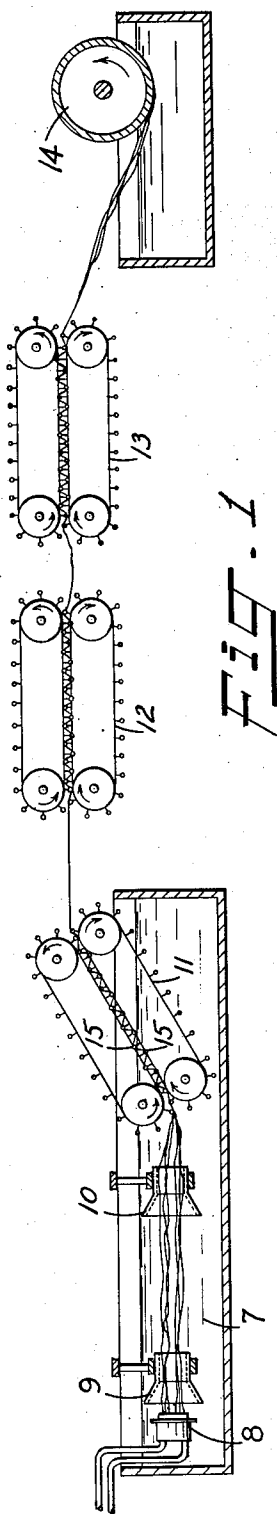
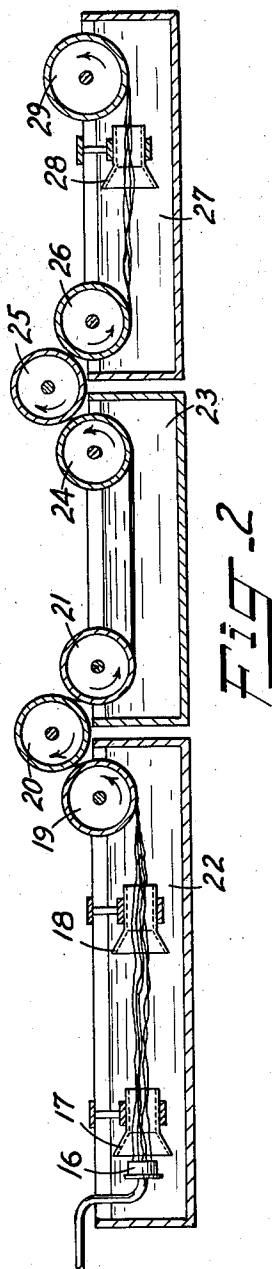
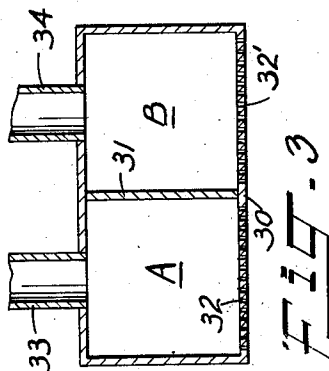
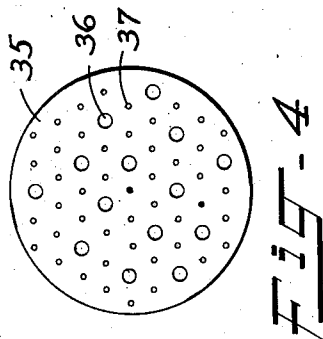


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METHOD OF MAKING LIGHTWEIGHT
FILAMENTOUS STRUCTURES
Filed April 12, 1944

2,461,094



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METHOD OF MAKING LIGHTWEIGHT
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10 Claims. (Cl. 18—47.5)

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This invention relates to methods for the production of ribbon-like or mat-like structures having a crinkled structure. This application is a continuation-in-part of my copending application Serial No. 479,889, filed March 20, 1943, now Patent 2,399,258, April 30, 1946, and my copending application Serial No. 490,009, filed June 8, 1943, now Patent 2,399,260.

In general, in the present invention, a filamentary bundle containing a mixture of filaments, preferably of the same material, having different characteristics of plasticity and/or elasticity is produced and subjected to stretching and relaxation. The bundle may be ribbon-like or mat-like in character. The filamentary bundle may comprise some filaments which are substantially truly elastic in character and relatively free of any plastic flow under the conditions of stretching, as well as other filaments which are essentially plastic in character so that the stretching effects an elongation which is substantially permanent and is not recovered, or is only partially recovered where a partial elasticity is present, upon subsequent relaxation when the stretching force is removed. Upon release of the stretching force from such a bundle of filaments, the elastic filaments return to their original length by virtue of their elasticity while the plastic filaments are caused to take a crinkled conformation because of the reduction in length of the elastic filaments.

The mixture of essentially elastic filaments with essentially plastic filaments may be obtained in various ways. For example, one or more filaments may be rendered plastic, such as by the application of heat, solvents, swelling or plasticizing agents, depending upon the particular material of which the filaments are constituted, and they may then be associated with one or more non-plasticized filaments of the same or different material with or without twisting. Again, filaments which are completely elastic and set up may be associated with freshly spun and still plastic filaments of the same or different material. In this latter case, the association may occur shortly after the plastic filaments leave the spinneret. Again, one or more filaments of small diameter may be spun simultaneously with one or more filaments of large diameter (which may be hollow, if desired) and passed through a common coagulating bath, from which the associated filaments emerge in different plastic and elastic conditions and are subjected to stretching in that state. This may be accomplished by having a single spinneret containing both large and small orifices, or by having a plurality of spinnerets one of which has large orifices and the other small orifices, from which different size filaments may be spun. Again, the same result may be accomplished by using two different spinnerets having the same size of orifices, but using differ-

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ent pump speeds for forcing the material through the orifices. Also a plurality of jets may be used when different spinning materials are employed. These materials may comprise different filament-forming components so adjusted that upon emersion from the coagulating bath the different types of filaments exhibit different characteristics of plasticity and elasticity, in which state they may be stretched. A plasticizer may be incorporated in one of the spinning materials for imparting to the filaments obtained therefrom a rubber-like elasticity, especially when vinyl resins are used. Also, the materials may comprise the same filament-forming component but use different solvents which are removed from the extruded filaments at different rates, thus assuring differences in elasticity and plasticity at the time of subsequent stretching. For example, a copolymer of vinyl chloride and vinyl acetate may be dissolved in dioxane and extruded through one spinneret, while a similar solution in acetone which is more volatile than dioxane may be extruded through another spinneret. The differences in plasticity and elasticity at the time of stretching, in the latter system, may be accentuated by extruding the solution in dioxane through larger holes than those of the spinneret through which the acetone solution is extruded. As an alternative to the use of separate spinnerets in any of the cases just mentioned, a type of spinneret or jet may be employed which is provided with suitable partitions back of the spinneret face, for dividing that space into separate regions which communicate with separate lines to different spinning supplies entirely, or through separate pumps to a common spinning line, so that the spinning material supplied to one of the regions back of the spinneret face passes through the orifices associated therewith and that supplied to the other region or regions back of the spinneret face is extruded through the other orifices in the spinneret, which may be of the same or of different size than the orifices associated with the other region. This type of spinneret is the subject matter involved in the co-pending application of Robert J. Taylor and Wesley L. Webb, Serial No. 492,702, filed June 29, 1943, now Patent 2,398,729.

Any of the systems just described for associating the different types of filaments may be used. The resulting filamentary bundle of weblike structure is subjected to stretching and then relaxation. Depending upon the conditions of manipulation, either the large or the small diameter filaments may be the component that undergoes the greatest crinkling. Thus, if a web-like bundle containing both large and small filaments, is subjected to a plasticizer therefor, so that the small filaments are well plasticized without substantially altering the essential elastic character of the large fila-

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ments, the small filaments will show the most crinkling in the product. Where, however, stretching is performed upon a mixture of freshly spun filaments of both large and small diameters, the small filaments being completely set and the large filaments still plastic, the large filaments will show the most crinkling in the product.

The stretching may be performed by any of the known means heretofore employed for stretching yarns or yarn-like bundles of filaments. Thus the bundle may be passed about a series of positively driven rolls in succession, at least one of said rolls being driven at a higher rate of speed than the roll immediately preceding it. Alternatively, the bundle may be passed over a thread-advancing device or reel of tapered construction such that the bundle is stretched as it proceeds laterally of the device or reel. It also may be passed between the nips of a plurality of pairs of rotating rolls in succession, at least one of said pairs of rolls being driven at a higher peripheral speed than an immediately preceding pair of rolls. These and alternative arrangements are illustratively represented in the drawings hereinafter, in which—

Figure 1 is an elevation of an arrangement adapted to handle the web-like filamentary bundles;

Figure 2 is another illustration of an arrangement for manipulating the web-like bundles;

Figure 3 shows a cross-section of one form of spinneret that may be used; and

Figure 4 is a face view of a modified form of spinneret that may be used in the invention.

Figure 1 shows a coagulating bath 7 with a spinneret 8 shown in more detail in Figure 4, for spinning two different spinning materials or solutions. A funnel guide 9 may be placed in proximity to the spinneret to control the motion of the filaments through the coagulating bath, and a second funnel guide 10 is positioned in the bath near the point of emergence of the filaments therefrom. The filaments, in the form of a web-like sheet with the filaments arranged either parallel or haphazardly intercrossed therein, proceed through a series of separate conveyor systems 11, 12, 13 in succession, and then to a suitable take-up device 14, on which the sheet may be collected with or without tension. Each conveyor device comprises a pair of superposed chain sections comprising interdigitating cross-pieces or girts 15 which seize the web-like sheet and hold it in zigzag conformation while moving the sheet through the device. This particular device forms no part of this invention, and its construction may be that of the device disclosed in my copending application Serial No. 530,683, filed April 12, 1944, patented October 2, 1945, No. 2,385,894. The second conveyor system 12 is operated at a higher rate of speed, in order to effect stretching of the flight of the web-like sheet extending between the two systems 11 and 12. The web-like sheet after leaving the second conveyor system 12, may be allowed to relax in its flight therefrom to the next conveyor system 13, which may be utilized for carrying the sheet during wet treating or drying thereof. From the latter conveyor system 13, the sheet may be continuously transferred to a suitable take-up device 14, such as a drum which may be operated while partially immersed in a liquid, such as water inert to the filaments, to obtain a wound band of intricately intercrossed filaments of the type disclosed in my prior patent 2,399,258. As in my prior application, the wound band, after col-

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lection, may be slit in the general direction of its width and may then be dried. The dried band is then seized at its four corners (or at numerous spaced points along each of the two sides which extend in the same general direction as the length of the filaments) and while maintaining it under tension along its length between the points of seizure, it is stretched out in the direction of its width. This stretching along the width is accompanied by a surprising expansion in the thickness of the material.

Figure 2 shows an arrangement similar to that of Figure 1 in that the object is to produce a web-like sheet of filaments comprising both large and small diameters. The spinneret 16 may be of the form shown in Figure 5 and the filaments pass through guides of funnel-like characters 17 and 18, then about rolls 19, 20 and 21, which are arranged to effect transfer of the web-like sheet as a sheet out of the coagulating bath 22 into a second bath 23 within which the filaments may be stretched as a sheet, such stretching being effected by virtue of the fact that the web-like sheet passes about the peripheries of another set of three rollers 24, 25 and 26, driven at higher speed than the first set. The second set of rollers serves also to remove the filaments as a web-like sheet out of the second bath 23, and to immerse them into a third bath 27 within which they proceed through a guide 28 to a suitable take-up device 29 which may be partially immersed in the liquid of the third bath. By maintaining the flights of filaments extending between the two sets of rollers and between the second set of rollers and the take-up device under liquid, the loss of the web-like character of the filamentary bundle is prevented, even though subjected to stretching during such free flights.

Figure 3 illustrates in cross-section a form of spinneret in which one spinning material may be extruded through certain of the orifices thereof and another spinning material extruded through certain other orifices thereof. To accomplish this, the space back of the spinneret face 30 is divided by a partition 31 into two or more separate regions (two such regions A and B being shown), each of such regions communicating with a separate set or group of orifices 32 and 32', which may or may not be of the same size. The regions A and B into which the space back of the spinneret is divided, is then associated with separate spinning solutions by means of separate feed lines 33 and 34 respectively. Of course, if it is merely desired to use a spinneret having orifices all of the same size and a single spinning solution, the regions back of the spinneret face may be connected through the separate lines 33 and 34 and separate pumps to a common supply line for the spinning solution and then two pumps operated at different speeds to produce differently sized filaments.

In Figure 4 the spinneret 35 has large orifices 36 and small orifices 37 heterogeneously intermingled. The use of this spinneret causes the production of a mixture of filaments having both large and small diameters, and the length of immersion in the bath 22 is controlled to effect substantially complete coagulation and setting of the small diameter filaments without destroying the elasticity of the large diameter filaments at the time of passage between the two systems 11 and 12 of Figure 1 or rollers 21 and 24 of Figure 2. The length of immersion depends upon the diameters of the small filaments produced, the coagulating medium and the particular spinning

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solution. For the treatment of filaments produced from a solution of a copolymer of vinyl chloride and vinyl acetate in acetone, under conditions such that the small filaments have diameters in the neighborhood of 10 microns, and the diameter of the large filaments has a value between about 75 to 150 or more microns, an immersion in a water bath at about 45° C. of about 24 inches is capable of completely setting the small diameter filaments without destroying the elasticity of the larger filaments.

Spinnerets of either of the types shown in Figures 3 and 4 may be used in either of the arrangements shown in Figures 1 and 2.

Besides producing wound bands of crinkled web-like filamentary sheets, expansion of the wound bands obtained by the arrangements of Figures 1 and 2 in accordance with the procedure disclosed in my Patent 2,399,258, produces a novel light-weight filamentous product useful as a heat insulation material, a buoyant material, for aerosol filtration, cushioning material and the like. Such products may comprise filaments having large diameters ranging from about 10 microns to 300 or more microns in diameter, and any desired proportion of small diameter filaments ranging from about 1 to 10 microns, or they may comprise any combination of small and large sizes. Because of the conditions and circumstances under which the wound bands are made in accordance with the present invention, the cutting of such a wound band transversely of its annulus and expansion transverse of the width of the band gives rise to products in which either the small or the large diameter filaments therein are much more highly crinkled than is the case of the filaments in the products of my prior copending application. Where the web-like sheet is collected with tension in the form of a wound band immediately after the sheet has been stretched, crinkling becomes manifest upon the cutting of the band in removing it from the collecting drum. Upon subsequent expansion of the product by stretching across its width, the crinkliness becomes more uniformly distributed throughout the product.

In general, the expanded mats made in accordance with this invention and the disclosure of my prior copending application comprise criss-cross filaments lying substantially in generally parallel and more or less undular planes, so that the mat is substantially laminar in character. The space occupied by the mat is extremely subdivided by the criss-cross filaments extending in undulated planes substantially at right angles to the thickness of the mat and to the fact that the lattice work formed by the filaments in one web is out of alignment with that in adjacent webs lying generally parallel thereto. The extreme intricacy of the network is particularly noticeable when a large number of filaments of extremely fine diameter and a relatively small proportion of large diameter filaments are converted into the product. The superimposition of web on web of such irregularly arranged intercrossing filaments with the additional waviness in the individual filaments produces a filamentous mass having an intricate network disposed across the path of travel in the direction of the thickness of the mat. All filaments in one web, lamination or strata do not contact all filaments in the next adjacent at the points where they appear to cross as the result of the distortion caused by the stretching. Besides the waviness resulting from the stretching employed in expanding the band into the mat,

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the contraction caused by the elongated elastic filaments when released causes additional waviness and crinkliness in those filaments which were in a plastic condition when the mixture was subjected to initial stretching. The result is that while all of the filaments in the product extend generally from one side thereof to an opposite side or edge thereof, many of the filaments are in a highly crinkled condition as the result either of the initial stretching of the mixed plastic and elastic filaments or of the subsequent stretching of the band to expand it into the form of a mat, or, in some cases, as the result of both factors. The mats produced in accordance with this invention are characterized by essentially the same structure as in my prior copending application, except that a mixture of different sized filaments are involved in the present mats and either the larger or the smaller filaments therein, or both the large and small filaments, are characterized by increased waviness and crinkliness, as compared to the mats of my earlier application.

While preferred embodiments of the invention have been disclosed, it is to be understood that changes and variations may be made without departing from the spirit and scope of the invention as defined by the appended claims.

I claim:

1. A method of producing filamentous products comprising the steps of stretching, in a direction generally longitudinally thereof, a wet filamentary bundle of web-like sheet structure comprising continuous filaments in a plastic condition mixed with continuous filaments in an elastic condition, collecting the sheet as such while still wet in the form of a multiple-layered winding, severing the winding across its width, drying the relaxed winding in the form of a band, and stretching the dried band out in the direction of its width while permitting it to expand in thickness.

2. A method of producing filamentous products comprising the steps of stretching, in a direction generally longitudinally thereof, a wet filamentary bundle of web-like sheet structure comprising continuous filaments in a plastic condition mixed with continuous filaments in an elastic condition, collecting the sheet as such while still wet and under tension in the form of a multiple-layered winding, serving the winding across its width, drying the relaxed winding in the form of a band, and stretching the dried band out in the direction of its width while permitting it to expand in thickness.

3. A method of producing filamentous products comprising the steps of stretching, in a direction generally longitudinally thereof, a wet filamentary bundle of web-like sheet structure comprising continuous filaments in a plastic condition mixed with continuous filaments in an elastic condition, collecting the sheet as such while still wet in relaxed condition in the form of multiple-layered winding, severing the winding across its width, drying the relaxed winding in the form of a band, and stretching the dried band out in the direction of its width while permitting it to expand in thickness.

4. A method of producing light-weight filamentous products comprising the steps concurrently forming in a common precipitating medium a mixture of wet continuous filaments having different rates of setting up, associating said filaments in a common bundle of web-like sheet structure, stretching the bundle in a direction generally longitudinally thereof while at

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least one of the filaments therein is essentially elastic in character and at least one other is still essentially plastic in character, collecting the sheet as such while still wet in the form of a multiple-layered winding, severing the winding across its width, drying the relaxed winding in the form of a band, and stretching the dried band out in the direction of its width while permitting it to expand in thickness.

5. A method of producing light-weight filamentous products comprising the steps of concurrently forming in a common precipitating medium a mixture of wet continuous filaments having different rates of setting up, associating said filaments in a common bundle of web-like sheet structure, stretching the bundle in a direction generally longitudinally thereof while at least one of the filaments therein is essentially elastic in character and at least one other is still essentially plastic in character, collecting the sheet as such while still wet and under tension in the form of a multiple-layered winding, severing the winding across its width, drying the relaxed winding in the form of a band, and stretching the dried band out in the direction of its width while permitting it to expand in thickness.

6. A method of producing light-weight filamentous products comprising the steps of concurrently forming in a common precipitating medium a mixture of wet continuous filaments having different rates of setting up, associating said filaments in a common bundle of web-like sheet structure, stretching the bundle in a direction generally longitudinally thereof while at least one of the filaments therein is essentially elastic in character and at least one other is still essentially plastic in character, collecting the sheet as such while still wet and in relaxed condition in the form of a multiple-layered winding, severing the winding across its width, drying the relaxed winding in the form of a band, and stretching the dried band out in the direction of its width while permitting it to expand in thickness.

7. A method of producing light-weight filamentous products comprising the steps of concurrently forming in a common precipitating medium a mixture of wet continuous filaments of a copolymer of vinyl chloride and vinyl acetate having different rates of setting up, associating said filaments in a common bundle of web-like sheet structure, in a direction, stretching the bundle in a direction generally longitudinally thereof while at least one of the filaments therein is essentially elastic in character and at least one other is still essentially plastic in character, collecting the sheet as such while still wet and under tension in the form of a multiple-layered winding, severing the winding across its width, drying the relaxed winding in the form of a band, and stretching the dried band out in the direction of its width while permitting it to expand in thickness.

8. A method of producing a light-weight filamentous product comprising the steps of concurrently forming in a common precipitating medium a mixture of wet continuous filaments of a copolymer of vinyl chloride and vinyl acetate comprising filaments of large diameter and filaments of smaller diameter which set up more rapidly than the larger filaments, associating

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said filaments in a common bundle in a direction generally longitudinally thereof of web-like sheet structure, stretching the bundle while at least one of the small filaments therein is essentially elastic in character and at least one of the large filaments is still essentially plastic in character, collecting the sheet as such while still wet and under tension in the form of a multiple-layered winding, severing the winding across its width, stretching the dried band but in the direction of its width while permitting it to expand in thickness.

9. A method of producing a light-weight filamentous product comprising the steps of associating in a common filamentary bundle of web-like sheet structure a mixture of wet continuous filaments responding differently to plasticizing media, subjecting the bundle while still in the form of a web-like sheet structure to a plasticizing medium, then stretching the bundle in a direction generally longitudinally thereof while still in web-like form and while at least one filament therein is in a plastic condition and at least one other filament therein is in a substantially elastic condition, collecting the sheet while still wet as such in the form of a multiple-layered winding, severing the winding across its width, drying the relaxed winding in the form of a band, and stretching the dried band out in the direction of its width while permitting it to expand in thickness.

10. A method of producing a light-weight filamentous product comprising the steps of associating in a common filamentary bundle of web-like sheet structure a mixture of wet continuous filaments of a copolymer of vinyl chloride and vinyl acetate which are of different sizes and thereby are differently affected by plasticizing media, subjecting the bundle to a plasticizing medium while maintaining it in sheet formation, stretching the web-like sheet in a direction generally longitudinally thereof while at least one filament therein is in a plastic condition and at least one other filament therein is in a substantially elastic condition, collecting the sheet as such while still wet and under tension in the form of a multiple-layered winding, severing the winding across its width, drying the relaxed winding in the form of a band, and stretching the dried band out in the direction of its width while permitting it to expand in thickness.

ROBERT J. TAYLOR

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Certificate of Correction

Patent No. 2,461,094

February 8, 1949

ROBERT J. TAYLOR

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows:

Column 6, line 50, for the word "serving" read *severing*; line 62, after the word "wet" insert *and*; line 63, after "of" insert *a*; line 69, after "steps" insert *of*; column 7, line 53, before "stretching" strike out "in a direction";

and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 20th day of December, A. D. 1949.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.