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Nishida

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[54] **METHOD FOR PRODUCING PILE FABRICS HAVING EXCELLENT APPEARANCE AND PROPERTIES**

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Aug. 15, 1972 Japan 47-81741

[52] **U.S. Cl.** .... **264/103;** 28/DIG. 1; 264/147; 264/168; 264/171; 264/210 F; 264/DIG. 47

[51] **Int. Cl.²** **D02G 1/20;** B29H 7/18

[58] **Field of Search** .... 264/171, 210 F, 168, 147, 264/103, DIG. 47; 28/DIG. 1

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Primary Examiner—Jay H. Woo
Attorney, Agent, or Firm—Woodhams, Blanchard and Flynn

[57] **ABSTRACT**

A pile fabric having excellent appearance and properties is produced by conjugate spinning a polyamide and a polyester in a side-by-side relation, applying to the resulting filaments firstly a non-aqueous oil composition and then an aqueous oil composition, drawing the thus treated filaments and taking them up on a bobbin, unwinding the filaments from the bobbin and allowing them to stand under a relaxed state to develop spontaneous crimps, compressing the crimp-developed filaments to a filling density of 150 – 380 g/l and then immersing them in water at a temperature of lower than 50°C and raising the temperature to higher than 80°C to set the spontaneous crimps and simultaneously splitting the filament into the two components and forming the resulting filaments in the pile fabric or by forming directly the drawn filaments obtained in the same manner as described above into a pile fabric to develop spontaneous crimps, jetting steam on the pile fabric surface to set the spontaneous crimps and immersing the pile fabric in water at a temperature of lower than 50°C and raising the temperature to higher than 80°C to split the filaments into the two components.

21 Claims, 18 Drawing Figures

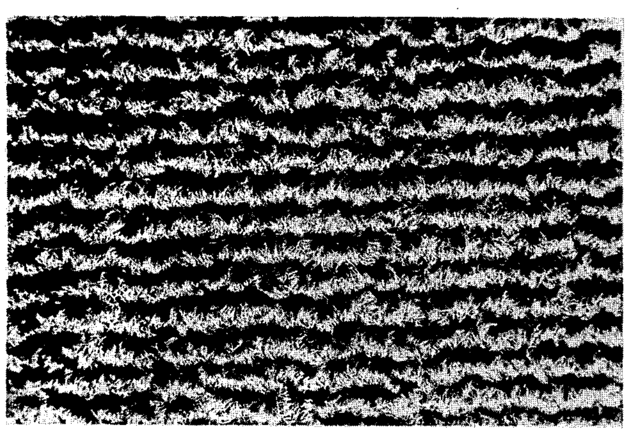


FIG_1

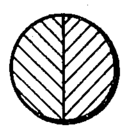


FIG_2

FIG_3

FIG_4

FIG_5

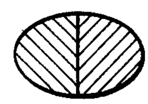


FIG_6A

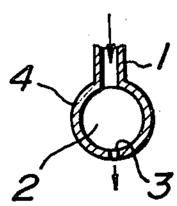


FIG_6B

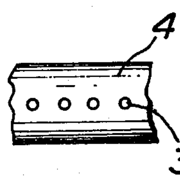


FIG_7A

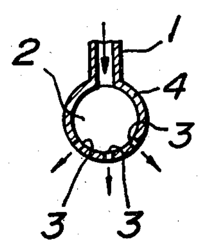


FIG_7B

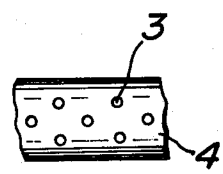


FIG_8A

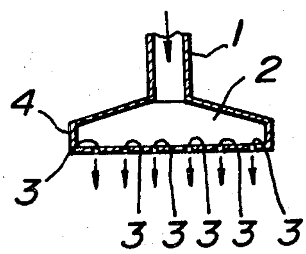


FIG_8B

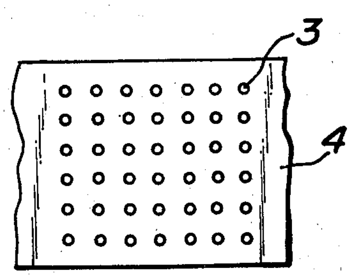


FIG_9

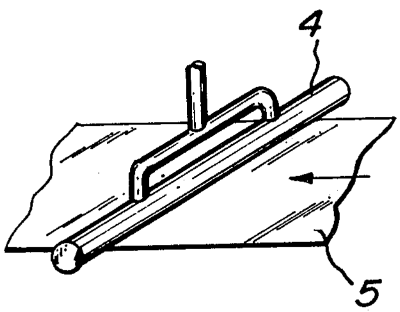


FIG_10

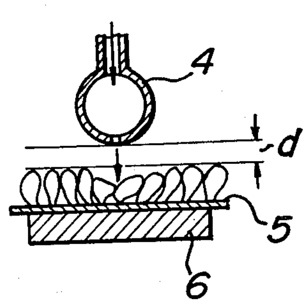


FIG_11

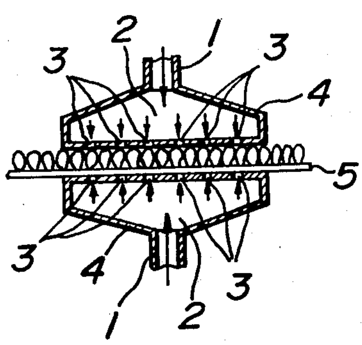


FIG_12

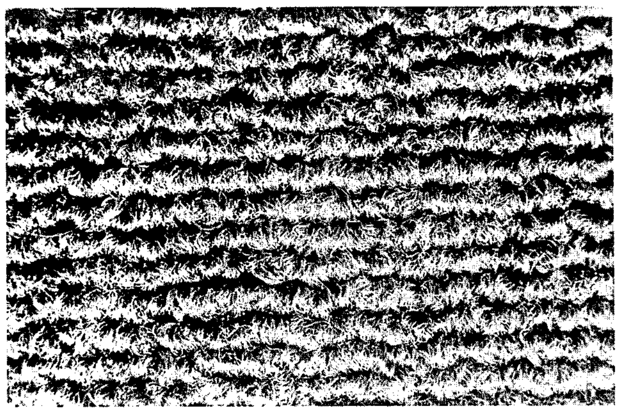


FIG_13

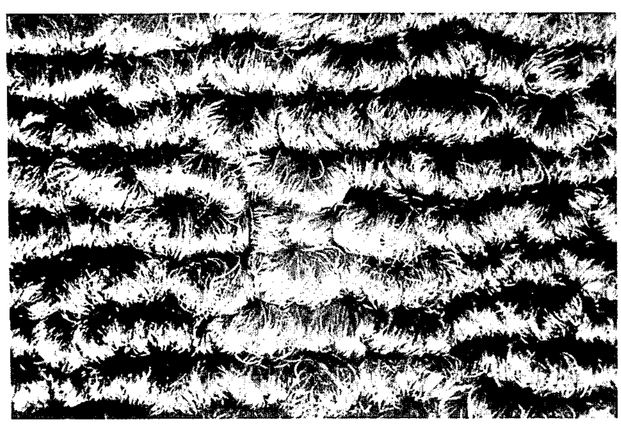


FIG_14

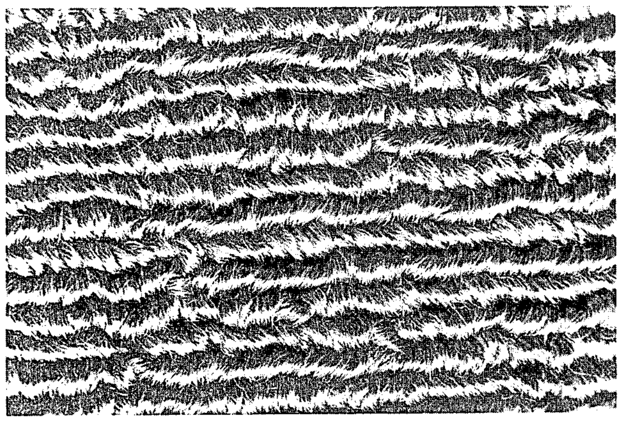
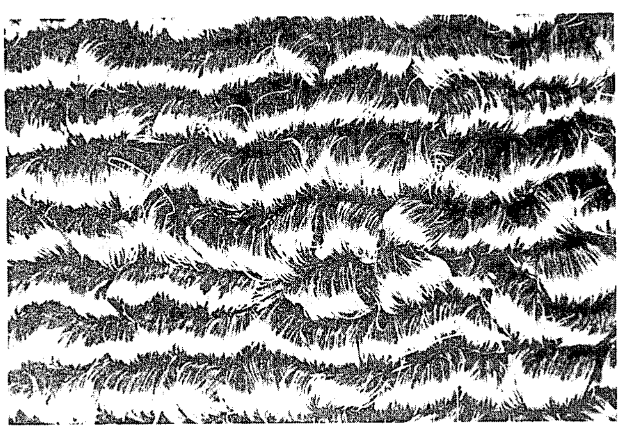


FIG_15



METHOD FOR PRODUCING PILE FABRICS HAVING EXCELLENT APPEARANCE AND PROPERTIES

The present invention relates to a method for producing pile fabrics having excellent appearance and properties and more particularly to a method for producing pile fabrics, particularly pile carpets having excellent appearance and properties from composite filaments in which polyamide and polyester are bonded in a side-by-side relation.

Recently, the tufting machines have been developed and the demand for pile carpets composed of synthetic fibers has rapidly increased and particularly the demand for the pile carpets composed of filaments has rapidly increased owing to their high durability.

Heretofore, in almost all of the filaments to be used for pile carpets, bulkiness is provided to straight filaments by a crimping process, such as stuffer box method, false twisting method and the like. Becuase if straight filaments per se are piled to form a carpet, the filaments forming the pile are gathered and the substrate (backing cloth) is seen between the piles and the appearance is quite poor and if the piles composed of straight filaments are densely tufted so that the substrate is not seen, the amount of filaments thus tufted is very large and such a means is disadvantageous in view of cost and the carpet becomes hard and the walking feel is very poor.

On the other hand, recently it has been attempted to produce pile carpets composed of filaments having self-crimpability in which two polymers are bonded eccentrically along the longitudinal direction of the filament but in this case it is necessary to effect previously a crimp developing and setting treatment in the filament state. If piles are formed by omitting these treatments and the scouring and dyeing are performed, the monofilaments constituting the piles concentrate and are crimped in the same shape and the piles are distorted and excess crimps are formed, consequently the covering, appearance, walking feel and the like of the resulting pile fabric are very poor.

As mentioned above, heretofore the filaments to be used for the pile carpet are subjected to a crimping proces but the crimping process needs a complicated and expensive apparatus and therefore the cost of the filaments is high. Furthermore, in the filaments unevenness of mechanical and thermal treatment is liable to be caused during said process and this unevenness results in defects of pile unevenness, streaks and the like.

For solving these defects, the inventor has diligently studied and found that pile carpets having excellent appearance and properties can be produced without effecting the above described crimping process by utilizing filaments having specific properties and composed of polyamide and polyester and the present invention has been accomplished.

The specific properties of the filaments of the present invention are firstly formation of spontaneous crimps in said filament and secondly the splitability of the two components.

The term "spontaneous crimp" used herein means the crimps developed due to the difference of elastic shrinkage of the two components when a filament obtained by eccentric conjugate spinning of two components having a difference in their elongation elasticity, such as polyester and polyamide, is drawn, the tension is removed and the filament is relaxed in air.

The term "splitability of two components" used herein means the property that the two components bonded along the longitudinal direction of the filament are split into the respective components. It has been well known that a filament obtained by conjugate spinning two components in a side-by-side relation develops crimps due to the difference of shrinkage of the two components and a stretchable fibrous structure and a bulky fibrous structure are formed by utilizing the crimpability. This concerns the filament composed of two components having mutual adhesion and in the previously utilized crimps, the shrinkage difference between the two components is positively caused by heating in a relaxed state and the formed crimps are set by heating and the concept of the spontaneous crimp used herein has never been seen.

In addition, the utility of the composite filaments composed of two splitable components has been well known and this has been disclosed in U.S. Pat. Nos. 3,350,488 and 3,117,906 and French Pat. No. 1495835 and all of these patents relate to a process for producing fine filaments and aim at the production of silky filaments and are different in the function, effect and object from the present invention and of course, the concept of the spontaneous crimp according to the present invention has never been found.

Polyamide and polyester have no adhesion and particularly when the fineness of the monofilament is very large as in carpet filaments, the side-by-side type composite filaments of these two components undergo splitting in an undrawn state and the drawing can not substantially be effected. However, according to the present invention it has been found that by selecting oil compositions to be applied in the spinning step, the adhesion is controlled and the filaments having spontaneous crimpability, which can be split into two components by a very simple process, can be produced and the present invention has been accomplished by utilizing these specific properties.

In the previous carpets composed of synthetic filaments, static electricity is accumulated on a human body when he walks on the carpet and when he touches a door handle, the electricity is discharged and a stimulation is given and an unpleasant feeling is caused but the present invention improves this point. Namely, the present invention provides a pile fabric composed of filaments in which the polyamide monofilaments which are charged positively and the polyester monofilaments which are charged negatively are complicatedly entangled and therefore the static electricities generated by the friction include both positive and negative charges which cancel each other and the carpet of the present invention is very low in static electrification.

The object of the present invention will be apparent from the above described explanation and it is to provide a method for producing a pile fabric having excellent appearance and properties at a low cost. Namely, the present invention provides a method for producing a pile fabric without needing the crimping step using a particular apparatus and step.

Another object of the present invention is to provide a method for producing a pile fabric of a very low electrification.

An aspect of the present invention is a method for producing a pile fabric in which a polyamide and a polyester are conjugate spun in a side-by-side relation at a cross-sectional area ratio of 1/3 – 3/1, the resulting filaments are applied firstly with a non-aqueous oil composition and then with an aqueous oil composition, the thus treated filaments are drawn and taken up on a bobbin, from the bobbin the filaments are unwound and left to stand under a relaxed state to develop spontaneous crimps, the crimp developed filaments are compressed under a filling density of 150 – 380 g/l and then immersed in water at a temperature of lower than 50°C and the temperature is raised to higher than 80°C to set the spontaneous crimps and simultaneously split the filaments into the two components and the resulting filaments are formed into the pile fabric.

Another aspect of the present invention is a method for producing a pile fabric in which a polyamide and a polyester are conjugate spun in a side-by-side relation at a cross-sectional area ratio of 1/3 – 3/1, the resulting filaments are applied firstly with a non-aqueous oil composition and then with an aqueous oil composition, the thus treated filaments are drawn and taken up on a bobbin, the filaments are formed into a pile fabric and then spontaneous crimps are developed, steam is jetted onto the pile fabric surface to set the spontaneous crimps and then the pile fabric is immersed in water at a temperature of lower than 50°C and the temperature is raised to higher than 80°C to split the filaments into the two components.

The polyamides suitable for the present invention are nylon-4, nylon-6 nylon-7, nylon-11, nylon-12, nylon-66, nylon-610, polymethaxylyleneadipamide, polyparaxylylenedecaneamide, polybiscyclohexylmethanedecaneamide and copolyamides consisting mainly of these polymers.

As the comonomer in the copolyamides, mention may be made of lactams, such as caprolactam, enanthlactam, laurolactam and the like; aminocarboxylic acids, such as aminocaproic acid, aminodecanoic acid, p-aminomethyl-benzoic acid and the like; nylon salts of diamines, such as hexamethylenediamine, nonamethylenediamine, undecamethylenediamine, m-xylylenediamine, p-xylylenediamine and piperazine with dibasic acids, such as adipic acid, sebacic acid, isophthalic acid, terephthalic acid and the like.

The polyesters are polyethylene terephthalate, polytetramethylene terephthalate, polyethylene oxybenzoate, poly-1,4-dimethylcyclohexane terephthalate, polypivalolactone and copolyesters consisting mainly of these polymers.

As the monomers in the polyesters, mention may be made of lactones, such as pivalolactone, ε-caprolactone and the like; aliphatic diols, such as ethylene glycol, trimethylene glycol, tetramethylene glycol, diethylene glycol, polyethylene glycol and the like; alicyclic diols, such as 1,4-cyclohexanedimethanol, 1,4-cyclohexanediol and the like; aromatic dicarboxylic acids, such as terephthalic acid, isophthalic acid, sodium sulfo-iso-phthalate, naphthalenedicarboxylic acid and the like; aliphatic dicarboxylic acids, such as adipic acid, sebacic acid, 1,10-decanedicarboxylic acid; alicyclic dicarboxylic acids, such as hexahydroterephthalic acid, hexahydroisophthalic acid and the like. When the dicarboxylic acids or diols are copolymerized, it is necessary to copolymerize the dicarboxylic acids and diols.

When the copolyamides and copolyesters are used, if the copolymerization ratio is too high, the adhesion of the two components becomes high and the two components are hardly split by the heat treatment of the pres-

ent invention and the effect of the present invention cannot be obtained and the mechanical properties of the resulting pile fabric is deteriorated and accordingly the copolymerization ratio is preferred to be less than 15 mol% based on the main component.

The conjugate ratio of the two components according to the present invention is a very important factor in view of the following two points.

One among them is the spontaneous crimp, one characteristic of the present invention is to utilize the spontaneous crimp generated when the filament is relaxed in air and therefore the effect of the present invention depends upon whether the filament has a high spontaneous crimpability or not. When the conjugate ratio of polyamide to polyester is outside the range of 1/3 – 3/1, the filament cannot have the required spontaneous crimpability and the effect of the present invention cannot be obtained.

The spontaneous crimp percentage of the filaments utilized in the present invention is desirable to be more than 40% when determined by the following process and when said percentage is 60 – 95%, the more preferable result can be obtained.

Process for determining the spontaneous crimp percentage (C_S) is as follows.

The length of the filament after the filament is left to stand in air at a humidity of 65% RH and a temperature of 25°C for 1 hour under a load of 0.1 mg/d, is l_S and the length when said filament is left to stand for 1 minute under a load of 0.1 g/d instead of the above load is l_T.

$$C_S = \frac{l_T - l_S}{l_T} \times 100\ (\%)$$

It is considered that the spontaneous crimps are generated due to the difference of elastic shrinkage of the polyamide and polyester components constituting the filament in a side-by-side relation and the fact that a filament has a high spontaneous crimp percentage means that both the components are satisfactorily bonded in the monofilament.

Another important point of the conjugate ratio is the problem of electrification of the resulting pile fabric. As mentioned above, the electrification of the pile fabric of the present invention is very low but when the conjugate ratio is beyond the range of 1/3 – 3/1, the balance of the positively charged polyamide and the negatively charged polyester is lost and one or the other of the positive and negative charges becomes excessive and an undesirable result is obtained.

A more detailed explanation will be made with respect to the conjugate ratio. When the conjugate ratio is within the range of 1/3 – 3/1, the effect of the present invention can be attained but in view of the durability of the resulting pile fabric, it is preferable that the amount of polyamide is larger than that of polyester and when the ratio of polyamide/polyester is 3/1 – 1/1, more particularly 5/2 – 3/2, a pile fabric having very excellent properties can be obtained, because polyamide is higher than polyester in the abrasion resistance and impact resistance.

For a better understanding of the invention, reference is taken to the accompanying drawings, wherein:

FIGS. 1 – 5 show cross-sectional views of the composite filaments to be used in the present invention;

FIGS. **6A, 6B, 7A, 7B, 8A** and **8B** show embodiments of steam jetting devices to be used in the method of the present invention. FIGS. **6A, 7A** and **8A** show cross-sectional views of the devices and FIGS. **6B, 7B** and **8B** show front views of the jet nozzles;

FIG. **9** is a perspective view of an embodiment for carrying out the steam jet treatment of the present invention;

FIG. **10** is a cross-sectional view of the steam jet treatment of the present invention;

FIG. **11** is a cross-sectional view of another embodiment for carrying out the steam jet treatment of the present invention;

FIGS. **12** and **13** are photographs for showing the appearance of the surfaces of the tufted carpets obtained by the method of the present invention; and

FIGS. **14** and **15** are photographs for showing the appearance of the surfaces of the tufted carpets made of splittable filaments of polyamide and polyester, which are not treated with the method of the present invention.

The side-by-side type composite filaments used in the present invention mean filaments wherein the two components are bonded in a parallel relation along the longitudinal direction of the monofilament and the cross-section is the shapes as shown in FIGS. **1 – 5.** In view of the properties of the resulting carpet, particularly durability, the shapes in which the two components after splitting have a substantially triangular shape as shown in FIGS. **2 – 4,** are preferable.

The important point in the production of the filaments according to the present invention consists in that the the extruded filaments are applied firstly with a non-aqueous oil composition and then with an aqueous oil composition.

The most essential point of the technical idea of the present invention consists in that the spontaneous crimps are set and the composite filaments are split into two components and this can be attained only by improvement of the adhesion of the two components to a required extent and control of the adhesion in such a manner that the filaments are split into two components by a simple heat treatment. As mentioned above, polyamide and polyester are essentially poor in the adhesion and therefore the composite filament of polyamide and polyester in a side-by-side relation is difficult to produce on an industrial scale but the present invention can solve this difficulty by selection of the spinning oil compositions.

It is not clearly understood why the process for applying the spinning oil compositions to be used in the method of the present invention is effective for attaining the object of the present invention but an assumption concerning this will be explained as follows. It has been found that the adhesion of the side-by-side type filament of polyamide and polyester is highly influenced by the water content in the oil composition to be applied in the spinning. Namely, when the water content in the spinning oil composition is high, the two components are readily split, whereas when the water content is decreased, the two components are difficult to split. This is because under an undrawn condition, polyamide filament absorbs water and swells considerably, while polyester filament does not substantially absorb water and does not swell. The polymers spun in the melted condition are near an absolutely dry condition and when an oil composition having a high water content is applied to the solidifying filament, the difference of the water absorbing property and swelling property of the polyamide and polyester appears considerably and the divergency of the bonding surface of both the components generates rapidly and highly and the filament is readily split into the two components.

On the other hand, when a non-aqueous oil composition having a low water content is applied, the above phenomenon does not occur and therefore the adhesion is improved. By the above explanation the reason why the non-aqueous oil composition is applied in the method of the present invention, will be understood. The reason why an aqueous oil composition is subsequently applied, is based on the following two points.

The first point consists in that when only the non-aqueous oil composition is applied, the winding of the filament is difficult. When the undrawn filament applied with only the non-aqueous oil composition is wound on a bobbin, the polyamide component absorbs gradually moisture in air and swells and the winding is readily destroyed and it is impossible to take-up a large amount of filament. In general, a non-aqueous oil composition is low in the affinity of mutual filaments and consequently when the drawn filament is taken-up, the filament is liable to disturb the wound form and when the denier of monofilament is large as more than 10 deniers, this defect readily occurs.

Accordingly, it is necessary to supplement this defect by applying an aqueous oil composition after the non-aqueous oil composition is applied. The spinning rate of synthetic fibers is usually more than several hundred meters per minute and therefore the non-aqueous oil composition and the aqueous oil composition are applied substantially simultaneously, but only by determining the sequence of applying of these oil compositions as described above, the production of the side-by-side type filament of polyamide and polyester is feasible. This is surprising and the reason is not clear.

The second point consists in that the adhesion of the two components is improved too much if only the non-aqueous oil composition is applied.

The inventor has found that the filament obtained by applying only the non-aqueous oil composition is too much improved in the adhesion of the two components and it is difficult in the following step to split the filament into the two components and therefore it is necessary to adopt the process for applying the two oil compositions in sequence according to the present invention.

In general, as the spinning oil compositions, a lubricating oil, such as mineral oils or fatty acid esters, is diluted together with a surface active agent and an antistatic agent with water or an organic solvent.

The term "non-aqueous oil composition" used herein means the spinning oil compositions having a low water content and the water content is preferred to be as low as possible and if the water content is less than 15%, the object of the present invention can be accomplished and if said content is less than 10%, a more preferable result can be obtained.

The term "aqueous oil compositions" used herein means the oil compositions wherein a lubricating oil is dissolved or emulsified toogether with a surface active agent and an antistatic agent in water and when the water content is more than 40%, such an oil composition is effective and the use of the oil composition containing a water content of 50 – 90% gives amore preferable result.

The lubricating oils including mineral oils; fatty acid esters such as methyl oleate, ethyl palmitate, propyl palmitate, n-butyl palmitate, n-butyl stearate, lauryl laurate, oleyl oleate; higher alcohols such as lauryl alcohol, oleyl alcohol.

The surface active agents and the antistatic agents cannot be distinguished distinctly and anionic, nonionic, cationic and amphoteric surface active agents are usable. As the surface active agents (emulsifiers), nonionic active agents, such as polyoxyethylene castor oil ether, polyoxyethylene oleyl ether, polyoxyethylene trimethylolpropane tristearate are preferable. As the antistatic agents, anionic active agents, such as potassium polyoxyethylenelauryl sulfate, potassium polyoxyethyleneoleyl phosphate, sodium dodecylbenzenesulfonate, sodium cetylsulfonate and the like are preferable.

As the diluting agents in the non-aqueous oil compositions, use may be made of aromatic hydrocarbons, such as benzene, toluene, xylene; halogenated hydrocarbons, such as trichloroethylene, perchloroetehylene, carbon tetrachloride, low boiling fractions of petroleum, such as gasoline, light oil, kerosene, ligroin and the like.

The amounts of the oil compositions deposited on the undrawn filament (excluding the volatile component) are 0.5 – 2.0% by weight in the non-aqueous oil composition and 0.3 – 1.5% by weight in the aqueous oil composition and the total amount of the oil compositions is preferred to be 0.8 – 2.5% by weight.

The undrawn filaments applied with the oil compositions in the above described manner may be drawn by any process but in order to prevent the splitting of the two components, it is preferable to use a hot pin (surface: satin, diameter: 30 – 20 mm) or a hot roller. The hot roller process by which the heat is sufficiently given by winding a few turns, is most preferable. When the drawing temperature is too low, yarn breakage and splitting occur, while when the temperature is too high, the adhesion is too much improved and the preferable temperature is 70° – 130°C, more particularly 80° – 100°C. The heat setting of the drawn filament may be either effected or not, but as mentioned hereinafter the difference of heat shrinkage between polyester and polyamide influences highly upon the production step of the pile fabric and the appearance and properties of the resulting pile fabric. Accordingly, the heat setting must be carefully carried out. Said temperature is usually preferred to be 100° – 160°C. If said temperature is too high, the shrinkage of polyester which is readily set, becomes low and the difference of shrinkage becomes too large and such a temperature is not preferable.

Namely, when the difference of length of the polyester monofilament and the polyamide after the splitting, which is caused due to shrinkage difference, is too small, the resulting pile structure is poor in the bulkiness and is not preferable, while when the difference is too large, loose filaments are formed on the structure surface and the appearance and properties are deteriorated and further when the above described first aspect process is carried out, the loose filaments get caught by a guide and the production of the pile fabric is very difficult.

In the production of the pile fabric according to the present invention, it is very valuable for obtaining the good pile fabric that the following tests are conducted with respect to the composite filaments.

One of them is a measurement of the above described spontaneous crimp percentage and said percentage is desirable to be more than 40% as described above.

Another is the split percentage of the two components of the filament owing to the heated water treatment and the shrinkage difference of the split polyamide monofilament and the split polyester monofilament after said treatment.

These measurements are referred to as "the heated water treatment measurements" hereinafter and they are as follows.

The monofilament prior to the heated water treatment is referred to as "monofilament" and each monofilament obtained by splitting into the two components is referred to as "fibril monofilament".

Heated water treatment measurement:

10 monofilaments are taken in a loop (total length of loop: 1 m) and this loop is immersed in water at a temperature of lower than 50°C and then the temperature of water is raised until the water is boiled, in 30 minutes and the boiling is continued for 10 minutes, after which the thus treated filaments are taken out and dried in air in a chamber having a humidity of 65% RH and a temperature of 25°C and then the split percentage and the shrinkage difference are determined.

Split percentage:

The total number of the "monofilaments" and the "fibril monofilaments" is read and this number is n.

$$\text{Split percentage (\%)} = \frac{n - 10}{10} \times 100$$

The split percentage must be more than 70% and if said percentage is more than 90%, the more excellent result can be obtained.

Shrinkage difference:

Each of the fibril monofilaments is applied with a load of 0.2 g/d and the length is read. The length of the filament having the maximum length is l_a and the length of the filament having the minimum length is l_b.

$$\text{Shrinkage difference} = \frac{l_a - l_b}{l_b} \times 100$$

When this value is 2 – 12%, the production of the pile structure is smooth and the appearance and properties of the resulting pile structure are good and when this value is 5 – 10%, the more favorable result can be obtained.

An explanation will be made with respect to the process for setting the spontaneous crimps and splitting the monofilament into the two components.

A process by which prior to the formation of the pile fabric the spontaneous crimps are set and the monofilaments are split into the two components is as follows.

The filaments obtained according to the above described process are relaxed in air to develop the spontaneous crimps and then compressed in a filling density of 150 – 380 g/l, after which the filaments are immersed in a warm water at a temperature of lower than 50°C and the temperature of water is raised to higher than 80°C to set the spontaneous crimps and simultaneously split the filaments into the two components, whereby filaments suitable for the production of the pile structure are obtained.

In order to relax the filament in air to develop the spontaneous crimps, the filament taken out from a bobbin is wound into a form in which the filament can be relaxed freely (referred to as "relaxed package"), for example, into a hank form, muff form or knit form. Of course, the relaxed package is preferably covered with a stretchable cover in such an extent that the development of the spontaneous crimps is not prevented and the filament is protected in the following steps. Then, the relaxed package is filled in a vessel and heat treated. Namely, the above described relaxed package is compressed and filled in a filling density of 150 – 380 g/l and subjected to the above described heated water treatment. This step will be explained with reference to an embodiment. That is, a plurality of filament packages wound in muff forms are charged in an Over-maier dyeing machine and on the packages a cover is put and the above described pressure is applied thereon and then water at a temperature of lower than 50°C is poured into the dyeing machine so as to immerse the packages, after which the temperature of water is raised to higher than 80°C. In this case the rate of raising temperature is not particularly defined. By this process the spontaneous crimps are set and this will be explained as follows.

Since the filament to be used in the present invention has a high spontaneous crimpability, when the filament is formed into a relaxed package, at once the crimps are developed. Then, the crimped filament is charged in a vessel in a high filling density of more than 150 g/l and heat treated, whereby the developed spontaneous crimps are set.

Thus the crimped yarns can be obtained without carrying out a specific crimping process.

In this heated water treatment, the temperature of the water when the treatment is started, is lower than 50°C and the temperature of the final hot water treatment is higher than 80°C and by this heated water treatment the filaments are split into the two components because of the specific property possessed by the filaments. The phenomenon that the filaments are split into the two components is very important and if the two components are not split by this heat treatment, the crimped form is varied prior to and after the treatment by the heat shrinkage difference between the two components.

If the heated water treatment is effected in a lower filling density than 150 g/l, the filaments are split into the two components under such a condition that the filaments readily move, consequently at the same time when the filaments are split, the crimps disappear, so that the filling density must be more than 150 g/l. While, when the filling density is extremely high, the spontaneous crimps are not only set by the heat treatment, but also there is formed the portion where the crimps owing to the compression of the mutual filaments are provided and the resulting filaments are very uneven in the crimp. Accordingly, the excessively high filling density of more than 380 g/l must be avoided. The filling density is preferred to be 200 – 350 g/l in order to set the crimps satisfactorily and to obtain more uniform crimped filaments.

In the heated water treatment, it is preferable in order to split the filaments fully and set the crimps more satisfactorily that the filaments are immersed in water at a temperature of lower than 40°C and the temperature is raised to higher than 90°C and said temperature is kept for a time of more than 30 minutes.

Next, the method wherein the filaments not subjected to the heated water treatment are formed into a pile fabric and then the formed spontaneous crimps are set and the filaments are split into the two components, will be explained.

This method comprises that the untreated filaments are formed into a pile fabric, for example, by tufting and then said pile fabric is left to stand in air to develop the spontaneous crimps in the filaments constituting the pile fabric, a steam jetting treatment is effected on the pile fabric surface and then the pile fabric is immersed in warm water at a temperature of lower than 50°C and the temperature is raised to a temperature of higher than 80°C to split the filaments into the two components.

The term "steam jetting treatment" used herein means that a steam is jetted onto the pile surface and does not mean that the pile is heat treated under a steam atmosphere. The jet of steam should be conducted in such an extent that the pile is vigorously compressed by the jet.

FIGS. **6 – 8** show embodiments of the steam jetting devices and in these drawings each A is the cross-sectional view and each B is a front view of the jet nozzle. In FIGS. **6** and **7,** a large number of nozzles are opened in a circular tube and in FIG. **8** the nozzles are opened in a given flat surface.

In these drawings, **1** represents a steam introducing tube, **2** represents a steam reservoir, **3** represents jet nozzles and the arrow represents the steam flow.

FIG. **9** shows an embodiment of operation of the present invention and the pile structure **5** moves immediately below the jetting device **4,** whereby the steam jetting treatment is effected.

FIG. **10** shows an embodiment for carrying out the steam jetting treatment, in which the pile structure **5** running immediately below the jetting device **4** is treated with the jetting device. **6** represents a support.

The shorter the distance (*d*) between the jet nozzle and the pile surface, the better the effect is and the distance is usually less than 1 cm. Furthermore, it is effective that *d* is minus, that is the jet treatment is effected while the pile is somewhat compressed and when the pile length is uneven, there is such an effect that the pile length is made uniform and such a method is rather preferable.

The object can be attained by effecting the jet of steam from above the pile but the jet may be effected from above and below the pile as shown in FIG. **11.**

This method is characterized in that the pile structure is subjected to the steam jetting treatment to set the spontaneous crimps and then the filaments are split into the two components.

When the filaments are split into the two components without effecting said treatment, the crimps disappear and a pile fabric having a low bulkiness and poor appearance and properties are obtained. The heat treatment other than the steam jetting treatment can not substantially effect the setting of the spontaneous crimps.

The inventor has found that in order to set the spontaneous crimps it is necessary to supply a large amount of heat to the filaments instantaneously and in this point, a satisfactory process other than the steam jetting treatment can not be found.

The adhesion of polyamide and polyester in the composite filament to be used in tthe present invention has been controlled in a given extent as mentioned above and as the result, the filaments are readily split by a heat treatment or a mechanical treatment and when the pile structure is heat treated relatively gradually under a dry heated atmosphere or a steam atmosphere, the heat treatment is effected while the splitting between the two components is advancing, consequently the preferable pile structure can not be obtained.

Another object of the steam jetting treatment consists in that the entaglement of mutual filaments constituting the pile is promoted by the jet and the bulkiness and properties of the resulting pile structure are improved.

The heated water treatment may be carried out by Wince dyeing machine, beam dyeing machine, Jiggar dyeing machine but in the pile structure the use of beam dyeing machine and Jiggar dyeing machine is somewhat difficult and Wince dyeing machine is the most preferable.

The conditions for the heated water treatment was already mentioned in detail with respect to the process wherein in the filament form, the spontaneous crimps are set and the filaments are split. Therefore, the explanation is omitted herein.

The reason why the filaments are split into the two components by the heated water treatment, is not clear but as mentioned above, the filaments to be used in the present invention are controlled in the adhesion of the two components properly and therefore the filaments are split into the two components by a simple heat treatment. The inventor has found that when the filaments are directly immersed in hot water at a temperature of higher than 80°C, the filaments are relatively difficult to split, while when the filaments are firstly immersed in water at a temperature of lower than 50°C and the temperature is raised, the filaments are readily split. Presumably this is because the water at a temperature of lower than 50°C penetrates into the bonded interface of the two components and the temperature of water is raised, whereby the molecular movement becomes vigorous resulting into that the filaments are readily split into the two components by the heated water treatment.

However, when the filaments are directly immersed in hot water at a temperature of higher than 80°C, the setting of crimps and the thermal variation of polymers constituting the filament proceed earlier than the penetration of water between the two components and the splitting of the two components is difficult.

The advantage that the filaments are split into the two components by the heated water treatment consists in that the temperature condition of this treatment is substantially the same as the temperature conditions of scouring and dyeing usually conducted.

That is, the scouring and dyeing are usually conducted as follows. The scouring solution or dyeing solution is contacted with a fibrous structure at a temperature of lower than 50°C and then the temperature of the solution is continuously raised to higher than 80°C. Accordingly, in the method of the present invention, the heated water treatment can be substituted with the scouring or dyeing step and the pile structure having excellent appearance and properties can be obtained without effecting a specific heat step.

An additional effect obtained in the present invention is as follows. The pile fabric obtained by the method of the present invention is very low in the electric charge and even if a human body walks on the pile structure, the accumulation of electric charge on the human body is very low. The reason has already been mentioned but the propriety will be understood from the fact that the filaments in the pile fabric according to the present invention are fully entangled.

FIGS. **12** and **13** are photographs showing surfaces of the tufted carpets obtained by the method of the present invention, which show that the filaments constituting the pile are complicatedly entangled and the bulkiness is high.

FIGS. **14** and **15** show photographs of tufted carpets formed of splitable filaments composed of polyester and polyamide, which are not produced according to the present invention. In these carpets, the direction of the filaments constituting the pile is uniform and the bulkiness is poor. When the direction of the filaments constituting the pile is uniform as in these piles, the fibril monofilaments having lower shrinkability gather on the surface, consequently such a carpet is not desirable in view of the electrification.

A further effect of the present invention consists in the following point. Since the pile fabric obtained by the method of the present invention is composed of two components of polyamide and polyester having quite different dyeabilities, a beautiful carpet having a high grade in which two colored filaments are mixed, can be easily obtained by a device of dyeing process.

Such a carpet has never been obtained by the conventional process using the conventional filaments and in this point the present invention is very advantageous.

The present invention is particularly effective for production of pile fabrics, that is a carpet composed of filaments of a large denier and the denier of filaments when applying to carpet is 10 – 50, preferably 20 – 40.

The following examples are given for the purpose of illustration of this invention and are not intended as limitations thereof.

In the preceding description and the following working examples, the method for producing the pile fabric is explained with respect to tufting process in order to make understanding easy but the present invention is not limited to this process and knitting process, weaving process and the like may be applied for production of the pile fabric.

Impact resistance and electric charge voltage on a human body of the pile fabric in the following Examples are determined as follows.

Impact resistance (retaining percentage of thickness %):

An impact piece composed of a synthetic rubber having an impact area of 3 cm^2 and a weight of 1 Kg is dropped on the pile fabric from a height of 10 cm repeatedly a given number of times at a rate of 30 times/-min and the heights of the pile are determined prior to and after such a test and are H_a and H_b, respectively.

$$\text{Impact resistance} = \frac{H_b}{H_a} \times 100$$

The measurement of the height of the pile is effected under a load of 20 g/cm^2.

Electric charge voltage on a human body:

A sample to be tested is adjusted in temperature and humidity in air at 20°C and 30% RH for more than 48 hours and then a human body walks on the sample more than 60 steps at a rate of 2 steps/sec, after which the electric charge voltage on the human body is determined while continuing the walking in the same manner as described above. The determined value varies with the walking but the average value is determined.

Example 1 (Preparation of filaments)

Using nylon-6having an intrinsic viscosity of 1.14 measured at 30°C in m-cresol and polyethylene terephthalate (abbreviated as PET hereinafter) having an intrinsic viscosity of 0.64 measured at 30°C in o-chlorophenol, various composite filaments were prepared as follows.

The molten nylon-6 and molten PET were separately pumped into a spinneret maintained at 280°C and joined in a side-by-side relation in various conjugate ratios as shown in the following Table 2, and then extruded through a circular or cross orifice of the spinneret. The resulting undrawn filaments were cooled and wound at a take-up velocity of 300 m/min while applying various oil compositions of different water content as shown in the following Table 1 by means of two step oiling rollers. In this case, the number of rotations of the oiling rollers was adjusted in such a manner that the amount of the oil composition adhered on the undrawn filament is 0.5 – 1.5% by weight in the first oiling step and 0.3 – 1.2% by weight in the second oiling step. The results of the thus obtained undrawn filaments are shown in the following Table 2. As seen from the results of Table 2, the operation was impossible when only the nonaqueous oil composition was applied on the filament.

Then, the undrawn filaments shown in Table 2 were drawn by contacting with a hot roller and a hot plate (length: 400 mm) at various setting temperatures as shown in the following Table 3 to obtain drawn composite filaments of 900 d/30 f. The drawing ratio was 3.75 – 3.82 times. The drawing treatment was not effected with respect to the undrawn filaments No. 1, 2, 5, 6 and 8 of Table 2.

The following Table 3 shows a number of the thus obtained drawn filament, the number of the undrawn filament, the temperature of the hot roller, the temperature of the hot plate, spontaneous crimp percentage, and split percentage and shrinkage difference in the heated water treatment. From the results of Table 3, it can be seen that the drawing of filaments cannot be satisfactorily effected, when the oil compositions are applied in the manner other than the present invention.

Table 1

Oil composition No.	Class	Lubricating oil (%)	Non-ionic surface active agent (%)	Anti-static agent (%)	Kerosene (%)	Water (%)
1	non-aqueous	30	17.5	2.5	45	5
2	″	30	17.5	2.5	40	10
3	″	25	19	3	39	14
4	other	20	15	2	40	23
5	″	18	10	2	38	32
6	aqueous	18	13	2	22	45
7	″	18	13	2	7	60
8	″	10	7	2	0	81

Table 2

Undrawn filament No.	Shape of cross section	Conjugate ratio (nylon-6/PET)	Oil composition No. at first roller	Oil composition No. at second roller	Winding operation
1	FIG. 1	1/1	1	not applied	A
2	″	″	1	5	″
3	″	″	1	6	good
4	″	″	1	8	″
5	″	″	2	2	A
6	″	″	2	4	″
7	″	″	2	7	good
8	″	″	3	4	A
9	″	″	3	6	good
10	″	″	4	7	″
11	″	″	7	not applied	″
12	FIG. 2	1/4	1	8	″
13	″	1/3	1	8	″
14	″	1/1	1	8	″
15	″	2/1	1	8	″
16	″	3/1	1	8	″
17	″	4/1	1	8	″

A: Wound filament is disturbed and the taking up on a bobbin is impossible.

Table 3

Drawn filament No.	Undrawn filament No.	Temperature for drawing setting °C: Hot roller	Hot plate	Spontaneous crimp percentage (%)	Heated water treatment measurement: Split percentage (%)	Shrinkage difference (%)
3-1	3	85	120	55	100	7
4-1	4	″	″	70	100	7
7-1	7	″	″	58	100	6
9-1	9	″	″	57	100	6
10-1	10	″	″	The filament is split into two components under undrawn condition, and loose filament is formed and drawing is impossible		
11-1	11	″	″			
12-1	12	″	″	30	80	6
13-1	13	″	″	43	90	4
14-1	14	″	″	75	100	6
15-1	15	″	″	72	100	7
16-1	16	″	″	61	90	7
17-1	17	″	″	38	70	7
15-2	15	80	not set	78	100	2

Table 3-continued

Drawn filament No.	Undrawn filament No.	Temperature for drawing setting °C		Spontaneous crimp percentage (%)	Heated water treatment measurement	
		Hot roller	Hot plate		Split percentage (%)	Shrinkage difference (%)
15-3	15	85	180	53	80	13
15-4	15	85	160	61	90	10
15-5	15	100	not set	66	80	8
15-6	15	135	not set	59	60	8

EXAMPLE 2

The drawn filaments shown in Table 3 were wound up in the form of a muff (1 Kg winding), respectively. As soon as this muff was relaxed in air, the filament shrunk to develop spontaneous crimps. The muffs were charged in a filling density of 300 g/l into Over-maier dyeing machine of 30 capacity and warm water of 50°C was filled therein and thereafter the temperature was raised up to 80°C in 30 minutes. Then, the muffs were heated at 80°C for 30 minutes and allowed to cool and taken out from the dyeing machine. Next, the thus treated muffs were dehydrated by a centrifuge and dried (at 115°C0 to obtain crimped filaments composed of fibril monofilaments. The number of crimps per 1 inch of the crimped fibril monofilament was measured to obtain a result as shown in the following Table 4. In this case, the number of crimps was measured according to JIS-L-1074-1935.

Table 4

Crimped filament No.	Drawn filament No.	Spontaneous crimp percentage (%)	Number of crimps
3-1	3-1	55	8.8
4-1	4-1	70	10.7
7-1	7-1	58	8.9
9-1	9-1	57	8.7
12-1	12-1	30	4.6
13-1	13-1	43	7.9
14-1	14-1	75	11.0
15-1	15-1	72	10.5
16-1	16-1	61	10.1
17-1	17-1	38	5.1
15-2	15-2	78	11.3
15-3	15-3	53	8.4
15-4	15-4	61	9.8
15-5	15-5	66	10.3
15-6	15-6	59	9.2

From the results of Table 4, it can be seen that good crimped filaments are obtained when the spontaneous crimp percentage is more than 40%.

EXAMPLE 3

Each of the drawn filaments used in Example 2 was subjected to scouring and dyeing in the Over-maier dyeing machine according to the following recipes to obtain beautiful dyed filaments wherein PET fibril monofilament was dyed in yellow and nylon-6 fibril monofilament was dyed in red.

The number of crimps of the dyed filaments was substantially equal to that of Example 2.

1. Scouring

Scouring bath:	soap content 1 g/l, soda ash 1 g/l, sodium tripolyphosphate 2 g/l
Bath ratio:	1 : 100
Temperature condition:	The bath temperature was raised from 40 to 80°C in 30 minutes and the scouring was effected at 80°C for 20 minutes.

2. Dyeing

Acid dye (red)	2% owf
Disperse dye (yellow)	3% owf
Carrier	3 g/l
Bath ratio:	1 : 100
Temperature condition:	The bath temperature was raised from 40 to 98°C in 30 minutes and the dyeing was effected at 98°C for 60 minutes.

3. Reduction cleaning

Sodium hydroxide	1 g/l
Hydrosulfide	1 g/l
Activator	0.5 g/l
Temperature condition:	80°C, 20 minutes

The thus obtained four dyed filaments were doubled while each of the filaments was twisted in a S direction at 60 T/M, and then tufted into a carpet under the following conditions.

Gauge 5/32 inch,	Stitch 8/inch,
Length of pile 5 mm	

The appearance, impact resistance and electric charge voltage on human body of the thus obtained carpet were observed and measured to obtain results as shown in the following Table 5.

Table 5

Carpet No.	Drawn filament No.	Conjugate ratio (nylon-6/PET)	Appearance	Impact resistance (%, 1000 times)	Electric charge on human body (KV)
3-1	3-1	1/1	uniform, high bulkiness	65	2.3
4-1	4-1	"	uniform, very high bulkiness	71	1.9
7-1	7-1	"	uniform, high	68	2.5

Table 5-continued

Carpet No.	Drawn filament No.	Conjugate ratio (nylon-6/PET)	Appearance	Impact resistance (%, 1000 times)	Electric charge on human body (KV)
			bulkiness		
9-1	9-1	"	uniform, high bulkiness	67	2.1
12-1	12-1	1/4	uniform, poor bulkiness, substrate is seen	52	5.0
13-1	13-1	1/3	uniform, high bulkiness	65	2.8
14-1	14-1	1/1	uniform, very high bulkiness	73	1.7
15-1	15-1	2/1	uniform, very high bulkiness	78	1.9
16-1	16-1	3/1	uniform, very high bulkiness	74	2.5
17-1	17-1	4/1	uniform, poor bulkiness, substrate is seen	56	4.8
15-2	15-2	2/1	uniform, high bulkiness	77	1.5
15-3	15-3	"	some unevenness in pile, high bulkiness	76	3.5
15-4	15-4	"	uniform, very high bulkiness	79	2.6
15-5	15-5	"	uniform, very high bulkiness	78	1.9
15-6	15-6	"	uneveness in pile	71	2.0

The tufting operation was stable except the case of the drawn filament No. 15-3. In case of the filament No. 15-3, the operation was frequently stopped, because the dyed filament twined around the guide and needle, so that it should be adjusted.

It is generally said that the shock due to discharge of static electricity accumulated in human body takes place when the electric charge exceeds 3 KV. The carpet composed only of nylon shows a value of more than 10 KV when the electric charge on human body is measured according to the method of the present invention. Therefore, it is obvious from the results of Table 5 that the electric charge of the carpet obtained by the present invention is considerably low as compared with that of the carpet composed only of nylon and the discharge shock is not caused.

On the other hand, the carpets No. 12-1 and 17-1 beyond the scope of the present invention are lower in electric charge than the carpet composed only of nylon, but are insufficient to prevent the discharge shock. Furthermore, these carpets are poor in the appearance and impact resistance.

EXAMPLE 4

The drawn filament No. 15-1 of Example 1 was wound in the form of a muff in the same manner as described in Example 2 and charged in a filling density as shown in the following Table **6** into an Over-maier dyeing machine and then dyed in the substantially same manner as described in Example 3 to obtain a dyed crimped filament. The number of crimps of the thus obtained crimped filament is also shown in Tbale 6.

Table 6

Crimped filament No.	Filling density (g/l)	Number of crimps
15-7	390	10.8
15-8	380	10.6
15-9	330	10.5
15-10	280	10.2
15-11	210	9.0
15-12	150	7.8
15-13	135	4.3

From the results of Table 6, it can be seen that when the filling density is less than 150 g/l, the number of crimps becomes considerably small so that the filling density is necessary to be more than 150 g/l.

Then, each of the crimped filaments No. 15-7 to 15-13 was tufted into a carpet in the same manner as described in Example 3. The appearance, impact resistance and electric charge voltage on human body of the thus obtained carpets were observed and measured to obtain results as shown in the following Table 7.

Table 7

Carpet No.	Crimped filament No.	Filling density (g/l)	Appearance	Impact resistance (%, 100 times)	Electric charge on human body (KV)
15-7	15-7	390	noticeable streaks, high bulkiness	68	2.1
15-8	15-8	380	uniform, high bulkiness	70	2.3
15-9	15-9	330	uniform, very high bulkiness	75	1.9
15-10	15-10	280	uniform, very high bulkiness	78	1.8
15-11	15-11	210	uniform, very	76	2.0

Table 7-continued

Carpet No.	Crimped filament No.	Filling density (g/l)	Appearance	Impact resistance (%, 100 times)	Electric charge on human body (KV)
			high bulkiness		
15-12	15-12	150	uniform, high bulkiness	69	2.4
15-13	15-13	135	low bulkiness, substrate is seen, poor	59	3.3

When the filling density of the crimped filament is more than 380 g/l in the dyeing, noticeable streaks appears in the obtained carpet, which is considered due to the dyeing uneveness and the crimping unevenness, and also the appearance is poor. When the filling density ranges in 150 – 380 g/l, good carpets can be obtained.

EXAMPLE 5

The drawn filament No. 15-1 of Example 1 was knitted into a cylindrical knitted goods by means of a cylinder needle machine having a cylinder diameter of 3½ inch and 40 needles. The resulting cylindrical knitted goods, as soon as relaxed, shrunk to develop spontaneous crimps. Then, the cylindrical knitted goods was charged in a filling density as shown in the following Table 8 into an Over-maier dyeing machine and dyed in the same manner as described in Example 3 and then dried and deknitted to obtain the dyed crimped filament. The number of crimps of the crimped filament is also shown in Table 8.

Table 8

Crimped filament No.	Filling density (g/l)	Number of crimps
15-14	390	11.8
15-16	380	11.7
15-17	300	11.9
15-18	150	8.2
15-19	135	4.6

From the results of Table 8, it can be seen that when the filling density is less than 150 g/l, the number of crimps becomes considerably small, so that the filling density is necessary to be more than 150 g/l.

The crimped filaments No. 15-14 to 15-19, respectively, were tufted into a carpet in the same manner as described in example 3. The appearance, impact resistance and electric charge voltage on human body of the thus obtained carpets were observed and measured to obtain results as shown in the following Table 9.

Table 9

Carpet No.	Crimped filament No.	Filling density (g/l)	Appearance	Impact resistance (%, 100 times)	Electric charge on human body (KV)
15-14	15-14	390	noticeable streaks, high bulkiness	65	2.5
15-16	15-16	380	uniform, high bulkiness	71	2.3
15-17	15-17	300	uniform, very high bulkiness	75	1.9
15-18	15-18	150	uniform, high bulkiness	68	2.1
15-19	15-19	135	low bulkiness, substrate is seen, poor	53	3.2

When the filling density is more than 380 g/l in the dyeing, noticeable streaks appears in the obtained carpet, which is considered due to the dyeing unevenness and the crimping unevenness, and the appearance is poor. When the filling density ranges in 150 – 380 g/l, good carpets can be obtained.

COMPARATIVE EXAMPLE 1

The drawn filament No. 15-1 of Example 1 was wound on a perforated bobbin (made of stainless steel) having a diameter of 100 mm (1 Kg winding) and dyed under the same conditions as described in Example 3 except that the dyeing solution was jetted through holes of the perforated bobbin. The thus dyed filament had a number of crimps of 2.6.

The dyed filament was tufted into a carpet in the same manner as described in Example 3. However, the substrate was seen because the fibril monofilaments constituting the pile were uniformly directed, and further the bulkiness and appearance were poor.

In order to improve surface covering property and not to see the substrate, it is necessary to tuft double yarns of five filaments into carpet.

FIG. **14** is a photograph showing the surface of the thus obtained carpet not following to the method of the present invention, while FIG. **12** is a photograph showing the surface of the carpet No. 15-1 of Example 3 according to the present invention. When both the carpets are compared with each other, the fibril monofilaments constituting pile in the carpet of the present invention (FIG. **12**) have satisfactory crimps and are entangled to each other, while in the carpet obtained by the method not following to the present invention (FIG. **14**) the fibril monofilaments are uniformly directed and are not satisfactorily entangled.

The impact resistance and electric charge voltage of the carpet shown in this comparative example (composed of double yarns of five filaments) were 58% and

4.9 KV, respectively, which are considerably inferior to the carpet according to the present invention.

From this result it can be seen that unless the filaments are treated in a relaxed package in which the filaments are wound so that they can freely shrink, a good carpet can not be obtained.

COMPARATIVE EXAMPLE 2

The filament No. 15-1 of Example 1 was wound in the form of a muff in the same manner as described in example 2. The resulting muffs were charged into an Over-maier dyeing machine and hot water was poured therein so as to develop spontaneous crimps. After the hot water was poured, the temperature in the dyeing machine lowered to 70°C, and then was raised up to 95°C in 15 minutes while heating and maintained at 95°C for 30 minutes. Thereafter, the filament was allowed to cool, taken out from the dyeing machine, dehydrated by a centrifuge and dried to obtain a crimped filament. However, this crimped filament was not substantially split into two components and had considerably crimping unevenness and was poor.

EXAMPLE 6

The four filaments of each filament Nos. 12-1, 13-1, 14-1, 15-1, 16-1 and 17-1 were twisted in a S direction at 60 T/M to obtain twisted filaments of 3600 d/120 f, and the thus twisted filaments were tufted under the following conditions to obtain a white carpet. In the carpet, the filaments developed spontaneous crimps.

Gauge 5/32 inch, Length of pile 6 mm	Stitch 9/inch,

The obtained carpet was moved just under a steam jet apparatus in which three jetting devices as shown in FIG. 7 are provided in parallel at a rate of 1 m/min as shown in FIG. 9 to effect a steam jet treatment.

The diameter of tube of the steam jetting device was 20 mm, the diameter of the get nozzle was 2 mm and the nozzles were arranged in zigazg at a distance of 5 mm. The steam pressure was 3.5 Kg/cm^2 and the height of the jet nozzle was set so as to contact with the pile (d=0). During the steam jet treatment, the surface temperature of the pile was 99°C.

After the steam jet treatment, each carpet was dyed by means of a Wince dyeing machine under the substantially same conditions as described in Example 3.

The following Table 10 shows the number of the dyed carpet, appearance, impact resistance and electric charge voltage on human body.

Table 10

Carpet No.	Drawn filament No.	Conjugate ratio (nylon-6/ PET)	Appearance	Impact resistance (%, 1000 times)	Electric charge on human body (KV)
12-2	12-1	1/4	low bulkiness, poor	55	4.7
13-2	13-1	1/3	split two components are satisfactorily entangled, high bulkiness	64	2.7
14-2	14-1	1/1	split two components are satisfactorily entangled, very high bulkiness	71	1.8
15-20	15-1	2/1	split two components are satisfactorily entangled, very high bulkiness	81	2.3
16-2	16-1	3/1	split two components are satisfactorily entangled, high bulkiness	69	2.7
17-2	17-1	4/1	poor bulkiness	59	4.1

From the results of Table 10, it can be seen that good carpets are obtained by the method of the present invention. When the conjugate ratio (nylon-6/PET) is out of the range of the present invention, i.e., 1/4 or 4/1, only carpets having poor bulkiness, low impact resistance and high electric charge are obained.

COMPARATIVE EXAMPLE 3

Three carpets No. 15-21, 15-22 and 15-23 were provided, i.e., the carpet 15–21 obtained by dyeing the white carpet composed of the filament No. 15-1 of Example 6 in the same manner as described in Example 6 without subjecting to a steam jet treatment, the carpet 15–22 obtained by heating the same white carpet in a steam atmosphere at 100°C for 1 minute and then dyeing it as described above, and the carpet 15–23 obtained by immersing the same white carpet in hot water at 95°C for 1 minute and then dyeing it as described above. Then, the appearance, impact resistance and electric charge voltage of three carpets were measured.

In any case, the appearance was poor and the bulkiness was low. Furthermore, the impact resistance was 56 – 60% and the electric charge voltage was 4.3 – 5.1 KV.

FIG. **15** is a photograph showing the surface of the carpet No. 15–22 beyond the scope of the present invention, while FIG. **13** is a photograph showing the surface of the carpet No. 15–20 of Example 6 according to the present invention. In FIG. **15**, the fibril monofilaments constituting the pile were uniformly directed and are not fully entangled. In FIG. **13**, the fibril monofilaments constituting the pile had crimps and were satisfactorily entangled to each other.

What is claimed is:

1. A method of producing a pile fabric, which comprises the steps of:
1. conjugate spinning a fiber-forming polyamide and a fiber-forming polyester in side-by-side relation at a conjugation ratio of from 1/3 to 3/1 to form bicomponent filaments;
2. applying to the bicompoment filaments of step 1 after they exit from the spinneret, first
a. from 0.5 to 2.0 wt. % of a spinning oil composition containing less than 10 wt. % of water, and then
b. from 0.3 to 1.5 wt. % of a spinning oil composition containing more than 40 wt. % of water;
the foregoing steps 2(a) and 2(b) being carried out without drawing the filaments;
3. drawing the bicomponent filaments of step (2) at a temperature of from 70° to 130°C, and then taking up the bicomponent filaments on a bobbin, the filaments at this time being substantially unsplit and uncrimped and possessing the inherent properties of a spontaneous crimp percentage of more than 40%, a split percentage of more than 70% and a shrinkage difference of from 2 to 12%;
4. unwinding the filaments from the bobbin, and permitting the filaments to relax in air to develop spontaneous crimps in the filaments;
5. placing the crimped filaments in a vessel at a filling density of from 150 to 380 grams of filament per liter of vessel volume, and therein immersing the crimped filaments in water having a temperature of less than 50°C and then raising the temperature of the water to more than 80°C to set the crimps and simultaneously to split the components of the filaments; and
6. forming the split filaments of step (5) into a pile fabric.

2. A method as claimed in claim 1, in which in step (4) after the filaments are unwound from the bobbin, they are wound in a relaxed package and the filaments in the relaxed package are permitted to relax in air to develop spontaneous crimps and, in step (5), the relaxed package is placed in the vessel and is immersed in water.

3. A method as claimed in claim 1, in which the pile fabric is a carpet and the filaments in the carpet have a denier of from 10 to 50.

4. A method for producing a pile fabric, which comprises the steps of:
1. conjugate spinning a fiber-forming polyamide and a fiber-forming polyester in side-by-side relation at a conjugation ratio of from 1/3 to 3/1 to form bicomponent filaments;
2. applying to the bicomponent filaments of step (1) after they exit from the spinneret, first
a. from 0.5 to 2.0 wt. % of a spinning oil composition containing less than 10 wt. % of water, and then
b. from 0.3 to 1.5 wt. % of a spinning oil composition containing more than 40 wt. % of water;
3. drawing the bicomponent filaments of step (2) at a temperature of from 70° to 130°C, and then taking up the foregoing steps 2(a) and 2(b) being carried out without drawing the filaments; the bicomponent filaments on a bobbin, the filaments at this time being substantially unsplit and un-crimped and possessing the inherent properties of a spontaneous crimp percentage of more than 40%, a split percentage of more than 70% and a shrinkage difference of from 2 to 12%;
4. forming the filaments of step (4) into a pile fabric;
5. permitting said pile fabric to stand in air to develop spontaneous crimps in the filaments in the pile fabric;
6. contacting the pile fabric with steam jets directed against the pile surface so as to strongly compress the pile and to set the spontaneous crimps in the filaments; and
7. immersing the pile fabric of step (6) in water having a temperature of less than 50°C and then raising the temperature of the water to more than 80°C to split the components of the filaments.

5. A method as claimed in claim 4, in which the pile fabric is a carpet and the filaments in the carpet have a denier of 10 to 50.

6. The method as claimed in claim 1, wherein said conjugate ratio of the polyamide to the polyester is 5/3 – 5/2.

7. The method as claimed in claim 1, wherein the filling density in step (5), is 200 – 350 g/l.

8. The method as claimed in claim 1, wherein said spontaneous crimp percentage is 60 to 95%.

9. The method as claimed in claim 1, wherein in step (5), the heated water treatment is effected as part of scouring or dyeing steps.

10. The method as claimed in claim 1, wherein the crimp developed filaments are immersed in water at a temperature of lower than 40°C and the temperature is raised to higher than 90°c and said temperature is maintained for more than 30 minutes.

11. the method as claimed in claim 1, wherein said non-aqueous oil composition comprises a lubricating oil together with surface active agent and an antistatic agent diluted with an organic solvent and containing less than 10% of water.

12. The method as claimed in claim 1, wherein said aqueous oil composition is a lubricating oil together with a surface active agent and an antistatic agent dissolved or emulsified in water and containing 50 to 90% of water.

13. The method as claimed in claim 1, wherein the total amount of the two oil compositions applied on the filaments is 0.8 to 2.5% by weight.

14. The method as claimed in claim 4, wherein said conjugate ratio of the polyamide to the polyester is 5/3 – 5/2.

15. The method as claimed in claim 4, wherein said spontaneous crimp percentage is 60 – 95%.

16. The method as claimed in claim 4, wherein in step (7), the heated water treatment is effected as part of scouring or dyeing steps.

17. The method as claimed in claim 4, wherein in step (7), the pile fabric is immersed in water at a temperature of lower than 40°C and the temperature is raised to higher than 90°C and said temperature is maintained for more than 30 minutes.

18. The method as claimed in claim 4, wherein said non-aqueous oil composition comprises a lubricating oil together with a surface active agent and an antistatic agent diluted with an organic solvent and containing less than 10% of water.

19. The method as claimed in claim 4, wherin said aqueous oil composition is a lubricating oil together with a surface active agent and an antistatic agent dissolved or emulsified in water and containing 50 to 90% of water.

20. The method as claimed in claim **4,** wherein the total amount of the two oil compositions applied on the filaments is 0.8 to 2.5% by weight.

21. The method as claimed in claim **4,** wherein the steam is jetted on the pile fabric from a distance of less than 1 cm.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3 917 784 Dated November 4, 1975

Inventor(s) Takeshi Nishida

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 23, line 1; change "of" to ---for---.

Col. 23, line 60; after "water;" insert ---the foregoing steps 2(a) and 2(b) being carried out without drawing the filaments;---.

Col. 23, lines 63 and 64; delete "the foregoing steps 2(a) and 2(b) being carried out without drawing the filaments;".

Col. 23, line 65; change "ment" to ---nent---.

Col. 24, line 28; change "wherein" to ---wherein in step (5)---.

Col. 24, line 31; change "90°c" to ---90°C---.

Col. 24, line 35; change "with" to ---with a---.

Col. 24, line 64; change "wherin" to ---wherein---.

Signed and Sealed this

twenty-third Day of *March 1976*

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks