March 5, 1968 L. E. LEFEVRE ET AL 3,372,221

PROCESS FOR PREPARING FILAMENTARY MICROTAPES OF LABYRINTHIAN CROSS SECTION

Filed Aug. 6, 1965

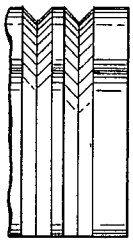


Fig. 2

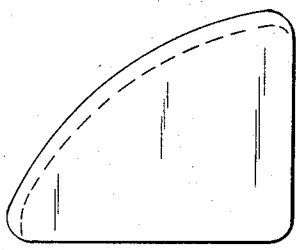


Fig. 1

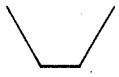


Fig. 3



Fig. 4



Fig. 5

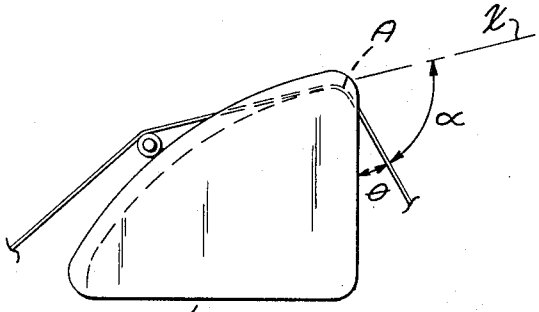


Fig. 6

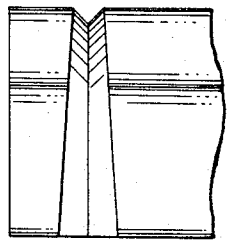


Fig. 7

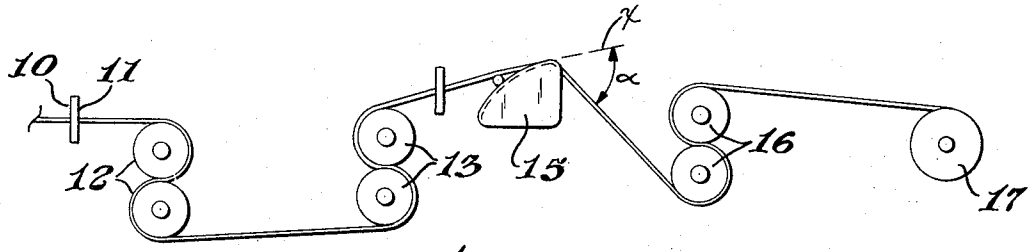


Fig. 8

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United States Patent Office

3,372,221

Patented Mar. 5, 1968

3,372,221

PROCESS FOR PREPARING FILAMENTARY MICROTAPES OF LABYRINTHIAN CROSS SECTION

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Continuation-in-part of application Ser. No. 338,279, Jan. 2, 1964. This application Aug. 6, 1965, Ser. No. 477,908

10 Claims. (Cl. 264—285)

ABSTRACT OF THE DISCLOSURE

This application discloses and claims a process for forming filamentary microtapes comprising the sequential steps of orienting a flat fused ribbon of an organic thermoplastic resinous material passing the so oriented and folded ribbon through restricting means of narrower width than the width of the flat oriented ribbon while maintaining minimum forwarding tension on said ribbon and finally withdrawing the so folded microtape from the restricting means at an angle of at least 15 degrees from the straight line projection of the microtape passage through said restricting means.

This invention relates to a process for preparing filamentary microtapes of labyrinthian cross section from flat tapes and ribbons. More particularly, it relates to such a process which provides exceptional control of the width and denier and cross-sectional configuration of said microtapes.

This application is a continuation-in-part of U.S. Ser. No. 338,279, filed Jan. 2, 1964 and now abandaned, which was a continuation-in-part of U.S. Ser. No. 30,248, filed May 19, 1960 and now abandaned.

For many applications and uses, it is desirable to have filamentary articles of other than the traditional solid cylindrical configuration. For example, flat tapes and ribbons would seem to be a suitable form for the manufacture of many woven and unwoven fabrics and similar articles. Such tapes and ribbons provide unusually high covering power per unit of volume and thus result in fabrics of less weight and of greater flexibility than those fabrics prepared from the prior filamentary articles of cylindrical section. However, when tapes or ribbons are employed in the usual weaving operations, it is usually necessary to twist, to plait, or otherwise to change the character of the flat tape or ribbon prior to weaving. Those operations result in a filamentary article which is characterized by poor control of width, denier, and cross-sectional geometry and result in fabrics having a hand that is little better than those prepared from the conventional cylindrical filaments.

One filamentary article that is finding increasingly wide usage in many applications is a filamentary microtape that is essentially rectangular, oval, or elliptical in peripheral silhouette. In cross section, however, these useful microtapes consist of a continuous transverse section of a tape or ribbon having the edges curled or having a transverse section of the tape or ribbon folded two, three, or more times back upon itself resulting, in effect, in a series of layers separated by air. This curling or folding results in a labyrinthian cross section. These microtapes of such labyrinthian section may be used directly in conventional textile operations and, when so used, are characterized in providing the high covering power per unit of volume inherent in such peripheral silhouette. In addition, these microtapes are relatively bulky due to the air spaces between the layers. The layered structure also lessens the

chance for fibrillation which is a serious problem with most oriented, polymeric articles.

These filamentary microtapes of labyrinthian cross section, when prepared from the known organic, thermoplastic, resinous materials, are of great desirability for several reasons. Tapes and ribbons from which the desired microtape may be formed are readily prepared. Thermoplastic microtapes permit such operations as thermal forming, heat sealing, embossing, calendering, and the like. However, the thermoplastic materials frequently require orientation if the optimum properties are to be achieved in the filamentary article. In many cases, it is necessary or at least desirable to the very attainment of the tape or ribbon to orient the tape or ribbon prior to fabrication. However, the oriented form of a polymer is subject to certain difficulties, such as fibrillation, when subjected to great stress. It would be desirable to have a process for preparing filamentary microtapes of labyrinthian cross section from continuous, coherent tapes and ribbons.

Accordingly, it is the principal object of this invention to provide a process for preparing filamentary microtapes of labyrinthian cross section, which process provides substantially rigid control of the microtape width and denier.

It is a further object of the invention to provide such a process utilizing a tape or ribbon of an organic, thermoplastic, resinous material.

It is a still further object of the invention to provide such a process which is utilizable with fused, oriented tapes or ribbons.

The above and related objects are achieved by means of a process comprising the sequential steps of orienting a flat, fused ribbon of an organic, thermoplastic, resinous material and introducing the so-oriented ribbon through restricting means of narrower width than the width of said oriented ribbon and withdrawing the shaped microtape from said restricting means at an angle of at least 15 degrees from the straight line projection of the ribbon through and past the restricting means and no greater than 15 degrees measured from a vertical plane through the path of said ribbon at its point of departure from said means while maintaining minimum forwarding tension on said oriented ribbon.

The tapes useful in the present method may be of any organic, thermoplastic, resinous material. As materials which may be advantageously used are the normally crystalline polymeric materials. These are the polymers which have a tendency to form crystallites or sites where small segments of a plurality of the polymer chains are oriented and held in position by secondary valence forces. This crystallite formation or crystallinity is unusually visible when the polymers are examined by X-ray diffraction. Typical of the normally crystalline polymeric materials falling within the advantageous definition are the polymers and copolymers of at least 70 percent by weight of vinylidene chloride with the remainder composed of one or more other monoethylenically unsaturated comonomers exemplary of which are vinyl chloride, vinyl acetate, vinyl propionate, acrylonitrile, alkyl and aralkyl acrylates having alkyl and aralkyl groups of up to about 8 carbon atoms, acrylic acid, acrylamide, vinyl alkyl ethers, vinyl alkyl ketones, acrolein, allyl esters and ethers, butadiene and chloroprene. Known ternary compositions also may be employed advantageously. Representative of such polymers are those composed of at least 70 percent by weight of vinylidene chloride with the remainder made up of, for example, acrolein and vinyl chloride, acrylic acid and acrylonitrile, alkyl acrylates and alkyl methacrylates, acrylonitrile and butadiene, acrylonitrile and itaconic acid, acrylonitrile and vinyl acetate, vinyl propionate or vinyl chloride, allyl esters or ethers

and vinyl chloride, butadiene and vinyl acetate, vinyl propionate or vinyl chloride, and vinyl ethers and vinyl chloride. Quaternary polymers of similar monomeric composition will also be known. It has been found that the normally crystalline copolymers composed of from about 92 to 99 percent by weight of vinylidene chloride and correspondingly from 8 to 1 percent by weight of acrylonitrile or of a lower alkyl acrylate have suitable polymerization characteristics, are well adapted for use in the manipulative steps in this process, and result in exceptionally useful filamentary articles. For these reasons, these vinylidene chloride-acrylonitrile and vinylidene chloride-lower alkyl acrylate copolymers represent a preferred species for use herein. It should be understood, however, that the process is not limited to the treatment of tapes and ribbons of normally crystalline polymers but that those formed from any non-elastic polymeric material may be used. There are many materials, such as polyvinyl chloride and polystyrene, which are capable of forming continuous, coherent articles which are orientable but do not normally form crystallites. The polymeric materials, whether crystalline or non-crystalline, may also include minor amounts of monomers, such as vinyl pyrrolidone, vinyl oxazolidinone, vinyl alkyl oxazolidinone, and the like, which are known to aid the dye-receptivity and other properties of fibrous materials. Likewise, it is possible for the polymers to contain interpolymerized light and heat stabilizers. Also operable in the present method are tapes and ribbons of polymeric materials, such as the polyolefins, including, for example, polyethylene, poly propylene, and copolymers of ethylene and propylene, and polyisobutylene. Equally useful in the method are the tapes and ribbons formed from condensation polymers, such as the polyamides including polyhexamethylene diadipamide, and the polyesters, including polyethyleneterephthalate. Also of utility are the tapes and ribbons of rubber hydrochloride and thermoplastic synthetic cellulose derivatives, including cellulose esters, such as cellulose acetate and collulose ethers, such as methyl cellulose and hydroxypropyl methyl cellulose. It should be apparent that any organic thermoplastic, resonous material which is capable of being formed into a flat or ribbon will find utility in the present invention.

The useful tapes for the present method are flexible tapes usually of about 0.001 to 0.005 inch in thickness and of about 0.1 to 1 inch in width. The thickness and width to be used in any given instance will depend in large measure upon the end product desired. The above limits are those which would normally be associated with the manufacture of filamentary microtapes to be used in conventional textile fabrics. When it is desired to make filamentary microtapes of greater size than, for example, about 0.3 inch, it would usually be found desirable to employ other known fabrication means, such as thermal extrusion for their preparation. Wide sections of tape, which are more accurately referred to as films, are not handled conveniently in the present procedural steps. However, it should be understood that the process is not limited precisely to the 1-inch maximum, since useful articles may be prepared herefrom, although usually with less control of width and cross section than with the narrower tapes.

As mentioned, the method of the present invention involves the passage of a flat tape in planar fashion through confining and restricting means to cause the formation of the desired labyrinthian cross section. By that it is meant that these means are of smaller dimension than the width of the flat tape passed therethrough. The confining and restricting means may take any given form wherein the cross-sectional area through which the tape passes is narrower than the flat tape itself. A particularly convenient and accordingly preferred means is a groove. With and given microtape the shape and dimensions of the groove determine in large measure the shape and final dimensions of the microtape. This point will become more apparent as the description of the invention proceeds.

The advantages and benefits, as well as the operation of the herein claimed process, will be more apparent from the following description and the appended drawings which illustrate a preferred procedural sequence for carrying out the process. In the drawing:

FIGURE 1 represents an end elevation,

FIGURE 2 represents a side elevation of a useful grooved shoe,

FIGURES 3–5 represent typical groove sections,

FIGURE 6 represents a preferred embodiment of the grooved shoe,

FIGURE 7 represents a preferred groove configuration, and

FIGURE 8 represents schematically a typical procedural sequence for carrying out the process.

In the embodiment illustrated in FIGURE 8, a flat, fused tape **10** or ribbon is fed through a suitable guide **11**, around a first pair of snubbing rolls **12**, then around a second pair of snubbing rolls **13** operated at a peripheral speed greater than that of the first snubbing rolls **12**. The tape **10** is then fed around or through a guide **14** which may consist of a grooved roller or the guides commonly used in the textile industry. The tape **10** or ribbon next passes through a groove located in a stationary grooved shoe **15**. The tape **10** or ribbon is then passed around a third pair of snubbing rolls **16** which maintains a minimum forwarding tension on the oriented tape. Finally, the folded microtape is wound on suitable collecting means **17**.

In the illustrated embodiment, the tape is caused to be oriented between the first and second snubbing rolls. Thus, the peripheral speeds to be used will depend in large measure upon the polymer used in forming the tape. With the preferred normally crystalline vinylidene chloride polymers, this ratio must be at least 2 to 1 and preferably should be about 4 to 1. Stretch ratios and therefore peripheral roll speeds to be used with other organic, thermoplastic, resinous material will be known or may be determined by simple preliminary experiment.

The shaping of microtape occurs in a stationary grooved shoe such as that illustrated in FIGURES 1 and 2 having grooves in a convex curvilinear surface.

The shape of the groove in the shoe determines to large extent the type of folding which occurs and, combined with the dimensions of the groove relative to the tape, determines the amount of folding that occurs. Typical grooves which provide the desired folding in the present invention are illustrated in FIGURES 3, 4, 5 and 6 of the appended drawings. In general, it has been found that grooves with divergent side walls, such as those of FIGURES 2–4, tend to encourage edge curling while grooves with parallel walls, such as that of FIGURE 5, tend to cause folding of the edge portions back upon the tape. Also as a general guide, the shape and dimensions of the bottom or root of the groove influences the resultant product. Thus, a flat-bottomed groove (FIGURE 3) having divergent side walls wherein the bottom is a small fraction of the width of the flat tape used will encourage the production of a microtape having tightly rolled edges with the rolled edges touching. As the width of the groove root is increased, the resulting microtapes will tend to have the curled edges more proportionately separated until a point is reached where the microtape, when magnified, will have the cross-sectional appearance of a ribbon with curled beaded edges. As the divergence of the groove walls approaches parallel, there is a tendency for a combination of folding and curling to occur. This effect can also be attained with a groove of configuration, such as that of FIGURE 4. In this effect, there is a small amount of curling at the extremities of the tape and the tape then folded back upon itself. It should be apparent that the process and apparatus is subject to the preparation of a wide variety of cross-sectional configuration. Judicious

selection of groove shape and dimensions, as well as of procedural conditions that will result in the desired microtape, can be made with but a few simple preliminary experiments.

It has been found that maximum mechanical effect is obtained when the tape enters the groove at somewhat of an arc, as opposed to tangential entry. To achieve such an effect, a rod or bar may be affixed to the heated shoe to bridge the groove transversely. When the tape is passed over the bar into the shoe, the proper angle of entry will be obtained.

An embodiment which is preferred is the use of a tapered groove of diminishing cross-sectional area. This permits a progressive reduction in area of the restricting means and results in more controllable and orderly folding of the tape or ribbon. This embodiment is illustrated in FIGURE 7.

It should be apparent that reproducibility of the microtape shape is obtained only when the conditions, such as the level at which the tape enters the groove, the depth to which it travels within the groove, and other factors. This is achieved by use of the aforementioned bar affixed to the shoe and by drawing the tape through the grooved shoe under constant minimum forwarding tension. This minimum forwarding tension is attained by the third set of snubbing rolls.

As mentioned, the process of the present invention permits the preparation of the microtapes from unoriented fused tapes or ribbons or from previously oriented tapes or ribbons. This process results in several benefits. It is capable of continuous operation and is capable of being fitted into an integrated scheme that would include the tape or ribbon-making procedural sequence immediately preceding the present process. The microtapes resulting from the process are characterized by a higher tenacity and a better hand than the tapes or ribbons from which they are formed. In addition, the microtapes are characterized by uniform width and denier and by the absence of any frayed, uneven, or torn edges.

By means of the present method and apparatus it is possible to prepare microtapes of a wide variation in width/thickness ratio. Thus, microtapes having a width which is about two times greater than its thickness may be prepared with little deviation in this ratio. Such a filament will approximate the known monofilaments and fibers of oval cross section. However, with the same apparatus and with minor change in conditions the width/thickness ratio may be changed to 10 to 1 or greater. By merely changing the groove size, it is possible to attain width/thickness ratios of 30 to 1 or higher. Microtapes of such width/thickness ratios closely approximate fine ribbons or tapes and yet are subject to unusually exact control of width and denier and have edges which are non-frayable and have high tear strength.

The present process also is readily adaptable to the production of tapes of different deniers with minimum change in apparatus and conditions. When two or more flat tapes or ribbons are stacked and passed through the herein claimed procedural sequence, there results a microtape of similar configuration to that of a single tape but with proportionately increased thickness and denier. The width of the so-laminated or plied tapes is relatively modestly increased over that of the single, flat tape.

It will be appreciated that width/thickness ratios, denier, and cross-sectional configuration may be influenced by tape width and thickness, as well as the above-mentioned factors. The tape width can be adjusted with the slitting means or to a significant extent within limits by hot stretching the flat tape during or subsequent to fusion. Tape thickness can be varied during its preparation or by the aforementioned plying technique.

The process may be employed with the aforementioned materials for the preparation of filamentary microtapes in a wide variety of deniers and width/thickness ratios. The preferred filamentary microtapes for textile applications generally range in denier from about 100 to about 3,000 and the width/thickness ratios range in widths that are about 2 to 30 times the thickness. It was also found that with some materials, such as the polyolefins, and with some ribbon thicknesses the use of a heated shaping device to warm the tape to a temperature below the fusion temperature of the polymeric material improves the flexibility and allows faster and easier shaping to occur.

The microtape must be drawn off the grooved shoe **15** at an acute angle (angle α in FIGURE 6) if the stated objectives of the invention are to be realized. It has been found that this deflection of the path of the tape is necessary if microtapes of uniform width are to be achieved. It has also been found that the angular deflection must be at least 15 degrees from the straight line projection (line X in FIGURE 6) of the path of the tape. When that angle is less than 15 degrees, the folding is irregular and non-uniform and the process is non-reproducible and erratic. Further, the angle should not exceed an angle (θ in FIGURE 6) of 15 degrees measured from a verticle plane through the path of said tape at its point of departure from the restricting means. If the deflection trespasses within that latter 15 degree area (angle θ in FIGURE 6), an undue stress is placed on the emerging microtape which may result in breakage and fibrillation. Preferably, the angle of deflection (α in FIGURE 6) should be from 15 to 30 degrees from the projected path to attain best results with the least amount of strain imposed on the microtape.

When the microtape is drawn through the angular deflection from the restricting means, the lip of the groove root (A in FIGURE 6) is preferably rounded to a small radius of curvature of about $\frac{1}{16}$ inch to prevent or to minimize breakage and fibrillation of the microtape.

With materials, such as the polyolefins, the use of heat shaping devices tends to result in more permanence of shape. Thus, although the polyolefins may be shaped cold, it is found that the resulting microtape tends to open slightly when any tension is released, as when the microtape is unwound from a package. Permanence is also assisted by keeping rolls **16** (FIGURE 8) as close to the shaping device as is practical.

It should be appreciated that the tapes and ribbons employed in the process may contain the usual additives, such as colorants, fillers, stabilizers, and the like.

It can thus be seen that the process is susceptible in flexibility of operation to a diversity of microtape cross-sectional configurations, deniers, and width/thickness ratios without the major retooling required by the prior known filament-making process when any change is contemplated.

The operation of the method of the process will be more apparent from the following illustrative examples wherein all parts and percentages are by weight.

Example 1

A ribbon prepared by the continuous coagulation and fusion of a latex of a copolymer of 97 percent vinylidene chloride and 3 percent acrylonitrile was made having a thickness of 0.002 inch and a width of 0.3125. The ribbons were supercooled by passing around a chilled roller, then snubbed and oriented to a stretch ratio of 4 to 1. The oriented ribbons were then passed over a guide into a groove in a stationary shoe made of polytetrafluoroethylene. Each groove was 0.025 inch in width. The microtapes were drawn through the grooved shoe under minimum forwarding tension by means of snubber rolls maintained at 110° C. The microtapes were withdrawn from the grooved shoe at an angle of about 45 degrees from the projected path of the tape. After snubbing, the tape was core wound. The resultant tape was so formed as to be, in effect, three layers thick and 0.025 inch wide.

Using the same procedure and same tapes but employing a groove in the grooved shoe which was 0.04 inch wide, a two-layer tape was made. In a similar manner to

the above, two- and three-layer tapes cut from rubber hydrochloride film, from tapes cut from a polypropylene film sold commercially as Profax, from tapes cut from a polyester film sold commercially as Mylar, from tapes cut from regenerated cellulose film, from tapes cut from cellulose acetate film, and from tapes cut from a film of hydropropyl methyl cellulose. In addition, tapes slit from polyethylene film having a melt index ranging from 0.3 to 1.3 were folded, using the same procedure. In the case of these film samples, the tapes were approximately 9/16 inch in width and were folded through a 0.075 inch groove. The exceptions were the polyester which was folded through a 0.125 inch groove and a 0.274 inch groove and the regenerated cellulose and cellulose acetate which were folded through a 0.129 inch groove. The polyester regenerated cellulose and cellulose acetate exhibited little or no drawing down during the orientation step and thus required a wider groove.

In all of the examples listed above, the variation in microtape width and denier was in the order of 10 percent. Microtape breakage was infrequent and, when it occurred, the microtape was easily restrung through the apparatus.

By way of contrast, all of the above procedures were repeated except that the ribbons were drawn through the grooved shoe without any angular deflection. In all cases, the ribbon rotated 90 degrees in the groove and passed through the groove edgewise. In some instances, a small amount of non-uniform folding occurred at one edge of the ribbon. In no case was a microtape suitable for textile purposes obtained in this manner. In addition, when the angular deflection was about 15 degrees (θ equals 75 degrees), the folding was erratic, non-uniform, and generally unacceptable from a textile fiber viewpoint. When the tapes were passed through the grooves at more than 75 degrees (angle θ is 15 degrees or less), the tapes broke frequently.

What is claimed is:

1. A process for preparing microtapes of labyrinthian cross section characterized in having a width that is at least two times greater than its thickness, said process comprising the sequential steps of orienting a flat, fused ribbon of an organic, thermoplastic, resinous material and passing the so-oriented ribbon through open-sided restricting means of narrower width than the width of the flat, oriented ribbon, withdrawing the so-formed microtape from said restricting means downwardly at an angle of at least 15 degrees from the straight line projection of the tape through and past the restricting means and no greater than 15 degrees measured from a vertical plane through the path of said tape at its point of departure from said means, while during said passage of said ribbon through said restricting means a minimum forwarding tension is maintained on said ribbon.

2. The process claimed in claim **1** wherein said organic, thermoplastic, resinous material is a normally crystalline polymeric material.

3. The process claimed in claim **2** wherein said normally crystalline polymeric material is a vinylidene chloride polymer composed of at least 70 percent by weight vinylidene chloride with any remainder of at least one monoethylenically unsaturated comonomer.

4. The process claimed in claim **3** wherein said vinylidene chloride polymer is a copolymer of vinylidene chloride and acrylonitrile.

5. The process claimed in claim **3** wherein said vinylidene chloride polymer is a copolymer of vinylidene chloride and an alkyl acrylate having from 1 to 8 carbon atoms in the alkyl group.

6. The process claimed in claim **1** wherein said ribbon is about 0.001 to 0.005 inch in thickness and from 0.1 to 1 inch in width.

7. The process claimed in claim **1** wherein said restricting means is of progressively decreasing dimensions.

8. The process claimed in claim **1** wherein said organic, thermoplastic, resinous material is a solid polyolefin.

9. The process claimed in claim **8** wherein said solid polyolefin is polyethylene.

10. The process claimed in claim **8** wherein said solid polyolefin is polypropylene.

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