United States Patent [19]

Dorschner et al.

[11] **3,707,838**

[45] **Jan. 2, 1973**

[54] **PROCESS FOR THE PRODUCTION OF STAPLE FIBERS**

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[22] Filed: **Aug. 25, 1969**

[21] Appl. No.: **3,259**

[30] **Foreign Application Priority Data**

Feb. 13, 1969 Germany....................P 19 07 205.0
Aug. 24, 1968 Germany....................P 17 85 203.8

[52] **U.S. Cl.**....................**57/157 R,** 28/72.2, 264/91, 264/103, 264/151, 264/210 F

[51] **Int. Cl.**..........................**D02g 1/16,** D04h 3/00

[58] **Field of Search**......264/210, 176, 103; 161/154, 161/173; 57/154, 157; 19/150, 156; 28/76, 72 NW

[56] **References Cited**

UNITED STATES PATENTS

2,986,780	6/1961	Bletzinger	19/156
2,264,345	12/1941	Tucker et al.	18/8 R
2,289,568	7/1942	Bloch	264/103
2,327,460	8/1943	Rugeley	264/210
2,411,659	11/1946	Manning	154/9
2,810,426	10/1957	Till et al.	154/27
3,072,513	1/1963	Schlarb	161/173
3,112,604	12/1963	Davis	161/173
3,260,640	7/1966	Owen	161/154
3,475,894	11/1969	Wilke et al.	264/103
3,502,763	3/1970	Hartmann	264/210
3,523,059	8/1970	Coates	161/154

FOREIGN PATENTS OR APPLICATIONS

1,008,703	11/1965	Great Britain	28/72 NW

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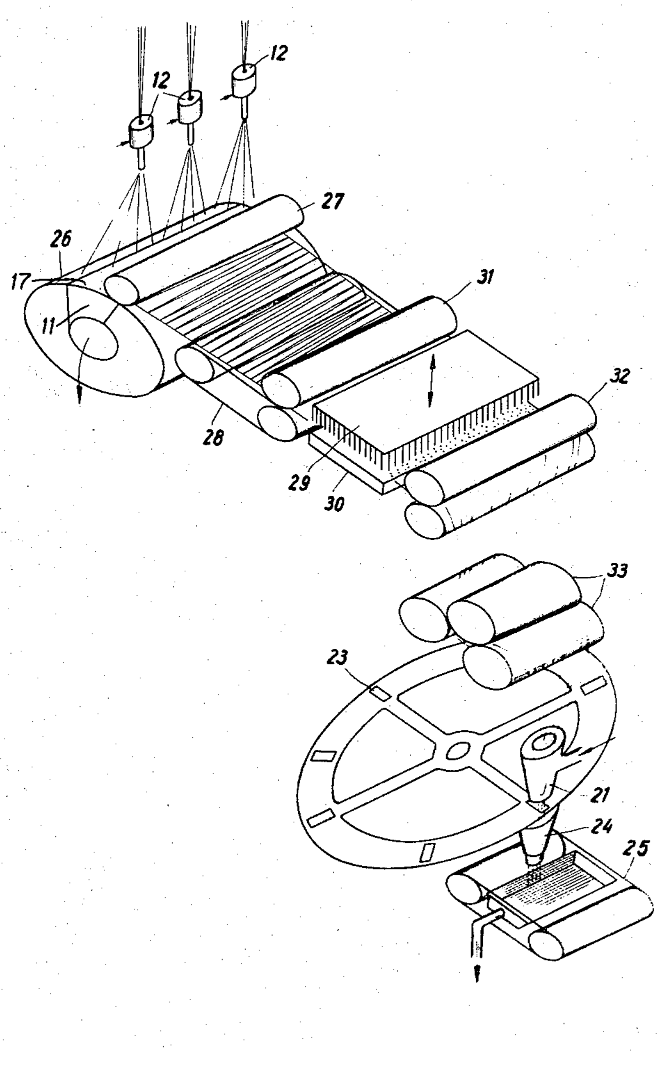
[57] **ABSTRACT**

Staple fibers are produced continuously and rapidly from a thermoplastic material by spinning and drawing filaments from the thermoplastic material, projecting the spun filaments at high speeds onto a lay-down receiver partly disposed over a vacuum zone so that ropy fiber aggregates are laid down on the receiver outside the vacuum zone and a random web is formed on the receiver above the vacuum zone, consolidating the resulting non-uniform web, twisting it into a strand and cutting the strand into staple fibers.

17 Claims, 3 Drawing Figures



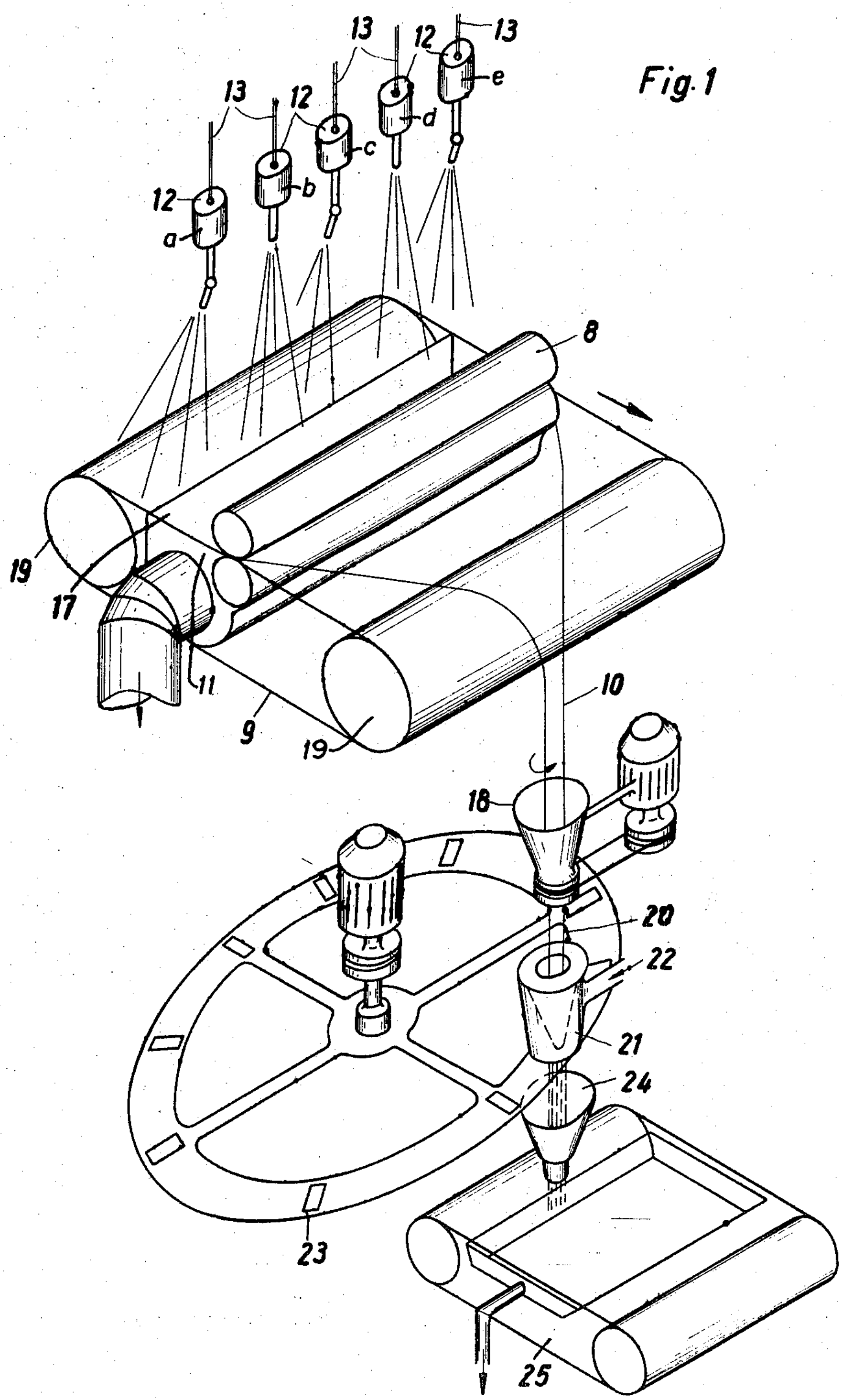


Fig. 1

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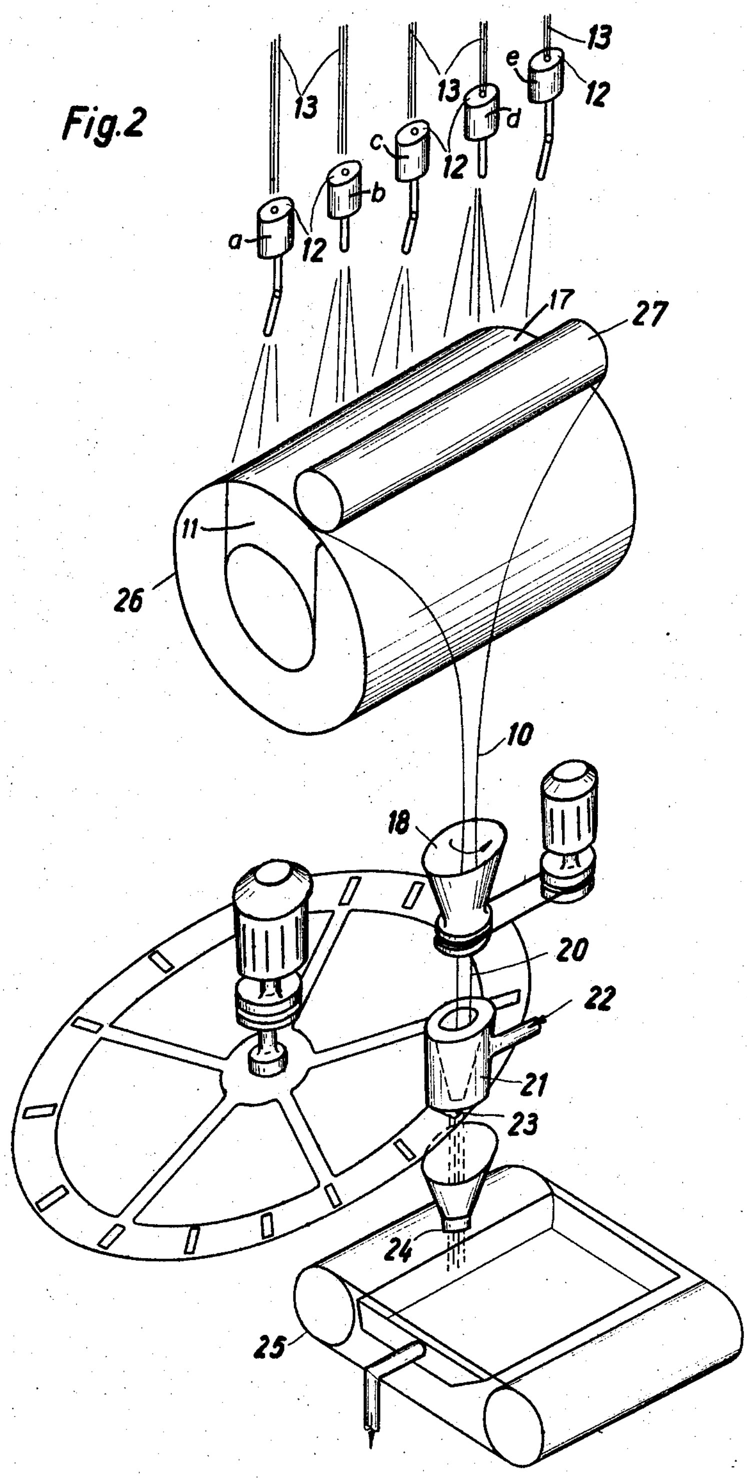
Fig.2



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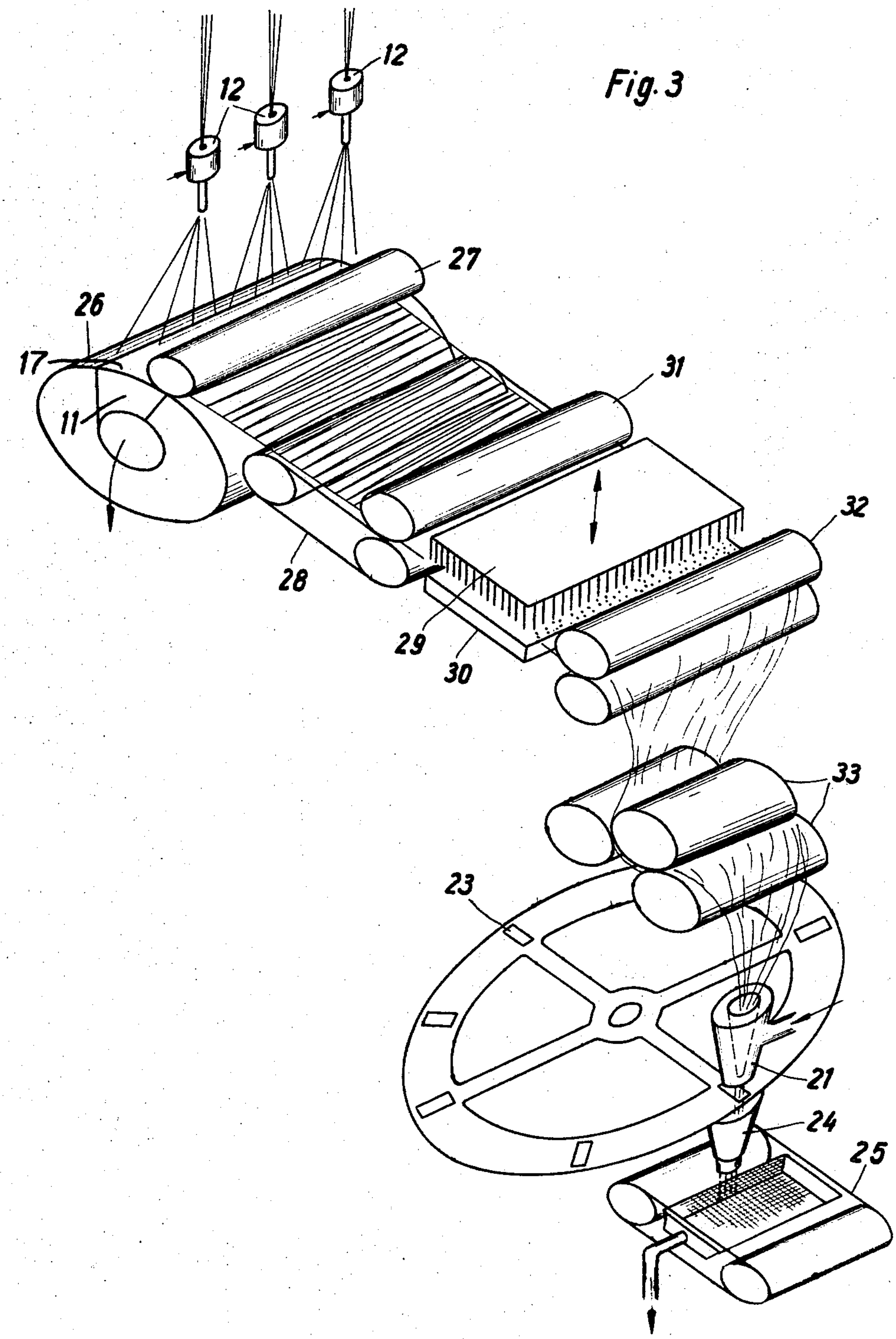

Fig. 3

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PROCESS FOR THE PRODUCTION OF STAPLE FIBERS

This invention relates to a process for manufacturing staple fibers from spinnable thermoplastic material in which the spun filaments are drawn off at high speed and are simultaneously stretched.

In conventional processes for the manufacture of staple fibers from spinnable thermoplastic resins, such as for example, polyesters, polyamides and polyolefins, a melt of the thermoplastic resin is extruded through spinnerets. The filaments, which harden on being contacted with an air stream, are drawn off and wound on a roll. The thus-manufactured filaments are then unwound from the spool, twisted together to form a cable, stretched and cut into the desired lengths to form the so-called staples. Because of the different process speeds which are used during spinning, drawing and cutting, the spinning step is separated from the subsequent working up. Instead of winding the spun filaments onto rolls immediately after spinning, it is also known, in the manufacture of staple fibers, to accumulate the spun fiber in storage containers. Such containers are open at the top and can accommodate amounts of spun fiber up to 200 kilograms. The placing of the spun filament in such containers permits filament speeds of only about 1000 meters per minute. In the taking up of filaments onto spools higher filament speeds, such as for instance 1500 meters per minute and higher can be attained. In order to easily unwind the rolled-up filament it is, however, necessary to apply to the filaments, prior to winding them onto the roll, a treating mixture. This treating mixture is usually a liquid mixture of lubricants, emulsifiers, reticulating agents, antistatic agents, oils and the like. The treating mixture applied to the filaments may constitute up to 2 per cent of the filament weight.

In known processes, it is impossible to attain a secure lay-down of filaments at filament speeds of greater than 1500 meters per minute. An additional disadvantage in conventional processes is that the spun material must be stored on spools or in containers prior to cutting them into staple fibers, thereby making it impossible to completely continuously manufacture the staple fibers.

It has now been found that spun filaments from thermoplastic material can be worked up continuously in a simple manner at high speed without the necessity of applying treating mixtures thereto.

A salient feature of the process of this invention is that the spun and drawn filaments are laid down on a lay-down surface moving continuously below the filament draw-off means, which lay-down surface is partly disposed over a vacuum zone in which a vacuum of at least 50 millimeters (water column) is maintained, i.e. where the pressure differential, relative to atmospheric pressure, is 50 millimeters(water column), and where the remaining part of the lay-down surface is disposed outside this vacuum zone. The filaments laid down on the surface are then pressed and twisted into a strand and the strand is cut into staple fiber. In the practice of this invention, it is desirable to lay down from 5 to 80 per cent of the filament outside the vacuum zone. Lay-down outside this zone results in the formation of ropy filament aggregates. The filaments impinging with high velocity on that portion of the air-permeable lay-down surface disposed above the vacuum zone are laid down in random and intermingled fashion and thereby provide cohesion of the long ropy fiber aggregates formed by filament lay-down outside the vacuum zone. The loose connection between the randomly laid down filaments and the long fiber aggregates enables handling, for subsequent processing, of the web laid down on the entire lay-down surface. In a preferred aspect of this invention the filaments laid down outside the vacuum zone are laid down before the vacuum zone is reached, i.e., before the lay-down surface passes over the vacuum zone.

In order to attain high filament draw-off speeds pneumatic draw-off means such as jets are used to draw off the filaments; in these pneumatic jets the filaments are drawn by contact with an expanding gas or vapor aspirating medium. On expansion of the aspirating medium to supersonic velocities, filament draw-off speeds of up to 4,000 meters per minute and higher can be attained. Preferably, several of such draw-off means e.g., pneumatic jets, are disposed above the vacuum zone at a distance of from about 0.5 to 2 meters and a plurality of filaments, e.g., up to several hundred filaments, are drawn through each pneumatic jet. Some of the draw-off jets blow the filaments directly onto that part of the continuously moving air-permeable lay-down surface which is disposed above the vacuum zone, a vacuum of from 50 to 300 millimeters (water column) being maintained therein. The remaining pneumatic draw-off jets blow the filaments, preferably angled against the direction of movement of the lay-down surface, onto the lay down surface outside the vacuum zone. The filaments laid down on that portion of the lay-down surface receiver above the vacuum zone are laid down randomly from long fiber strands. The term "outside the vacuum zone" as used herein is intended to refer to that portion of the continuously moving air-permeable lay-down surface which is not disposed above the vacuum zone and through which no air is drawn into the vacuum zone.

Illustrative of continuously moving air-permeable lay-down surfaces are endless wire or screen meshes which are carried and are actuated by two rotating rolls. A vacuum chamber is disposed below the middle portion of the upper level of the continuously moving wire or screen mesh belt. However, it is also possible to use an air-permeable, e.g., perforated, drum as a continuously moving lay-down receiver; in this case, the vacuum chamber is disposed inside the drum to suck air through the top surface of the drum.

Optimally, the filaments laid down outside the vacuum zone are laid down in the form of long, ropy filament aggregates. This can be attained, for instance, by disposing the vacuum zone, i.e. the vacuum chamber, immediately behind (in terms of the direction of movement of the belt) the guide roller of the endless belt. A portion of the filaments is then laid down along the portion of the belt which is bent as it passes over the guide roller in the form of long, ropy filament aggregates. The procedure is similar when a rotating perforated drum is used as the lay-down surface.

The non-uniform laid down web constituting the product fabric is then removed from the endlessly moving lay-down surface, and compressed, suitably by means of two pressure rollers. The contacting pressure between the pressure rollers can be up to 60 atmospheres. The compressed product fiber is then twisted into a strand. The twisting should be carried out in such a way that the twisted strand is turned through at least 5 complete rotations per running meter. The twisting of the product fiber can be achieved by means of a rotating funnel into which the product is introduced and wherefrom the twisted strand is then drawn. This rotating funnel is equipped with internal followers or grippers which effect the twisting.

The twisted strand is led to a cutting device in which the strand is cut into staple fibers. Until the strand is cut, an unravelling or untwisting of the strand must be prevented. This is preferably achieved by leading the twisted strand through a fluid ejector in which the fluid is introduced tangentially to the strand and subjects the strand to a twisting torque and simultaneously to a tensioning force. The simplest fluid for this use is water. The cutting into the staple fiber lengths is then effected in wet cutting devices known in the art in which the strand is cut with rotating knives.

An alternate embodiment of this invention concerns a process for the continuous production of staple fiber from thermoplastic material in which the filaments are spun, drawn off, oriented, laid down, and subsequently cut into staple fibers. In the process according to the invention the filaments are laid down in the form of a web which is then needled while under orienting tension and collected into a strand which is cut into staple fibers.

To effect this embodiment of the invention, thermoplastic materials especially, for instance, polyolefins, polyamides, polyurethanes, polyvinyls, polyacrylates and polyesters are used. The filaments, which form a type of web on the laydown surface, are then led into a needling device. To improve the handling of the filaments while they are led into the needling device, it is often desirable to consolidate the filaments somewhat, for instance by compressing them. The filaments laid down in the web are then needled in an oriented form, that is to say, the longitudional tensioning of the endless filaments during the needling process is so oriented that a majority of the filaments run in one preferred direction. In order to effect this orientation the web is subjected to a longitudional drawing force during the needling process. One of the simplest techniques for achieving the longitudinal drawing force is to draw the needled web from the needling device at a speed which is from about 1.2 to about 10 times the feed-in speed of the non-needled web. Preferably the take-off speed of the needled web is from 1.5 to 7 times the feed-in speed of the non-needled web. In order to attain the required take-off speed one can simply increase the circumferential speed of the pair of rollers actuating and supporting the needled product belt to be 1.2 to 10 times, preferably 1.5 to 7 times, the corresponding speed of the roller pair which feeds the non-needled web into the needling device. Through this there is effected an excellent longitudional orientation of the filaments in the web during the needling process so that the needling web obtained consists primarily of filaments lying parallel to each other. The needling also imparts more firmness and strength to the web which enables easier subsequent handling. .The needling device suitable for needling the web in accordance with this invention can be any conventional needling apparatus which permits maintaining longitudinal tension on the web during the needling process.

The oriented needled web is then, as described above, twisted together into a strand and cut in suitable cutting apparatus into staple fibers of the desired staple lengths.

A fuller understanding of the process of this invention and various embodiments thereof may be had by reference to the following drawings in which:

FIG. **1** is a schematic representation of the processing of the laid-down filaments into staple fibers;

FIG. **2** represents an alternate embodiment of the apparatus shown in FIG. **1**; and

FIG. **3** shows the longitudinal drawing of the laid-down filaments prior to cutting.

With reference to FIG. **1**, five pneumatic drawoff devices **12** are arranged below the spinning apparatus (not shown). Through each draw-off device a filament bundle **13** is drawn off. An endless perforated lay-down surface **9** is supported and actuated by rollers **19**. Below the lay-down surface there is a vacuum chamber **11** connected with a vacuum conduit leading to the lay-down surface. The draw-off devices **12** are provided at their exits with ball and socket joints with the aid of which air and filament aggregates can be deflected from the vertical filament direction. While the draw-off jets *b* and *d* blow the filaments directly into the low pressure zone **17** onto that portion of the perforated lay-down receiver which is disposed above the vacuum chamber **11**, the jets *a*, *c* and *e* lay down the filament aggregates onto the perforated lay-down receiver moving over the curved portion of the left roller **19**. The belt moves longitudinally in the direction of the arrow. The laid-down product fabric is then compressed between the pressure rollers **8** and twisted by rotating funnel **18** into a strand **20**. The strand is led through water jet **21** into which is introduced water, tangentially to the strand, at point **22**. The jet **21** holds the strand **20** under tension, draws the strand from funnel **18** and leads it, under maintenance of a twisting torque thereon, to the rotating knives **23** which cut the strand into staple fiber. The staple fiber/water mixture is led over funnel **24** to sieve belt **25** to remove the water.

With reference to FIG. **2**, a different apparatus for carrying out the process of this invention is shown in schematic and perspective view by way of illustration. In this embodiment an air-permeable perforated drum **26** is fitted to be the lay down surface. Below the spinning apparatus (not shown) again five pneumatic draw-off jets **12** (*a* to *e*) are arranged. Through each draw-off jet is led a filament bundle **13** consisting of a plurality of monofilaments. The draw-off jets *b* and *d* blow the filament bundles directly onto the vacuum zone **17** of the rotating drum **26**. Beneath the vacuum zone **17** there is disposed the vacuum chamber **11**. The draw off jets *a*, *c* and *e* are again fitted with ball and socket joints with the aid of which the air and fiber aggregates are laid down in the direction of rotation of the perforated drum before they reach the low vacuum pressure zone. The non-uniform product fiber is compressed between the perforated drum **26** and the pressure roller **27**. The compressed product fiber is then led through the rotating funnel **18** which twists it to a strand **20**. The twisted strand is led into water jet **21** into which water is introduced tangentially. The water jet **21** draws the twisted strand from the funnel **18** and, under maintenance of a twisting torque, leads it to the rotating cutting knives **23** which cut the strand into staple fiber. The mixture of staple fiber and water is led through sieve arrangements **25** in which the water is separated from the staple fiber.

It is of course possible to lead the mixture of water and staple fiber directly to any desired further processing, e.g., into a paper-making machine.

EXAMPLE 1

In an apparatus as shown in FIG. **1**, 600 polypropylene filaments were drawn through each draw-off jet. Each jet was supplied with compressed air at a pressure of 22 atmospheres. The distance between the spinning equipment and the jets was 6 meters. The vacuum in the vacuum chamber **11** was at 130 milliliters (water column). The lay-down receiver was 1.2 meters wide and was moved longitudinally at a forwarding speed of 38 meters per minute. The draw off speed of the filaments, which had a denier of 1.5, was about 4,300 meters per minute. The approximate weight of the laid down non-uniform product fiber was about 50 grams per square meter of lay-down area. The product fiber was consolidated by subjecting it to a contact pressure of 35 atmospheres and twisted to a strand with 11 to 12 complete twisting turns per meter. The water supplied to the water jet **21** was under a pressure of 4 atmospheres. The speed of the rotating knives **23** was so adjusted that a median staple fiber length of from 8 to 10 millimeters was obtained.

EXAMPLE 2

In an apparatus according to FIG. **1**, 200 polypropylene filaments were drawn off through each draw-off jet and laid down on the lay-down receiver. The filament bundles drawn off by jets *b* and *d* were directly laid down in the vacuum zone **17** while the filament bundles drawn by the three other draw-off jets were laid down over the portion of curvature of the roll **19** onto the perforated lay-down belt **9**. The denier of the monofilaments was 15. The distance between the spinnerets and the draw-off jets was 9 meters. The filaments were spun at a through-put rate of 6.85 grams per minute per spinneret orifice so that the filament draw-off speed was about 4,100 meters per minute. The velocity of the moving belt lay-down surface was about 75 meters per minute. The web weight was about 78 grams per square meter. A manometer which indicated the vacuum in the vacuum chamber **11** showed 190 millimeters water column. The staple fibers produced had a median length of 30 millimeters. The remaining process conditions were as in Example 1.

EXAMPLE 3

In an apparatus according to FIG. **2**, 600 nylon-6 filaments were drawn through each of five draw-off jets. The distance of the draw-off jets from the five spinnerets was 7 meters. The draw-off jets *b* and *d* blew the nylon filaments directly into the vacuum zone **17**. The remaining draw-off jets laid their filament bundles down along the perforated drum in longer bundles of 2 to 4 meters. The speed of rotation of the drum was set at 95 meters per minute. The pressure roll pressed the non-uniform web only to the extent that it was held at the pressure line. The water jet **21** was supplied with water at a pressure of 6 atmospheres. Staple fibers with a median staple length of 80 millimeters were obtained.

According to FIG. **3** there is possible another embodiment apparatus suitable for carrying out the process of this invention. Such apparatus comprises essentially draw-off jets **12**, rotating drum **26** as the lay-down surface, conveyor belt **28**, needling device **29**, **30**, feed-in roller pair **31**, take-off roller pair **32**, triple rollers **33**, and a cutting device as shown in FIGS. **1** and **2**. The web-like product formed as described above is compressed, with the aid of pressure roller **27**, sufficiently that it can be taken from the lay-down surface and moved onto conveyor belt **28**. The conveyor belt **28** forwards the web product to the needling device placed downstream. The form of the web shown in FIG. **3** does not correspond to the actual appearance of the web product and is shown in this way schematically only for purposes of simplicity and illustration. The moving belt **28** is supported and actuated by two rotating rollers in which the right roller, as shown in the illustration in the drawing, forms, together with an additional roller, the feed-in roller pair **31** of the needling device **29**, **30**. The circumferential velocity of the feed-in roller pair **31** is thus equal to the speed of the conveyor belt **28**. The needling device **27**, **30** consists of needle board **29** and screen **30**. The needle board **29** carries a plurality of needles which may be of a variety of constructions. The needle board **29** is moved up and down in rapid sequence whereby the needles pierce the web lying on the screen **30** and effect a mutual clamping of the filaments onto each other, thus consolidating the web. In this needling process any conventional needling device may be used as long as it permits tensioning of the web during the needling process, which tensioning is necessary to achieve the oriented needling according to the process of this invention. In the apparatus illustrated in FIG. **3** longitudinal tension is applied to the non-needled web by adjusting the circumferential velocity of the take-off roller pair **32**, through which the needled web is led, to be greater than the circumferential velocity of the feed-in roller pair **31**. The oriented needled web is passed through triple rollers **33** and led to the water jet **21** which is actuated with tangentially introduced water. The web is gathered into a strand in in-take jet **21** and led by the water jet, under tensioning, to the rotating cutting apparatus which, in the example shown, contains eight knives **23**. In this cutting device the web is cut wet to the desired staple length. The wet cutting is desirable to avoid heating of the fiber material. Any conventional cutting devices which is capable of cutting a strand into staple fibers is suitable for use in this invention. The mixture of staple fibers and water is led over funnel **24** to sieve belt **25** in order to separate the water which is removed by sieve action on the sieve belt **25**. The separated staple fibers are then forwarded to further processing. The water is collected in a sump below the sieve belt and removed therefrom. It can be again used for driving the water jet.

By employing the process of the invention staple fibers with a good staple diagram, i.e., filament length distribution, can be produced at very high spinning velocities.

EXAMPLE 4

Polypropylene having a melt index (i_5) at 230°C. of 6 is melted in a 24 millimeter diameter extruder at 230°C. to 340°C. and led over three spinning pumps to three spinnerets having 400 orifices each and spun therethrough. The spinneret through-put rate was 1.34 grams per minute per orifice. The resulting filaments were gathered into three filament bundles and each filament bundle was led to a separate draw-off jet. (The draw-off jets and the subsequent apparatus components were similar to those illustrated in FIG. 3). The three draw-off jets *l* are positioned at a distance of about 6 meters below the three spinnerets. The draw-off jets were actuated by compressed air at 22 atmospheres which was expanded inside the jet to about one-half atmosphere (gate) and to supersonic velocity and then brought in contact with the filaments which were blow downwardly. Upon exiting from the draw-off jets *l*, the polypropylene filaments had a denier of 2.9, corresponding to a filament draw-off speed of 4,140 meters per minute. The filament bundles were blown by means of the expanded air onto a moving perforated drum **26**, laid down as a web, and compressed by pressure roll **27**. The working speed of the drum, the forwarding speed of the conveyor belt **28** and the circumferential velocity of the feed-in roller pair were all 23 meters per minute. In each case the web was introduced by way of the feed-in roller pair **31** into the needling device **29,30**, which was operated at 900 cycles per minute, and then needled in oriented fashion under the tensioning force caused by the greater circumferential velocity of the take-off roller pair **32**. The circumferential velocity of the take-off roller pair was 65 meters per minute, i.e., the circumferential velocity of the take-off roller pair was 2.8 times as great as the circumferential velocity of the feed-in roller pair **31**. The oriented web was led over the triple rollers **33** by means of the draw-in water jet to a cutting device equipped with eight knives **23** and cut to a staple length of about 45 millimeters of cut length. The staple fiber is separated from the water on sieve belt **25**. An analysis of the staple diagram (filament length distribution) resulted in the following values:

42%	32 millimeters
51%	48 millimeters
Ca. 2%	50–65 millimeters
Ca. 4%	40 millimeters
Ca. 1%	65–70 millimeters

After drying the staple fibers could be worked up into various products using conventional machinery.

It is to be understood that the preceeding Examples and description are given by way of illustration and that other embodiments will be apparent to those skilled in the art. Accordingly, no unnecessary limitations of this invention are to be implied therefrom.

What is claimed is:

1. Process for the continuous production of staple fibers from thermoplastic synthetic material which process comprises spinning and drawing filaments from the thermoplastic material, laying down the filaments onto a continuously moving air-permeable carrier surface wherein 95 to 20 percent of the filaments are laid down over a vacuum zone disposed underneath a portion of said carrier surface in which a vacuum of at least 50 millimeters (water column) is maintained and wherein the remaining filaments are laid down on the portion of the carrier surface outside said vacuum zone in the form of ropy fiber aggregates before the carrier surface reaches the vacuum zone, consolidating the resulting non-uniform filament lay-down web, twisting said web into a strand and then cutting the strand into staple fibers.

2. Process as claimed in claim **1** in which the vacuum in said vacuum zone is 50 to 300 millimeters (water column).

3. Process as claimed in claim **1** in which the filament lay-down web is compressed between a roller pair.

4. Process as claimed in claim **3** in which the compressing pressure is up to 60 atmospheres.

5. Process as claimed in claim **1** in which said strand is twisted through at least 5 complete rotations per running meter.

6. Process as claimed in claim **1** in which said twisting is effected by a rotating funnel.

7. Process as claimed in claim **1** in which the twisted strand is tensioned and subjected to a twisting torque until the strand is cut.

8. Process as claimed in claim **1** in which the twisted strand is led and pulled through a water jet.

9. Process as claimed in claim **1** wherein the spun filaments are drawn off by pneumatic draw-off means at draw-off speeds in excess of 2,500 meters per minute and then projected onto the carrier surface.

10. Process as claimed in claim **9** wherein the filaments are drawn off using pneumatic jets and have a jet exit velocity of about 4000 meters per minute.

11. Process as claimed in claim **1** wherein at least some of the filaments laid down outside the vacuum zone are laid down along a curving portion of the lay-down surface.

12. Process as claimed in claim **1** wherein the filaments are laid down in the form of a random web, needled under tensioning in oriented fashion, gathered into a strand, and then cut into staple fibers.

13. Process as claimed in claim **12** wherein the random web is consolidated by compression prior to needling.

14. Process as claimed in claim **12** wherein the web is subjected to longitudinal tensioning during the needling process.

15. Process as claimed in claim **12** in which the web is taken off from the needling device at a speed which is 1.2 to 10 times as great as the feed-in speed of the web into the needling device.

16. Process as claimed in claim **12** in which the web is taken off from the needling device at a speed which is 1.5 to 7 times as great as the feed-in speed of the web into the needling device.

17. Process as claimed in claim **1** in which the strand is cut while wet.

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