United States Patent

[11] 3,607,611

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[33] Japan
[31] 43/73752, 42/82250 and 42/82257

[54] COMPOSITE FILAMENT HAVING CRIMPABILITY AND LATENT ADHESIVITY

22 Claims, 36 Drawing Figs.

[52] U.S. Cl. 161/173, 161/177
[51] Int. Cl. D02g 3/00
[50] Field of Search .... 161/177, 173; 264/171–174; 18/8 SC

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Primary Examiner—Jay H. Woo
Attorney—Stevens, Davis, Miller and Mosher

ABSTRACT: A composite filament suitable for manufacturing ladies' stockings having a crimpability comprising at least two fiber-forming components differing in shrinkability, which has such a particular cross section that one component is interposed into the other component, for example, in a wedge-shape and occupies only 5 to 30 percent of the peripheral surface of the filament, is manufactured by flowing two independent same or different spinning materials in opposite directions to each other in two ducts each connecting to a common conduit and combining them and interposing a thin layerlike flow of another spinning material different from the above-described spinning materials between the two spinning material flows at the combined portion in the above-described particular cross-sectional shape and then extruding the thus combined spinning materials through the conduit from a common orifice.

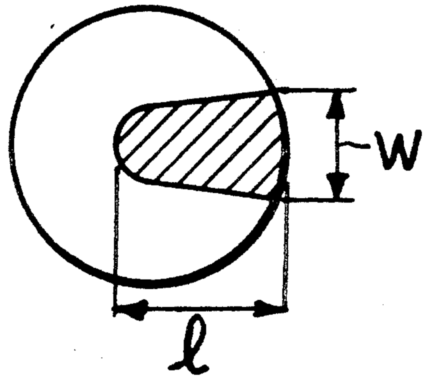


Fig. 1

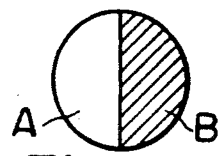


Fig. 2

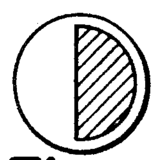


Fig. 3

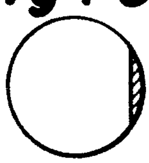


Fig. 4

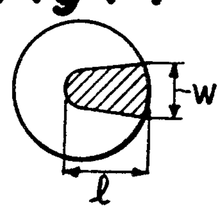


Fig. 5

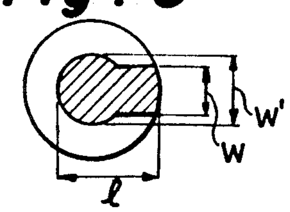


Fig. 6

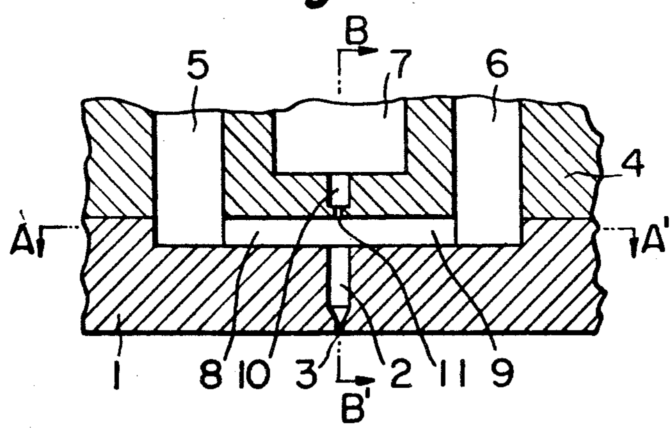


Fig. 12

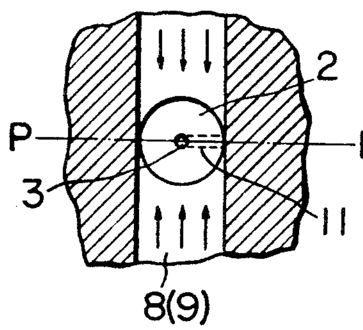


Fig. 8

Fig. 7

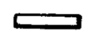


Fig. 9

Fig. 10

Fig. 11

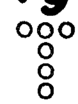


Fig. 13

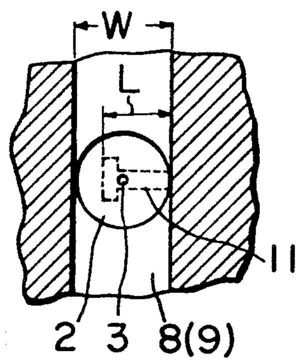
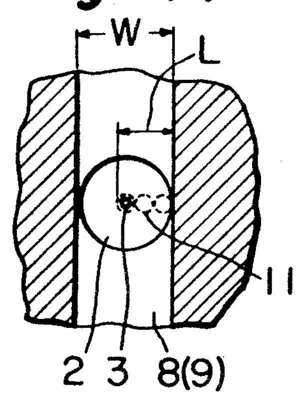


Fig. 14



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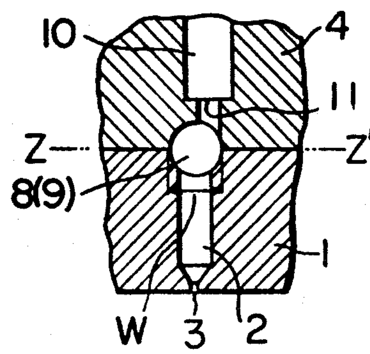

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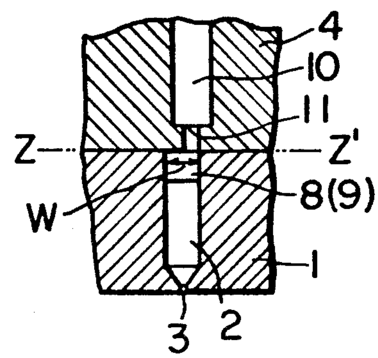
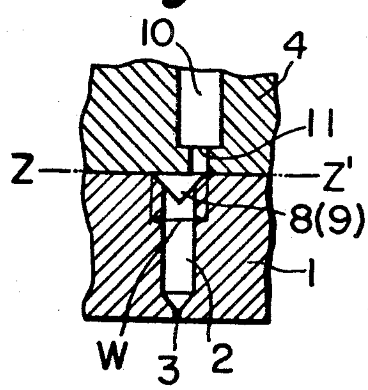


Fig. 17



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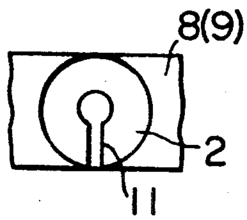

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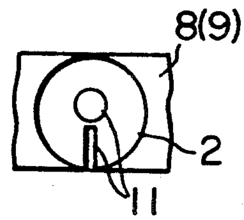

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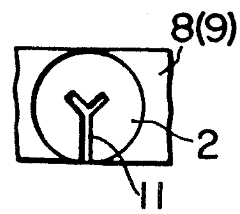

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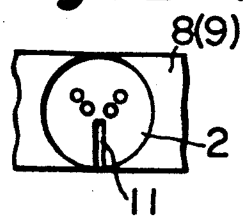

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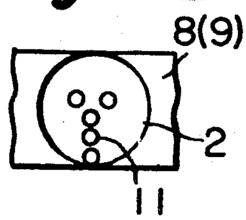

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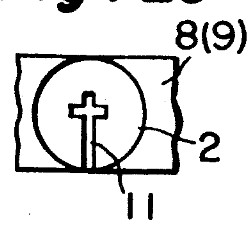

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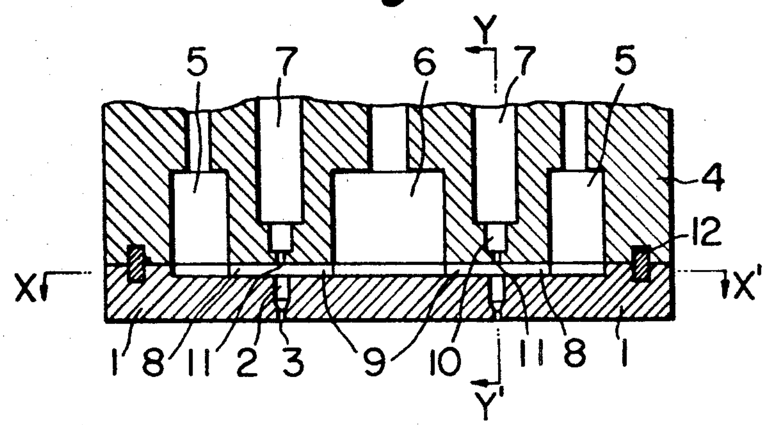

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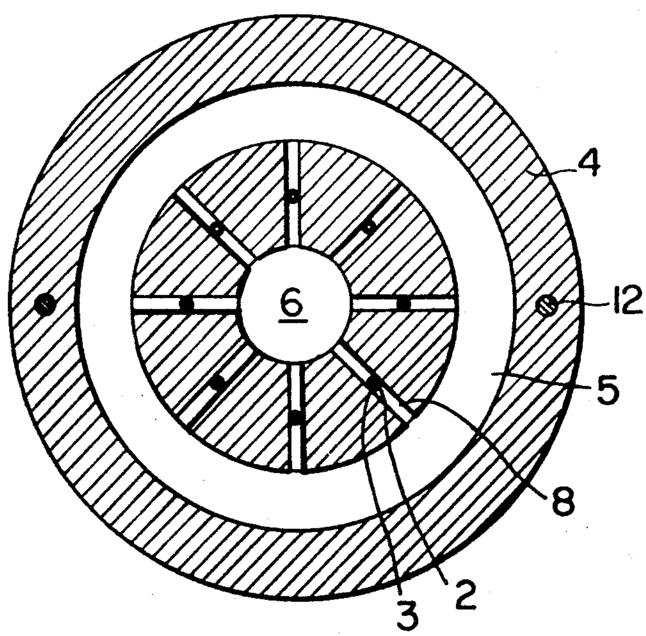

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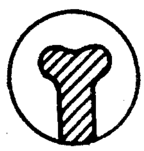

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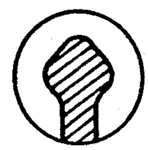

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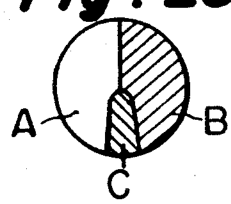

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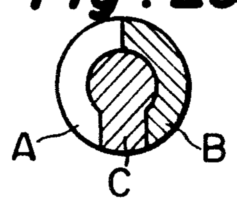

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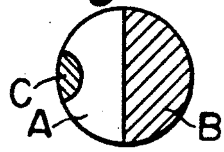

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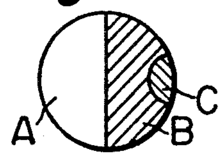

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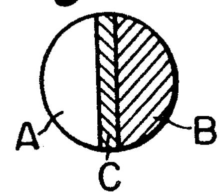

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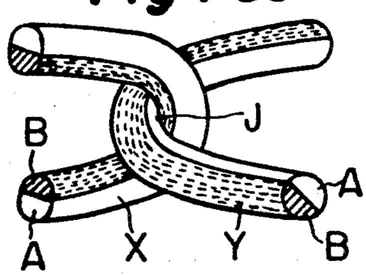

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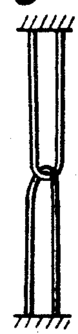
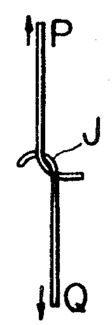


Fig. 35



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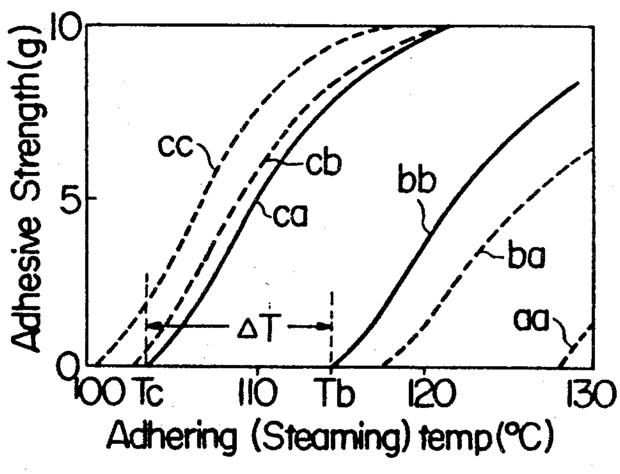

COMPOSITE FILAMENT HAVING CRIMPABILITY AND LATENT ADHESIVITY

The present invention relates to composite filaments wherein at least two thermoplastic linear polymers are uniformly bonded along the longitudinal direction of the unitary filament and the method and apparatus for producing thereof.

It has been well known that composite filaments, in which a plurality of fiber-forming components consisting of thermoplastic synthetic linear polymers and having different heat shrinkabilities and swelling properties are eccentrically bonded extending along the longitudinal direction of the unitary filament uniformly, have latent crimps, which are developed by a heat or swelling treatment, and further such composite filaments are useful for the production of stretchable knit goods, especially sheer circular knit goods (e.g. ladies' stockings). Moreover, the Japanese Pat. application No. 32,738/64 by the inventors and in U.S. Pat. No. 3,286,490 by B. E. Martin have already disclosed that self-bonding composite filaments, one component of which is a polymer having a selective sensitivity against tack-inducing agents, such as heat and a reagent (This polymer being referred to as a latent adhesive component hereinafter.) are formed into fibrous structures, such as knit wear, nonwoven fabrics, substrate for synthetic leather, etc., and the filament crossover contacts in the resulting structure are bonded with the tack-inducing agent to stabilize the configuration of the structure.

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

FIGS. 1–3 are cross-sectional views of conventional two-component composite filaments respectively;

FIGS. 4 and 5 are cross-sectional views of two-component composite filaments according to the invention;

FIG. 6 is a vertical sectional view of one embodiment of a spinneret according to the invention;

FIGS. 7–11 are diagrammatic views for showing shapes of apertures;

FIGS. 12–14 are diagrammatic views for showing relative positions between the aperture and the conduit respectively;

FIGS. 15 and 16 are diagrammatic views for showing various shapes of the ducts respectively;

FIGS. 18–23 are diagrammatic views for showing modified shapes of apertures respectively;

FIG. 24 is a vertical sectional view of a spinneret according to the invention;

FIG. 25 is a cross-sectional view the spinneret shown in FIG. 24 taken on line X—X';

FIGS. 26 and 27 are cross-sectional views of two-component composite filaments according to the invention respectively;

FIGS. 28 and 29 are cross-sectional views of three-component composite filaments according to the invention respectively;

FIGS. 30–32 are cross-sectional views of conventional three-component composite filaments respectively;

FIG. 33 is a diagrammatic view illustrating a contact point of filaments;

FIGS. 34 and 35 are diagrammatic views for showing a method for the determination of adhesive strength between filaments; and

FIG. 36 is a graph for showing a relation between adhering temperature and adhesive strength.

First of all, in order to manufacture uniform sheer circular knit goods having beautiful appearance, particularly ladies' stockings with the use of composite filaments, it is required that filaments have proper difference in the crimpability and dyeability between leg portion and welt, heel and toe portions, because the knitting system of the leg portion is different from that of the welt, heel and toe portions. That is, when two-component filaments having a cross section as shown in FIG. 1 in which two polymers having different dyeabilities (e.g. hompolyamide and copolyamide) are arranged in the same conjugate ratio in a side-by-side relation, are knitted into ladies' stocking, for example when multifilaments of 40–50d/6–15f are used in welt portion and monofilaments of 10–30 deniers are used in leg portion, the width of welt (shape under tensionless state) in the resulting stockings is often smaller than the leg portion due to the fact that denier of single filaments constituting the multifilament in the welt is smaller and the stitch in the welt is coarser, so that the appearance of the stockings is often poor. In order to improve such an unbalanced shape of stockings, it is necessary to use two-component filament having reduced crimpability in the welt.

According to one of the conventional methods, eccentric sheath-core relation two-component filaments having a kidney-shaped core as shown in FIG. 2 (disclosed, for example, in the Belgian Patent No. 621,472 specification) are used in the welt. However, in these filaments, one component covers the surface of the filament, so that when the two components are different in the dyeability (generally, two components having different shrinkabilities are more or less different in the dyeability), if side-by-side relation two component filaments composed of the same components with those used in the welt yarn are used in the leg, the dyeability of the welt is considerably different from that of the leg.

Generally speaking, even when filaments composed of the same polymers are used in the welt portion and in the leg portion, the color of the welt portion is apt to be light. This is due to the difference in the reflection of light between monofilament and multifilament. Therefore, it is most desirable that the dyeability of filaments for welt is somewhat higher than that of filaments for leg. That is to say, it is necessary that the dyeability of composite filaments for welt is moderately higher than that of composite filaments for leg and that the crimpability is properly reduced.

Second, in order to manufacture acceptable run-resisting fabrics by using the above-described self-bonding composite filaments, a limited amount of the filament crossovers should be bonded in the fabrics and if the bonded crossovers are too many, the fabrics are not adequate because of poor stretch conformability or fit. Accordingly, in order to accomplish the required bonds, the latent adhesive component should occupy a limited area of the periphery of the filament. Namely, even the filament as shown in FIG. 1, wherein latent adhesive component occupies about 50 percent of the periphery of the filament, gives too much bonding to the fabric and the above-described defect appears and further uneven crimps are developed and the surface of fabric is not uniform.

For the purpose of obviating such defects, if it is intended to spin filaments, in which the amount ratio of the latent adhesive component in the composite filament is decreased and the ratio of said component occupying on the surface of filament is decreased, for example two-component filament having a cross section as shown in FIG. 3 the amount ratio of both the component is too different and it is difficult to effect the spinning smoothly and the ratio of surface area varies highly by a slight variation of extrusion ratio of two components, so that it is difficult to obtain filaments having an excellent uniformity. Accordingly, it is very desirable to obtain self-bonding two-component filaments having a reduced latent adhesivity, wherein the amount ratio of two components occupying in filament, namely, each extrusion rate of two components is balanced to an acceptable extent and only the area ratio of latent adhesive component occupying the surface area of the filament is decreased.

The inventors have found that the above-mentioned two problems can be advantageously solved by novel two-component filaments having cross sections as shown in FIGS. 4 and 5, in which a polymer having a high dyeability or latent adhesivity is used in the hatched wedge-shaped or keyhole-shaped component, and the present invention has been accomplished.

Furthermore, self-bonding two component filaments having the above-mentioned cross section is reduced in both the latent adhesivity and the crimpability, but for highly stretchable ladies' stockings, filaments having both excellent crimpability and reduced latent adhesivity are often desired.

The inventors succeeded in satisfying the above-mentioned requirement by the use of three-component filaments having a novel structure, which consists of two components having different heat shrinkabilities for providing crimpability and the third component having a latent adhesivity, and accomplished this invention by defining a novel method and apparatus for producing these composite filaments.

The object of the invention is to provide a two-component filament having a reduced crimpability and a properly biased dyeability.

Another object of the invention is to provide a two-component filament having a crimpability and a reduced latent adhesivity.

Further object of the invention is to provide a three-component filament having an excellent crimpability and a reduced latent adhesivity together.

Another important object of the invention is to provide sheer circular knit goods, such as ladies' stockings having uniform appearance and even color in whole in spite of composing of at least two portions having different knitting systems.

Further an important object is to provide run-resisting knit wears and highly stretchable run-resisting knit wears.

These and other objects of the invention will be more apparent from the following description.

The above-mentioned objects can be firstly attained by spinning composite filaments with the use of a spinneret of the present invention having a novel structure.

That is, the spinneret according to the invention comprises a spinneret plate provided with at least one conduit and at least one orifice each connecting to the conduit, a distributing block superposed at the rear of the spinneret plate and provided with two side reservoirs and a central reservoir located between the side reservoirs; ducts lying along the abutting surface of the spinneret plate against the distributing block and connecting the two side reservoirs to an inlet of each conduit respectively; and a feed nozzle, one end of which opens to the central reservoir and the other end of which opens to the upper portion of the duct opposite to the conduit and traversing the longitudinal direction of the duct, the latter opening being an aperture having a length smaller than the width of the duct and being transmitted at one sidewall of the duct; said spinneret being provided with further means for supplying spinning materials into both the side reservoirs respectively; and means for supplying another spinning material into the central reservoir.

For a better understanding of the spinneret according to the invention, reference is taken to the accompanying drawings.

Referring to FIG. 6, a spinneret plate **1** provided with a conduit **2** and an orifice **3** connecting to the conduit **2** through a tapered portion. A distributing block **4** is superposed at the rear of the spinneret plate **1**. The distributing block **4** has two side reservoirs **5** and **6** and a central reservoir **7** located between the reservoirs **5** and **6**. Ducts **8** and **9** are arranged at the abutting surface of the spinneret plate **1** against the distributing block **4**, and they are connected to the side reservoirs **5** and **6** respectively and to the inlet of the conduit **2**. These two ducts **8** and **9** may be formed either in the upper surface of the spinneret plate **1**, in the lower surface of the distributing block **4**, or cross the both plates. Furthermore, the ducts **8** and **9** may be provided in a certain angle on the both side of the inlet of the conduit **2**, but most preferably they are substantially aligned.

The above-described central reservoir **7** is connected to a joined portion of the two ducts **8** and **9** through the feed nozzle **10**. Namely, one end of the feed nozzle **10** opens in the central reservoir **7** and the other end connects to the joined portion of the ducts through an aperture.

The shape and arrangement of the above-described aperture, which constitute an essential portion for the spinneret of the invention, will be explained in more details.

Firstly, according to the purpose, the aperture may be a single rectangular slit as shown in FIG. 7, or may be composed of a plurality of small holes aligned closely to one another as shown in FIG. 8, or may be a combination of these apertures. Alternatively, the aperture may be either a single keyhole-shaped slit, a T-shaped slit as shown in FIG. 9, a plurality of small holes having different diameters as shown in FIG. 10, or a plurality of small holes arranged in T-shape as shown in FIG. 11. In some case, the aperture may be a single small hole. However, in any case the length L of the aperture **11** should be smaller than the width W of the ducts **8** and **9** as shown in FIGS. 12–14. When the aperture **11** is composed of a plurality of small holes, the length L means a length between both ends of these small holes and the width W of the ducts **8** and **9** means a width of the ducts lying in the abutting surface of the spinneret plate **1** and the distributing block **4**.

Furthermore, the cross section of the ducts **8** and **9** may be circular, quadrilateral, triangular and any other shape, but in order to attain the object of the invention the width of the ducts **8** and **9** should be maximum at the abutting surface of the spinneret plate against the distributing block. Accordingly, in the present invention, the width W of the ducts **8** and **9** means the width of the ducts in the abutting surface. Embodiments of the cross-sectional shape and the width W of the ducts **8** and **9** are shown in FIGS. 15, 16 and 17, which represent circle, quadrilateral and triangle, respectively.

FIG. 12 shows a fundamental relative portion between these apertures and the conduit **2**. These apertures open in such a manner that the longitudinal direction of the opening traverses the ducts **8** and **9** and aligns with a joined line P—P' of these ducts, namely on a center line of the inlet of conduit **2**. As shown in FIGS. 15–17, one end of the total length of the aperture **11** makes contact with one end of the total width of the ducts **8** and **9** and consequently, as mentioned above, the length of the aperture is smaller than the width of the ducts, so that the other end of the aperture does not make contact with the other end of the width of the ducts.

The relative positions between various embodiments of the aperture having modified shapes and the conduit are further shown in FIGS. 18–23.

FIGS. 24 and 25 show a useful modified embodiment of the spinneret of this invention. In this embodiment, eight orifices **3** are arranged along a concentric circle having an axis located on the spinneret center on the spinneret plate. Furthermore, in the distributing block **4**, there are provided with an annular central reservoir **7** such that the reservoir corresponds to the annular arrangement of the orifices **3**, an annular side reservoir **5** surrounding the outside of the central reservoir **7** concentrically, and a side reservoir **6** located in the center portion of the spinneret.

In an abutting surface of the spinneret plate **1** against the distributing block **4**, ducts **8** and **9** extend radially which connect conduits **2** of the orifices to two side reservoirs **5** and **6** respectively. Pins **12** serve to adjust the relative position of the apertures **11** and the orifices **3**.

Next, a practical operation of spinning for attaining the object of the present invention will be explained with respect to the case where the spinneret according to the present invention is used.

In the spinneret shown in FIG. 6, when the side reservoirs **5** and **6** are charged with a melt spinning material A and the central reservoir **7** is charged with a different spinning material B, the spinning material A is passed from the reservoirs **5** and **6** into the ducts **8** and **9** respectively, and joined at the conduit **2** and then extruded through the orifice **3**. On the other hand, the spinning material B in the central reservoir **7** is extruded through the feed nozzle **10** and the aperture **11** into the flow of the above spinning material A in a form of a thin layer and joined with the spinning material A and then extruded through the orifice **3** to form a composite filament. In this case, since the one end of the aperture **11** is in contact with the one sidewall of the ducts **8** and **9** extending along the width thereof as mentioned above, the spinning material B is extruded in the form of thin layer on the abutting line of the two flows of the spinning material A such that one end of the spinning material B makes contact with one of the sidewalls of the ducts **8** and **9** and that the other end of the spinning material B does not make contact with the other sidewall of the ducts **8** and **9**. Thus, the spinning material B can occupy a part of the surface of the composite filament. The above-mentioned abutting line means a line where two flows of the spinning material A supplied from two side reservoirs **5** and **6** are considered to be abut together. The abutting line is in alignment with a line P—P′ where the above-mentioned two ducts **8** and **9** are communicated each other.

In the arrangement shown in FIG. **12**, a line P—P′ crossing perpendicularly to the ducts **8** and **9** and passing the center of the conduit **2** is called the abutting line.

The above-mentioned spinning material B corresponds to a wedge-shaped component of the composite filament as shown in FIG. 4 or a keyhole-shaped component of the composite filament as shown in FIG. **5**.

If the configuration of the aperture **11** is varied, it is possible to obtain a composite filament whose components are different in shape.

In order to obtain two-component composite filaments, one component of which forms a wedge-shape, as the aperture a plurality of closely aligned small holes as shown in FIG. **8** or a linear slit as shown in FIG. **7** are used. For the production of two-component composite filaments, one of which forms a keyhole-shape, apertures composed of keyhole-shaped slit as shown in FIGS. **18** and **19**, T-shaped slit as shown in FIG. **9**, a plurality of small holes having different diameters as shown in FIG. **10** or a plurality of small holes arranged in T-shape as shown in FIG. **11** are used. Similarly, the composite filament as shown in FIG. **26** can be obtained by using apertures composed of Y-shaped slit as shown in FIG. **20**, a plurality of small holes and a slit as shown in FIG. **21** or a plurality of small holes arranged in Y-shape closely as shown in FIG. **22**.

Furthermore, the composite filament as shown in FIG. **27** can be obtained by using a crossed slit as shown in FIG. **23** as the aperture.

Other variously modified apertures can be used depending upon the object.

As one embodiment of the composite filaments obtained in the present invention, ones having a circular cross section are shown in FIGS. 4 and 5, which can be obtained by using a circular orifice 3, but of course, it is possible to obtain composite filaments having various cross sections by varying the shape of the orifice.

Another important spinning process for attaining the object of the present invention consists in that to the two side reservoirs **5** and **6** of the above-described spinneret, for example, spinning materials A and B having different heat shrinkabilities, swelling properties and the like are fed separately, and a spinning material C which is different from both spinning materials A and B and has a selective sensitivity to a tack-inducing agent, such as heat or a reagent, is fed to the central reservoir **7**. The fundamental cross section of the three-component filament thus obtained is as shown in FIGS. **28** and **29** and the latent adhesive component C having the selective sensitivity to the tack-inducing agent interposes partially in a wedge-shape or keyhole-shape in the abutting surface of the two components A and B bonded in a side-by-side relation.

The above-mentioned characteristics of the spinning method of the present invention are as follows:

Namely, this spinning process comprises flowing two independent spinning materials in opposite directions to each other in two ducts each connecting to a common conduit and combining them and interposing a thin layerlike flow of another spinning material different from the above-mentioned spinning materials between the two spinning material flows at the combined portion in such a manner that the longitudinal direction of the cross section of the thin layer is perpendicular to the direction of the above-mentioned two opposite flows and that the thin layer is so shifted that one end of the layerlike flow is in contact with one sidewall of the above-mentioned duct, but the other end thereof is not in contact with the other sidewall of the duct and then extruding the thus combined spinning materials through the conduit from the orifice. When the above-mentioned independent flows are same, a two-component composite filament can be obtained, while when they are different, a three-component composite filament can be obtained. In this case, when a latent adhesive component is used as the thin layerlike flow, the two-component or the three-component filament having latent adhesivity can be obtained.

As seen from the above-described explanation, the composite filament obtained by the method of the present invention consists in a composite filament having a crimpability comprising at least two components differing in shrinkability which extend uniformly and continuously along the longitudinal axis, said components bonding directly to each other and occupying a part of the peripheral surface of the filament continuously, the smallest surface area occupied by one component being 5 to 30 percent, preferably 5 to 20 percent, of the total surface area of the filament.

In the cross section of such a filament, it is preferable that the above-described component occupying the minimum surface area is interposed in a wedge-shape into the other component as shown in FIG. **4** or in a keyhole-shape into the other component as shown in FIG. **5**.

The term "wedge-shape" used herein means one in which as shown in FIG. 4, $l \geqq w$ and w is the maximum value of the width of the wedge and the term "keyhole-shape" means one in which as shown in FIG. 5, $l \geqq w' > w$.

If in two-component filament having such a cross section that one component is interposed into and bonded with the other component, the component which is not the wedge-shaped component as shown in FIG. **4** or the component which is not the keyhole-shaped component as shown in FIG. **5** has a higher dyeability, composite filament having a reduced crimpability and a dyeability biased property to a higher dyeability can be obtained. Such a bonding configuration is useful for two-component composite filament having self-adhesivity and it is possible to reduce surface area of the adhesive component without biasing the conjugate ratio (volume ratio) of two component extremely. Such a two-component filament is useful for yarn for producing sheer circular knit fabric, particularly, welt, toe and heel portions of ladies' stockings.

Moreover, a desirable structure of the filament of this invention is composed of three-components.

The present invention consists in a three-component filament having crimpability and latent adhesivity, which consists of two components A and B having different shrinkabilities and another component C having a latent adhesivity against said two components, (1) said three components being bonded to each other uniformly along the entire length of the filament, (2) every component being directly to each other, (3) every component occupying a part of the peripheral surface of the filament continuously, (4) the surface area occupied by the adhesive component C being 5 to 30 percent, preferably 5 to 20 percent, of the total surface area of the filament and (5) a temperature at which the adhesive component C begins to exhibit adhesivity, being at least 5° C., preferably 10° C., lower than those temperatures of the other components A and B.

One of the features of the filament of the present invention lies in a relative arrangement of the three components. FIG. **28** is a cross-sectional view of a three-component filament according to the invention. The adhesive component C is positioned between the components A and B, but does not separate the components A and B from each other. The three components are directly bonded to each other. In FIGS. **30–32** showing conventional filaments the components C and B of the filament shown in FIG. **30** do not directly adhere to each other. In FIG. **31** the components A and C are separated and in FIG. **32** the components B and A are separated.

FIG. **33** is a diagrammatic view illustrating a contact point of filaments in the knit goods. Two filaments X and Y make contact each other at a point J. The adhered point density in the products depends upon which component faces to the contacting surface at the contact point J. That is, in FIG. 33, the component facing to the contact point J is the component B in the filament X and the component A in the filament Y. Microscopical examination of a contact point in plain-stitched stretchable stockings composed of conventional two-component filaments under tension with respect to the component at the contact surface shows that the component A or the component B faces to the contact point in many cases (60 to 80 percent), and the boundary line of both components A and B faces to the contact point in a relatively low probability (30 to 50 percent). This is based on the fact that as the filaments are bent at the contact point, they have a tendency to be in the most stable state in the condition. Because, it is an unstable state that the boundary line faces to the contact point. Therefore, it can be expected that if the adhesive component C is arranged at one side of the boundary line, the adhesive component C faces to the contacted point in a probability of 15 to 25 percent. Actual determination of the adhered point density in stockings, which are obtained by knitting with the use of filaments as shown in FIG. 28 and being subjected to crimp-developing and adhering treatments, showed 5 to 30 percent of adhered point density in many cases.

The adhesive component C will be explained hereinafter. Of course, all thermoplastic polymers are softened by heating, and thermoplastic polymers having a softening temperature lower than the thermal decomposition temperature have latent adhesivity. Therefore, all the three components constituting the filament of the present invention have latent adhesivity practically. However, among them only the component C serves as an adhesive component in the present invention. It is necessary that the components A and B do not exhibit adhesivity under such a condition that the component C adheres sufficiently, i.e. the component C has a selective sensitivity for tack-inducing agents. Furthermore, care must be taken such that the strength and the crimpability are not lost by the adhering treatment of the component C in the practical treatment. As the tack-inducing agents, use may be made of heating or solvents, but heating is practically advantageous. The use of saturated steam is particularly advantageous. It is common to use steam in the finishing process of fiber. In the production of run-resisting stockings by self-adhesion of filaments, it is advantageous that the stockings are dyed and then the filaments are adhered at the same time with the post boarding of the stockings. During the post boarding, filaments are heated for 10 to 60 seconds with saturated steam under tension caused by the shrinking force of the filaments themselves. The steam is usually used at a temperature of 110°to 130° C. As the adhesive components C, one showing adhesivity by the above-mentioned steam is preferably used.

Determination of the adhesive strength is carried out as follows:

Two filaments composed only of a sample polymer to be determined were firstly fixed so as to form a crossover contact point as shown in FIG. 34. These entangled filaments are heated at a predetermined temperature, cooled, taken out and cut so as to leave the contact point J as shown in FIG. 35. The points P and Q are pulled by means of a fiber tensile tester, for example, Instron universal tester, to determine the tension when the filaments at the contact point J are separated. A monofilament of 15 to 20 deniers usually has an adhesive strength of less than 30 g. This adhesive strength varies depending upon the adhering treatment conditions. It is heating velocity, heating time, heating temperature and pressing force (tension of filament) at the contact point that have the strongest influence upon the adhesive strength.

FIG. 36 is a graph showing a relation between adhering (steaming) temperature and adhesive strength. Adhesive or sticking strength varies depending upon not only the kinds of polymers themselves but also the kinds of partner polymers to be adhered. Now, three components are called as A, B and C. The adhesive strength when the component C is adhered with the component C, that when the component C is adhered with the component B and that when the component C is adhered with the component A are different from each other. FIG. 36 shows relations between adhesive strength and temperature in various combinations of the components A, B and C. In FIG. 36, the curve CC shows the relation when the component C is adhered with the component C. In FIG. 14 the rising point Tc of the adhesive strength-temperature curve of the component C with the component A is called as adhesion-beginning temperature of the component C. This adhesion-beginning temperature usually varies depending upon the partner polymer to be adhered. The adhesion-beginning temperature Tc of the component C includes three different adhesion-beginning temperatures, which are Tcc (adhesion-beginning temperature of the component C with the component C), Tca (adhesion-beginning temperature of the component C with the component A) and Tcb (adhesion-beginning temperature of the component C with the component B), but among them the highest (for example, in this case Tca) is practically used as the adhesion-beginning temperature of the component C.

In order to reduce the adhered point density and to maintain sufficient strength in the products, the heating should be carried out within a temperature range where the adhesive component C adheres with sufficient adhesion strength but the other components A and B do not exhibit adhesivity.

Suppose that the component B adheres to the component C at a lower temperature than the component A does. In this case, if the component C exhibits sufficient adhesivity at a temperature less than the adhesion-beginning temperature Tb of the component B, the object of the present invention can be attained. The adhesion-beginning temperature Tb of the component B includes Tbb and Tba, but the lower temperature should be discussed with respect to the adhesivity in connection with Tc. If the softening or sticking temperature decreases in the order of $A>B>C$, Tca and Tbb can be used as Tc and Tb respectively. When, Tc is sufficiently apart from Tb, i.e. the difference ΔT between Tb and Tc is sufficiently large, the object of the present invention can be attained. In the present invention, ΔT is more than 5° C., preferably more than 10° C.

As the spinning materials to be used for two-component or three-component filaments of the present invention, mention may be made of fiber formable thermoplastic synthetic linear polymers, for example, polyamide, polyester, polyester-amide, polyester-ether, polyacrylonitrile, polyolefin, polystyrene, polycarbonate, polyvinyl chloride, copolymers thereof, mixtures thereof and the like.

While, as the latent adhesive components, ones having a lower-softening or sticking temperature than that of the other components are used, and it is necessary that the adhesion-beginning temperature Tc is at least 5° C., preferably more than 10° C., lower than the adhesion-beginning temperatures of the other components as described above. In order to cause adhesion during post boarding in the production of stockings as described above, adhesive components which adhere in a saturated steam at 110° C. to 130° C., preferably 115° C., to 125° C., are preferably used.

As polyamides suitable for such a latent adhesive component C, mention may be made of a plenty of copolyamides and mixed polyamides. Homopolyamides having a low softening or sticking temperature, for example, polyhexamethylene isophthalamide may be used. The determination of adhesion-beginning temperature can be effected in such a manner that the adhesive strength of a filament is measured as described above, and that a curve showing a relation between the adhering treatment temperature and the adhesive strength is plotted, and then the temperature at the rising point of the curve is read.

Filaments having both latent crimpability and reduced latent adhesivity according to the invention are very useful for the production of ladies' stockings. That is to say, when such filaments are knitted into stockings and the resulting stockings are subjected to a suitable crimp-developing treatment and adhering treatment, then novel stockings having stretchability and run-resisting property can be obtained.

The invention will be explained by the following examples.

EXAMPLE 1

A copolymer, which was composed of nylon-6 (hereinafter abridged as 6) and nylon-66 (hereinafter abridged as 66) in a copolymerization ratio of 6/66=8/2 (by weight) and had a melting point of 181° C. and an intrinsic viscosity of 1.12 in *m*-cresol at 25° C., was melt spun and drawn to 4.2 times its original length at room temperature in a conventional manner to obtain a filament E of 15 deniers. The filament E was placed as shown in FIG. 34, relaxed by 10 percent, and treated with saturated steam at various temperatures for 30 seconds to determine the adhesive strengths. The results are shown in Table 1. The heating velocity was controlled so as that the temperature was raised from 80° C. to predetermined temperature within 30 to 60 seconds. The adhesive strength is shown in an average value of 10 samples.

TABLE 1

Treating temperature (°C.)	Adhesive strength (g)
100	0
105	2.0
110	4.3
115	7.1
120	9.2

From table 1, adhesive strength-temperature curves as shown in FIG. 36 were obtained. It was found that the adhesion-beginning temperature Tee of the filament E with the same filament E was about 101° C.

In the same manner, a relation between treating temperature and adhesive strength of the filament E entangled with nylon-6 filament was determined to obtain a result as shown in Table 2.

Table 2

Treating temperature (° C.)	Adhesive strength (g)
100	0
105	0
110	2.2
115	4.7
120	5.8

Table 2 shows that the adhesion-beginning temperature Te_6 of filament E with nylon-6 filament is 106° C.

The adhesive strength is highly influenced by the pressure and the tension at the adhering treatment as described above. In this example, the adhesive strength of filament, when the filament shrank by 10 percent, was determined. However, the adhesion-beginning temperature and the adhesive strength are often varied by the shrinking percentage or relax ratio of the filament used. A test of adhesivity under a constant load can be effected by suspending a weight to a sample filament. However, it is most advantageous that a practical product is subjected to adhering treatment and then the adhesive strength is determined. For example, in case of stockings, the adhesive strength can be determined in such a manner that a stocking knitted with the use of sample filaments is subjected to a crimp-developing treatment, and after dyeing, the stocking is further subjected to an adhering treatment (in this case, it is preferable to effect post boarding too), then the tension of unknitting is determined. The adhesive strength between two kinds of filaments can be determined with the use of a two-feed knitting machine.

Thus, as the result of the determination of adhesive strengths of various polyamides and copolyamides, it was found that an adhering treatment at least 5° C. higher than the adhesion temperature give an adhesive strength (i.e. more 2*g*) necessary for practical use.

EXAMPLE 2

As component A, nylon-6 having an intrinsic viscosity of 1.20 in *m*-cresol was used. As component B, a copolymer of nylon-6 with polyhexamethyleneisophthalamide (hereinafter abridged as 6I) in a copolymerization ratio (by weight) of 6/6I=9/1, which had a melting point of about 192° C. and an intrinsic viscosity of 1.21 in *m*-cresol, was used. As component C, the copolyamide 6/66 used in example 1 was used.

These three components were melted separately and fed into a spinneret for conjugate spinning as shown in FIG. 24 in a feed ratio (i.e. conjugate ratio by volume) of A/B/C=50/40/10 by means of gear pumps to obtain a three-component filament having a cross section as shown in FIG. 28, which was filament I. Furthermore, filaments F, G and H having cross sections as shown in FIGS. 30, 31 and 32 respectively were spun through three conventional side-by-side type spinnerets. In the spinning procedure, each filament was spun through a spinneret at 260° C., cooled, taken up and drawn 4.2 times its original length at room temperature. Each of the resulting filaments had a fineness of about 17 deniers.

Each filament was twisted at a rate of 100 T/M, wound on an aluminum bobbin, heat-set for 15 minutes with saturated steam at 75° C., and then knitted into a plain stitched stocking by means of a conventional knitting machine for seamless stockings having 400 needles. In these stockings, low shrinkable nylon-6 filaments of 50 d/16 f were used for the welt, toe and heel, and the above-mentioned filaments were used for the leg. The resulting stockings were called as stockings F, G, H and I corresponding to the filaments used for the legs respectively.

Each stocking was treated with saturated steam at 100° C. for 30 minutes under tensionless state to develop crimps, packed and dyed in a Smith drum in a conventional manner. The dyed stocking was placed in a form, and subjected to post boarding in such a manner that the temperature was raised from 80° C. to 116° C. in 30 seconds and maintained at 116° C. for 30 seconds by means of saturated steam to effect post boarding. After dried and cooled, the stocking was taken out from the form and left to stand for 24 hours in a room maintained at 25° C. and 65 percent RH. The resulting stocking had adhesive strengths of 5.8 g. (average value) in the ankle portion and 4.3 g. (average value) in the leg-top (upper leg) portion. The adhered point densities of the obtained stockings are shown in table 3. Among these stockings, the stocking I made of the filaments I has the most excellent stretchability.

TABLE 3

Stocking	Adhered point density of leg-top portion (%)	Stretchability	Run-resisting property
F	63	poor	excellent
G	72	poor	excellent
H	59	poor	excellent
I	23	good	good

In the above table 3, the adhered point density (%) is shown by the number of adhered points per 100 of contacted points (two per one stitch) of filaments. The number of the adhered points can be calculated by the following way. Namely, a variation of tension, when unknitting the stocking, is measured and from the number of peaks of tension thus measured and a length of the unknitted filament, the number of adhered points are calculated. The number of adhered points can also be calculated by a microscope.

In the nylon-6 stocking used in this example, the adhesion-beginning temperature Taa of nylon-6 component with the same nylon-6 component was higher than 125° C., that Tcb of copolyamide 6/6I with another copolyamide 6/66 was 118° C. and that Tca of copolyamide **6/66** with nylon-6 was 108° C., which shows that ΔT is 10° C.

EXAMPLE 3

As component A, nylon-66 having an intrinsic viscosity of 1.10 in *m*-cresol at 30° C. was used. As component B, a copolymer of nylon-66 with nylon-610 (hereinafter abridged as 610) in a copolymerization ratio (by weight) of 66/610=2/3, which had a melting point of about 200° C. and an intrinsic viscosity of 1.15 in *m*-cresol, was used. As component C, a mixed polyamide obtained by melting 2 parts of copolymer 66/610 used in the component B together with 1 part of 6I (melting point: about 170° C.) was used.

These three components were melted separately and spun through a spinneret as shown in FIG. **24** at 280° C. in a conjugate ratio (by volume) of A/B/C=5/5/2 to obtain a filament having a cross section as shown in FIG. **28**. The resulting filament was drawn 3.9 times its original length on a draw pin at 90° C. to obtain three-component filament J of 15 deniers/monofilament. Furthermore, monocomponent filaments each composed of the component A, B or C alone were spun in the same manner, and the adhesion-beginning temperatures (in wet state) were determined to obtain Taa>125° C., C, Tbb=120° C., Tca=105° C. and ΔT=15° C.

A stocking was knitted with the use of the filaments J in the leg in the same manner as described in Example **2**, and subjected to a crimp-developing treatment. After dyeing, the stocking was subjected to boarding with saturated steam at 118° C. for 45 seconds to obtain a stocking having excellent stretchability and run-resisting property.

EXAMPLE 4

As component A, polyethylene terephthalate having an intrinsic viscosity of 0.65 in *o*-chlorophenol at 30° C. was used. As component B, plyethylene-oxybenzoate having an intrinsic viscosity of 0.61 was used. As component C, a copolyester of polyethylene terephthalate/polyethylene adipate=70/30 (by weight) having a melting point of 188° C. was used. These three components were spun into a three-component filament in a conjugate ratio of **5/5/1** in the same manner as described in example **3** and the resulting filament was drawn 3.6 times its original length on a draw pin at 105° C. to obtain filament K of 240 d/80 f. Furthermore, one-component filaments each composed of the component A, B or C alone were spun in the same manner, and the adhesion-beginning temperature in dry state was determined to obtain Taa>250° C., Tbb>220° C. and Tca=190° C. A large number of filaments K were arranged uniformly to form a tow. The tow was subjected to crimp-developing treatment in a relaxed state, while being passed through boiling water. The tow was cut and dried to obtain crimped staple fibers of 5 cm. length. Furthermore, when the tow composed of filaments K was firstly cut and then subjected to crimp-developing treatment, substantially same crimped staple fibers were obtained.

A web was produced from the above-mentioned staple fibers and pressed by means of a hot roll at 195° C. to obtain a fairly stretchable and bulky nonwoven fabric. Test of elongation showed that the nonwoven fabric had a reversible elongation of 45 percent. On the contrary, a nonwoven fabric produced from staple fibers composed only of the components A and C in a conjugate ratio of 10/1 had a reversible elongation of 17 percent.

Furthermore, when a web was produced with the use of staple fibers of filament K and subjected to crimp-developing treatment with saturated steam at 100° C. in a relaxed state, then the web shrank to about 1/3 in length (1/9 in area). The shrunk web was pressed by means of a hot roll at 195° C. to obtain a nonwoven fabric, which had a reversible elongation of 55 percent.

The determination of reversible elongation was made as follows:

A test piece having a width of 2 cm. and a length of 10 cm. is determined with respect to the recovering percentages for various elongations, and then the elongation showing 80 percent recovering percentage is multiplied by **0.8** In general, as the elongation is higher, the recovering percentage lowers, so that the elongation showing 80 percent recovering percentage can be determined by plotting a relation between elongation and recovering percentage.

It has been hitherto known that after two-component composite filaments or staple fibers are formed into a weblike product, the product is heated to cause adhesion of low softening point component in the product. However, in this method, nonwoven fabrics having the above-mentioned highly reversible elongation and bulkiness cannot be obtained. In the conventional two-component filament, as the adhesive component is heated up to substantially the same temperature with the softening temperature, the strength is substantially lost. As the result, for example, when a two-component composite filament having a conjugate ratio of 1/1 is subjected to such a treatment that adhesion of one component occurs, the total strength of the composite filament lowers to about a half of its original strength. The decrease of strength caused by the adhesion can be obviated by the use of small amount of adhesive component, but the latent crimpability of the resulting filament is extremely poor, so that fibrous product having bulkiness and stretchability cannot be obtained. In the filament according to the invention or the staple fiber obtained by cutting the filament, the main components A and B show small decrease in the strength by the adhering treatment and have sufficient latent crimpability, so that fibrous products, such as knit goods, woven fabrics, webs and nonwoven fabrics, having excellent properties can be obtained.

As the component A suitable for polyester three-component filaments, mention may be made of aromatic polyesters having a melting point higher than 240° C., for example, homopolyesters, such as polyethylene terephthalate, poly-1,4-bis-methylcyclohexane terephthalate and the like, and copolyesters of said homopolyester with less than 10 percent by weight of the other copolymeric components. As the component B, mention may be made of polyesters, copolyesters, polyester-ethers, copolyester-ethers, and mixtures thereof, each having a melting point of 210° to 240° C. As the component C, mention may be made of polyesters having a softening point of 160° to 210° C. It is necessary that the component C adheres to the components A and B at conjugate spinning, so that copolymers containing polyesters, such as polyethylene terephthalate and the like and polyesterethers, such as polyethylene-oxybenzoate and the like can be preferably used for the component C.

EXAMPLE 5

Nylon-6 having an intrinsic viscosity of 1.20 in *m*-cresol at 25° C., and a copolymer having an intrinsic viscosity of 1.25 as in *m*-cresol at 25° C. and consisting of 90 parts by weight of nylon-6 and 10 parts by weight of polyhexamethylene isophthalamide (hereinafter abridged as 6/6I) were used as spinning materials. A spinneret as shown in FIG. **24**, which had an aperture composed of a T-shaped slit, was used. Temperature of the spinneret was maintained at 275° C. **50** parts by weight of the melted copolymer 6/6I and 50 parts by weight of nylon-6 were fed into the reservoirs **5** and **6**, and the reservoirs **7** by means of gear pumps respectively. The two spinning materials were bonded and extruded through an orifice **3** into the air, cooled and taken up at a rate of 600 m./min. in a conventional manner, while oiling. The taken up undrawn filaments were drawn 3.69 times their original length at room temperature to obtain filament F_1 of 45 d/7 f, the unitary filament of which had a cross-sectional view as shown in FIG. **5**.

As a control, the same nylon-6 and the same copolymer 6/6I are conjugate spun in a conventional manner to obtain side-by-side relation two-component filament F_2 of 45 d/7 f, the unitary filament of which had a conjugate ratio of 1/1 and a cross-sectional view as shown in FIG. **1**.

The shrinking percentage in hot water and the number of crimps of Filaments F_1 and F_2 are shown in table 4.

TABLE 4

	Shrinking percentage in hot water (%)	Number of crimps per cm.
filament F_1	65	9
Filament F_2	83	16

The determination of shrinking percentage in hot water was made as follows:

A sample having a length of l_0 is dipped in boiling water for 10 minutes under no lead and then airdried to obtain a shrunk filament having a length of l_1.

The shrinking percentage in hot water is calculated by the following formula:

$$\text{Shrinking percentage in hot water (\%)} = \frac{l_0 - l_1}{l_0} \times 100$$

EXAMPLE 6

Spinning materials of nylon-6 and the copolyamide 6/6I used in example **5** were conjugate spun in a conventional manner to obtain an undrawn two-component filament having a conjugate ratio (by weight) of 1/1, and the undrawn filament was drawn 3.9 times its original length at room temperature to obtain filament F_3 of 15 d/monofilament having a cross section as shown in FIG. **1**.

Filament F_1 obtained in example **5** was twisted to 200 T/M, taken up on an aluminum bobbin and treated with saturated steam at 105°C. for 15 minutes to obtain filament F_{11}. Filament F_2 obtained in example **5** was twisted and treated in the same manner as described above to obtain filament F_{12}. While, the filament F_3 was twisted to 120 T/M, taken up on an aluminum bobbin and treated with saturated steam at 75°C. for 15 minutes to obtain filament F_{13}. A plain stitched seamless stocking was knitted with the use of filaments F_{11} in welt, toe and heel, and filaments F_{13} in the leg by means of a knitting machine having 400 needles. Then the stocking was treated with saturated steam at 100°C. for 20 minutes under tensionless state to develop crimps. After dyed, the stocking was placed in a form, subjected to boarding with saturated steam at 116°C. for 45 seconds, taken out from the form, and left to stand for one day in a room at 25°C. and 65 percent RH under no tension to obtain stretchable stocking H_1. Another stocking was knitted with the use of filaments F_{12} in the welt, toe and heel, and filaments F_{13} in the leg, and subjected to finishing in the same manner as described in stocking H_1 to obtain stocking H_2. The width of welt and the width of the upper leg portion of the resulting stretchable stockings under tensionless state are shown in table 5.

TABLE 5

	Width of welt (cm.)	Width of the upper leg portion (cm.)
Stocking H_1	12.3	11.5
Stocking W_2	10.1	11.5

As seen from table 5, in stocking H_2, the width of welt is smaller than that of the upper leg portion, and they are unbalanced. On the contrary, in stocking H_1, the width of welt and the width of the upper leg portion were well-balanced.

Moreover, in stocking H_2, the welt has a color tone somewhat lighter than the leg, but in stocking H_1, the welt had substantially the same color tone with the leg.

EXAMPLE 7

An experiment was carried out to produce self-adhesive filaments, in which surface area occupied by the adhesive component in a filament is reduced, as raw filaments for the production of run-resisting stockings.

Nylon-6 used in example **5**, and an adhesive component of a copolymer having an intrinsic viscosity of 1.1 in *m*-cresol at 25° C. and consisting of 80 parts by weight of nylon-6 and 20 parts by weight of polyhexamethylene adipamide (hereinafter abridged as copolymer 6/66) were used as spinning materials. A spinneret as shown in FIG. **24**, which had inner orifices composed of a linear slit, was used. Temperature of the spinneret was maintained at 275° C. 80 parts by weight of melted nylon-6 and 20 parts by weight of the melted copolymer 6/66 were fed into reservoirs **5** and **6**, and reservoirs **7** by means of gear pumps respectively. The two spinning materials were bonded and extruded through an orifice **3** into the air, cooled, and taken up at a rate of 600 m/min in a conventional manner, while oiling. The taken up undrawn filament was drawn 3.89 times its original length at room temperature to obtain filament F_4 of 15 d/monofilament. Filament F_4 had a cross section as shown in FIG. **4**.

As a control, the same nylon-6 and the same copolymer 6/66 were conjugate spun in a conventional manner to obtain side-by-side relation two-component filament F_5 having a conjugate ratio of nylon 6/copolymer 6/66 =92/8. Filament F_5 had a cross section as shown in FIG. 3. In the resulting filaments F_4 and E_5, both the average values of surface areas occupied by the adhesive component (copolymer 6/66) were about 20 percent. However, the unevenness of surface areas in the longitudinal direction of a filament and between filaments was 18 to 24 percent in filament F_4, while the unevenness in filament F_5 was as large as 7 to 30 percent.

What is claimed is:

1. A crimpable composite filament comprising at least two synthetic mutually melt spinnable thermoplastic components of different shrinkability, said components selected from the group consisting of polyamides, polyesters, polyesteramides, polyacrylonitriles, polyolefins, polystyrenes, polycarbonates, polyesterethers, polyvinyl chloride, polyvinylidene chloride, and mixtures thereof, each of which extends uniformly and continuously along the filament longitudinal axis, each component occupying the peripheral surface of the filament, the smallest surface area occupied by either component being between 5 and 30 percent of the total surface area, the main body of the component of the smallest surface area lying within the other component and taking the form of a wedgelike structure as viewed in filament cross section, the inwardly extending length of said structure being at least equal to its greatest length.

2. The filament as claimed in claim **1** , wherein the length of said wedge is more than 1.5 times of the width of said wedge.

3. The filament as claimed in claim **1**, wherein the surface area occupied by said wedge is 5–20 percent of the total surface of the filament.

4. The filament as claimed in claim **1**, wherein the volume occupied by the wedge-forming component is 5–50 percent of the total volume of the filament.

5. The filament as claimed in claim **1**, wherein said wedge-forming component has a softening and adhesion-beginning temperature of at least 5° C. lower than that of the other component.

6. The filament as claimed in claim **1**, wherein each of said components is a polymer selected from the group consisting of polyamides, polyesters, polyacrylonitriles, polyolefins, polystyrenes, polycarbonates, polyesterethers, polyvinyl chloride, polyvinylidene chloride, and polymer blends thereof.

7. The filament as claimed in claim 1, wherein wedge-forming component and another component are nylon-6 and a mixture of nylon-6 with polyhexamethyleneisophthalamide respectively.

8. The filament as claimed in claim 1, wherein wedge-forming component and another component are mixture of nylon-6 with polyhexamethyleneadipamide and nylon-6 respectively.

9. The filament as claimed in claim 1, wherein the cross section of the filament is circular.

10. The filament as claimed in claim 1, wherein the cross section of the filament is noncircular.

11. The filament as claimed in claim 1, wherein the length of said wedge is more than 1.5 times of the width of said wedge.

12. The filament as claimed in claim 1, wherein the surface area occupied by said wedge is 5–20 percent of the total surface of the filament.

13. The filament as claimed in claim 1, wherein the volume occupied by the wedge-forming component is 5–50 percent of the total volume of the filament.

14. The filament as claimed in claim 1, wherein said wedge-forming component has a softening and adhesion-beginning temperature of at least 5° C. lower than that of the other components.

15. The filament as claimed in claim 14, wherein said wedge-forming component has a softening and adhesion-beginning temperature of at least 10° C. lower than that of the other components.

16. The filament as claimed in claim 14, wherein said wedge-forming component has a softening and adhesion-beginning temperature of at least 10° C. lower than that of the other components.

17. A filament as defined in claim 1, wherein the body of said filament other than said wedgelike component is composed of two components of different shrinkability, and said wedgelike component possesses the property of latent adhesivity relative to the other two components which adhesive property begins to exhibit itself at a temperature at least 5° C. lower than that of the other two components.

18. The filament as claimed in claim 17, wherein each of said components is a polymer selected from the group consisting of polyamides, polyesters, polyacrylonitriles, polyolefins, polystyrenes, polycarbonates, polyesterethers, polyvinyl chloride, polyvinylidene chloride, copolymers thereof and polymer blends thereof.

19. The filament as claimed in claim 17, wherein wedge-forming component and another component are nylon-6 and a copolymer of nylon-6 with polyhexamethyleneisophthalamide respectively.

20. The filament as claimed in claim 17, wherein wedge-forming component and another component are copolymer of nylon-6 with polyhexamethyleneadipamide and nylon-6 respectively.

21. The filament as claimed in claim 17, wherein the cross section of the filament is circular.

22. The filament as claimed in claim 17, wherein the cross section of the filament is noncircular.