangements in which a plurality of individual,
continuous continuous filament fibers are handled in a closely
associated, substantially or essentially parallel relation-
ship. This is particularly the case for many of the wet
spun synthetic textile materials including those that are
derived from fiber-forming acrylonitrile polymer com-
positions, particularly polycrylonitrile and other fiber-
forming copolymers that contain in the polymer mole-
cule at least 8th percent by weight of acrylonitrile.

The main purpose and chief concern of the present in-
vention is to provide an improved process and highly ad-
vantageous apparatus for use in conjunction therewith
for washing or leaching undesired extractable constitu-
ents or impure substances, or both, from the various ar-
ificial and synthetic textile fiber materials during the
processing in the form of multiple continuous filament
from tow bundles subsequent to spinning. It is a particular
object and specific regard of the invention to deal with the
washing of wet spun synthetic textile materials,
especially fibers from acrylonitrile polymer compositions
that are obtained in an aqueous form upon their spinning
and during their immediately subsequent processing and
handling prior to drying, such as the water-swollen or
hydrated filamentary structures that may be derived by
wet-spinning extrudable solutions of acrylonitrile fi-
bers in polycrylonitrile-dissolving aqueous saline sol-
vents, particularly zinc chloride and its saline equivalents
for such purpose, into aqueous, non-polymer-dissolving
coagulating spin bath solutions of the same salt or salts.
And, as can readily be comprehended by those who are
skilled in their calling, the broader aspects of the pres-
ent invention include an improved process and appara-
tus for any liquid treatment upon any filamentary ma-
terial, including those of natural origin, wherein it may
be desired to handle the filaments in a tow-like gather-
ing (such as in silver or roving-resembling arrangements)
for passage through many successive treating liq-
uid which may be beneficial to the fibers (such as bleach
liquids, dyebaths, scouring solutions, finish and lubricant
applying compositions and the like) wherein the liq-
uid is caused to flow such that its general and overall
manner of progression through the bath is either concur-
rent with or countercurrent against the filamentary ma-
terial being treated therein.

The indicated objectives and their associated advan-
tages and benefits may be achieved readily by practice of
the present invention. Accordingly, the present proc-
ess, essentially stated, comprises passing a tow bundle
or equivalent array of textile fibers, which advantageous-
ly may be freshly spun artificial or synthetic textile fibers
in continuous filament structure, through a bath of a
beneficial treating liquid therefor, which advantageously
may be a bath of washing liquid for removing residual
spinning solution solvent or other impurities, or both,
from the freshly wet or otherwise spun filaments, where-
in the liquid in said bath is being moved through a plu-
rality of at least two intercommunicating stages (of which
said bath is comprised) in a generally concurrent or
countercurrent direction with or against the direction
of travel of said tow bundle through said bath, and, in
each of said stages, diverting a portion of the treating
liquid that is contained therein for forced passage through
and between the individual filaments or fibers in said
tow bundle in a direction that is concurrent with the
passage of said tow bundle, said diverted portions in
all but the first and last stages of said bath being directed to
the next adjacent stages that are in bidirectional se-
quence with the stage from which it is being diverted.
Advantageously, the liquid in said treating bath is
passed in a generally overall or continuous manner of
flow against the tow bundle being passed in non-inter-
rupted submersion through the sequential bath stages and
the liquid that is contained in and diverted from each
stage excepting the first and last is obtained from the next
adjacent upstream stage (with respect to the flow of
treating liquid through said bath) and being admitted to said bath in or through the last of said
stages and being withdrawn from said bath after having
ultimately passed therethrough from the first of said stages.
More advantageously, each of said stages is comprised
(or may conveniently be considered to be comprised)
of an open, liquid-containing section and a contained, liquid-
containing, chamber section, each of which are continuous
and in communication with one another and with opposite
type liquid-containing means in each of the next adjacent
stages, said liquid in each stage being diverted from said
confined chamber therein downstream countercurrent through said tow bundle into said open section in the same stage and upstream concurrent with said tow bundle into the open section of the next adjacent upstream stage, said liquid in each confining chamber of each stage being obtained and circulated from the open section of the next adjacent upstream stage.

Apparatus that is in accordance with the invention is comprised of physical means for handling the tow bundle and the beneficial treating liquid therefor in the same multiple stage bath in the выше indicated manner.

The invention is further delineated and manifest, in both process and apparatus embodiments that are not intended to be limiting thereof, in the following description and specification, taken in connection with the accompanying drawing, wherein:

Figure 1 is a plan view of an apparatus adapted to accomplish the practice of the present invention which is illustrated in a fragmentary manner;

Figure 2 is a side elevation in cross section of an apparatus similar to that depicted in Figure 1 as might be seen along the line 2—2 therein with certain of the features drawn in phantom outline and showing, in addition thereto, a bath of beneficial treating liquid in the apparatus and a tow bundle being passed therethrough for treating according to the present process; and

Figures 3 and 4 are elevations in section taken along the lines 3—3 and 4—4 in Figure 1, respectively.

With initial reference to the first figure of the drawing, there is shown an apparatus that is adapted for utilization in the liquid treatment of textile fiber tow bundles and the like by the process of the invention. The apparatus consists of a flat, relatively shallow elongate pan or trough 5 for containing a desired bath of any beneficial treating liquid (not shown in Figure 1). The trough 5 is divided or separated along its length into a plurality of adjacent, communicating, liquid treating units or stages that are sequentially designated by the letters A, B, M, N and Z and which are separated, for clarity, by the dotted lines that are interspersed therebetween. A final extra stage X is provided at the end of the bath (and is also an integral part thereof) to facilitate the admission of liquid to the bath at the rate of withdrawal of the treated tow bundle therefrom. Although it is usually convenient and preferred to add all or substantially all of the continuous fresh supply of treating liquid at one end of the bath, it is quite apparent that portions of the total treating liquid can be added at one or more of the intermediate stages for withdrawal of the spent or (partially spent) liquid from the bath.

As has been indicated, any desired plurality of stages may be employed, depending upon the particular liquid treatment being effected and the conditions under which it is being performed as well as the efficacy, degree or extent of treatment that is desired to be achieved. In general, for purposes of washing freshly spun tow bundles, it is usually advantageous to employ at least six and frequently more advantageous to utilize eight or more separate stages in a bath designed for accomplishment of any conventional treatment.

Each of the stages A, B, M, N, and Z is comprised of contiguous open, liquid-containing sections, designated A1, B1, M1, N1 and Z1, respectively, and enclosed, liquid-containing sections or chambers, designated A2, B2, M2, N2 and Z2, respectively. The open sections are alternately disposed in each stage towards the tow-introducing end of the trough 5 in the direction of the roller guide 6, which is adapted to be submerged in the bath of treating liquid and to pass the tow bundle into immersion therein upon its introduction to the bath. Each of the open sections is in communication with the contiguous confined section in the succeeding stage through a tow and liquid passing aperture, designated 7, 8, 9, 10 and 11 in each of the stages A through Z, respectively. Each of the confined liquid-confining sections is in passing and liquid diverting communication with the immediately adjoining open sections in the next adjacent stage through an aperture, designated 12, 13, 14, and 15 in each of the stages A, B, M, N and Z. The aperture 12, for example, that connects confined section A2 with open section B1 is shown in elevation in Figure 3. The aperture 8 between sections B1 and B2 can be seen in Figure 4. In the last stage Z, the liquid confining section Z2 is in communication with the extra stage X through the aperture 16.

As is implied earlier in the foregoing, the wash unit or stage designation that is employed herein is arbitrarily based on convenience and for purposes of preferred delineation. If desired, and possibly in better keeping with certain viewpoints that may be maintained in the art of extractive processes, each of the stages could well be considered as spanning or extending between the points of countercurrent liquid flow from each of the enclosed chambers directly to each adjacent open section. According to such concept, for example, the chamber M2 and the open section N1 would comprise a single stage as would the chamber N2 and open section Z1, and so forth. In either event, as can readily be appreciated, both the process and apparatus of the present invention would function and be embodied in the same way with only the indicated difference in definition being at variance.

Reverting to the descriptive scheme herein adhered to, a conduit connects each of the open sections excepting for the first with the immediately adjacent confined section in the adjoining stage towards the tow-introducing end of the trough 5. Thus, confined section A2 is connected with open section B1 through the conduit 17; M2 with N1 through conduit 21; and N2 with Z1 through conduit 23. The confining section Z2 in the last stage is connected with the extra stage X with conduit 25.

Each of the conduits 17, 19, 21 and 23 is adapted to withdraw liquid from an upstream, open, liquid-containing section (with respect to the flow of countercurrently moving liquid) and pass it into the immediately adjacent downstream section in a generally countercurrent manner of transmission through the bath for dual simultaneous diversion from each of the confining sections with and against the tow bundle (also shown in Figure 1) traveling through each of the stages in the bath. The conduit 25 that connects the extra stage X with the confining section Z2 of the last stage X admits the freshly introduced treating liquid for generally countercurrent flow progression through the sequential stages of the baths. The same...

As is apparent, the extra stage X may be dispensed with if it is desired to directly admit the fresh liquid to the confining section Z2 of the last stage and to withdraw the treated tow bundle, without purposive countercurrent diversion of treating liquid, from the confining section of the last stage through suitable liquid sealing means that may be provided therein. Usually, however, it is more convenient and of obvious advantage to provide an extra open, liquid-containing section beyond the last confining section in the sequential stages (as is depicted) to facilitate mating both liquid and tow-handling requirements. It is usually suitable, in such instances, to concurrently divert treating liquid from the last confining section in the stages to such extra stage with the tow bundle passing through the bath.

From the foregoing, it is apparent, and as is shown in Figure 2 of the drawing, that treating liquid is circulated in a generally countercurrent manner through the bath L by being admitted to the extra stage X in the bath, passed therefrom to the confining section Z2 in the last stage; partially forwarded or diverted countercurrently to the tow bundle T through and between the individual filaments or fibers thereof through the aperture 11, 13, 14, 15 in each of the stages Z, A, B, M and N, and thence therefrom to the confining section N2 in the next adjacent downstream stage N, and so forth until it has been finally transmitted to the open section A1 in the first
stage of the bath from which it is withdrawn as spent or used treating liquid through the outlet conduit 27. Pump means 18, 20, 22, 24 and 26 in or with each of the conduits 17, 19, 21, 23 and 25, respectively, may advantageously be employed to accomplish the generally countercurrent liquid forwarding action. During the countercurrent flow of the treating liquid through the stages in the bath, a portion of the liquid that is being circulated through each stage is diverted or recycled concurrent with the fiber from each of the confined sections A2, B2, M2, N2, Z2 and X2 into the immediately adjacent upstream open section (B1, M1, N1 and X1, respectively) through the apertures 12, 13, 14 and 15, respectively, in the confined sections of each of the sequential stages. As has been mentioned, a portion of the liquid in the confined section Z2 of the last stage may be recycled into the extra stage X, if so desired.

The relative liquid forwarding and recycle rate that is effected with the diverted liquid from the confined sections in the stages throughout the bath is generally best when it is about the same in each stage. Of course, it may vary in specific instances with the particular liquid treatment that is being effected. It is ordinarily advisable for the net countercurrent forwarding rate of the liquid from each of the confined sections to each of the open sections in each stage to be sufficient to effect an optimum concentration of extracted impurities at the exit of each chamber and to secure all the desired flushing action through and between the filaments or fibers in the tow during their passage through the intercommunicating apertures. Thus, as can be seen, a balance must be struck in specific instances between the volume of liquid that is desired to be handled and the efficacy of treatment considered suitable, taking into account (especially in extractive processes) that larger quantities of treating liquid frequently assure a more thorough and complete treatment. The countercurrent forwarding rate, as will be apparent, does not particularly depend upon the relative speed with which the tow bundle is being passed through the bath or upon its size or the number of filaments that it contains. Rather than any of these, the net countercurrent forwarding rate is approximately fixed and equal to the quantity of treating liquid being admitted to the bath per unit time, regardless of the quantity of tow being treated therewith.

It is usually desirable for the tow-accommodating size of the apertures that provide passage for the tow and liquid between the sequential stages in the bath to be shaped to fit fairly against the tow, regardless of the particular configuration in which the tow bundle is being handled. It is usually satisfactory, incidentally, to employ generally round tow bundles and to provide round matching apertures for its passage through the stages, although relatively flat, ribbon-like tow bundles and the like arrays (or tow having other desired configurations) can also be handled through appropriately formed apertures. A relatively close-clearing aperture for the tow handle permits an extremely effective flushing and washing action of the treating liquid on the filaments or fibers in the tow to be achieved during the passage of the tow through the interconnecting apertures, particularly of the liquid being forwarded countercurrently against the tow. In this connection, it is usually desirable (though not an absolute necessity) to employ tow bundles that are of considerable magnitude in the practice of the invention, such as those that may be comprised of in the neighborhood of 3,000 and oftentimes many more individual gathered filaments or fibers.

When freshly spun filaments are being washed, it is usually advantageous for the proportion of diverted wash liquid in each stage that is forwarded countercurrent against the tow and recycled with the tow to be in a ratio of not more than one part by volume of forwarded liquid to each 5 parts by volume of recycled liquid. More advantageously, this proportion of diverted wash liquid that is countercurrently forwarded is in a ratio of the indicated variety that is not greater than one to 20. Preferably, the ratio is not more than one part by volume of forwarding liquid for each 30 parts by volume of recycle, especially when freshly wet spun acrylonitrile polymer squagel filaments are being washed in an aqueous liquid.

The ratio of forwarding and recycling liquid in each stage may be set and adjusted in various ways to divert the desired proportions of liquid countercurrent against and concurrent with the tow from the confined sections. The simplest manner, as is apparent, is to accomplish the desired proportioning by using the forwarding and recycling apertures leading out of the confined spaces as pressure-dropping orifices of different effect and consequence in each stage to facilitate realization of the desired diverse, oppositely-directed rates of flow of the separate liquid streams being diverted from each confined section. The cross-sectional area or diameter of the apertures can be varied to accomplish this effect, with given sized tow bundles and given liquid supply pressures to each of the various flowing sections.

More advantageously, pressure dropping orifice tubes of suitable length and cross-sectional proportions (beneficially with the concurrent tubes having a slightly larger cross-sectional area than the countercurrent tubes at each oppositely flowing point of liquid diversion) may be employed for this purpose. Thus, longer and shorter tubes having respectively greater and lesser pressure-dropping effects may be utilized to proportion the flow of forwarding and recycling liquid in each stage in a manner that will be apparent to those skilled in the art. The longer the tube and the greater the pressure drop it achieves, the less will be the flow through the aperture in which such tube is provided.

The tube orifice members 39, 31, 32, 33 and 34 in the apertures 7, 8, 9, 10 and 11, respectively, which accommodate the countercurrent forwarding flow of liquid from the confining sections A2, B2, M2, N2 and Z2, respectively, in the stages A, B, M, N and Z, respectively, as is shown in the drawing, may be made longer than the tube orifice members 35, 36, 37, 38 and 39 in the same sections that control the concurrent recycling flow of the treating liquid in order to effect a relatively greater rate of liquid recycling than forwarding in and from each of the stages. As can be appreciated, the relative rates of forwarding and recycling, especially that relative to the same diameter orifice tubes, are generally proportional to the length of the tubes employed, taking into account the flow retarding and assisting action of the tow passing against or with the liquid through the various tubes involved. When properly proportioned and sized tubes are employed, an excellent control of relative liquid forwarding and recycle flow rates can be attained in each stage. Furthermore, the employment of tubes greatly facilitates the realization of an optimum manner of the flushing action that is involved during the liquid treatment, especially in the countercurrent passage of liquid through the tow bundle, due to the pronounced dazing effect thereby caused in the tow.

If desired, incidentally, the confined sections can be provided with removable covers and the tubes (and enclosing wall portions of the confined sections) furnished with closeable slot arrangements to facilitate cleaning of the tow bundle in and through the stages in the bath. An additional feature of great advantage in apparatus according to the invention is the provision of liquid level maintaining spillovers or wiers in each of the open sections of the stages about each of the points of liquid withdrawal therefrom. These are depicted in the drawing as the box-like spillway partition structures 40, 41, 42, 43, 44 and 45 in each of the open sections of the stages A, B, M, N, Z and in the extra stage X, respec-
Such partitions, or means equivalent thereto, effectively control the liquid level in the bath at a desired height (or depth of liquid) and facilitate achievement of the desired manner of fluid handling during the process. They also permit larger conduits to be employed for transfer of the liquid from stage to stage without difficulties due to possible overflow or overwithdrawal and advantage may be taken of pumping means to be employed that have float valve controls so as to be quickly responsive to changes in operating conditions.

To further illustrate the invention, an apparatus similar to that shown was employed to wash a round tow bundle of about 3000 individual continuous filaments of freshly wet spun polyacrylonitrile aqueous fibers that had an ultimate individual fiber size, when finally dried and converted to finished form, of about 3 denier each and which, upon withdrawal from the coagulating spin bath in aquagel form prior to washing, contained about 9 parts by weight of a 43 percent by weight aqueous zinc chloride solution for each part by weight of polymer, on a dry weight basis, in the tow bundle. The wash bath had a total length of about 9 feet and a width of about 6 inches. It contained aqueous wash liquid at a depth of about 2½ inches. It was divided into eight stages for washing, except for the first stage and the extra stage in the bath had a length of about 10 inches, about ¾ of which in each stage was the confined chamber section with a height in each chamber equal to the depth of the bath. Each of the apertures for diverting liquid from the confined sections had effective outlet diameters of about ½ inch and were in the form of pressure-dropping tube orifices; the countercurrently forwarding tubes having lengths of about 5 inches and the concurrently recycling tubes about 1¼ inches. The tow bundle was passed through the bath at a linear rate of about six feet per minute. Fresh water was admitted to the extra stage at about 200 cubic centimeters per minute. The liquid was circulated through the bath with a forwarding rate in each stage countercurrent to the tow bundle of about 200 cubic centimeters per minute and a recycle rate in each stage of about 6,000 cubic centimeters per minute. The spent aqueous wash liquid that was withdrawn from the first stage contained about 35 percent by weight of dissolved zinc chloride that was extracted from the aquagel. The washed tow bundle, upon withdrawal from the extra stage, contained about 4 parts per weight of water for each part of polymer and was less than 0.05 percent by weight of zinc chloride, based on the weight of the fiber. Upon subsequent drying, the aquagel was converted into excellent quality, fine denier polyacrylonitrile textile fibers.

Analogous good results can be obtained when the present invention is practiced to wash other freshly spun artificial and synthetic fibers and for the accomplishment of other desired liquid treatments on tow bundles and the like arrays of various textile filaments and fibers using baths of either generally concurrent, but preferably countercurrent, liquid streams. As will readily occur to those having an interest in the present invention, generally concurrent flowing baths are provided and handled in a manner that is approximately the reverse or opposite of that which has been described.

Since many changes and modifications in the practice of the invention can be made without substantially departing from its intended spirit and scope, it is to be understood that the invention is to be construed and interpreted as it is set forth and defined in the hereto appended claims.

What is claimed is:

1. Process for treating textile fibers in tow bundle and the like form with beneficial treating liquids which comprises passing said tow bundle through a circulating bath of said liquid that is separated into a plurality of at least two individual stages which are in tow bundle-passing and liquid flowing communication with one another; and, in each of said stages, diverting a portion of the treating liquid that is contained therein for forced passage through and between said tow bundle in a direction that is countercurrent thereto and diverting the balance of said liquid for forced passage through and between said tow bundle in a direction that is concurrent therewith.

2. Process for treating textile fibers in tow bundle and the like form with beneficial treating liquids which comprises passing said tow bundle through a bath of said liquid circulating said bath in a generally countercurrent flow to the tow bundle in the bath, said bath consisting of at least two separate, intercommunicating stages, the liquid in each of said stages being partially contained in an open condition nearest to the tow-introducing end of said bath and partially contained in a continuous, confined condition; said tow bundle being passed through each portion of said liquid portions in each of said stages; passing fresh treating liquid through the last of said stages furthest from the tow-introducing end of said bath and circulating it through each of said stages in such a manner that a portion of the liquid is forwarded countercurrently from said confined portion of liquid in each stage through and between said tow bundle passing therethrough and the balance of said liquid is recycled countercurrently from said confined portion of liquid in each stage to the open portion of liquid in the adjacent upstream stage with said tow bundle passing therethrough; said liquid being passed downstream in said bath from the open portion of liquid in each stage to the confined portion of liquid in the next adjacent downstream stage.

3. The process of claim 2, wherein said bath is divided into at least eight stages.

4. The process of claim 2, wherein a greater proportion of said liquid being circulated through said bath is diverted countercurrent with said tow bundle from each stage than countercurrent against it therein.

5. The process of claim 4, wherein the tow bundle consists of freshly wet spun continuous filament acrylonitrile polymer aqueagel fibers and said liquid is an aqueous washing liquid therefor.

6. The process of claim 5, wherein said bath is divided into at least eight stages and at least 20 parts by volume of said aqueous wash liquid is diverted concurrent with said tow bundle from each stage for diverting liquid in each stage in forced passage through and between a tow bundle passing through said aperture in directions both concurrent with and countercurrent to said tow bundle passing therethrough; and pump means for circulating treating liquid longitudinally through said bath in a general path of flow relative to the direction of the tow bundle when it is passed therethrough.

7. Apparatus of the character described and for the purposes indicated comprising a pan for containing an elongate bath of beneficial treating liquid for textile fibers; structural means in said pan dividing said bath into a plurality of intercommunicating stages; tow-advancing means for longitudinally passing a tow of textile fibers through said bath and each of the stages therein; means defining an aperture in the structure of each of said stages for diverting liquid in each stage in forced passage through and between a tow bundle passing through said aperture in directions both concurrent with and countercurrent to said tow bundle passing therethrough; and pump means for circulating treating liquid longitudinally through said bath in a general path of flow relative to the direction of the tow bundle when it is passed therethrough.

8. Apparatus of the character described and for the purposes indicated comprising a pan for containing an elongate bath of beneficial treating liquid for textile fibers; structural means in said pan dividing said bath into a plurality of intercommunicating stages, said structural means forming in each of said stages an open, liquid-containing section; and a confined, liquid-containing section therein in communication with one another and in the same sequence in each of the stages in said bath, said open and confined sections of sequential alternate stages being in communication with one another; tow-advancing means for longitudinally passing a tow of textile fibers through said bath and each of the alternate sec-
tions of each of said sequential stages; means defining an aperture in the structure of each of said confined sections in each of said stages for diverting liquid in each stage in forced passage through and between a tow bundle passing through said apertures in directions both concurrent and countercurrent to said tow bundle passing therethrough; pump means for admitting and circulating treating liquid longitudinally through said bath in a general path of flow relative to the direction of the tow bundle when it is passed therethrough; and conduit means for passing liquid from each of said open sections in each of said stages excepting the first to the adjacent confined section in each sequential stage in the same path as the general direction of circulation of said liquid in said bath.

9. Apparatus of the character described and for the purposes indicated comprising a pan for containing an elongate bath of beneficial treating liquid for textile fibers; tow-advancing means for longitudinally passing a tow bundle of textile fibers in and through said bath; pump means for admitting fresh treating liquid at one end of said bath and circulating it therethrough in a path of flow generally countercurrent to said tow bundle; a sequential spaced plurality of liquid-confining chambers formed in and physically dividing said pan with adjacent open sections therebetween and at the tow-introducing end of said bath, each of said chambers having a pair of apertures formed in one of each of their sides that extend across said pan, each of said apertures in said chambers being in liquid-transmitting communication with the adjacent open sections of said bath-containing pan between said chambers and being further adapted to longitudinally accommodate and transmit said tow bundle in submersion in said bath when it is being passed therethrough; a plurality of conduit means, each of said conduit means connecting an open section in said bath-containing pan toward the tow-introducing end of said bath, each of said conduit means being adapted to pass liquid from each of said open sections to each of said chambers adjacent thereto in the same direction as the general path of circulation of said liquid through said bath; and a pump in each conduit for transmitting liquids in the indicated direction in each of said conduits.

10. The apparatus of claim 9 and including, in combination therewith and in addition thereto, liquid flow-restricting means for proportioning the rates of liquid flow in opposite directions from each of the pair of apertures in each of said chambers to said adjacent open sections when a tow bundle is being passed through said bath and circulating it therethrough in a path of flow generally countercurrent to said tow bundle; a sequential spaced plurality of liquid-confining chambers formed in and physically dividing said pan with adjacent open sections therebetween and at the tow-introducing end of said bath, each of said chambers having a pair of apertures formed in one in each of their sides that extend across said pan, each of said apertures in said chambers being in liquid-transmitting communication with the adjacent open sections of said bath-containing pan between said chambers and being further adapted to longitudinally accommodate and transmit said tow bundle in submersion in said bath when it is being passed therethrough; a plurality of conduit means, each of said conduit means connecting an open section in said bath-containing pan toward the tow-introducing end of said bath, each of said conduit means being adapted to pass liquid from each of said open sections to each of said chambers adjacent thereto in the same direction as the general path of circulation of said liquid through said bath; a pump in each conduit for transmitting liquid in the indicated direction in each of said conduits; and a wiper-like spillway at the point of communication of each of said conduit means with each of said open sections for withdrawing liquid from each of said open sections into each of said conduits.

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UNITED STATES PATENT OFFICE  
CERTIFICATION OF CORRECTION  

Patent No. 2,949,337  
August 16, 1960  

Charles F. Oldershaw  

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.  

Column 10, list of references cited, after line 69, insert the following:  

2,674,113 Schrenk --------Aug. 6, 1954  

Signed and sealed this 9th day of May 1961.  

(SEAL)  
Attest:  

ERNEST W. SWIDER  
Attesting Officer  

DAVID L. LADD  
Commissioner of Patents