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[54] **SEMI-CONTINUOUS FILAMENT COMBINATION YARN**

[75] Inventor: **George A. Watson,** Davidson, N.C.

[73] Assignee: **Celanese Corporation,** New York, N.Y.

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Related U.S. Application Data

[60] Division of Ser. No. 25,675, April 6, 1970, Pat. No. 3,664,115, and a continuation-in-part of Ser. Nos. 606,982, Jan. 3, 1967, abandoned, and Ser. No. 763,468, Aug. 5, 1968, Pat. No. 3,504,489, which is a division of Ser. No. 650,795, July 3, 1967, Pat. No. 3,417,560, and a continuation-in-part of Ser. No. 382,263, July 13, 1964, abandoned.

[52] **U.S. Cl.** ..... **57/140 BY**

[51] **Int. Cl.** **D02g 1/00**

[58] **Field of Search** ..... 57/140 BY, 140 R, 139, 57/157 R, 167; 19/65 T, 66

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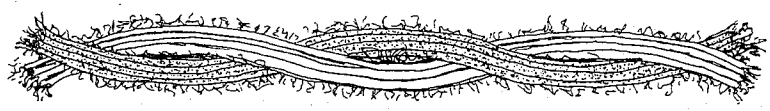
Primary Examiner—Donald E. Watkins

Attorney, Agent, or Firm—Andrew F. Sakyo, Jr.

[57] **ABSTRACT**

A method, apparatus and product comprising producing a semi-continuous filament yarn having staple yarn characteristics from crimped tow comprising longitudinally slitting a deregistered tow comprising different fibers into strips of filaments either with or without a tow spreading stage and subsequently twisting the strips into yarn. The tows differ from each other in the fibers they contain, but each individual tow may contain a relatively uniform blend of different fibers.

5 Claims, 6 Drawing Figures



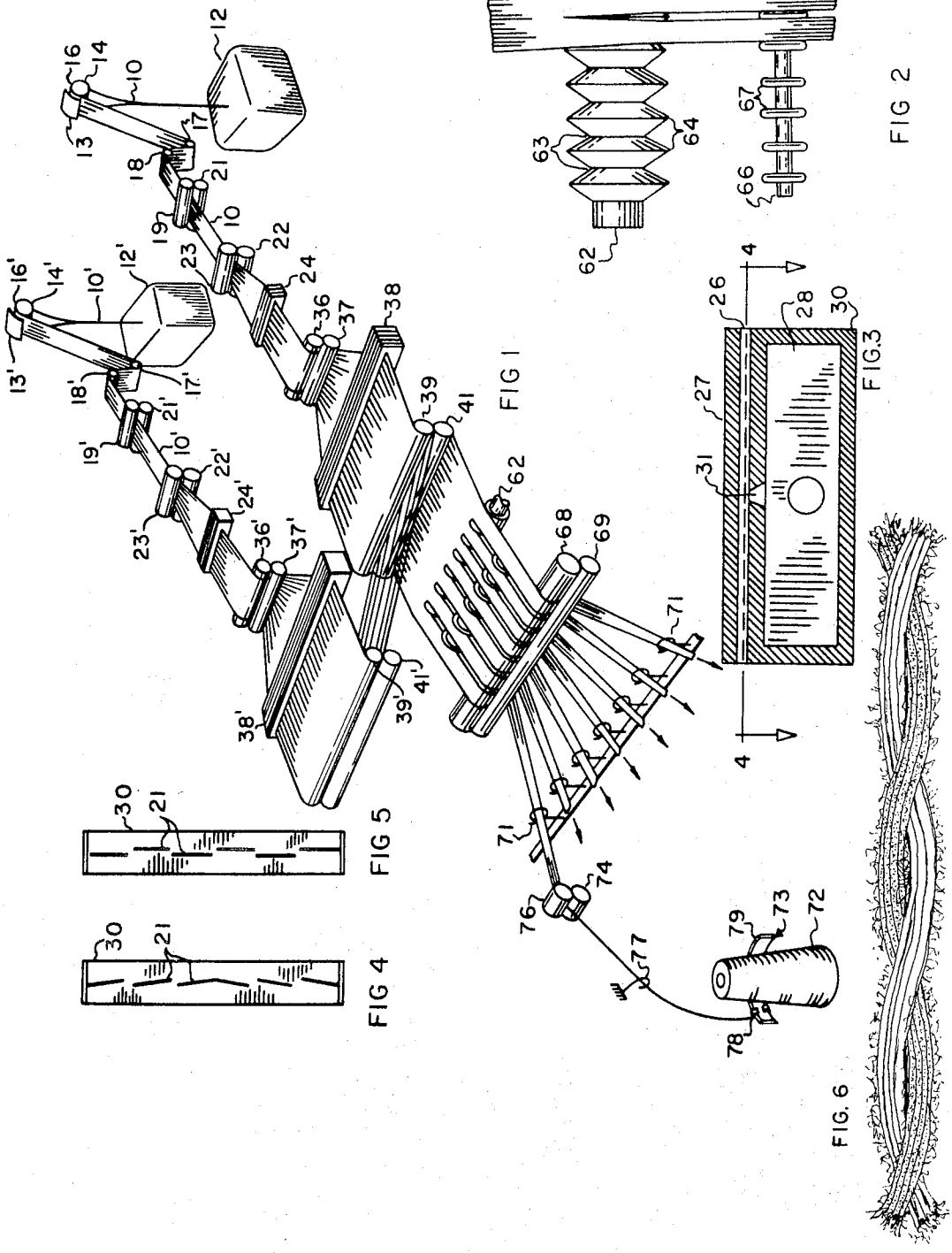


FIG 1

FIG 2

FIG.3

FIG 4

FIG 5

FIG. 6

SEMI-CONTINUOUS FILAMENT COMBINATION YARN

BACKGROUND OF THE INVENTION

This is a division, of application Ser. No. 25,675 filed Apr. 6, 1970, now U.S. Pat. No. 3,664,115 and application Ser. No. 25,675 is a continuation-in-part of Ser. No. 606,982, filed Jan. 3, 1967, now abandoned and Ser. No. 763,468, now U.S. Pat. No. 3,504,489 filed Aug. 5, 1968, which is a division of Ser. No. 650,795, filed July 3, 1967, now United States Letters Patent No. 3,417,560, which patent is a continuation-in-part of Ser. No. 382,263, filed July 13, 1964, now abandoned.

This invention relates to the production of continuous filament yarn from continuous filament fibers and more particularly to the production of a combination yarn from a tow of deregistered crimped filaments, wherein the tow contains different fibers.

The deregistration or opening of a tow of continuous crimped filaments is known in the art. Previously, such deregistration was effected in the production of cigarette tow in a manner described by Dunlap et al. in U.S. Pat. No. 3,156,016.

It is an object of the present invention to provide a novel, substantially continuous filament combination yarn. It is another object of this invention to provide a bulky yarn of substantially continuous filaments wherein the fiber length averages about 6 inches or more. These and other objects will become apparent to those skilled in the art from a description of the invention which follows.

SUMMARY OF THE INVENTION

In accordance with the invention, a method for producing yarn from continuous filaments is provided, comprising passing two or more continuous moving tows of crimped continuous filaments made up of different fibers through a common or separate tow opening and deregistering zone, deregistering said tows, combining the tows, if opened separately, slitting the resulting deregistered combined tow longitudinally into a plurality of fibrous strips and collecting said strips as a combination yarn. Preferably, the slitting is effected after at least one spreading stage.

The reference herein to "different" fibers is intended to include fibers differing in any attribute. Thus, the fibers may differ in dyeability, or in cross-section, or in degree of crimp, or in color, or in the material of which they are made. For certain purposes, the fibers may differ in stiffness; for example, one tow may be composed predominantly of fibers of greater stiffness than those of the tow or tows. Such increased stiffness may be attained, for example, by using fibers of heavier denier or fibers of non-circular cross-section (e.g., of cruciform, triangular, trilobal, "H" or other cross-section while fibers of circular cross-section may predominate at the other face), or fibers of inherently stiffer material (e.g., of polyethylene terephthalate which is stiffer than nylon-6 or nylon-66). The "different" fibers may be blends of fibers; for example, one fiber blend may differ from the other only in the proportions of its components; thus, one tow band may contain an 80:20 blend of two fibers and the other band of different fibers may be composed of a 50:50 blend of the same two fibers.

As indicated, for some purposes each band of fibers may be composed of a blend of fibers. Thus, in producing a differential shrinkage combination yarn, it is desirable to blend a shrinkable fiber with a fiber stable under the conditions of treatment. For example, fibers which shrink when heat is subsequently applied to the yarn (e.g., fibers of polypropylene or polyvinyl chloride, or cold drawn polyester fibers) may be intimately blended with fibers (such as heat-set polyester fibers which are stable) under the same heat-treatment.

More specifically, in a preferred embodiment, two or more lightweight webs are produced by passing each opened tow of crimped continuous filaments through an air spreader in which the moving tow, in flattened condition, is confined between parallel walls while streams of air or other suitable gas are directed at the tow across its full width. It has been discovered that it is possible in this manner to spread the tow readily, and very evenly, to great widths to produce webs of extreme fineness, such as webs containing less than about 600, e.g., 500 filaments per inch of width, and in which the average air space per fil is appreciably greater than the diameter of the filaments, thus providing ready means for slitting the web longitudinally into yarn of as few as about 100 filaments up to about 10,000 filaments or more as may be desired.

The average air space per fil is the average space between the filaments of the web measured on a line in the plane of the web, perpendicular to the longitudinal direction of the filaments of the web, said space being calculated on the assumption that all the filaments are arranged in a single plane, with no filaments crossing other filaments. It may be calculated simply from a knowledge of the average diameter of the filaments (D_F), the width (w) or the substantially uniform web and the number of filaments (n) in said width, according to the formula: Average Air Space Per Fil $= (w - nD_F) \div n$.

In the preferred forms of the invention, the average air space per fil is a plurality of times (e.g., five, 10 or more times) as great as the average filament diameter. Such webs may have densities well below one ounce per square yard, e.g., 1/10 to 1/4 or 1/2 ounce per square yard.

The invention will be described more fully by reference to the drawings in which:

FIG. 1 is a schematic view of a process in accordance with the present invention illustrating tow-opening, tow spreading and the subsequent splitting of a lightweight web to form a plurality of yarns;

FIG. 2 is an enlarged partial plan view of the slitting apparatus of FIG. 1;

FIG. 3 is a sectional view of an air spreader particularly useful in the present invention;

FIG. 4 is a plan view along line 4—4 of the arrangement of the air openings of the air spreader; and

FIG. 5 is another plan view along line 4—4 of an alternate arrangement of the air openings of the air spreader;

FIG. 6 is a view of a combination yarn produced by the process illustrated in FIG. 1.

Referring to FIG. 1, a band of crimped continuous filament tow **10** is drawn from bale **12** through a banding jet **13** comprising a stationary cylinder **14**, having a slit running lengthwise of the cylinder at its highest point, and a curved baffle member **16** parallel to, and spaced about the thickness of the tow **10**, from the adjacent surface of said cylinder, so that the tow band **10** passes between said baffle member **16** and cylinder **14**.

Air under pressure is supplied to the interior of the cylinder **14** and emerges as a stream from the slit of said cylinder, the slit being cut at an angle such that the air stream has a component in a direction opposing the forward motion of the stream. The air jet preconditions the tow for further processing by removing snags, false twists, straightens and flattens the tow and, if desired, spreads the tow somewhat to provide a uniform thickness. Tow band **10** is hence passed around stationary tensioning bars **17** and **18** to help smooth and uniformly pretension said band, said bars being adjustably mounted, so that their angle to the horizontal may be varied, to adjust the position of the band on subsequent processing equipment with which the band comes into contact downstream of said bars.

After leaving bar **17** and **18** the band passes into the tow opening zone. The tow may be conveniently opened or deregistered, to prepare it for the air spreading steps by subjecting it while moving in a predetermined path, to a differential gripping action between a plurality of points spaced from one another both longitudinally and traversely in the path so that certain laterally spaced sections of the tow are positively gripped relative to other lateral spaced sections of the tow, alternating with the grip sections, which are not gripped at all or are gripped at different relative points. In this manner there is produced a relative shifting of the adjacent filaments longitudinally along the tow whereby the crimps are moved out of registry with one another. The shifting action is a function of the differential positive gripping of the tow. Preferably, although not necessarily, the differential gripping action is such that a relative lateral displacement between adjacent filaments of the tow is also effected, so that the combination of two transverse filament movements brings about the complete opening of the tow.

Several methods for effecting the differential gripping action are known in the art as well as several different apparatuses for effecting the differential gripping, which apparatuses deregister the tow with varying degrees of success. A preferred apparatus is disclosed in the aforementioned Dunlap et al. patent.

Typically, the differential gripping action is achieved by using at least one pair of rollers, one of which is smooth surfaced and the other of which is patterned over its entire periphery. The most preferred apparatus comprises a plurality of such pair of rollers arranged in tandem wherein one of each pair of rollers comprises a smooth surfaced roller coated with a resilient material such as rubber and the other roller has alternating lands and grooves. Preferably, the lands and grooves form helical threads of about 8 to 20 per inch.

Thus, the tow is passed through the nip of a pair of rolls **19** and **21** prior to being passed through a second pair of rolls **22** and **23.** In the most preferred embodiment, rolls **19** and **23** are the patterned rolls, such as threaded steel rolls and rolls **21** and **22** are resilient surfaced rolls.

Each pair of rolls is individually driven at a predetermined controlled speed. Generally, only one roll of each pair is positively driven while the other is in yieldable compressive contact with the driven roll and rotates due to the passing of the tow between the rollers. The differential gripping action and deregistering is produced by driving the second pair of rollers at a faster rate of speed than the first pair. Thus, the second pair of rollers is typically driven at a rate of about 1.1 to about 8 times and more preferably at a rate of about 1.2 to about 3.0 times that of the first pair.

On leaving the deregistration zone, the crimp in the tow is out of registry with adjacent filaments. While the tow at this point can be combined with one or more similarly deregistered tows of different fibers and slit into a plurality of sections to produce yarn, it is highly preferred to pass the tow through at least one spreading stage and more preferably two or more spreading stages to thereby spread the tow into a thin web prior to combining with one or more similarly processed tows and slitting into yarn. By spreading the tow to several times its original width, much greater uniformity and control of filament content are obtained.

Various spreading means can be used to spread the deregistered tow into a uniform web. Such means include mechanical spreading bars, diverging belts, air jets and the like. The most preferred means is the air jet, also known as a banding jet.

The tow is spread as shown in FIG. **1** by means of a first spreader **24.** The tow is pulled through spreader **24** by the action of driven rollers **36** and **37** about which tow **10** is S wrapped. In passing through spreader **24,** the tow is spread about two to four times the width of the tow exiting from the deregistration zone. As is preferred in the present invention, the tow is preferably again spread, such as in second spreader **38** wherein the spread band is again spread two to about four times the width of the web drawn through rollers **36** and **37.** Again, the web is drawn through spreader **38** by means of another set of driven rollers **39** and **41.** Thus, the spreading action preferably spreads the tow into a web at least twice the original width of the tow and more preferably two to about ten times the original tow width. In the most preferred embodiment, for the production of yarn of high filament uniformity, the tow is spread four to about eight times the width of the tow exiting from the deregistration zone.

From rollers **39** and **41** the spread web is combined with one or more spread webs of different fibers by any suitable means, such as passing the webs between **2** rotating rolls, then passed to a slitting zone wherein the composite web is slit into a plurality of web sections. Numerous means of slitting can be utilized such as roller **62** having circumferential parallel circular V shaped grooves **63** separated by circular sharp parallel ridges **64** operating in conjunction with a hot wire apparatus **66** comprising a series of spaced electrically heated wires **67** having operative portions penetrating said web in alignment with each ridge **64.** As the web is drawn through the slitting zone by the action of another pair of driven rollers **68** and **69,** the web is slit into narrow portions by the groove **63** and ridge **64** portions of roller **62.** Heated wires **67** complete the slitting by severing cross lying filaments tying the slit webs together. Preferably, tension is exerted on the web being slit by driving rollers **68** and **69** at a peripheral speed in excess of the feed rate, such as about 5 percent greater than the peripheral speed of rollers **39** and **41.**

It will be readily recognized that numerous other means for slitting a web can be used to accomplish substantially the same slitting action with correspondingly good results. For instance, the slitting action can be accomplished by a knifing action which accomplishes longitudinal cutting in a manner similar to the coaction of the heated wire and ridge and groove apparatus illustrated.

The narrow web bands produced by the cutting action are diverged to eye guides **71** in spaced relationship to each other, from which they are taken up with a twist on bobbin **72** mounted in ring spinner **73** of the conventional type or other yarn take up means. In such ring spinners, as is well known, the bundle of filaments passes through driven feed rolls **74** and **76,** stationary balloon guide **77** and moving traveler **78** mounted on reciprocating ring rails **79** before passing onto bobbin **72.**

The resulting yarn is very bulky. Its strength is substantially that of continuous filament yarn but it has the appearance of a staple fiber yarn because of the presence of projecting ends, on the order of about **10** projecting filament ends per inch and loose loops or arches, each made up of a small number of crimped filaments, that is about one or two filaments, lying along the main body of the yarn. Of course, the number of projecting filament ends will vary between about 3 to 30 or more per inch, depending on the filament count, the degree of spreading, the deregistering means used, the type of filament and the like. Knitted fabrics of this yarn have an extremely soft pleasant feel, very suitable for baby sweaters, bulky sweaters and the like.

Alternatively, if desired, the yarn produced can be further drawn into yarns of a lower filament count by drafting the yarn to the breaking point of individual filaments, thereby forming a modified staple yarn of long variable filament length. Various apparatuses are known which will accomplish this type of drafting and these apparatuses can be used in conjunction with the present invention to thus pass the web band through a drafting zone prior to twisting and winding on bobbins.

Referring more specifically to the air spreaders used in the present invention as illustrated in FIG. **3, 4** and **5,** tow **10** is passed through space **26** which separates air chamber **28** of plenum box **30** from back plate **27.** Air pressure is exhausted through slit **31** thereby impinging upon the fibrous web as it is passed through space **26.** Thus, the spreading operation is effected on the tow as it is passed through the air spreader in a flattened condition between parallel walls while a stream of suitable gas is directed onto the tow at a right angle across its full width. Advantageously, the air spreading is effected in a plurality of stages as described above, each of which spread the tow to a greater width than in the preceding stage. For best results, the tow in any one stage is isolated from the effect of the following stage by passing the tow through drawing rollers such as **36** and **37,** and **39** and **41** between each spreading stage.

The air spreaders themselves advantageously have air delivery slits or other suitable openings in one or both of the parallel walls between which the tow passes. The slits lead from a plenum box or air chamber supplied with air at a constant pressure. In one highly effective apparatus, a series of slits is provided, each running in a direction transverse to the direction of movement of the tow and so arranged that all portions of the tow are subjected to the air stream from said slits. Surprisingly, it has been found that even when the width of the air spreader is **8** feet or more, the tow spreads uniformly from the outer edges of the tow, where the resistance to air would be expected to be less, to attain substantially the same density as the central portions of the tow.

The pressure in the plenum chamber may vary considerably. One suitable range is about 1 to 5 pounds per square inch gauge pressure. Higher pressures such as about 100 pounds per square inch gauge can be used, but these are generally not necessary and are economically wasteful. Surprisingly, little air is needed to expand the tow. Despite the fineness of the webs, the walls of the tow-confining zones of the air spreaders need not be correspondingly close together. Thus, very good results have been obtained with tow confining slots one tenth inch in width.

Advantageously, the webs are spread to such an extent that when further air spreading is attempted, while the length of the web is kept constant, the web strongly resists such spreading and returns to its previous width. That is, if a graph is plotted relating to air pressure in the spreader to the degree of lateral spreading of the moving web, it is found that there is substantially no additional pressure needed to effect spreading up to a certain width, after which the air pressure required rises sharply. The web density at which the sharp change occurs is termed herein the "potential web density." This potential web density will vary, depending on the type of tow which is employed and particularly on the degree of intermingling and crossing over of the tow filaments. In general, optimum tows have potential web densities below about one ounce per square yard and preferably less than about 1/2 ounce per square yard. Surprisingly, webs of such densities are easily handled and maintain their unity without disintegration during ordinary handling.

By spreading the web to such low densities, the filament count in the yarn can be varied to within precise limits by varying the distances between the plurality of slitting means. Thus, the slitting can be effected to produce a slit web of about 0.1 to about 6 inches or more in width and more preferably in the range of about 0.2 to about 1.5 inches. It will thus be readily recognized that the resulting yarn can be varied from a filament count of about 5 filaments or less up to about 10,000 filaments or more by adjusting the width of the slit web and the density of the web being split. Preferably, yarns having a filament count of less than 10,000 are preferred and more preferably, yarns having a total denier of about 500 to 7,000.

As an example, a tow having a denier of 42,000 made up of 3 denier per filament fibers is commonly spread from a crimped tow in registry of about 4 or 5 inches to a deregistered spread tow of about 50 inches. By combining two such tows and slitting the spread webs to one inch webs, a yarn having a filament count of 560 fils is produced. This count can, of course, be readily reduced by drafting as hereinbefore described.

In the slitting of the web, there will be portions of filaments which cross other filaments and which are ranged at small angles, both left and right, to the general direction of the filaments of the spread web. The hot wires or other cutting means will cut through these filaments so that the resulting yarn will have some filament ends giving some of the effect of a staple fiber yarn. Because of the deregistration of the crimped filaments in the web, the yarns produced in this manner are very bulky. When the webs are made of filaments of high tenacity such as a tenacity above about 2 grams per denier, as is the case with filaments of terephthalate polyesters, it is advantageous to use devices other than hot wires for cutting. Thus, a series of anvil rollers com-

prising rotating, shearing discs mounted alternately on parallel axes at the sides of the discs in close contact having a scissors-like effect on the filaments which pass between the rollers may be employed. One advantage of an anvil roller arrangement is that in addition to being used for slitting webs of stronger fibers, it gives a product free from occasional fused zones which may be formed when hot wires are used on thermoplastic filaments such as cellulose acetate.

The present invention is useful with any combination of continuous filament material which have been crimped prior to deregistration. The process is particularly useful with filaments of polyethylene terephthalate polyester and cellulose acetate of the usual acetyl content of about 54 to 55 percent calculated as acetic acid. However, the invention is also equally applicable to other tows such as those made of other polyesters such as polyesters of 70/30 isophthalic and terephthalic acids and other glycols such as dimethylolcyclohexane; linear super polyamides such as nylon-6 and nylon-66; polyacrylonitrile and copolymers of acrylonitrile; olefinic polymers and copolymers such as isotatic polypropylene; other organic derivatives of cellulose such as esters and/or ethers of cellulose, for example cellulose propionate and cellulose acetate propionate and the like; highly esterified cellulose containing less than 0.29 free hydroxyl groups per anhydroglucose units such as cellulose triacetate; rayon and the like.

The number of filaments in the starting tow can vary within wide limits and may range up to as high as about one million with a denier per filament as high as about 25, that is, in the range of about 0.5 to about 25 and more preferably in the range of 1 to 20 denier per filament. The number of crimps per inch of tow may range up to as high as about 80, but for the most end products a crimp of about 3 to 50 crimps per inch, preferably about 3 to 20 crimps per inch of starting tow are found to be exceptionally satisfactory.

The invention will be described more fully by reference to the example which shows certain preferred embodiments of the present invention.

EXAMPLE 1

In accordance with FIG. **1**, a plurality of yarns were produced from two lightweight webs using a band of crimped polyethylene terephthalate tow having about 50,000 5 denier filaments and a band of crimped cellulose acetate tow having about 24,000 3.3 denier filaments, each crimped at a frequency of about 9.5 crimps per inch. The tows were deregistered and air spread in two stages to a web 30 inches wide, and combined to produce a composite web having a density of about 4 ounces per square yard. The spread web was fed at a rate of about 45 feet per minute to a slitting zone comprising a roll **62** having circumferential parallel circular V-shaped grooves **63** (FIG. **2**) separated by circular sharp parallel ridges **64,** and a hot wire arrangement **66** having a series of spaced electrically heated wires **67** having operative portions penetrating said web, there being one such wire **67** for each groove **63** engaged by the web, said wires being aligned with said ridges. The web was drawn through the slitting zone **62** by the action of a pair of rolls **68** and **69** about which the slit narrow portions of the web made S wraps. The rolls were driven at a peripheral speed 5 percent greater than the peripheral speed of rolls **39** and **41.** Ridges **64** (and wires **67**) were spaced one inch apart so that the web was slit into portions each of **864** denier and the number of filaments was about 288. From roll **69** these portions diverged to eye guides **71,** spaced further apart, from which they were taken up with a twist of 1-½ turns per inch on rotating driven bobbins **72** mounted in ring spinners **73** of conventional type. In such ring spinners, as is well known, the bundle of filaments passed through driven feed rolls **74** and **76,** stationary balloon guides **77,** and moving travelers **78,** mounted on reciprocating ring rails **79,** before passing onto the bobbin **72.**

The resulting yarn was very bulky. Its strength was substantially that of a continuous filament yarn, but it had the appearance of a staple fiber yarn because of the presence of projecting ends (on the order of about 10 projecting filaments ends per inch) and loose loops or arches each made up of a small number of crimped filaments (e.g., of one or two filaments) lying along the main body of the yarn. Knitted fabrics of this yarn have an extremely soft, pleasant feel, very suitable for baby sweaters, for example.

The combination yarns of this invention contain at least 10 to 20 percent of every different fiber component. This insures a combination yarn having a substantially uniform blend of each different fiber component.

In the same manner, other continuous filament crimped fibers are deregistered, spread, combined and slit into yarns with correspondingly good results.

While there have been described various embodiments of the present invention, the method described is not intended to be understood as limiting the scope of the invention as it is realized that changes therein are possible. It is intended that each element cited in the following claims is to be understood as referring to all equivalent elements for accomplishing substantially the same results in substantially the same or equivalent manner. It is intended to cover the invention broadly in whatever form its principles may be utilized.

What is claimed is:

1. A semi-continuous filament yarn comprising a plurality of at least two different deregistered crimped yarns of varying filament length ranging from staple length to continuous filament length wherein the different yarns have a differential shrinkage and have staple yarn bulk and fiber characteristics and yarn strengths approaching those of continuous filament yarn.

2. The yarn of claim **1** having from about 3 to 30 projecting filament ends per inch.

3. The yarn of claim **1** having from about 100 to 10,000 filaments.

4. The yarn of claim **1** consisting essentially of cellulose acetate and polyester fibers.

5. The yarn of claim **1** consisting essentially of cellulose acetate and nylon fibers.

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