D. F. BABCOCK
PROCESS AND APPARATUS FOR THE PRODUCTION OF
ARTIFICIAL FIBERS AND THE LIKE
Filed Aug. 9, 1939

Fig. 1

Fig. 2

Dale Friend Babcock INVENTOR.

BY

ATTORNEY
This invention relates to the production of artificial filaments, yarns, ribbons, and the like. More particularly, it relates to an improved process for the production of such artificial structures from melts of organic filament-forming compositions, for example, melts of synthetic linear polymers, which structures are subject to elongation upon exposure to atmospheric conditions.

In the melt spinning of synthetic linear polymer yarns, great difficulty has been experienced in obtaining satisfactory wound packages. The difficulty was largely due to elongation of the yarn by absorption of moisture upon exposure of the wound packages of yarn to atmospheric conditions.

In the spinning of artificial filaments, yarns, ribbons, and the like from melts of organic filament-forming compositions, the filaments issue from the spinneret substantially free from absorbed moisture. Many of such organic filament-forming compositions, for example, synthetic linear polymers, after being spun, absorb moisture from the air and as a result increase in length. Even if the dry yarn is wound on a support, such as a bobbin, under considerable tension, the increase in the length of the yarn accompanying moisture absorption causes the yarn to loosen on the bobbin, and the yarn tends to slip from the bobbin. The wound yarn package is consequently distorted and assumes a bumpy, blistered appearance. This results in inequalities in the yarn since the yarn in various portions of the bobbin may be free to elongate to different extents. The package formation is unsatisfactory both from the point of view of spinning operation and delivery of the thread to subsequent processes. At sufficiently low spinning speed, the filaments may pick up moisture either from the air or from liquid water applied to them in the form of a finish, or otherwise, and the greater part of the increase in length of the thread accompanying moisture absorption is brought about before the yarn is wound up under tension. At higher spinning speed, moisture applied by these means is not absorbed quickly enough, i.e., before it is wound on the bobbin, and poor package formation is the result.

It is, therefore, an object of the present invention to provide an improved method for the spinning and winding of yarns, fibers, ribbons, and the like from molten organic filament-forming compositions, which structures have a tendency to elongate due to a moisture absorption from the atmosphere.

It is a further object of the present invention to provide an improved process for the spinning of molten organic filament-forming compositions, and to wind the same into a package which will not be subject to loosening of the spun product due to elongation as a result of the absorption of moisture from the atmosphere.

It is another object of this invention to provide an improved process for the spinning and winding of fibers, yarns, ribbons, and the like from molten organic filament-forming compositions which comprises the treatment of the structure with steam between the spinneret and the wind-up position.

It is still another object of this invention to provide an improved apparatus for the steam treatment of freshly formed fibers, yarns, ribbons, and the like.

Other objects of the invention will appear hereinafter.

The objects of the invention may be accomplished, in general, by applying to freshly formed artificial fibers, yarns, ribbons, formed from molten organic filament-forming compositions, between the point where they are extruded, and the point where they are wound into a package, steam or atmosphere having an elevated temperature and a high relative humidity, in such an amount and for such a period of time, as will prevent objectionable elongation of the yarn in the wound package upon subsequent exposure to the atmosphere.

The nature of the invention will be more clearly apparent by reference to the following detailed description when taken in connection with the accompanying illustration, in which:

Figure 1 is a diagrammatic side elevation view of one form of apparatus constructed in accordance with the present invention.

Figure 2 is a side elevational view, with parts in section, showing a modified form of apparatus for the steam treatment of yarn.

Referring to Figure 1 of the drawing, reference numeral 11 designates a spinneret through which the molten organic filament-forming composition is extruded. The extruded composition passes from the spinneret 11 in the form of a bundle of filaments 12, which filaments pass through a cooling chimney 15; a cooling medium is passed through the cooling chimney 15 in a direction at right angles to the passage of the bundle of filaments 12. The cooling medium is passed into header 17 and
2,289,860

from the header through a plurality of conduits 18 into the cooling chimney. The cooling medium, for example, air, is passed at right angles across the bundle of filaments 13 and outwardly from the cooling chimney 16 through a plurality of perforations 21. The bundle of filaments is passed from the cooling chimney through a steam treatment enclosure 23. A quantity of steam is passed into the enclosure 23 through header 25 and branch conduits 27, 10. The volume of steam may be controlled by means of valve 29. Any condensed steam which may form within the steam treatment enclosure 23 will pass to the bucket 31 at the bottom of the enclosure from which the water may be withdrawn through conduit 33.

After passage of the bundle of filaments through the steam treatment enclosure 23, they are passed into contact with a liquid finish applying roller 35. The bundle of filaments is then passed around feed rolls 37 and 39 and is then wound onto bobbin 40.

In the modified form of steam treatment enclosure shown in Figure 2 of the drawing, reference numeral 50 designates a cylindrical enclosure in which steam is applied to the bundle of filaments 13. The enclosure 50 is provided with a sleeve 52 which is smaller in diameter than the diameter of the enclosure 50. A steam jacket 54 is positioned around the enclosure 50. A steam inlet 56 is connected at the upper portion of the steam jacket and an outlet for the steam is provided at 58 at the bottom of said steam jacket. The steam, in this modification, is preferably under pressure considerably above atmospheric. Steam is passed from the jacket 54 to the enclosure 50 through the small openings 58. The steam under pressure passes against sleeve 52, and then fills the enclosure 50. The steam is not permitted to condense on the walls of the enclosure 50, since the temperature of such walls is above the condensation point of the steam. This is obviously due to the fact that the steam in the jacket surrounding the enclosure has a pressure above atmospheric. The only condensation of steam within the enclosure 50 is, therefore, on the bundle of filaments 13. This modified form of steam enclosure is preferably provided with threading means for threading the thread through the enclosure. The threading means comprises conduit 68 which passes through the walls of the steam jacket and the enclosure 50. The outwardly projecting end of conduit 60 is connected to a source of a fluid under pressure. The conduit 68 is positioned to slant obliquely through a bundle of filaments by means of a fluid such as air downwardly through the steam treatment chamber 50. After the threading operation the air is turned off.

The following specific examples are submitted to illustrate the specific details of the invention as applied to filaments, yarns, ribbons, and the like spun from molten synthetic linear polymers. It is to be understood that the invention is not limited to the specific details set forth in these illustrative examples.

Example I

Solid particles of polyhexamethylene adipamide, having a melt viscosity of approximately 300 poises, were fed into a nitrogen-filled melt chamber onto a melting element maintained at 283° C. The polymer melted and formed a pool beneath the melting element from which it was pumped, by means of a gear pump, into a screen pack having a diameter of about 3/4" and comprising approximately ten 16-mesh, three 30-mesh, three 80-mesh, ten 150-mesh, one hundred twenty-five 200-mesh, and ten 325-mesh screens. The polymer was forced through a spinneret having an outside diameter of 0.625", and containing 15 perforations of approximately 0.002" in diameter located on a 9/32" diameter circle. The yarn after issuing from the spinneret entered the cooling chimney where it was cooled and solidified by air traveling at right angles to the direction of the thread at about a rate of 16 cu. ft. a minute. The yarn after passing from the cooling chimney was passed through the atmosphere for a distance of about 10', and then passed into the steam treatment enclosure which was approximately 45' in length. Steam was supplied to the steam treatment enclosure in such an amount that it gently but just visibly issued from the top and bottom of the enclosure. A suitable finish was applied to the yarn from a water emulsion by means of a roll positioned about 4" below the top of the steam treatment enclosure. After traveling a distance of about 12' downwardly from the finish applying roller, the yarn passed about two feed rolls positioned about 19" apart and was then led to a bobbin positioned about 36" from the second feed roll and there wound into the form of a yarn package. The yarn was wound at the rate of 3500 feet per minute and the pump rate so adjusted that the denier of the yarn was approximately 153. The peripheral speed of the second feed roll was 0.78% less than that of the wind-up bobbin in order to apply tension to the yarn. For the same reason the peripheral speed of the first feed roll was 0.50% less than that of the second feed roll. Under these conditions the bobbin containing about one pound of yarn was wound and gave excellent compact package formation. When this bobbin of yarn was stored for two days over water no blisters appeared and the package of yarn remained tight on the bobbin.

If, in the above example, no steam is passed through the steam treatment enclosure but with all other conditions remaining the same, only a small quantity of yarn can be wound onto a bobbin. Even if water is applied to the surface of the yarn at a point just below the steam treatment chamber, only a small package can be wound. Bad irregularities and blisters appear on the surface of the package after it is stored for about one hour in an atmosphere having a relative humidity of about 60%.

Example II

Yarn of 150 denier and 11 filaments is spun at a speed of 3670 feet per minute from molten polyhexamethylene adipamide in a manner similar to that described in the preceding example. The peripheral speed of the second feed roll is 0.25% less than the peripheral speed of the bobbin, and the peripheral speed of the first feed roll is 0.25% less than the peripheral speed of the second roll. The steam treatment enclosure, the top of which is placed about 10" below the bottom of the cooling chamber, is constructed as illustrated in Figure 2 of the drawing. Steam is passed through the jacket surrounding the steam treatment enclosure at 10 to 12 pounds pressure. Steam is passed from the jacket to the enclosure through a small opening, such as opening 58 shown in Figure 2, which opening has a diameter of about 3/4 of an inch. The steam is de-
flected downwardly by means of sleeve S2 so as not to disturb the thread. Under these conditions, bobbins of yarn are produced which contain over one pound of yarn, and in which the yarn does not loosen or blister even when the packages are exposed to atmosphere having a high relative humidity.

As pointed out above the length of the steam treatment enclosure required will depend on the thread speed and the yarn and filament deniers. For example, when spinning 150 denier yarn with 11 filaments at a speed of 3300 feet per minute, the use of a steam treatment enclosure having a length of 45° results in the production of a yarn package which will become only slightly soft after two days' storage over water. The use of a steam treatment enclosure having a length of 25° under the same conditions will result in the production of a yarn package which is somewhat softer than that obtained with a longer enclosure; however, packages produced from an enclosure of this length under the above-mentioned conditions will be satisfactory. On the other hand, if the steam treatment enclosure is reduced to a length of 17° under the above-mentioned conditions, the threading of the yarn is not sufficient to produce a completely satisfactory package of yarn. As a general rule for the spinning of yarns and filaments of the usual deniers used in textile fabrics, a steam treatment enclosure of a length that it will subject the yarn to treatment with steam for a period of 0.04 of a second will produce a satisfactory yarn package.

When the length of the steam treatment enclosure is made longer than is required for sufficient conditioning of the yarn at a given thread speed for a given denier yarn, the yarn is not harmed and the package formation is good. At lower thread speeds, for example, thread speeds of the order of 1000 feet per minute, fair package formation can be obtained by the application of steam to the yarn at a point just below the cooling chamber. However, even under these conditions, just the right amount of water must be applied. If too much water is applied, surface water remains on the yarn when it is wound up on the bobbin and the yarn sips and splits so that the package spreads out during spinning. If there is too small a quantity of water applied to the yarn, the package blisters in the manner described above. Therefore, even in the case of low thread speeds, the present invention has a distinct advantage.

Although the present invention is described with particular reference to synthetic linear polyamides, it is obviously broadly applicable to the melt spinning of any organic filament-forming material in which the spun product will elongate upon subsequent contact with the atmosphere containing the usual moisture content. Therefore, besides being applicable to the spinning of filaments and the like from synthetic linear polyamides such as are described in the U.S. patent to Carothers No. 2,071,250, which may be prepared, for example, by a process of condensation polymerization, it is applicable to the melt spinning of other synthetic linear polymers, for example, polyesters, polyacetals, and various interpolymer such as polyester-polyamides, etc. It is also applicable to the melt spinning of ethylene polymers, vinyl polymers, polystyrene and polyacrylic acid derivatives as well as some cellulose derivatives, wherever the difficulty of elongation upon subsequent exposure to the atmosphere occurs.

Likewise, filaments, yarns or ribbons may contain modifying agents such as delusterants, plasticizers, pigments, dyes, antioxidants, resins, etc., without interfering with the operativeness of the present invention.

The present invention has been described with specific reference to the use of steam for the treatment of the filaments, yarns, and the like. Although steam is much preferred, the objects can be substantially accomplished by the use of air, or other gaseous medium having an elevated temperature and a high relative humidity. It is preferred, in accordance with this modification of the invention, to use air or the like having a temperature above 150° F. and having a relative humidity of at least 90%.

Many modifications of the design of suitable steam treatment enclosures may be used. It is only essential that the yarn be kept in contact with steam for a sufficient time to pick up the required amount of moisture. For ease in threading, the steaming enclosure might be provided with a narrow slot along the length of the steaming enclosure through which the thread may be slipped, and this slot may be furthermore provided with spring pressed covering means so that the slot may be covered after the yarn is positioned in the enclosure.

Although feed rolls for drawing the thread through the above-described apparatus are preferred, they are not essential to the invention. If no feed roll is used in the apparatus, the yarn will be passed from the spinneret through the treatment members and wound directly on a rotating bobbin. Guides of any desired design may be used for furnishing the necessary tension in place of feed rolls. If the steam is applied to the yarn between the feed rolls, or between the last feed roll and the bobbin, the speed of the second feed roll and the bobbin in the first case, or the bobbin in the second case, would have to be greater than that of the first, or the first and second feed rolls to allow for the elongation of the yarn as it absorbs moisture.

The use of steam between the spinneret and the wind-up, in accordance with the present invention, makes it possible for the steam to absorb moisture and increase in length before it is wound up under tension on the bobbin. Steam conditioned yarn appears to undergo much less change in dimensions with changes in humidity of the surrounding atmosphere than does unconditioned yarn. This apparently is not due to a smaller change in moisture content because of higher initial content, but seems to be an inherent property of the steamed yarn. For example, when samples of steamed and unsteamed yarn are held over CaCl₂ overnight, then measured, and subsequently wet with water and again measured, the unsteamed sample will elongate approximately 6% and the steamed sample approximately 3%. This indicates that the effect of steaming is not merely humidification.

This is very surprising and a very welcome property since it facilitates handling of the yarn especially when transferring it from package to package during textile operations.

Steam treatment of yarn between the spinneret and the wind-up roll makes it possible to spin fibers from melts at a high rate of above 1,000 feet per minute, and obtain well-built packages on bobbins which will not blister or loosen on the wound package. As above indi-
cated, the use of water is particularly ineffective for the purposes and objects of the present invention when spinning at high rates of speed. Yarn steam treated in accordance with the present invention undergoes less change in dimension when exposed to conditions of higher temperature than similar untreated yarns, and they are less susceptible to changes in relative humidity of the atmosphere. Humidity control and air conditioning in the spinning room are not required when yarns are steam treated in accordance with the present invention.

Obviously, many other changes and modifications can be made in the above-described method and apparatus without departing from the nature and spirit of the present invention. It is, therefore, to be understood that the invention is not to be limited except as set forth in the appended claims.

I claim:

1. In a process which includes the spinning of a molten composition of a synthetic linear polymer in the form of a continuous structure, the passing of the structure through a solidification zone, and the winding of the solidified structure, without cold drawing the same, in the form of a package, the step which comprises contacting said structure, between said solidification zone and the point where said structure is wound, with steam, whereby the tendency of said structures to elongate in said package is reduced.

2. In a process which includes the spinning of a molten composition of a synthetic linear polymer in the form of a continuous structure, the passing of the structure through a solidification zone, and the winding of the solidified structure, without cold drawing the same, in the form of a package, the step which comprises contacting said structure, between said solidification zone and the point where said structure is wound, with steam, whereby the tendency of said structures to elongate in said package is reduced.

3. In a process which includes the spinning of a molten composition of a synthetic linear polymer in the form of a continuous structure, the passing of the structure through a solidification zone, and the winding of the solidified structure, without cold drawing the same, in the form of a package, the step which comprises contacting said structure, between said solidification zone and the point where said structure is wound, with steam, whereby the tendency of said structures to elongate in said package is reduced.

4. In a process which includes the spinning of a molten composition of a synthetic linear polymer in the form of a continuous structure, the passing of the structure through a solidification zone, and the winding of the solidified structure, without cold drawing the same, in the form of a package, the step which comprises contacting said structure, between said solidification zone and the point where said structure is wound, with steam, whereby the tendency of said structures to elongate in said package is reduced.

5. In a process which includes the spinning of a molten composition of a synthetic linear polymer in the form of a continuous structure, the passing of the structure through a solidification zone, and the winding of the solidified structure, without cold drawing the same, in the form of a package, the step which comprises contacting said structure, between said solidification zone and the point where said structure is wound, with steam, whereby the tendency of said structures to elongate in said package is reduced.

6. In a process which includes the spinning of a molten composition of a synthetic linear polymer in the form of a continuous structure, the passing of the structure through a solidification zone, and the winding of the solidified structure, without cold drawing the same, in the form of a package, the step which comprises contacting said structure, between said solidification zone and the point where said structure is wound, with steam, whereby the tendency of said structures to elongate in said package is reduced.

7. In a process which includes the spinning of a molten composition of a synthetic linear polyamide in the form of a continuous structure, the passing of the structure through a solidification zone, and the winding of the solidified structure, without cold drawing the same, in the form of a package, the step which comprises contacting said structure, between said solidification zone and the point where said structure is wound, with steam, whereby the tendency of said structures to elongate in said package is reduced.

8. In a process which includes the spinning of a molten composition of a synthetic linear polyamide in the form of a continuous structure, the passing of the structure through a solidification zone, and the winding of the solidified structure, without cold drawing the same, in the form of a package, the step which comprises contacting said structure, between said solidification zone and the point where said structure is wound, with steam, whereby the tendency of said structures to elongate in said package is reduced.

9. In a process which includes the spinning of a molten composition of a synthetic linear polyamide in the form of a continuous structure, the passing of the structure through a solidification zone, and the winding of the solidified structure, without cold drawing the same, in the form of a package, the step which comprises contacting said structure, between said solidification zone and the point where said structure is wound, with steam, whereby the tendency of said structures to elongate in said package is reduced.

DALE FRIEND BABCOCK.