Nov. 12, 1940. E. G. GUENTHER 2,221,023

PRODUCTION OF STAPLE FIBER YARNS

Filed April 21, 1938 3 Sheets-Sheet 1

FIG. 1

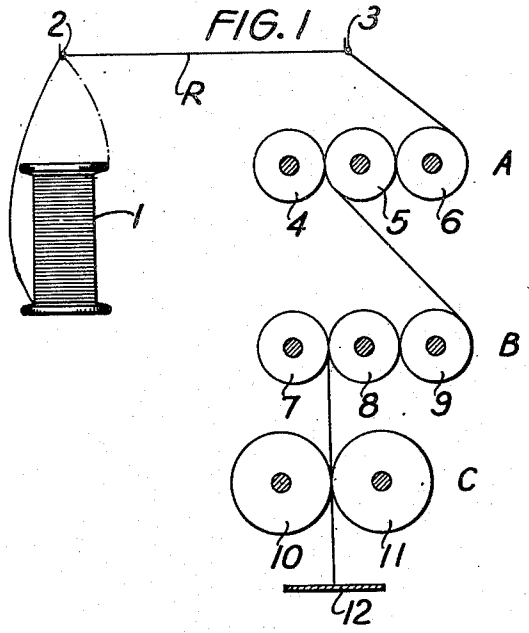


FIG. 2

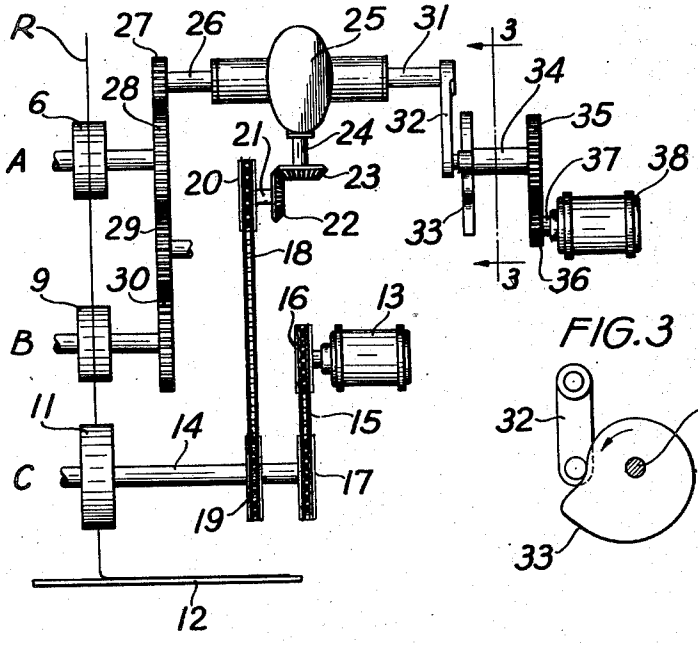


FIG. 3

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FIG. 4

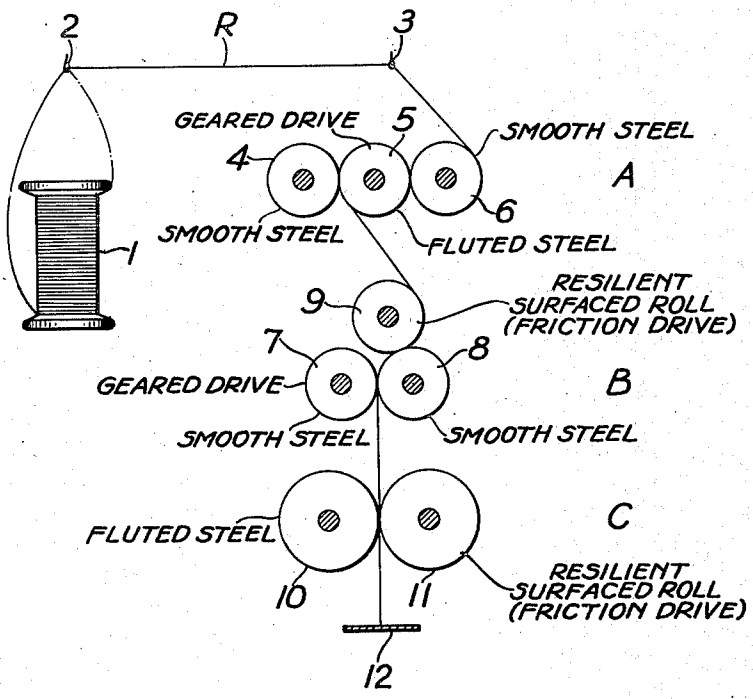


FIG. 5



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PRODUCTION OF STAPLE FIBER YARNS

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FIG.6

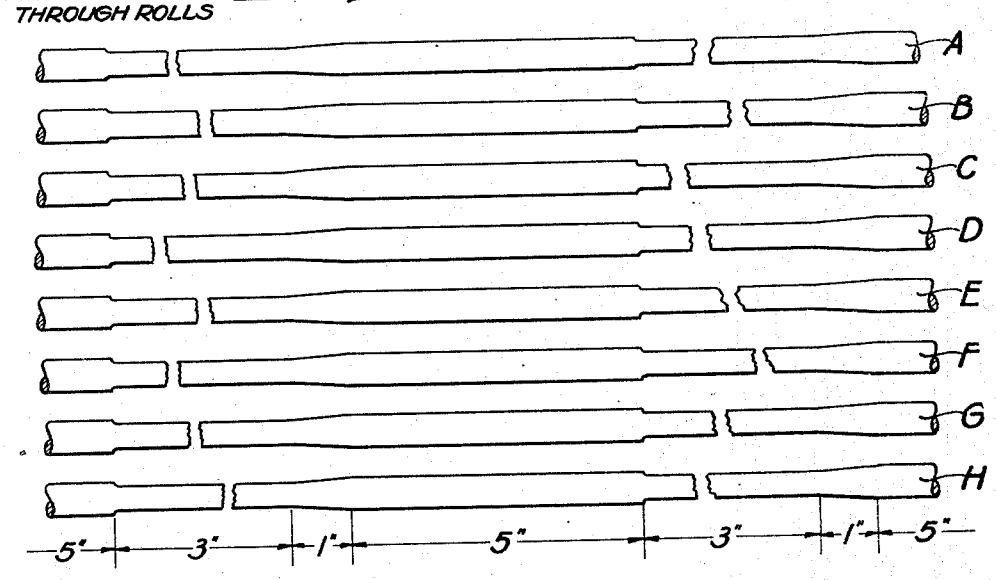
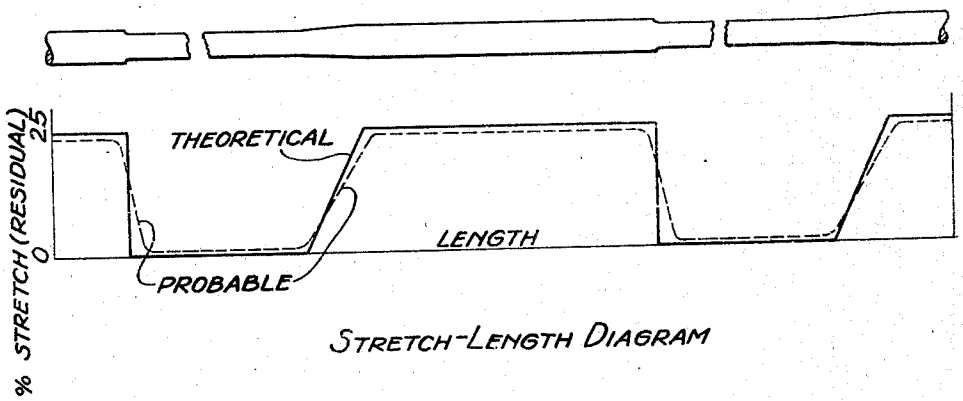


FIG.7



STRETCH-LENGTH DIAGRAM

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2,221,023

UNITED STATES PATENT OFFICE

2,221,023

PRODUCTION OF STAPLE FIBER YARNS

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Application April 21, 1938, Serial No. 203,412

2 Claims. (Cl. 19—1)

This invention relates to the production of synthetic staple yarns, and more particularly to a means and method for the production of an improved type of synthetic staple having heretofore unknown properties.

As the art of making synthetic yarns of various types has developed, numerous efforts have been made to produce such yarns in staple lengths in imitation of natural staple fibers, such as those of cotton, wool, and other materials. One method of producing such staple yarns is as follows:

A plurality of strands of synthetic filaments are either drawn together directly from a spinning machine to a stapling machine or yarn cutter, or a group of such filaments are warped together and thus fed to a stapling machine. The staples thus produced are further processed in order to crimp, lubricate, dye or tint them and are then usually opened by one or more picking operations. This material is then fed to a carding machine. If the staples are short, say ¾ inch to 1½ inches, they may be carded on a cotton card, or if, for example, from 4 inches to 7 inches in length, they may be carded on a woolen or worsted card. The sliver obtained from such carding operation is then further processed through drafting, drawing, combing, gilling, reducing, roving, and spinning operations to produce the final spun yarn.

One of such methods of producing synthetic staple yarns by the cutting method involves feeding a substantially parallel band of filaments into a device in which the filaments are severed by a cutter positioned at an oblique angle to the line of travel of the band. The resulting bundles of cut filaments are then drawn together and drafted to a spinnable sliver. This process, however, suffers the defect that random distribution of the filaments, which is important in producing spun yarn, is obtained only along the axis of filaments and not in a plane normal thereto. The process also suffers the disadvantage that it is extremely difficult to obtain a thin band of filaments and to handle so delicate a structure.

Various other modifications of the cutting method of producing synthetic staple yarns and various combinations of the cutting step with other processing operations have been employed, the particular combination of steps depending upon the system of fabric manufacture in which the staple is ultimately to be employed and also depending upon the various characteristics of the material being processed. In the manufacture of cut staple yarn in accordance with any of these processes a great deal of machinery must be used to form the opened filaments into the final twisted or spun yarn. Furthermore, most of these processes are extremely injurious to the synthetic filament material, some operations breaking a portion of the filaments into extremely short lengths or fly, while other operations stretch the filaments so much that they possess little of their original resiliency and tensile strength. The carding processes, for example, are the most detrimental and notwithstanding that the art has made great strides in recent years in improving such processes, it is still difficult to operate cards satisfactorily on synthetic staple.

In an attempt to minimize the disadvantages inherent in the above-mentioned processes, several methods have been proposed for the manufacture of synthetic staple yarn which are based upon the principle of stretch-breaking. According to one of such processes, a roving of substantially parallel continuous synthetic filaments is fed to a series of sets of drafting rolls, the sets being spaced apart from each other a predetermined distance and the successive rolls being operated at such a peripheral speed as to stretch the individual filaments to and beyond their breaking points, thereby reducing them to staple lengths. The operation of the process is such that a random distribution of breaks is obtained, thereby at least theoretically producing a spinnable sliver. This broken sliver may be further blended, drafted, reduced, or subjected to other operations to form the final desired spun yarn product. This process is an improvement over the cutting methods heretofore employed inasmuch as it greatly reduces the amount of machinery required to obtain a spinnable sliver. However, the process has several serious disadvantages. First, due to the fact that each filament is stretched throughout its length to its breaking point, the natural or inherent stretch or elasticity of the material is removed during the breaking operation with the result that the filaments are left with little "life" or elasticity. In fact, the residual stretch is so low in most cases that yarn spun from such filaments has insufficient elasticity to permit its use on knitting or weaving machines. Second, a great deal of fly or very short staple is produced in this process. This not only tends to reduce the strength of the yarn but also tends to produce slubs in the spinning, knitting, and weaving op-

erations to which the yarn may ultimately be subjected.

This invention has as its principal object to overcome the above-mentioned difficulties of the prior art processes and to provide a process wherein a new and improved type of synthetic staple yarn may be easily and economically produced. Another object is to produce synthetic staple yarns which possess to a very considerable extent their original elasticity or stretch and their original tensile strength. A further object is to produce a spinnable sliver composed of synthetic staple yarns throughout which the individual staples are distributed at random and in such manner as to produce a spun yarn of improved strength and resiliency. A still further object is to provide a type of spun yarn in which random distribution of the filaments is obtained, not only along the axis of the filaments, but also in planes normal or at oblique angles thereto. Another object is to improve generally upon the stretch-breaking process of producing synthetic staple fiber yarns whereby the characteristics of the resulting product may be positively controlled. Other objects will appear hereinafter.

These objects are accomplished by the following invention which, in its broader aspects comprises dividing continuous or substantially continuous synthetic filaments into segments of desired length by passing them through a processing cycle during part of which cwycle the filaments are subjected to substantially no stretching action and during the remainder of which each of the filaments is subjected, for a restricted portion of the segment length, to a stretch sufficient to rupture the filaments. One embodiment of the invention comprises passing a substantially parallel band or roving of synethetic filaments through successive sets of draft rolls driven in such manner as to give an intermittent feed and draft and to subject the filaments only at certain restricted portions of their length to the full breaking tension. In such a process, during the first part of the cycle all the rolls run at substantially the same surface speed. During the second part of the cycle one set of rolls is stopped, while the next succeeding set of rolls continues to operate at its usual surface speed, until stretch-breaking of the filaments held by the stopped rolls occurs, whereupon the cycle is repeated.

In the following examples and description I have set forth several of such preferred embodiments of my invention but they are included only for the purpose of illustration and not as a limitation thereof.

In the accompanying drawings, Fig. 1 is a diagrammatic representation of the essential features of an apparatus suitable for carrying out the process of the invention and illustrates the steps thereof.

Fig. 2 is a diagrammatic illustration of one type of mechanism which may be employed for driving the various rolls illustrated in Fig. 1 in accordance with the conditions of the process.

Fig. 3 is an elevational view of the cam and follower mechanism employed for controlling the power feed to the first two sets of rolls illustrated in Fig. 1.

Fig. 4 is a diagrammatic elevational view of a modified arrangement of the holding rolls.

Fig. 5 is a diagrammatic representation of the approximate distribution or arrangement of the staple fibers in the roving which emerges from the stretch-breaking rolls.

Fig. 6 is a diagrammatic representation of a plurality of filaments (greatly magnified) which have been stretch-broken in accordance with our process.

Fig. 7 is a graphical representation showing how the theoretical (and probable actual) residual stretch varies along the length of the staple fibers.

The stretch-breaking of filaments in accordance with my invention is carried out by means of a series of rolls. The essential features of such a mechanism are illustrated in Fig. 1 in which the numeral 1 designates a supply spool from which a strand or roving R comprising a multiplicity of filaments is unwound, passing over suitably positioned guides 2 and 3 and thence to a series of rolls A, B, and C.

The first set of rolls A functions as delivery rolls and comprises a set of three individual rolls 4, 5, and 6. The second set of rolls B comprising individual rolls 7, 8, and 9 are the holding rolls. The third set C comprises drafting rolls 10 and 11.

Rolls 4, 5, and 6 of set A may each have a diameter of two inches and are preferably formed of steel. The surfaces of rolls 4 and 6 are smooth while the surface of roll 5 is preferably fluted. Holding rolls 7, 8, and 9 of set B are likewise formed of steel and have a diameter of two inches. The surface of roll 9 may be covered with a suitable resilient or yielding material such as rubber, cork, leather or the like to reduce the tendency toward slippage of the filaments. Drafting rolls 10 and 11 of set C have a slightly larger diameter than those of either set A or B, say three inches. Roll 11 is also preferably covered with resilient material. The individual rolls of each set make contact as illustrated in Fig. 1. Rolls A function to deliver the roving R to the holding rolls B, while drafting rolls C are adapted at one part of the cycle of operation to stretch the filaments to and beyond their respective breaking points.

An alternative and, in fact, preferred arrangement of the holding rolls constituting set B which is designed to reduce slippage of the filaments to a minimum, is illustrated in Fig. 4. In this arrangement rolls 4, 5, and 6 are as illustrated in Fig. 1, roll 4 being gear driven from a suitable source of power such as shaft 26 of Fig. 2 and having a fluted steel surface, while rolls 4 and 6 have smooth steel surfaces. Likewise, rolls 10 and 11 are as shown in Fig. 1, roll 10 being driven by a suitable source of power and roll 11 being operated by friction drive. Rolls 7, 8, and 9, however are not arranged in the "three high" relationship, roll 9 being so positioned that the bite of rolls 8 and 9 is as close as possible to the bite of rolls 7 and 8. As in Fig. 1 roll 7 is gear driven as is roll 8, while roll 9 is friction driven through contact with roll 8. The purpose of roll 9 in this alternative and preferred arrangement is the same as the purpose of roll 9 in the previously described arrangement in Fig. 1, i. e., to hold or snub the filaments against slippage. However, should excessive slippage occur between rolls 7 and 8 of Fig. 1 and should rolls 8 and 9 effectively snub this slippage the filaments would be stretched along the path between the bites of rolls 7 and 8 and 9. By placing roll 9 in the position shown in Fig. 4 the bites between the rolls 7 and 8 and 8 and 9 are brought closer together, thereby reducing the length of

filaments that would be stretched should excessive slippage take place.

The speeds of various sets of rolls are controlled in accordance with the demands of the process as will be more fully set forth hereinafter and in such a manner as to give a roving composed of a multiplicity of heterogeneously stretch-broken filaments, that is, a roving in which part of the filaments are disposed along the axis of the roving while another part of the filaments are disposed in a plane perpendicular or at various angles thereto. The roving or mass of broken filaments passes from the drafting rolls 10 and 11 onto the surface of an endless conveyer belt 12 which conducts the filaments to gilling, drafting, and other textile machinery which it may be desired to employ in producing a given type of spun yarn.

Although I have shown in Fig. 1 only one supply spool, it will be understood that in actual operation a plurality of supply spools are employed and the threads or strands are led therefrom and caused to converge at some common point to produce a roving of substantially parallel filaments of the desired denier which then enters the process at delivery rolls A.

Before proceeding to a description of the mechanism by which the various sets of rolls are driven, it is desirable to refer to a typical example of the carrying out of the various steps involved in my improved stretch-breaking process. Keeping in mind the defects of the prior art as discussed above, particularly the stretching of the filaments until they are all attenuated throughout their length and thus completely losing their natural resiliency, it will be seen that the principal problem to be solved was to provide a process which would have all of the advantages of the above-mentioned stretch-breaking process, but in which the staples would emerge from the process with most of their original elasticity, or extensibility, tensile strength and other physical properties. In order to achieve this result it was necessary to provide some means of feeding the filaments continuously through the stretch-breaking rolls but in a manner in which only a portion of each filament was subjected to the full breaking tension.

Referring now to Fig. 1, in accordance with the invention the roving R of substantially parallel continuous synthetic filaments of say 6000 denier is fed to the delivery rolls A, being snubbed around roll 6 and between rolls 5 and 6 and 4 and 5 in the manner shown. For purposes of illustration the yarn will be assumed to have a stretch of 25%, that is, any individual filament will be capable of a 25% elongation before breaking. The yarn as it emerges from between rolls 4 and 5 passes around roll 9 thence between rolls 8 and 9 and then between rolls 7 and 8. These particular rolls may be designated holding rolls, since they serve actually to hold the yarn during the stretch-breaking part of the cycle of operation. The yarn in passing from rolls A to rolls B is maintained under only sufficient tension to kep it taut and to prevent slippage around rolls B. This relatively small amount of tension may result in giving the yarn a stretch of the order of 2–5%, but this is insufficient to have any substantially deleterious action on the yarn. The yarn passes from the bite of holding rolls 7 and 8 to the drafting rolls 10 and 11, emerging therefrom as intermeshed segments of staple fibers which flow continuously onto the endless belt conveyor 12.

Assuming, for example, that it is desired to produce a nine inch staple, rolls A and B will be spaced apart about five inches betwen centers and B and C about three inches. In accordance with my invention the drive provided for rolls A, B, and C is of such characteristics and is so operated that all of the rolls rotate at approximately the same surface speed for a distance of about eight inches on the surface of the drafting rolls C. Rolls A and B are stopped instantaneously while rolls C operate until a length of one inch has been thrown out. This sudden stopping of rolls A and B and the continued rotation of the rolls C results in the stretch-breaking of the filaments that are gripped by holding rolls B. This breaking action does not take place at one point in the segment of a filament between B and C but occurs at random anywhere along this length. It is only because of this random breaking that the roving can hold together and remain sufficiently continuous to flow through the process. The staples which are thrown out of the rolls C and deposited on the conveyer belt 12 may then be transported to a gill box or other drafting device or may be wound with twist or false twist into balls or may be subject to other processing steps as desired.

As the process described above is carried out with the distance between rolls B and C equal to three inches, the following are the approximate characteristics of the staple thrown out. For a nine inch staple there will be three inches of the filament which has been subject to stretch-breaking (losing practically all of its stretch), five inches of normal (unstretched) yarn and one inch of yarn which has been stretched progressively from 0 to 25% (the breaking point). These figures are based on yarn which has an original inherent stretch of 25% and are used by way of illustration only. The spacing of the rolls and the time during which the stretch-breaking action takes place will be adjusted in accordance with the type of filament material being operated upon, but in any event the various sets of rolls are so operated that the draft rolls can act upon only that portion of the roving held between rolls B and C and only for a sufficient length of time to stretch each of the filaments confined to that length or segment of the roving to its breaking point. It should be particularly noted again that the breaks do not occur all at one place in the roving, since otherwise the roving would be completely severed, but on the contrary the filaments break at random points of natural or induced weakness, thus maintaining the substantial continuity of the sliver even after the mass of staple fibers leaves the drafting rolls and reaches the belt conveyer.

Preferably the position of the conveyer belt with respect to the rolls C is such that an approximate overlapping of the bunches of filaments emerging from between the rolls C is produced. In actual operation a plurality of sets of drafting rolls such as C feed to one or more belts thus obtaining a good overlapping and blending of the bunches of filaments. At this point it is also possible to blend yarns of different characteristics in order to obtain what may be referred to as a mixed spun yarn.

The over-lapped bunches of filaments are, as stated, susceptible of drafting by means of gill boxes, Casablancas apron drafting mechanisms, or drafting rolls, either with or without break-draft or loading rolls. Most successful results

have been obtained using the double faller gill box.

The product of say 200 sets of drafting rolls, as described above, may be diverted by belts to one gill box. If the gill box were set up with an overall draft of 6 inches, for example, a "top" of approximately 200,000 denier would be obtained. This top may be further gilled, blending with other tops to secure uniformity and then be drawn down to a roving of spinnable size. The processes of gilling, drawing, and spinning are not capable of greatly damaging the filaments and thus a yarn of high quality having good stretch and being free from fly may be obtained from synthetic staple filaments produced in accordance with my invention.

Referring now to Figs. 2 and 3 of the drawings one example of a suitable intermittent drive for the rolls A, B, and C will be described.

A drive motor 13 is connected to the shaft 14 of roll 10 of draft rolls C by a chain drive comprising chain 15 and sprockets 16 and 17. Optionally, a belt or gear drive may be employed if desired. No power connection exists between roll shaft 14 and the other roll shafts, except through the drive chain 18 connected to sprocket 19 mounted on shaft 14 and sprocket 20 mounted on miter gear shaft 21. Shaft 21 carries bevel gear 22 which meshes with another bevel gear 23 mounted on shaft extension 24 of planetary differential transmission 25 of conventional type. Transmission shaft 26 delivers power to rolls 4 and 7 through a gear train composed of gears 27, 28, 29 and 30, the ratio of the various gears being such as to drive rolls comprising sets A and B at the same or approximately the same surface speed.

A third shaft extension 31 of transmission 25 carries a cam roller swing arm 32 which is displaced back and forth by the cam 33 driven through shaft 34, gear 35 meshing with drive gear 36 mounted on the shaft 37 of another drive motor 38.

The speed, design of the cam 33, ratios of gearing, etc., are such that as the cam is rotated it acts through the differential in known manner to cause power to be transmitted intermittently from drive motor 13 to rolls A and B in such manner that rolls A and B are driven at approximately the same surface speed as the bottom rolls C for a pre-determined length of time, that is, such a length of time as will permit a predetermined length of roving to pass between the rolls, then instantaneously stopping rolls A and B for a pre-determined length of time, but continuing to drive rolls C. In other words, rolls C are driven continuously during the operation of the process, but rolls A and B are driven intermittently because of the fact that the power supply to drive shaft 26 is momentarily cut off, the period of dwell being determined by the speed and the contour of the face of cam 33.

It will of course be understood that the above described drive for rolls A, B, and C represents only one suitable form of apparatus which may be employed for the purpose of obtaining the desired intermittent drive. Any other suitable mechanical or electrical control may be substituted for the differential transmission unit without departing from the invention.

It will also be understood that various changes in the conditions of operation of the process may be made within the scope of my invention, depending upon the type of synthetic yarn material dealt with, the type of staple being produced and various other factors. In the present process the length of the staple is governed, both by the manner in which the respective sets of rolls are operated and the distance these sets of rolls are spaced apart from one another. The ratch or distance between the holding rolls B and the draft rolls C is preferably kept as small as possible in order to reduce to a minimum the length of the individual filaments which will be subjected to the full breaking tension when the rolls A and B are momentarily stopped during the actual stretch-breaking cycle of the process. It will be evident that the closer the rolls are together, the smaller will be that portion of a given stretch-broken filament which will have been attenuated to its breaking point, and consequently the more resiliency or extensibility will the individual staple have after stretch-breaking.

In order to regulate the length of the staple being produced an appropriate adjustment may be made in the manner of driving the various sets of rolls, and particularly in controlling the time during which the power is supplied to or cut off from rolls A and B, and also, if desired, by adjustment in the distance between the sets of rolls, or by both such adjustments. It will be apparent that the period of dwell, that is, the period during which the rolls A and B will be stationary and functioning merely to hold the yarn during the stretch-breaking step, can be altered merely by altering the contour of the face of the cam 33.

Not only may the length of the staple and that portion of the individual staples which are subjected to the breaking tension be controlled by an adjustment of the distance between the sets of rolls and an adjustment of the period during which the stretch-breaking tension is applied, but also the degree of stretch left in the filaments along their length may be varied, if desired, simply by adjusting the speed of the rolls B and C with respect to one another during the "normal" part of the cycle, that is, that period during which the yarn is not subjected to the actual breaking tension. For example, if rolls B and C are operated at the same surface speed, the filaments on the average have nearly the same stretch as the original unbroken filaments. If however, the speed of rolls C is greater than that of rolls B during the "normal" part of the cycle, a certain amount of the potential stretch or resiliency of the filaments may be removed before the breaking step and consequently the average stretch or resiliency of the filaments in a bundle or roving of such staples will be substantially less than that of the original unbroken material. Thus the degree of loss of stretch may be controlled by an adjustment of the relative speed of rolls B and C. If desired, the relative speed of rolls A and B may also be adjusted so that the yarn passing between these rolls is subjected to a certain amount of stretch or draft.

Although I have found it convenient to describe my improved stretch-breaking process by reference to the manufacture of a yarn having a staple length of about nine inches, it will be apparent that the process may be so regulated as to produce almost any desired staple length, as above indicated. While my process is particularly advantageous in the manufacture of cellulose acetate staple yarns, it may be applied with equal facility to yarn composed of or containing other cellulose derivatives, such as the mixed and single organic acid esters of cellulose, cellulose ethers, viscose, and other synthetic yarn material.

It will be readily understood that the product

obtained by the process of my invention is unique in that it is a stretch-broken type of staple yarn which may retain all or substantially all or any pre-determined percentage of its original resiliency or potential stretch. The product is characterised by the fact that the individual filaments have been stretched or attenuated to their breaking point only for a limited and segregated portion of the staple length, while the remainder of the staple length of yarn remains substantially in its original condition. However, as above pointed out, the degree of stretch or resiliency of the final product may vary within very wide limits from close to 0% stretch to 100% of the original stretch of the material before it enters the process.

The characteristics of my product will be more fully understood by reference to Fig. 6 of the drawings in which I have shown how breaking of the individual filaments occurs during the passage of a strand of eight filaments through the rolls. It will first be observed that the breaks from filament to filament occur at random, severance taking place at a point along a given filament which is weaker than the remainder of the filament. Obviously, the filaments will not all break at the same point, since the points of weakness will not occur at the same place in two or more filaments, except by the merest chance. If this random breaking did not occur, it would be impossible to operate the process continuously and to produce a continuous sliver, since the strand of filaments would be completely severed between the holding rolls and the drafting rolls and no continuous feed of the yarn would be possible.

It will also be observed from Figs. 6 and 7 that each filament has an attenuated and an unattenuated portion, that is, a portion in which the yarn retains its original physical properties such as stretch (ability to be stretched), resiliency, tensile strength and the like. This unstretched or unattenuated portion is of the utmost importance and serves to distinguish my staple fiber product from any similar stretch-broken product of the prior art. It will of course be readily appreciated that, the more nearly do the staples retain the characteristic properties of the original yarn, the higher will be the quality of the threads into which they are ultimately spun. It will also be appreciated that only by a process such as herein described can such a product be produced.

In Fig. 6 I have shown eight filaments A, B, C, D, E, F, G, and H disposed in parallel relationship and evenly spaced apart in the same plane. In actual practice, however, the filaments lie close together in the form of a strand or roving and, upon breaking, the staples are disposed at random throughout the resulting sliver. In other words, there is a heterogeneous disposition of the broken fibers in the product.

It should be noted that in the case of a nine inch staple produced on the machinery and under the conditions specified above, there will be, as shown in Fig. 7, a three inch segment which has been fully stretched or attenuated, that is, attentuated to its breaking point. Following this is a one-inch segment in which the residual stretch varies progressively all the way from 0% to 25% (assuming a yarn having an original inherent stretch of 25%). Finally, there is a five inch segment which is substantially or completely unstretched or unattenuated.

The theoretical amount of residual stretch in the staple fibers along their length is illustrated by the stretch-length diagram of Fig. 7 which is self-explanatory. It is probable that the actual residual stretch follows rather closely the theoretical as indicated.

Referring to Fig. 5 it will be seen that the individual staple fibers are heterogeneously disposed in different planes throughout the sliver. This figure illustrates the general nature of the material and the fact that the staples leave the process in the form of a continuous spinnable sliver.

The roving produced in accordance with my invention is distinguished by the fact that, due to the random, but what may be referred to as the "segregated breaking" of the filaments, the individual staples in the roving are heterogeneously disposed therethrough and in planes perpendicular or oblique to the axis of the roving. In face, this is one of the distinguishing features of my invention and makes possible the production of a yarn possessing a much higher degree of resiliency and strength in the ultimate spun yarn product. The staple product as it emerges from my process may be employed directly in the manufacture of spun yarns according to the well-known woolen, worsted, or cotton systems employing the standard types of textile machinery. My product may be employed for such purposes without further processing, although it may be desirable to treat the yarn at any stage of the stapling operation or before or after actual stretch-breaking with any suitable anti-static or lubricating compositions.

What I claim is:

1. The process of producing synthetic staple fibers of predetermined staple length, which comprises dividing a strand or roving, composed of a plurality of substantially continuous filaments maintained in substantial parallelism, into segments of desired length by continuously feeding the filaments to a stretch-breaking device, permitting the filaments to run substantially free until a predetermined length of filaments has been fed, then stopping the feed at one point along the segment undergoing treatment while continuing the feed of that portion of the filaments beyond the stopping point until the filaments are stretched to and beyond their breaking point.

2. The process of producing synthetic staple yarn from a strand or roving of continuous filaments which comprises dividing the filaments into staple lengths while maintained in substantial parallelism by carrying the filaments through a processing cycle in which the whole length of each of the staples is subjected to substantially no stretching action during the first part of the cycle and in which only a restricted portion of each staple is subjected during the remainder of the cycle to a stretch sufficient to rupture the filaments.

EDGAR G. GUENTHER.