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3,095,343

METHOD FOR TREATING CONTINUOUS FILAMENTARY TOWS

Filed Sept. 15, 1960

3 Sheets-Sheet 2

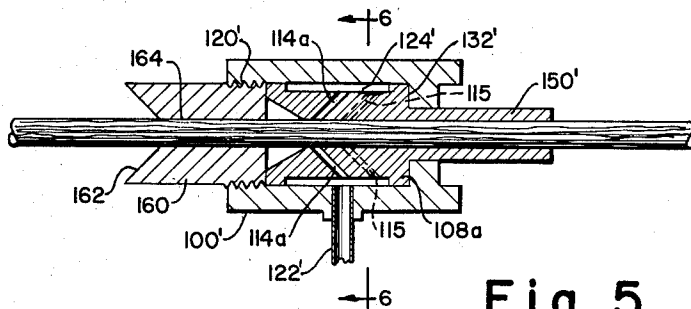


Fig. 5

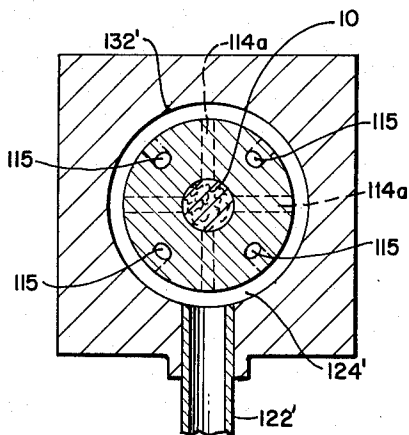


Fig. 6

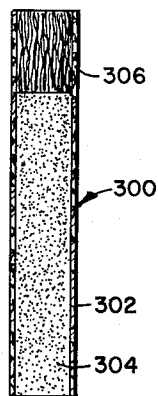


Fig. 9

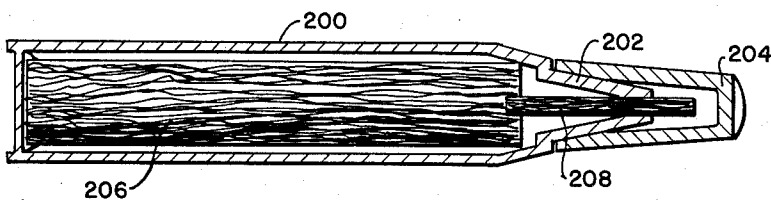


Fig. 8

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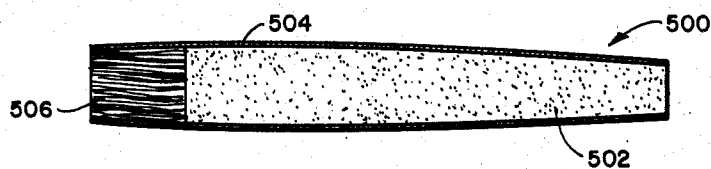
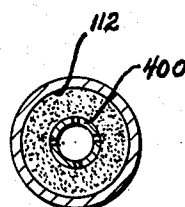
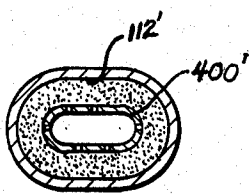
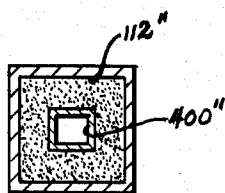
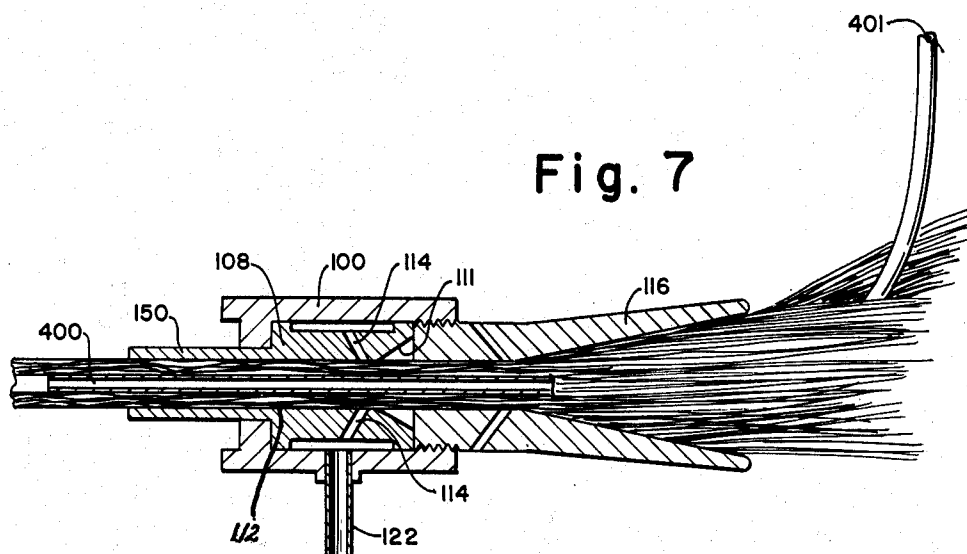
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METHOD FOR TREATING CONTINUOUS FILAMENTARY TOWS

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3 Sheets-Sheet 3



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3,095,343

METHOD FOR TREATING CONTINUOUS FILAMENTARY TOWS

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Filed Sept. 15, 1960, Ser. No. 56,189
11 Claims. (Cl. 156-180)

This application is a continuation-in-part of application Serial Number 16,683, filed March 22, 1960.

This invention relates to fibrous bodies having as a major constituent cellulose acetate fibers; to processes of treating such bodies; and to apparatus for handling such bodies in accordance with such processes. More specifically, the invention is concerned with the handling of, processing of, and products formed from, continuous filamentary tows having the filaments thereof randomly oriented primarily in a longitudinal direction.

The term "continuous filamentary tow," as used in this specification and the appended claims, means a material such as that which results when filaments spun from a plurality of spinnerets are brought together and combined, preferably with filaments from other spinnerets, to form a continuous body of fibers "randomly oriented primarily in a longitudinal direction." The term "randomly oriented primarily in a longitudinal direction" as used in this specification and the appended claims, is intended to describe the condition of a body of fibers which are as a whole longitudinally aligned, and which are, in the aggregate, in a parallel orientation, but which have short portions running more or less at random in non-parallel diverging and converging directions.

Continuous filamentary tows of cellulose acetate fibers have been heretofore used and processed to adapt segments thereof for use as cigarette filters. Generally, the fibers of the tow are formed with spinneret devices, and the strands exiting from such spinneret devices are bunched together to form a "raw" tow which is wound into a bale for subsequent processing. The subsequent processing operations usually involve, in addition to unwinding of the raw tow, spreading apart of the fibers of the tow to provide a relatively thin fiber layer, tensioning of the fibers to eliminate the crimps therein, impregnating the fiber layer with a plasticizer to bind adjacent fibers together, gathering the "bonded" layer through a suitable funnel or the like to form a treated cylindrical tow, and then wrapping the treated tow in a suitable paper to form a rod. The paper-covered rod is then cut into small segments by an ordinary cigarette cutting machine and "cured," or maintained in lengths and "cured."

Generally, the term "curing" has been used in the art to designate final bonding of fibers by the plasticizer. Such "curing" has been effected heretofore by letting the formed paper-covered segments or lengths of the treated tow age for an extended period of time unheated, or by subjecting the same to heat, as in an oven, for an hour or more to soften the plasticizer and permanently bond the tow fibers together.

While satisfactory cigarette filters have been made in accordance with the handling, treating and curing operations described in some detail above, certain disadvantages, as listed below, are inherent in such prior processes:

(1) With prior processes, non-uniform bonding of tow fibers cannot be detected until after a tow is formed into a rod and cured. Moreover, with prior processes, no compensation is made for non-uniformity in plasticizer distribution. Accordingly, it is believed that tows made

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by prior techniques which have been used do not, in fact, comprise uniformly-bonded fiber structures.

(2) With prior processes, tow rods are cut into segments while still somewhat soft. This appears to give rise to dislodging of individual fibers, uneven cuts, and in some instances mechanical problems.

(3) An extended time was required for "curing" a treated tow in accordance with prior practices because (a) the plasticizers do not bond well after initial set, and without heat, only effect some bonding after prolonged periods; and (b) oven heating of a treated tow must be extended before the central portions of the tow are affected, particularly when the tow is "cured" in lengths and/or covered with a paper overwrap.

(4) The continuous filamentary tows treated in conformance with the procedures outlined above required a paper overwrap to maintain dimensional stability, because the tow, when so treated, prior to curing and, in most cases, after curing, in and of itself is pliable and stretchable and the fibers of the tow are not sufficiently bonded together to maintain a defined stable shape.

(5) Continuous filamentary tow segments as formed heretofore were limited to use as cigarette filters because (a) they required a paper overwrap, and the only widely-used, and thus economical, overwrap equipment was the cigarette machines; and (b) because paper or other dimensionally-stable overwraps prevent utilization of the tow segments for certain applications.

I have discovered that the foregoing disadvantages can all be overcome and many advantages can be obtained by following the prior art banding, tensioning and impregnating practices to form a raw tow into a plasticizer-impregnated layer of continuous uncrimped filaments, and then departing from the prior art by curing the continuous filamentary tow simultaneously with, or immediately after, gathering of such impregnated layer into a final rod shape.

Accordingly, a primary object of the present invention is to provide a method of, and apparatus for, treating a continuous filamentary tow whereby the same is cured simultaneously with, and as rapidly as it is formed from a spread plasticizer-impregnated layer into a gathered rod-like structure.

Still a further primary object of the present invention is to provide a method and apparatus, conforming with the preceding object, which method and apparatus insure complete and uniform bonding of all adjacent fibers within a tow and dimensional stability of the finished tow without overwrap, whereby an unwrapped tow rod can be economically formed with various diameters and cut into segments suitable for use as adsorbers or applicators or container filter stoppers, as well as improved cigarette and cigar filters, or other smoke filters.

Yet another and still further primary object of the present invention is to provide an improved inexpensively-manufactured fiber adsorber and/or applicator which has all of the advantages of ordinary adsorbers, and which, in addition, provides for controlled fluid dispensing and is not subject to "linting" or "fuzzing."

An additional primary object of the present invention is to provide a method of, and apparatus for, treating a continuous filamentary tow to substantially increase the liquid-holding properties thereof.

Yet other and still further objects of the present invention are: (a) to provide a method and apparatus for forming an improved unwrapped continuous filamentary tow having firmly-bonded fiber constituents and preferably a stiffened peripheral layer; (b) to provide a method and apparatus conforming with all of the hereinstated objects, and adapted to form tows having various shapes and sizes, as well as tows with central hollow passages

therein; (c) to provide a method and apparatus as prescribed in subparagraph (a) wherein segments of the tow are adapted for use as smoke filters, appliance filters, valve filters, and/or filter stoppers for medicine bottles; (d) to provide a method and apparatus as prescribed in subparagraph (a) above, wherein the segments of the tow are adapted for use as pigment and dye storing and dispensing means; flavor and perfume storing and dispensing means; medicinal and/or antibiotic applicators; lubricant and antioxidant applicators, such as gun barrel cleaners; and controllable adhesive, glue and paint applicators; (e) to provide a method and apparatus conforming with subparagraphs (c) and (d) wherein the tow segments when put to the stated uses are inert, insoluble, non-toxic, chemically safe for the human touch, and so constructed as to (1) prevent separation of liquid solution and emulsion components carried by the segments, and (2) allow for controlled dispensing of the adsorbed compositions.

Aside from the foregoing general objects of the present invention, the following specific objects are important: (1) the provision of a method of curing tow fibers simultaneously with their gathering into a rod-like structure, which method utilizes known expedients such as steam streams and air streams and does not require expensive or elaborate equipment and/or excessive pressures or temperatures; (2) the provision of apparatus components which aid in effecting the desired curing, and which can efficiently operate continuously over extended periods; (3) the provision of a method and apparatus which are designed to be utilized in production lines wherein a tow can be processed at speeds up to at least 100 meters per minute, and the objects of subparagraphs (1) and (2) above are satisfied; (4) the provision of an apparatus, as prescribed in subparagraph (2), and having readily changeable components whereby tows of differing diameters can easily be handled; (5) the provision of a method and apparatus conforming with all of the preceding objects wherein properties of the final product are controllable in accordance with predetermined correlated relationships between the speeds, pressures and temperatures utilized for selected operations; and (6) the provision of a method and apparatus conforming with all of the preceding objects wherein the continuous filamentary tow has as a major constituent cellulose acetate, which can be mixed, according to the invention, with other materials, such as cellulose, viscose, cotton, asbestos, metal fibers, wood fibers, and/or sawdust to provide certain desired characteristics.

In its simplest aspects, the invention provides, in a method of forming a continuous rod-like tow having fibers therein randomly oriented primarily in a longitudinal direction and including the steps of impregnating a spread layer of tow fibers with a plasticizer and gathering the tow into a rod-like formation, an improved curing operation which comprises uniformly bonding the fibers of the tow as it is gathered together by moving the tow through a confined area and directing steam onto the tow in said area, whereby the steam passes through said tow. The aforesaid improvement, in more detail, includes passing the steam onto the tow under pressure whereby the steam travels through the gathered fibers in a direction opposite the direction in which said tow is moving. In accordance with the preferred embodiment of the invention, the steam is directed onto the tow in streams making an angle of approximately 45 degrees with the longitudinal axis of the tow, since I have found that more effective penetration and better bonding is achieved when the steam is passed onto the tow at this angle instead of various other angles.

The application of the steam to the filamentary tow as it is gathered together appears to result in softening of the tow fibers and the plasticizer carried thereon, and definitely has the effect of uniformly bonding the fibers of the tow together as they are gathered. By passing the

steam onto the tow under pressure in a confined area at an angle to the longitudinal axis, and in a direction opposite the direction of movement, of the tow, the steam is caused to pass through the tow, between the fibers and past the fibers as they are being gathered together. All of the filaments and all of the plasticizer is thus at least substantially uniformly heated, and bonding is at least substantially uniform throughout.

As the tow moves beyond a steam-treating station operating in accordance with the present invention, it contacts the surrounding atmosphere, and the tow fibers and plasticizer harden, thus giving the tow some dimensional stability, and a stiffened peripheral layer. However, movement of the tow is usually effected by pulling thereon, and the steam-treated tow while firmly bonded and having substantially improved dimensional stability over a nonsteam-treated tow, does not have complete dimensional stability immediately and the pulling deforms the tow to a certain extent. Moreover, without further treatment fiber fusion can result so that the total fiber surface area of a tow is reduced and/or the tow becomes excessively stiff.

I have found that complete dimensional stability can be easily obtained by immediately passing the steam-treated tow through another confined area wherein dry air is passed onto the tow preferably under pressure and in a direction opposite to the direction in which the tow is moving. The air drying of the steam-treated, plasticized, gathered, filamentary tow produces a quick setting of the plasticizer as well as cooling of the plasticized tow fibers in their bonded state and causes the exterior surface of the tow to be hardened or stiffened whereby the tow has complete dimensional stability and can be handled as a unitary body without the need of an exterior coating or wrapping. Moreover, by air-treating the tow, reduction of total fiber surfaces by fusion of adjacent fibers is substantially prevented, and the tow is not allowed to become overly stiff because of such fusion.

In addition to the improved curing steps generally discussed above, the invention provides suitable apparatus for carrying out the method and a new and improved product.

The apparatus, in its simplest aspects, comprises a housing, a core member carried by and partially within the housing and having a tow passageway therethrough, and a tow-receiving closure for the housing having a passageway aligned with that of the core member. The housing has a gas inlet and the core member is provided with a plurality of gas passageways communicating the gas inlet with the tow passageway. In accordance with the preferred embodiments of the invention the gas passageways slope into the tow passageway in a direction toward the tow-receiving closure for the housing. The tow-receiving closure is preferably removably secured to the housing whereby the core members, like the closure members, can be easily changed for handling tows of different diameters. Basically, the same construction is used for the steam treatment as for the air treatment; however, the tow-receiving closure for the "steam treating" housing has an extended and flared tow-forming portion, and such portion preferably is provided with escape passageways.

The new and improved product of the invention is one made in accordance with the process herein described, and comprises basically a body of continuous filaments randomly oriented primarily in a longitudinal direction, the major portion of the filaments being cellulose acetate fibers, the fibers being bonded to adjacent fibers by a plasticizer, the peripheral layer of fibers providing a stiffened peripheral shell for the body, and the body being adapted for use as a filter and/or applicator and/or adsorber.

The various aspects of the invention will be better understood, and objects other than those specifically set forth above will become apparent, when consideration is given to the following detailed description of the illus-

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trative and preferred embodiments of the invention. The description refers to the annexed drawings, wherein:

FIGURE 1 presents schematically a production-line assembly of stations past which a continuous filamentary tow can be moved for treating in accordance with the method of the invention;

FIGURE 2 is a cross-sectional side view of an apparatus provided by the invention for handling and steam-treating a tow, in accordance with the method of the invention;

FIGURE 3 is a transverse cross-sectional view of the apparatus shown in FIGURE 2, FIGURE 3 having been taken on the line 3—3 of FIGURE 2;

FIGURE 4, like FIGURE 3, is a transverse cross-sectional view of the apparatus shown in FIGURE 2; however, FIGURE 4 is taken on the line 4—4 of FIGURE 2;

FIGURE 5 is a cross-sectional side view of an apparatus provided by the invention for handling and air-treating a tow in accordance with the method of the invention;

FIGURE 6 is a transverse cross-sectional view of the apparatus shown in FIGURE 5, FIGURE 6 having been taken on the line 6—6 of FIGURE 5;

FIGURE 7 is a cross-sectional side view of an apparatus provided by the invention, which is similar to that shown in FIGURE 2, but which in addition incorporates a central tow passageway forming member so that hollow tows can be produced thereby;

FIGURES 7(a), (b) and (c) are schematic cross-sectional representations of alternative core passageway and tow passageway forming member shapes;

FIGURE 8 is a cross-sectional side view of a container housing an adsorber and applicator assembly constructed in accordance with the invention, and made from components processed in accordance with the invention;

FIGURE 9 is a cross-sectional side view of a cigarette provided with a filter made in accordance with the invention; and

FIGURE 10 is a cross-sectional side view of a cigar provided with a filter made in accordance with the invention.

For purposes of clarity and to facilitate a complete comprehension of the invention, the method, apparatus, and product phases are considered hereinbelow under separate headings.

GENERAL METHOD

In the present description, it is assumed that a continuous filamentary tow has been formed for spinneret devices by any one of the established techniques being widely used in the industry today for formation of "cigarette filter" tows, and that the same has been wound upon a bale for storage whereby it can be withdrawn from the bale as desired for further processing. Such a tow is referred to herein as a "raw" or "untreated" tow, and, as known to workers in the art, the fibers of a raw or untreated tow are normally crimped and not bonded together.

(A) *Initial treatment.*—In accordance with the invention, in accordance with prior art practices, and as shown in FIGURE 1, the raw tow 10, in crimped form, is taken from a supply bale 11 through an elevated banding device 12 which comprises multiple jets disposed to blow air under pressure against the raw tow so as to separate the individual fibers thereof. The banded tow then passes over a guide roller 13 to two spaced pairs of rollers 14, 15 with the vibrator 16 disposed therebetween for alternately applying tension to, and relaxing the tow so that it becomes completely open, i.e., the fibers are generally separated and at least substantially uncrimped. From the rollers 15 the tow passes another banding device 17 which is similar to the device 12 and serves to spread the tow into a thin fiber layer. The fiber layer is then passed through a plasticizing device 18 wherein a suitable plasticizer is sprayed by jets onto the fibers.

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(B) *Curing the tow.*—Although the tow is preferably initially processed according to the known techniques described above, it should be understood (1) that other forms of apparatus and other techniques may be used to provide a spread layer of at least substantially uncrimped fibers impregnated with a suitable plasticizer, and (2) that the basic improvement provided by the method of the invention lies in the processing and curing of such spread layer of impregnated fibers.

In accordance with the method of the invention, the spread layer of impregnated fibers leaving the plasticizer station 18 is fed to a first curing station wherein the fibers are simultaneously heated and gathered together. Disposed at this first curing station 19 is a heating and shaping apparatus which may comprise, as shown in FIGURE 1, a tube or nozzle 19' having a funnel-shaped mouth or entrance 19a leading into the forming passageway 19b of the tube. The passageway 19b has a diameter corresponding to the diameter desired for elements which are to be produced, and serves to shape the tow into a rod. Steam can be admitted into the tube through a suitable inlet 20 to hasten and more uniformly and adequately heat the fibers and plasticizer of the tow during its passage through the tube, or, alternatively, a mixture of heated or vaporized water and plasticizer may be sprayed on the tow during its passage through the first curing station 19 for the same purpose. In any event, a vaporized heated gas is passed onto the tow, or, more particularly, the plasticizer-impregnated layer of tow fibers, as such layer is gathered into a rod-like formation within the confined area defined by the tube 19'. Preferably, steam is used for the first curing treatment, and such steam is passed into the confined area defined by the tube under pressure and at an angle with respect to the longitudinal axis of the tow whereby the steam travels counter-current to the direction of movement of the tow. Although I have found that a substantial increase in bonding of the tow fibers is achieved by merely subjecting the tow to steam immediately after the layer of impregnated fibers is gathered into a rod-like formation, and while the same is confined, I have also found that more uniform bonding of the fibers and greater dimensional stability of the tow can be obtained when the steam is directed onto the tow counter-current to the direction of movement thereof, and at a 45-degree angle with respect to the longitudinal axis of the tow whereby the steam passes through the tow and out of the tow entrance end of the first curing station so that the incoming impregnated layer of fibers is heated as it is gathered into a rod-like structure.

While FIGURE 1 presents schematically the type of apparatus which may be used at the first curing station, preferably a gathering and steam-treating apparatus such as that described in detail hereinbelow and shown in FIGURE 2 is used at the first treating station. The pressure of the steam being passed onto the tow, and the speed at which the tow is moved to the first curing station will vary to a certain extent with the apparatus being used and/or other conditions. However, when the preferred embodiments of the invention are adopted, I have found that suitable bonding of the fibers can be achieved at tow speeds of between 50–100 meters per minute with steam being introduced at a rate of between six pounds per hour to ten pounds per hour with tows adapted to be cut into segments for use as cigarette filters. Preferably, the steam introduced is saturated at an initial pressure of 20 pounds p.s.i.g.

The tow, in the form of a rod-like structure as it emerges from the first curing station, is generally self-sustaining in shape and in cured condition. The term "cured" as used in the art means a tow obtained from a process by which the fibers of the tow are bonded to adjacent fibers after the fibers have been gathered into a rod-like structure. The process of the present invention pre-

pare a cured tow more readily and with improved characteristics over those of the prior art.

A tow which has left a first curing station of a production line operated in accordance with the present invention can be passed directly to an ordinary cigarette machine cutting apparatus and severed into segments, and there is no need to apply a paper overwrap thereto. However, I have found that once the tow passes the first curing station and is a cooperating mass within the confines of a stiffened peripheral layer, a superior product can be obtained by immediately fixing the dimensions of the rod without developing further stiffness or reducing the total fiber surface by fusion of the fibers.

Thus, notwithstanding the fact that a tow which has been passed through a first curing station, such as that designated by numeral 19, possesses some dimensional stability and can be severed into segments, the preferred embodiments of the invention provide for subjecting the tow to a second curing action immediately after its emergence from the first curing station.

More specifically, in accordance with the preferred embodiments of the invention, the tow which emerges from the first curing station 19 is fed directly to a second curing station 50 wherein dry air is passed onto the tow and through the tow to set the fiber components and plasticizer components of the tow so that it has complete dimensional stability without excess stiffness or fiber fusion. Preferably, the air which is passed onto the tow at the second curing station 50 is perfectly dry, has a temperature of 90° F. or below, and is maintained under a pressure of between 50 and 100 p.s.i.g. Moreover, for optimum results, the air should be passed onto the tow counter-current thereto and at an angle of substantially 45 degrees to the longitudinal axis of the tow. A suitable apparatus for air-treating the tow at the second curing station 50 is shown in FIGURE 5 and described in more detail herein-after.

The steam streams and air streams are preferably passed onto the tow circumferentially thereof, and the steam-injecting apparatus (best shown in FIGURE 2) as well as the air-injecting apparatus (best shown in FIGURE 5) provide for passing the respective gaseous streams onto the tow at spaced points about the periphery thereof so that uniform treating is achieved.

A tow which has been passed through a first and second curing station and treated as described above not only has substantially uniformly-bonded fibers within the tow, but, in addition, has a stiffened peripheral layer or crust which gives the tow complete dimensional stability. As the tow leaves the first curing station 19, it has some dimensional stability; however, it is not completely set, and thus pulling of the tow, as suggested above, can result in some deformation thereof, particularly when the tow has a substantial diameter. In addition, as also suggested above, the fibers of the tow can become fused to reduce surface area and cause excess stiffness. For this reason, in accordance with the invention, the second curing station is so disposed that the tow is cooled therein to essentially room temperature within .02 to .05 second after it emerges from the first curing station. By minimizing the time for travel between the first and second curing stations, any tendency of the tow to deform is minimized, and the fiber components and plasticizer components of the tow are set without excess fiber fusion, and in a cellular formation, or to give a cellular product. The air treatment not only insures against undesirable stiffness, but also cools and dries the tow so that it can be wrapped immediately, if desired, without causing deformation and wrinkles in the overwrap.

From the foregoing discussion, it should be apparent that a tow which is treated in accordance with the present invention has uniformly-bonded fibers and complete dimensional stability as it leaves the second curing station. Moreover, it should be apparent (a) that no subsequent operations need be performed on the tow except for the

cutting thereof into segments; (b) that the uniformly-bonded dimensionally-stable tow is produced as rapidly as the tow is banded, tensioned, impregnated, and gathered; and (c) that the linear tow speeds can be at least as great as those encountered in conventional production lines operated in accordance with prior art practices. Moreover, it should be apparent that no paper overwrap is required prior to severing of the finished tow into segments. Of course, it may be desired in some instances for special purposes to provide a special exterior coating on the tow, and such may be done without departing from the invention by using an annular brush or spray such as that schematically shown in FIGURE 1 and designated by the numeral 21. The formed tow can then be fed to a cutter 24, severed into segments such as those designated by the letter S, and stored in a suitable container 25.

(C) *Tow materials*.—Various materials capable of being formed into a continuous tow comprising a body of fibers randomly oriented primarily in a longitudinal direction may be treated in accordance with the method of the invention and used to form products provided by the invention. It is an important feature of the invention, however, to form the continuous filamentary tow from cellulose acetate fibers, and according to the preferred embodiments of the invention, any products produced comprise at least 50% cellulose acetate fibers. For certain uses, and to achieve certain filtering and/or adsorbing and/or liquid-holding properties, the cellulose acetate fibers may be mixed with other materials, such as, cellulose, viscose, cotton, cellulose acetate-butyrate, cellulose propionate, activated carbon, asbestos, metal fibers, wood fibers, and sawdust, and/or mixtures thereof.

(D) *Suitable plasticizers*.—While the particular plasticizer which is sprayed onto the spread layers of tow fibers at the plasticizing station 18 may be any one of the many known types of plasticizers which will serve to suitably bond together the continuous filaments being treated, preferably the plasticizer used is one selected from the group consisting of diethoxyethyl phthalate, dimethoxyethyl phthalate, triethyl citrate, tributyl citrate, tricresyl phosphate, glycerine triacetate, glycerine tripropionate, triphenyl phosphate, ethyl phthalyl, ethyl glycolate, acetyl triisohexyl citrate, acetyl triethyl citrate, dimethyl phthalate, diethyl phthalate, triethyl phosphate and tribetachlorethyl phosphate.

(E) *Fiber and tow denier*.—The denier of individual fibers and the total denier of the tow may be varied as desired to achieve any given finished tow characteristic. I have found, however, that best results can be obtained when the individual fiber denier ranges between 1.6 and 16, and the total denier of the tow ranges between 37,000 and 500,000. Of course, this includes the total denier range of 37,000 to 100,000 normally used in the production of cigarette filters.

APPARATUS

The preferred forms of apparatus used for treating a tow at the first and second curing stations in accordance with the method of the invention are shown in FIGURES 2 through 6.

(A) *Steam-injecting apparatus*.—The steam-injecting apparatus, which is best shown in FIGURE 2, comprises a housing 100 at least partially open at either end thereof and defining a treating chamber 102 extending between the openings 104 and 106 at opposite ends of the housing 100. A core member 108 is disposed within the chamber 102 in juxtaposition to the forward end 110 of the chamber. The core member has a tow passageway 112 therethrough which extends between the ends of the housing, and the core member also has fluid passageways 114 therein which extend angularly into the tow passageway 112. A closure member 116 is provided for closing the rear end of the chamber or the end opposite the end designated by numeral 110. The closure member has a tow passageway 118 therethrough. Cooperating means

are provided on the housing 100 and closure member 116 for removably securing the closure member in position. Preferably such cooperating means take the form of screw threads 120 which allow for removably securing the closure member to the housing with the tow passageway 118 in the closure member coaxial with the tow passageway 112 in the core member. An inlet conduit 122 extends through a side wall of the housing and communicates with a chamber passageway 124 whereby the conduit and chamber passageway serve as means for providing communication between the exterior of the housing 100 and the fluid passageways 114 in the core member. With this general construction, the tow 10, when moved through the tow passageways 118 and 112, can be subjected to fluid introduced through the inlet conduit 122 while the tow is confined within the passageways.

The closure member 116 is an elongated funnel-type member having a tow passageway with a first tapered portion 118a leading into a second portion 118b of uniform cross section. The tow passageway 112 in the core member 108 has a uniform cross section throughout its length and this cross section corresponds to and is equal to the cross section of the second portion 118b of the tow passageway in the closure member 116.

The portion of the passageway 118 which receives the impregnated fiber layer leaving the plasticizing station 18, namely, portion 118a, is tapered to provide a funnel-like structure leading into the portion 118b of uniform cross section. Thus, the impregnated fiber layer is, as the tow is pulled through the apparatus of FIGURE 2, gathered into a rod-like structure.

After the tow has been gathered into the rod-like structure, it passes next through the core member 108 which, preferably, as shown in FIGURE 2, has a tapered recess leading into the tow passageway 112. The core member may have any suitable outline conforming with the cross section of the chamber 102; however, preferably, both the chamber and the core member are generally cylindrical in shape. The core member is provided with end flange projections such as those designated by numeral 132, and these flange projections serve as means for supporting the core member in spaced relation to the side walls of the chamber to provide the chamber passageway 124 between the core member and the side walls of the chamber. The fluid passageways 114 communicate with this chamber passageway, as does the inlet conduit 122, and thus steam passed into the inlet conduit 122 passes through the fluid passageways 114 in the core member and onto the tow in a direction counter-current to the movement of the tow. Preferably, the fluid inlet passageways 114 make an angle A of 45 degrees with respect to the longitudinal axis of the tow or the longitudinal axis of the tow passageway in the core member. Steam which is so passed onto the tow travels through the tow due to the pressure within the chamber in a direction opposite to the direction of movement of the tow. Thus, steam which enters through the inlet conduit 122 is caused to move through the tow rearwardly of the fluid passageways 114 and into the tow passageway of the closure member 116. It will be remembered that this closure member 116 has a tow passageway 118 which serves to gather the tow and, accordingly, the steam which is moving rearwardly through the tow serves to heat the fibers of the tow and plasticizer impregnated thereon as the same is being gathered into a rodlike formation. Preferably, this treatment takes place as the fibers of the tow are assuming their ultimate disposition, or, more particularly, as the fibers are moving from the tapered portion of passageway 118 into the portion of uniform cross section.

To release air pressure within the tow, as it is assuming its ultimate dimension, the closure member 116 is provided with a series of escape passageways 140 extending between the tow passageway 118 and the exterior surface of the closure member. Preferably the escape pas-

sageways 140 slope into the tow passageway 118 and communicate with the same at least substantially at the junction of the tapered portion 118a and the portion 118b of uniform cross section.

The threaded coupling of the closure member 116 with the housing 100 serves to provide an effective seal at the rear end of the treating chamber 102, and the bearing of the forward face 109 of the core member against the front wall 110 of the housing serves to provide an effective seal at the forward end of the chamber. Preferably, the core member 108, in addition to having the features described above, also is provided with a forwardly-extending nozzle portion 150 through which a continuation of the tow passageway 112 is provided. The nozzle portion 150 has a peripheral shape and size whereby it engages the surrounding walls of the opening 104 in the forward end of the housing 100. It has been found that with this construction a sufficiently effective seal is provided, but it should be understood that suitable sealing washers and/or packings may be incorporated in the apparatus of FIGURE 2 if desired.

It should also be understood that while I have shown a cylindrical core member and a cylindrical chamber, the chamber and core member may be made square or rectangular or of any other suitable shape. Similarly, while the inlet conduit 122 has been shown as attached to a flanged bore in the housing side wall, to provide an inlet conduit, any other suitable form of inlet conduit which can be coupled with a source of steam or other heated vapors may be used.

Although the steam-injecting apparatus described above is suitable for many applications, I have found that generally the same type of apparatus can be used, with slight modification, to provide a tow having a passageway running therethrough. In this connection, particular attention is directed to FIGURE 7, wherein the modified form of apparatus for producing a tow having a central passageway therein is shown. The FIGURE 7 apparatus includes the same basic components as the apparatus of FIGURE 2, namely, a housing 100, a core member 108, and a closure member 116. The tow passageways, steam inlet passageways, and air release passageways are provided in the apparatus of FIGURE 7, as in the apparatus of FIGURE 2, and a detailed explanation of the apparatus, and function of each of the passageways, need not be repeated.

The basic difference between the apparatus of FIGURE 7, and the apparatus of FIGURE 2, is that the apparatus of FIGURE 7 includes a tow passageway forming member which preferably comprises an elongate tube 400. The tube 400 extends through the nozzle portion 150 of the core member, the tow passageway 112 in the nozzle and the core member, and the tow passageway in the closure member 116. The rear portion of the tube 400 is preferably bent upwardly, as shown, and the tube is apertured. Steam is passed into the entrance end 401 of the tube 400, just as steam is passed into the inlet conduit 122 of the housing 100. The amount of steam introduced, pounds per hour per square inch cross section of the tow, and the steam saturation, can be the same as for the steam introduced through the inlet conduit 122.

The tube 400 is supported centrally within the core member 108, or more particularly the tow passageway 112 thereof, by the fibers of the tow which are passing through the apparatus. To insure central disposition of the tube 400, the same can be initially adjusted if necessary.

The tube 400 as shown is circular in cross-section, however, it should be understood that the tube can be square in cross-section, or oval in cross-section, or of any other cross-sectional shape desired. Preferably, the shape of the tube corresponds to the shape of the passageway 112 in the core member 108 but the cross-section of the tube can differ from the cross-section of the core passageway 112 if desired.

The apparatus shown in FIGURE 7, as suggested, in-

cludes a tube 490 having a circular cross-section. FIGURE 7(c) shows a transverse cross-section of the core passageway 112 and the tube 490 as the same would appear when a circular tube and circular core passageway construction is utilized in the apparatus of FIGURE 7. FIGURES 7(a) and 7(b) present alternative core passageway shapes and alternative tube cross-section shapes. Prime numerals are used in FIGURES 7(a) and 7(b) to designate corresponding components.

(B) *Air-injecting apparatus.*—The air-injecting apparatus of the invention is constructed in generally the same way as the steam-injecting apparatus, as will be apparent from a review of FIGURES 5 and 6. However, instead of providing a funnel-type closure member at a rear end of the housing, an elongate plug 160 is provided and the elongated tow gathering passageway 118 such as shown in FIGURE 2 is replaced by a slightly tapered recess 162 on the end of plug 160 leading into a tow passageway 164 of uniform cross-section. Of course, the plug 160 need not be elongate; however, the elongate construction is preferred because it is more easily handled.

The core member 108a of the air-injecting apparatus is substantially identical with the core 108 of the steam-injecting apparatus; however, preferably two sets of fluid inlet passageways are provided in the air-injecting apparatus. More specifically, in addition to the fluid inlet passageway group 114a, there is provided a second inlet fluid passageway group 115. The inlet passageway groups each comprise a series of individual fluid passageways and the passageways in both groups are preferably disposed at a 45-degree angle with respect to the longitudinal axis of the core member tow passageway and slope toward the rear end of the housing or toward the closure member whereby fluid passed into the housing is directed counter-current to the direction of movement of the tow through the housing. The passageway groups are preferably offset. In FIGURES 5 and 6, prime numerals have been used to designate components of the air-injecting apparatus which correspond directly with components of the steam-injecting apparatus shown in FIGURES 2-4.

The tow passageways in the core members, and the uniform cross section portions of the tow passageways in the closure members correspond exactly with the outer contour of the rod-like tow structure which is being produced. This is an important feature of the invention, because, as explained above, the method of the invention provides for confining the tow during the steam treating and air treating operations whereby it obtains the dimensional stability and uniform bonding characteristics desired. Thus, when the operation is to be carried out on a tow having a larger or smaller diameter than that shown in FIGURES 2-6, it is necessary to change the size and/or shape of the tow-receiving passageways. With the apparatus provided by the present invention, this is easily achieved. The closure members can be made with passageways of various sizes, as can the core members. Accordingly, when it is desired to use the apparatus for processing different size tows, it is only necessary to remove the closure members, remove the cores, insert in each housing a different core member having a tow passageway of appropriate size, and then tighten on a closure member also having the appropriate size tow passageway. There is no need to disconnect any of the steam conduits or any of the air conduits, nor is it necessary to in any way move the housings.

PRODUCT

A tow which has been processed in accordance with the method of the invention as described above, and which has been passed through suitable apparatus for carrying out the method such as that also described above, generally is cut into segments or lengths for future use. The segments, as explained, may be used for smoke filters, valve filters, stopper plugs, adsorbers, and/or applicators, as well as for other purposes outlined in detail herein-

above. Notwithstanding this fact, it is important to understand that one of the principal features of the invention is the provision of (a) an improved cigarette filter, and (b) the provision of a new type of adsorber and/or applicator.

The improved cigarette filter and the new type of adsorber and/or applicator generally comprise a body formed from continuous fibers randomly oriented primarily in a longitudinal direction and having a stiffened peripheral layer or crust formed of the same materials as the interior portion of the body.

The fibers of the body are preferably cellulose acetate; however, cellulose acetate and other materials set forth hereinabove as being suitable tow materials can be combined to provide the final product. Of course, in accordance with the invention, the body also includes a suitable plasticizer, and preferably one selected from the group of plasticizers set forth above. However, in accordance with the preferred embodiments of the invention, the ultimate product consists only of the continuous fibers randomly oriented primarily in a longitudinal direction and the plasticizer with which the fibers are impregnated. The stiffened peripheral layer consists of exactly these materials, and the amount of plasticizer adjacent fibers of the stiffened peripheral layer appears to be no greater than the amount of plasticizer adjacent fibers within the interior of the body.

An example of a dispenser formed in accordance with the present invention is shown in FIGURE 8. The dispenser includes any suitable housing or containing means such as that designated by numeral 200. Preferably, however, the containing means is provided with a nozzle 202 and a closure cap of some type such as that designated by numeral 204. Disposed within the containing means is an adsorber 206 which comprises a body of continuous cellulose acetate fibers randomly oriented primarily in a longitudinal direction and treated in accordance with the method of the present invention. The adsorber 206 is coupled with an applicator 208 having the rear end thereof in contact with the adsorber forward end. The applicator 208 also comprises a body of continuous cellulose acetate fibers randomly oriented primarily in a longitudinal direction and treated in accordance with the present invention. However, the total denier of the applicator 208 and the denier of the fibers thereof differ from the total denier and the denier of the fibers of the adsorber 206. The adsorber 206 has a main function of holding as much fluid as possible, while the applicator 208 has a main function of dispensing or applying the fluid uniformly in controlled amounts. Thus, the denier of the applicator is selected to provide suitable fluid control dispensing characteristics, whereas the denier of the adsorber 206 is selected to provide desired liquid-holding characteristics. The applicator 208 and adsorber 206 are filled by dipping or injection with a material to be dispensed, such as, for example, paint, perfume, or antiseptic.

Another example of a product which utilizes the invention is presented in FIGURE 9. In that figure the numeral 300 is used to generally designate a cigarette comprising a paper overwrap 302, a body of tobacco 304, and a cigarette filter element 306. The cigarette filter element 306 comprises a segment of a tow treated in accordance with the present invention and thus has a stiffened peripheral layer or crust. The cigarette filter element 306 is coupled with the cigarette paper 302 directly and there is no intermediate layer of paper between the periphery of the filter 306 and the outside paper covering 302 of the final cigarette.

Still another example of a product which utilizes the invention is presented in FIGURE 10 wherein the numeral 500 generally designates a cigar. The cigar comprises a tobacco fill 502 and a leaf-tobacco overwrap 504. Within the tobacco overwrap 504, at one end of the cigar, there is provided a cigar filter 506, which filter comprises

a segment of a tow treated in accordance with the present invention.

EXAMPLES

The various aspects of the invention described in detail hereinabove are illustrated further by the following examples.

Example 1.—A continuous filamentary tow of yarn-type unplasticized dull cellulose acetate having 8 crimps per inch produced by a crimping machine, 12 denier per filament, and 80,000 total denier was passed through a banding device, and over a tension roller as shown in FIGURE 1, and slack was removed from the tow. The tensioned tow was next passed through two pairs of control drafting rolls as illustrated in the accompanying drawing (FIGURE 1) for the purpose of opening the tow and breaking up bundles therein. The open tow was thence directed to an air jet bundle breaking and banding device of a type such as that described above. Air jets from below the tow operating at a pressure of 1.5 pounds gauge were directed against the tow and succeeded in further breaking any individually-formed bundles therein and opening or banding the tow to provide a fiber mass of web-like form, approximately 12 inches in width. Thence, the opened and banded fiber was sent through a chemical conditioning station or plasticizing station where it was continuously sprayed with 8% of glycerine triacetate plasticizer. The sprayed, webbed fiber layer was then passed through a steam-treating apparatus such as shown in FIGURE 2 at a linear tow speed of 50 meters per minute and approximately 6 pounds per hour of steam was introduced through the fluid inlet conduit of the housing. The steam was saturated at an initial pressure of 20 pounds per square inch gauge and passed through the tow softening the same and uniformly bonding the fibers of the tow as it was gathered together in the apparatus. The tow was then moved from the steam-treating apparatus at the same linear speed and through an air-treating apparatus such as shown in FIGURE 5, whereby within .03 second after leaving the steam-treating apparatus it was cooled to essentially room temperature. Air having a temperature of approximately 90° F. was introduced into the air-injecting apparatus of FIGURE 5 through the inlet conduit of the housing at a rate of about 5 cubic feet per minute and under an initial pressure of 80 p.s.i.g. The tow after leaving the air-injecting apparatus was cut into segments of suitable length, for future use as cigarette filters.

Example 2.—A tow was treated exactly as set forth in Example 1 and then the segments were used to form a filter cigarette constructed as shown in FIGURE 8.

Example 3.—A tow was treated exactly as set forth in Example 1 except the tow was cut into segments approximately two inches in length and suitable for use as applicators.

Example 4.—A tow was treated exactly as set forth in Example 1 except the glycerine triacetate plasticizer was replaced by 7% acetyl triiso hexyl citrate.

Example 5.—A tow was treated exactly as set forth in Example 1 except the tow was formed of 60% cellulose acetate fibers and 40% cotton fibers.

Example 6.—A tow was treated exactly as set forth in Example 1 except it was moved through the steam-treating and air-treating apparatus at the rate of 100 meters per minute and 10 pounds of steam per hour was introduced through the inlet to the housing.

Example 7.—A tow was treated exactly as set forth in Example 1 except the same was moved through the steam-treating and air-treating apparatus at the rate of 75 meters per minute and 9 pounds of steam per hour was introduced through the inlet to the steam-treating housing.

Example 8.—A tow was treated exactly as set forth in Example 1 but the denier per fiber and total denier of the tow was varied as shown in Table I, and the fiber weight was determined. After the tows had been treated

as set forth in Example 1, segments of each tow were dipped in ink, and the excess ink was allowed to drip off. The segments were then weighed to determine the ink absorbed.

TABLE I

Sample No.	Fiber Construction (Denier)	Weight Fiber (g.)	Ink Adsorbed (cc.)	Ratio, cc./g.
1-----	8/80,000	0.65	4.0	6.2
2-----	12/80,000	0.66	3.5	5.3
3-----	8/80,000	0.68	4.5	6.6
4-----	12/80,000	0.67	4.5	6.7

Comparison example.—A tow was treated exactly as set forth in Example 1, except no steam was introduced into the steam inlet of the steam-injection apparatus, and no air was introduced into the air inlet of the air-injection apparatus. The denier per fiber and total denier of the tow was adjusted as set forth in Table I, and the fiber weight was determined. The tow emerging from the air-injecting apparatus was cut into segments. The segments of the tow treated in accordance with this example were then dipped in ink, and the excess ink was allowed to drip off. The ink saturated segments were then weighed, and the results were as set forth in Table II below.

TABLE II

Sample No.	Fiber Construction (Denier)	Weight Fiber (g.)	Ink Adsorbed (cc.)	Ratio, cc./g.
1-----	1. 6/37,000	0.67	3.5	5.2
2-----	2. 9/87,000	1.07	3.0	2.9
3-----	3. 8/80,000	1.00	3.0	3.0
4-----	4. 12/80,000	0.98	4.0	4.0
5-----	5. 8/80,000	0.99	3.0	3.0
6-----	6. 12/80,000	0.98	3.0	3.0
7-----	7. 9/87,000	0.93	3.5	3.8
8-----	8. 5/80,000	0.90	3.5	3.9

The tow produced in all of the examples except for the comparison example had a stiffened peripheral layer and complete dimensional stability. Moreover, as is apparent from a review of the results set forth in Tables I and II above, the tow segments treated in accordance with the present invention had almost twice the ink-holding power of comparable fiber construction segments treated in accordance with the comparison example. The ink-holding power of sample 1 of Table II was increased because of the use of a fiber having a very small denier. Thus, the method of the invention not only yielded the result of providing a completely dimensionally-stable tow having a stiffened peripheral crust, but in addition it provided the result of increasing the liquid-holding properties of a continuous tow of fibers randomly oriented primarily in a longitudinal direction.

Although detailed quantities have been used in the foregoing examples, it has been found (a) that the particular plasticizer and amounts thereof are not critical, so long as the plasticizer is compatible with the tow fibers, and (b) that the method of the invention can be carried out within the following ranges which yield preferred results:

- (1) Tow speed: 2 to 100 meters per minute.
- (2) Steam introduced: 5 lbs. per hour to 500 lbs. per hour per square inch cross-section of tow.
- (3) Steam saturation: 100% at initial pressure of between 0 p.s.i.g. and 70 p.s.i.g.
- (4) Cooling time after leaving steam-treating apparatus: preferably .02 to .05 second.
- (5) Air temperature: preferably not over 90° F.
- (6) Air introduced for cooling: preferably 10 cu. ft. per minute to 1000 cu. ft. per minute per square inch of tow cross-section.

After reading the foregoing detailed description of the various aspects of the present invention, it should be apparent that the objects set forth at the outset of this

specification have been successfully achieved. Various modifications of the illustrative embodiments of the invention presented hereinabove may become apparent to those of ordinary skill in the art. Accordingly,

What is claimed is:

1. In a method of treating a continuous filamentary tow comprising cellulose acetate fibers randomly oriented primarily in a longitudinal direction and including the steps of spreading the tow into a fiber layer, impregnating the fiber layer with a plasticizer and gathering the fiber layer into a rod-like formation, the improvement of uniformly bonding the fibers of the tow as gathered by moving the tow through a confined area and directing steam onto the plasticizer-impregnated tow in said area whereby the steam passes through said tow circumferentially thereof at an angle of approximately 45° with respect to the longitudinal axis of the tow, and counter-current to movement of said tow.

2. In a method of treating a continuous filamentary tow of fibers primarily composed of cellulose acetate and randomly oriented primarily in a longitudinal direction and including the steps of spreading the tow into a fiber layer and impregnating the fiber layer with a plasticizer, the improvement of simultaneously gathering the impregnated layer into a tow of rod-like formation and uniformly bonding the fibers of the tow by moving the same through a confined area and passing steam onto the tow in said area and counter-current to the direction of movement of the tow whereby the steam travels through said tow in a direction opposite the direction in which said tow is moving.

3. In a method of forming a continuous tow comprising at least 50% cellulose acetate fibers randomly oriented primarily in a longitudinal direction and including the steps of spreading the tow into a fiber layer, impregnating the fiber layer with a plasticizer and gathering the fiber layer into a tow of rod-like formation, the improvement of uniformly bonding the impregnated fibers of the tow and giving dimensional stability thereto by moving the tow through a first confined area and directing steam onto the tow in said first area whereby the steam passes through said tow and immediately thereafter passing the tow through a second confined area and directing air onto the tow in said second confined area whereby said air passes through said tow.

4. The improvement defined in claim 3 wherein said steam and said air are passed onto said tow circumferentially thereof at an angle of approximately 45° with respect to the longitudinal axis of the tow, and counter-current to movement of the tow.

5. The improvement defined in claim 4 wherein said tow is moved through said areas at a linear speed of between 50 and 100 meters per minute; wherein said steam is passed onto said tow at the rate of between 5 and 500 pounds per hour per square inch of tow cross-section; wherein said air has a temperature no greater than 90° F. and is passed onto said tow at the rate of between 10 and 1000 cu. ft. per minute per square inch of tow cross-section; and wherein said air cools said tow to a temperature of no greater than 90° F. within .02 to .05 second after said tow leaves said first confined area.

6. In a method of treating a continuous filamentary tow comprising cellulose acetate fibers, the steps of spreading the continuous tow into a continuous fiber layer, impregnating the continuous fiber layer at least

substantially uniformly with a plasticizer, and immediately thereafter gathering said layer into a continuous rod-like formation while simultaneously passing steam there-through to cure the same and give dimensional stability thereto.

7. In a method of fabricating cellulose acetate tow into filter elements having a self-sustaining form, the steps of applying a plasticizer to the tow, passing the plasticized tow through a confined area wherein the tow is formed into a rod with the fibers thereof drawn together, and heating the plasticized tow during its passage through said confined area to effect rapid curing thereof and firm bonding of its fibers together, wherein said rod has a cross-sectional size equal to the cross-sectional size of said filter elements, and wherein said plasticized tow is heated by passing steam into said tow within said confined area at a location within said confined area where said tow has been formed into said rod of said cross-sectional size.

8. In a method of fabricating cellulose acetate tow into filter elements, the steps of applying a plasticizer to the tow, passing the tow through a heated confined area and introducing steam into the tow during its passage through said confined area to effect rapid curing thereof.

9. The method of claim 8 further including the step of shaping said tow into a rod of predetermined final cross-section during its passage through said confined area and wherein said steam is introduced into said tow as shaped into said rod of predetermined cross-section.

10. In a method of treating a continuous filamentary tow comprising cellulose acetate fibers randomly oriented primarily in a longitudinal direction and including the steps of spreading the tow into a fiber layer, impregnating the fiber layer with a plasticizer and gathering the fiber layer into a rod-like formation, the improvement of uniformly bonding the fibers of the tow as gathered by moving the tow through a heated confined area and directing steam onto the plasticizer-impregnated tow in said area whereby the steam passes through said tow, effecting at least substantially uniform curing thereof.

11. In a method of fabricating cellulose acetate tow into filter elements, comprising the steps of banding and stretching the tow to separate fibers thereof, applying a plasticizer to the separated fibers of the tow, passing the plasticized tow through a forming nozzle wherein the tow is formed into a rod with the fibers thereof drawn together, passing steam through said tow during its passage through said nozzle to cure said tow, and cutting the cured tow into filter elements of a self-sustaining form.

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