March 14, 1961 R. H. SPEAKMAN ET AL 2,974,391

PROCESS AND APPARATUS FOR MAKING CRIMPED FILAMENTS

Filed Nov. 30, 1956

FIG. 1.

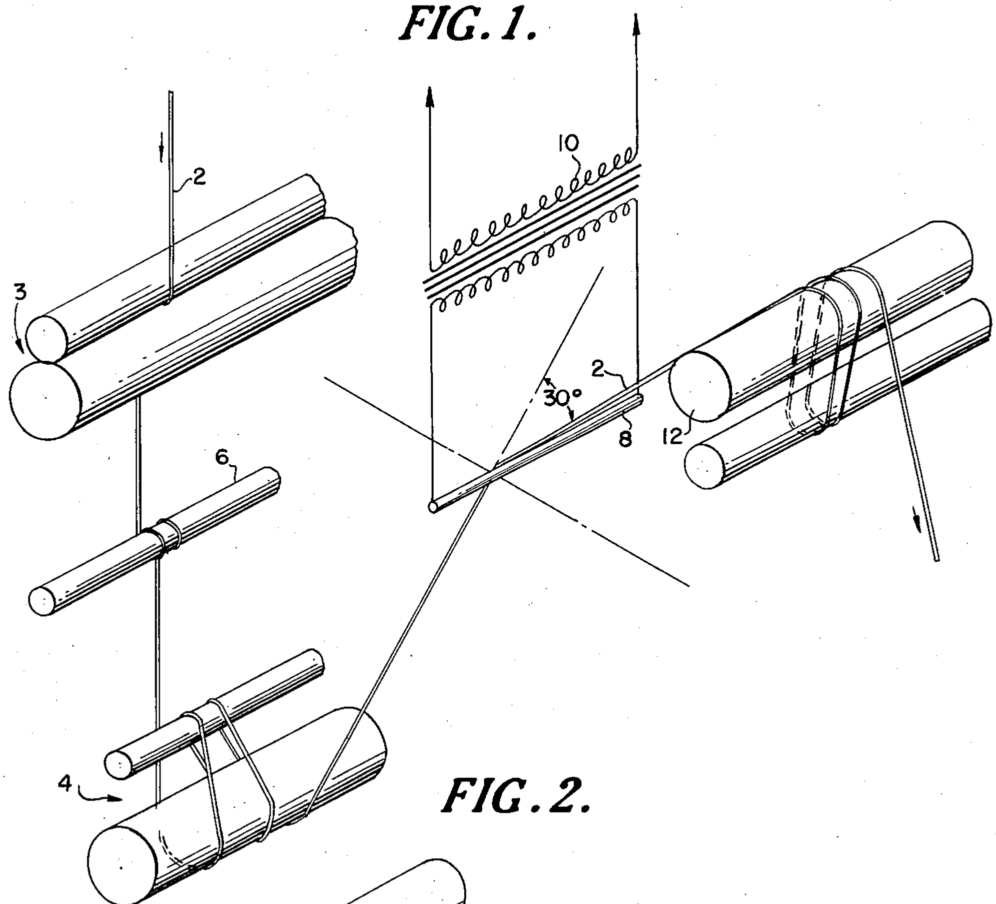
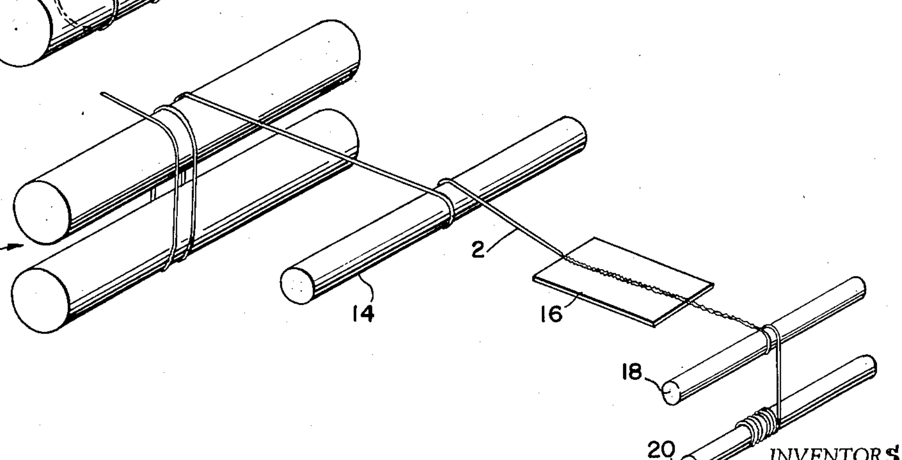


FIG. 2.



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United States Patent Office 2,974,391 Patented Mar. 14, 1961

2,974,391

PROCESS AND APPARATUS FOR MAKING CRIMPED FILAMENTS

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Filed Nov. 30, 1956, Ser. No. 625,291

Claims priority, application Great Britain Nov. 30, 1955

12 Claims. (Cl. 28—1)

This invention relates to a process for making crimped continuous filaments, more particularly it relates to a process for making bulked crimped filament yarn from continuous thermoplastic synthetic linear polymer filaments.

We now provide a process which gives stable crimp in thermoplastic synthetic linear polymer filaments and which makes much higher operating speeds possible.

According to our invention potentially crimped continuous thermoplastic synthetic linear polymer filaments are made by heating moving continuous filaments non-uniformly while passing over a narrow surface heated to a temperature above the melting temperature of the filaments, in such a way that the filaments are heated on one side only continuously along their length, while under a tension to give a stretch to the filaments of not more than 10%. The latent crimp in the potentially crimped filaments is brought out when the filaments are heated and relaxed by subjecting them to a heat treatment while they are under a tension which permits free or controlled shrinkage. Preferably this heating is at a temperature above the second order transition temperature and below, e.g. at least 40° below, the melting temperature of the filaments.

In one form of our invention the filaments are heated non-uniformly by passing them rapidly over an electric resistance wire, heated above the melting temperature of said filaments.

In our process the filaments become latently crimped by a thermal effect when the filaments are subjected to the transversely non-uniform heat treatment, above the melting temperature of the filaments on their periphery on one side of the filament axis only. The crimp at this stage is only small or latent and becomes clearly visible when the filaments are relaxed and heated.

Our process permits the use of very high speeds hitherto not attainable in the known crimping processes. Speeds of at least 100 m. per minute can be used, but the preferred speeds are those used for drawing the filaments; speeds of 1,000 m. per minute have given good results. Because of these high speeds our process can conveniently be used in the drawing process before the filaments are wound up.

If it is desired to combine the treatment of our invention with the drawing of the filaments in one continuous operation it is necessary that the filaments should be drawn before the treatment on the narrow heated surface.

Our invention, therefore, also comprises drawing thermoplastic synthetic linear polymer filaments to at least 3 times their length, as spun, between for example a pair of feed and draw rolls, followed by passing the filaments over a narrow surface, heated to a temperature above the melting temperature of the filaments, while under a tension to give a stretch to the filaments of not more than 10%, preferably heating the filaments a second time to a temperature above the second order transition temperature of the filaments and below, preferably at least 40° below, the melting point of the filaments, while they are under a tension sufficiently small to allow free or controlled shrinkage.

The thermoplastic synthetic linear polymer filaments, which can be treated in our process comprise the fibre-forming polyamides and the highly polymeric polymethylene terephthalates, as well as copolymers of these, containing minor amounts of non-fibre-forming polymers such as polyethylene isophthalate.

In the case of polyethylene terephthalate and nylon filaments the temperature of the narrow heated surface may be above 270° C. but can be as high as 900° C. The crimps per inch obtained in the filaments after relaxation, rise steeply from 20 crimps per inch at 300° C. to 45 crimps per inch at 600° C. when they fall off steeply again to 20 crimps per inch at 900° C.

The heating of the filaments for the second time and when released from tension brings about relaxation, causing shrinkage which enhances the crimp and gives best results if it takes place at a temperature well above the second order transition temperature of the thermoplastic synthetic polymer, i.e. between 180–220° C. in the case of polyethylene terephthalate.

We also provide an apparatus for carrying out our invention comprising a feed means for the filaments such as a driven feed roll, one or more narrow surfaces such as electrically heated wire or a pin, or a bar, means for heating said narrow surfaces well above the melting temperature of the filaments to be treated, and means for forwarding the filaments under tension to stretch the filaments not more than 10% while passing them over the heated surfaces, e.g. by a suitably positioned second driven roll, and winding means for collecting the filaments and preferably means for relaxing and heating the filaments.

The narrow heated surface is preferably convex and with a circular or semi-circular section. The radius of curvature affects the resulting crimps per inch in the filaments. Using a circular cross section diameters of 0.25 to 2.5 mm. are particularly suitable. An electric resistance wire connected to a rheostat and a transformer may be used.

The electric resistance wire is preferably kept at a red heat by a suitable electric current, while the filaments are passed transversely in contact across the red hot wire at such a rate that they are heated non-uniformly. The wire may be slowly advanced, for example transversely to the path of the filaments, to prevent wear in that part over which the filaments pass.

The filaments may be passed over the narrow heated surface while wet, for example, with a lubricant spin finish solution, care being taken that the amount of lubricant is not excessive, because large amounts of lubricant have been found to cause frequent breakage of the filaments.

The filaments should be passed over the narrow surface with as little change in direction as possible to avoid filament breakages. We have found that a change in direction of 45° should not be exceeded for continuous running without breakages. The filaments, if in a yarn or tow should preferably be spread out into a ribbon when passing over the narrow heated surface in order to obtain continuous heating on one side of each filament. When passing the filaments over the heated surface, rotation of the filaments may take place, so that the heated portion describes a helical path. However, as long as a non-uniform heating is applied continuously to each moving filament, regular crimp will be obtained.

Our process can also be introduced into a spin draw process in which very high wind-up speeds are used, which make a separate drawing step unnecessary, the filaments being passed over the narrow heated surface after the drawing, when the filaments are under a small tension, to stretch them not more than 10%.

The relaxation can be carried out immediately after passing over the narrow heated surface or at a later stage of manufacture. The relaxation and second heating may be by any known means such as treatment with hot inert fluids such as liquids or gases, radio frequency heating, contact with a heated metal surface or in an oven. The filaments may be relaxed at zero tension, for example when laid into cans, or under controlled shrinkage between a feed and winding device. If desired, the crimped filaments of our invention may be cut into stable fibres of the required length. The filaments may be relaxed before or after cutting in staple fibres.

The crimped filaments or yarn, can, if desired, be plied with other crimped yarn or an uncrimped yarn. The treated filaments can be woven or knitted into textile articles before or after the relaxation treatment, the best results however are obtained if the yarn is relaxed before knitting or weaving. The filaments and yarns made by the process of our invention are suitable for textile application when an increased bulk and elasticity are required.

The invention may be better understood by reference to the following specific examples of preferred embodiments which illustrate but do not limit the invention and by reference to the accompanying diagrammatic drawing in which:

Figure 1 illustrates the formation of a latent crimp in filaments by passing them over a heated wire; and

Figure 2 shows the relaxation of the latently crimped filaments in a separate continuous process.

Example 1

Referring to Figure 1, samples of undrawn 35 filament polyethylene terephthalate yarn **2** are drawn at draw ratios between 1:3 and 1:4 times, between feed rolls **3** and draw rolls **4** whilst localising the draw point on a snubbing pin **6** heated to 90° C. The drawn filaments coming from the draw rolls **4** are passed over a narrow heated surface **8** with a change in direction of the filament path of 30° of arc at 600 m./min. The narrow heated surface **8** is provided by a resistance wire of circular cross section 80 thousands of an inch diameter, through which currents from 22–38 amperes are fed from a transformer **10**, in steps of 2 amperes. The temperatures as measured on the wire by a thermocouple, below the contact point with the filament yarn are 380–600° C. The filaments when passing over the narrow heated surface **8** are stretched 4% and wound-up by means of the second pair of draw rolls **12**. The wound up filaments of 2 denier per filament have latent crimp which is brought out when the filaments are released from tension and heated by immersion in hot water at 90° C. for 2–10 minutes.

Example 2

Polyethylene terephthalate filament yarn is treated as in Example 1 but the final heat and relaxation treatment is carried out in a separate continuous process as follows with reference to Figure 2.

The wound up 2 denier filament yarn on rolls **12** is unwound over a feed roll **14** at 50 m. per minute, then for heating and relaxing it is passed in contact over a flat hot plate **16** which is 20 cm. long. heated to 170–200° C. and then to a more slowly rotating take-up roll **18**, which allows a relaxation of from 1.5:1 to 2:1 in the yarn, as it passes through the hot zone, or over the hot plate. The latent crimp in the yarn becomes apparent at this stage.

After leaving the take-up roll **18** the yarn is wound up, as at **20**, under a tension which just straightens out the crimp.

Two or three yarns can be heated and relaxed simultaneously by plying, before passing the yarns to the feed roll and thence to the flat hot plate.

The single or plied yarn is suitable for textile application where bulked and crimped yarns are required. The full crimp appears as the filaments pass over the hot plate, in a relaxed condition.

Example 3

Polyethylene terephthalate filaments are spun and drawn in one operation, using a fluid tension gradient and a surface speed of 800 m./min. on the draw roll. From the draw roll the filaments are passed over a narrow heated surface, i.e. a metal bar of circular cross section 5 mm. in diameter. The metal bar is heated to 400° C. by means of a low voltage electric current from a transformer connected to the electric mains. The filaments are spread out in a ribbon whilst passing over the bar and are tensioned by stretching them 3% of their length as they are wound up by a bobbin rotating at the appropriate speed. The wound up filaments, of 2 denier per filament, are then heat treated in a separate operation as in Example 2, when crimped yarn having an increased bulk, compared with untreated yarn, is obtained.

Example 4

100 denier drawn 3 denier per filament nylon yarn is heat treated over resistance wire as in Example 1 and relaxed in a separate operation as in Example 2. A bulked crimped nylon filament yarn is obtained.

What we claim is:

1. A process for potentially crimping melt spun synthetic linear polymer filaments in which the full crimp is brought out by a heat relaxation treatment, comprising passing the filaments, which have been coated with lubricant, over a narrow heated surface while under a tension sufficient to maintain the filaments in contact therewith, but insufficient to crimp said filaments by mechanical stress, at a speed of 100 to 1,000 meters per minute, said surface being maintained at a temperature between the melting temperature of the filaments and 900° C. so that the filaments are heated on one side only continuously along their length and thereby become potentially crimped, without showing any useful crimp when released from tension but having at least 20 crimps per inch after heat relaxation in water at 90° C. for at least two minutes.

2. A process according to claim 1, in which the filaments are heated when relaxed from tension at a temperature above the second order transition temperature and at least 40° C. below the melt temperature of the filaments.

3. A process comprising drawing filaments to at least 3 times their length as spun, followed by the process of claim 1.

4. A process according to claim 1, wherein the temperature of the narrow heated surface is between 270–900° C.

5. A process according to claim 4, wherein the filaments are spread out into a ribbon when passed over the narrow heated surface.

6. A process for making potentially crimped continuous thermoplastic synthetic linear polymer filaments by heating moving continuous filaments non-uniformly while passing over a wire heated to a temperature between the melting temperature of the filaments and 900° C. at a speed of 100 to 1,000 meters per minute in such a way that the filaments are heated on one side only continuously along their length, while under a tension to give a stretch to the filaments of not more than 10%, and slowly advancing the wire transversely to the path of the filaments passing thereover.

7. A process for making potentially crimped continuous thermoplastic synthetic linear polymer filaments by heating moving continuous filaments non-uniformly while passing over a narrow surface heated to a temperature between the melting temperature of the filaments and 900° C. at a speed of 100 to 1,000 meters per minute in such a way that the filaments are heated on one side

only continuously along their length, while under a tension to give a stretch to the filaments of not more than 10%, and rotating the filaments while passing over the narrow heated surface.

8. A continuous process for making potentially crimped filaments in which the full crimp is brought out by a heat relaxation treatment, comprising drawing synthetic linear polymer filaments at least three times their length as spun, passing the filaments which have been coated with lubricant under a small tension to stretch them not more than 10%, after drawing, over a smooth narrow heated surface maintained at a temperature between the melting temperature of the filaments and 900° C. at a speed of 100 to 1,000 meters per minute so that the filaments are heated on one side only continuously along their length and thereby become potentially crimped, without showing any useful crimp when released from tension but having at least 20 c.p.i. after heat relaxation in water at 90° C. for at least 2 minutes.

9. A process for potentially crimping melt spun synthetic linear polymer filaments comprising maintaining a narrow smooth surface at a temperature between the melting temperature of the filaments and 900° C., and heating the filaments on one side only continuously along their length by passing the same over the surface at a speed of 100 to 1,000 meters per minute and at an angle and under tension sufficient to maintain the filaments in contact therewith, but insufficient to crimp said filaments by mechanical stress.

10. A process for crimping melt spun synthetic linear polymer filaments, comprising: maintaining a narrow smooth surface at a temperature between the melting temperature of the filaments and 900° C.; heating the filaments on one side only continuously along their length by passing the same over the surface at 100 to 1,000

meters per minute and at an angle and under tension sufficient to maintain the filaments in contact therewith, but insufficient to crimp said filaments by mechanical stress, to impart a potential crimp thereto; reducing the tension upon the filaments to permit shrinkage, and heat treating the relaxed filaments to develop the potential crimp.

11. An apparatus for forming potentially crimped filaments for synthetic linear polymer filaments which comprises in combination means for feeding and forwarding filaments under tension, said means comprising feed and draw rolls to draw the filaments at least three times their length as spun, with snubbing means for localizing the draw point, a smooth narrow surface maintained in contact with said filament at a fixed distance between said feeding and winding means, and means for maintaining the temperature of said narrow surface above the melting temperature of the filament to be treated, said smooth narrow heated surface being located to bring about a change in direction of the filament path sufficient only to maintain contact between the filaments and the narrow surface and less than 45°.

12. An apparatus according to claim 11, wherein the narrow heated surface is between 0.25 and 2.5 mm. wide.

References Cited in the file of this patent

UNITED STATES PATENTS

2,445,042	Silverman	July 13, 1948

FOREIGN PATENTS

164,127	Australia	July 15, 1955
522,045	Belgium	Feb. 10, 1954
558,297	Great Britain	Dec. 30, 1943