

[54] **METHOD FOR MANUFACTURING  
SYNTHETIC MULTICORE ELEMENTS**

[72] Inventors: **Shigeru Fujii; Takashi Miwa; Kazushige Noji; Chikatsu Okagawa**, all of Nagoya-shi; **Masamichi Toki**, Otsu-shi, all of Japan

[73] Assignee: **Toray Industries, Inc.**, Tokyo, Japan

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[58] Field of Search .....**156/166, 167, 180, 296; 28/73**

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*Primary Examiner*—Benjamin R. Padgett

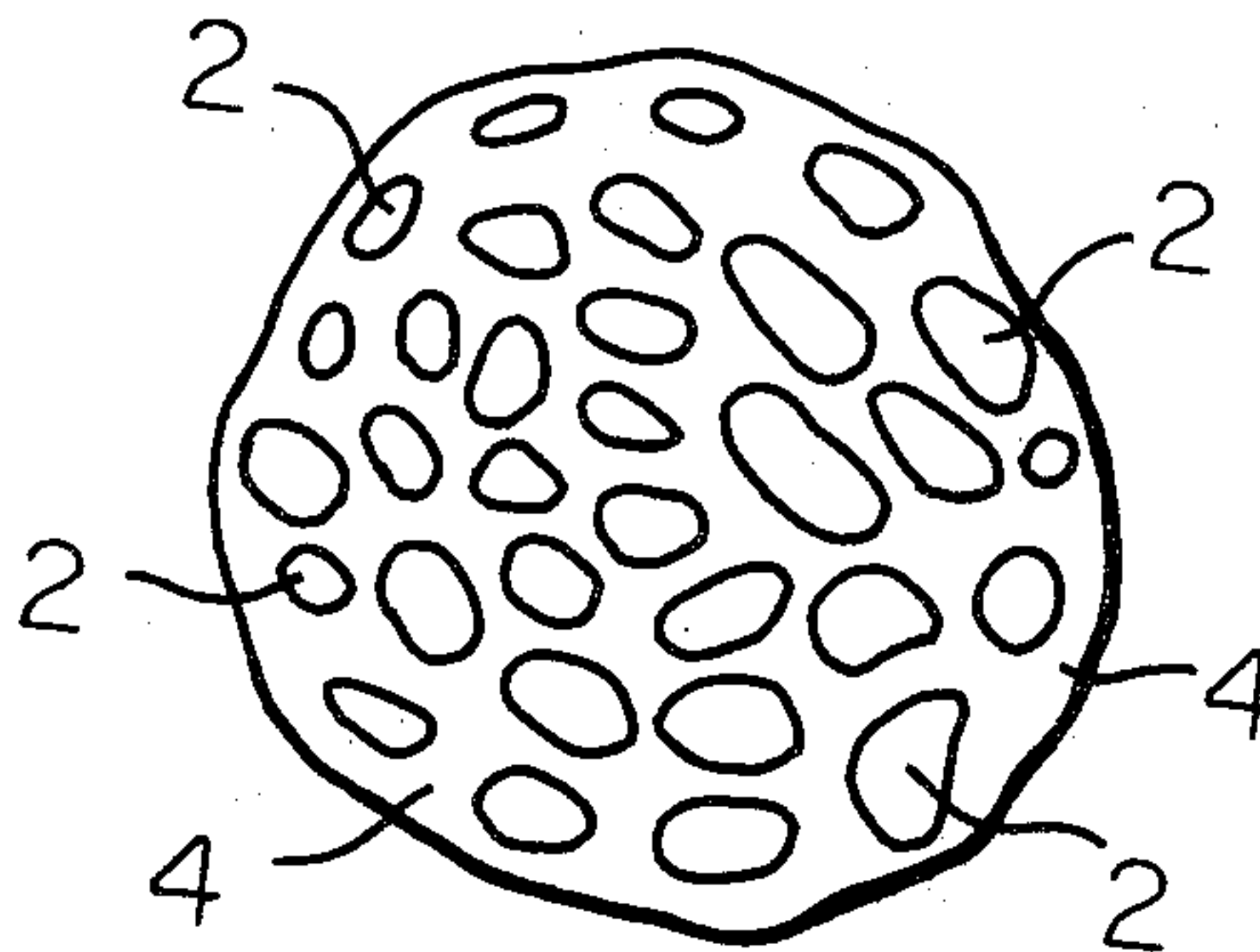
*Assistant Examiner*—B. H. Hunt

*Attorney*—Robert E. Burns and Emmanuel J. Lobato

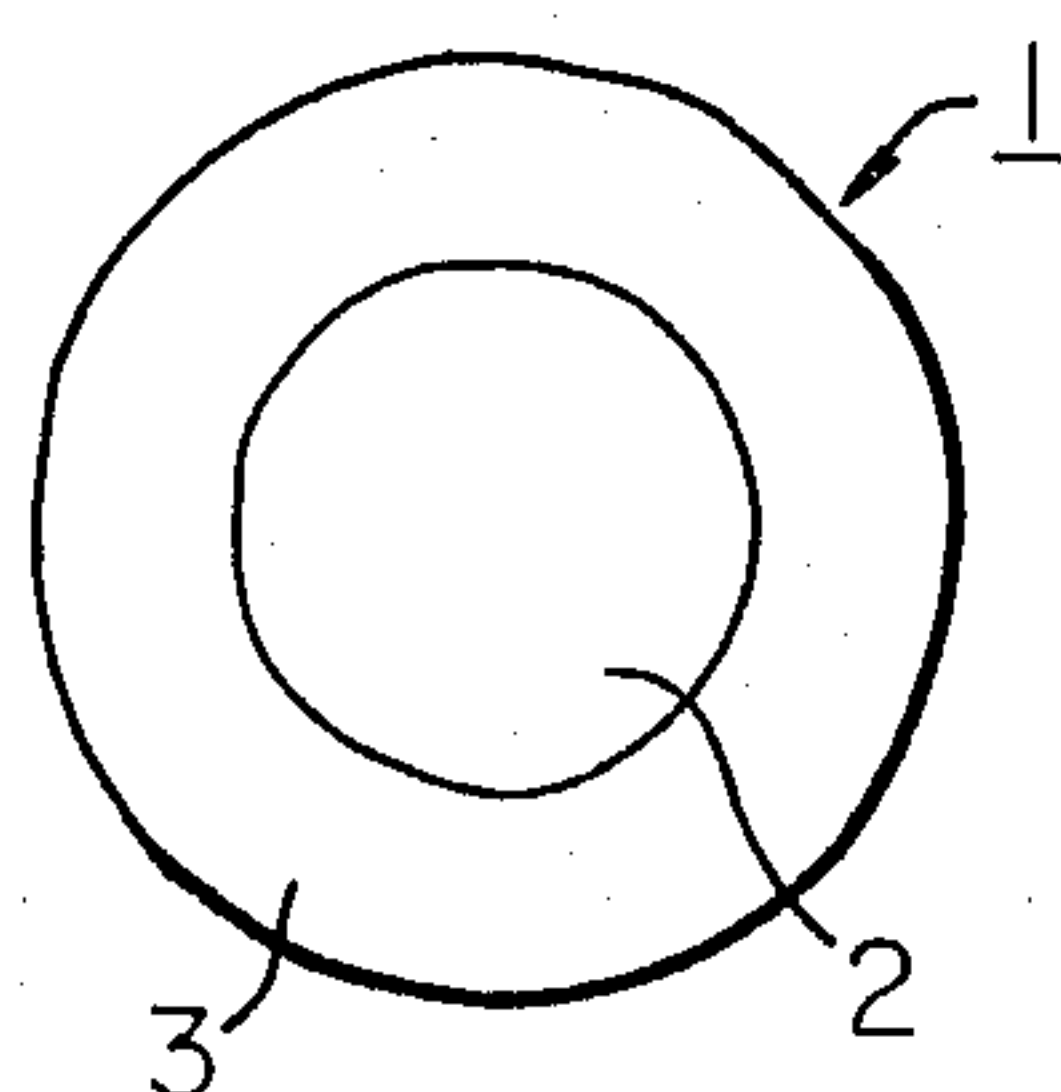
[57] **ABSTRACT**

A method for manufacturing improved synthetic bonded filament yarn by forming a unit composite from matrix and island components, assembling a plurality of the unit composites into a randomly bundled multifilament yarn and heating the multifilament yarn at a temperature between the melting points of both components. The cross section of the unit composite can be obtained in any of so-called sheath-core configuration, randomly distributed configuration and bimetallike configuration of the components. The bonded filament yarn has excellent flexibility and a unique surface condition having many wrinkles thereon and the bonded filament yarn of the present invention can be advantageously used for numerous industrial uses such as chafer fabrics of tires, bowstrings, fishing nets, guts of rackets, etc.

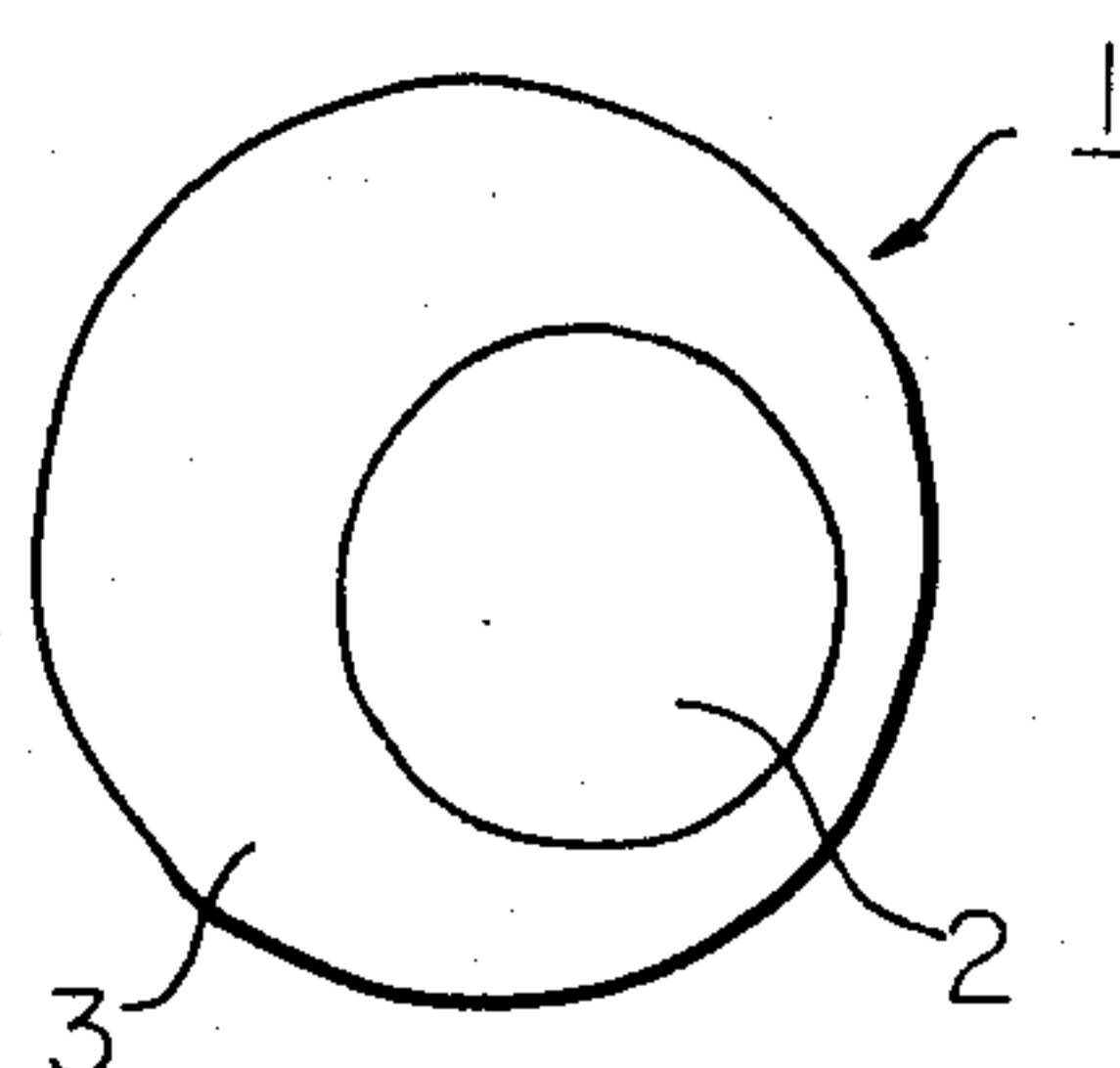
**12 Claims, 9 Drawing Figures**



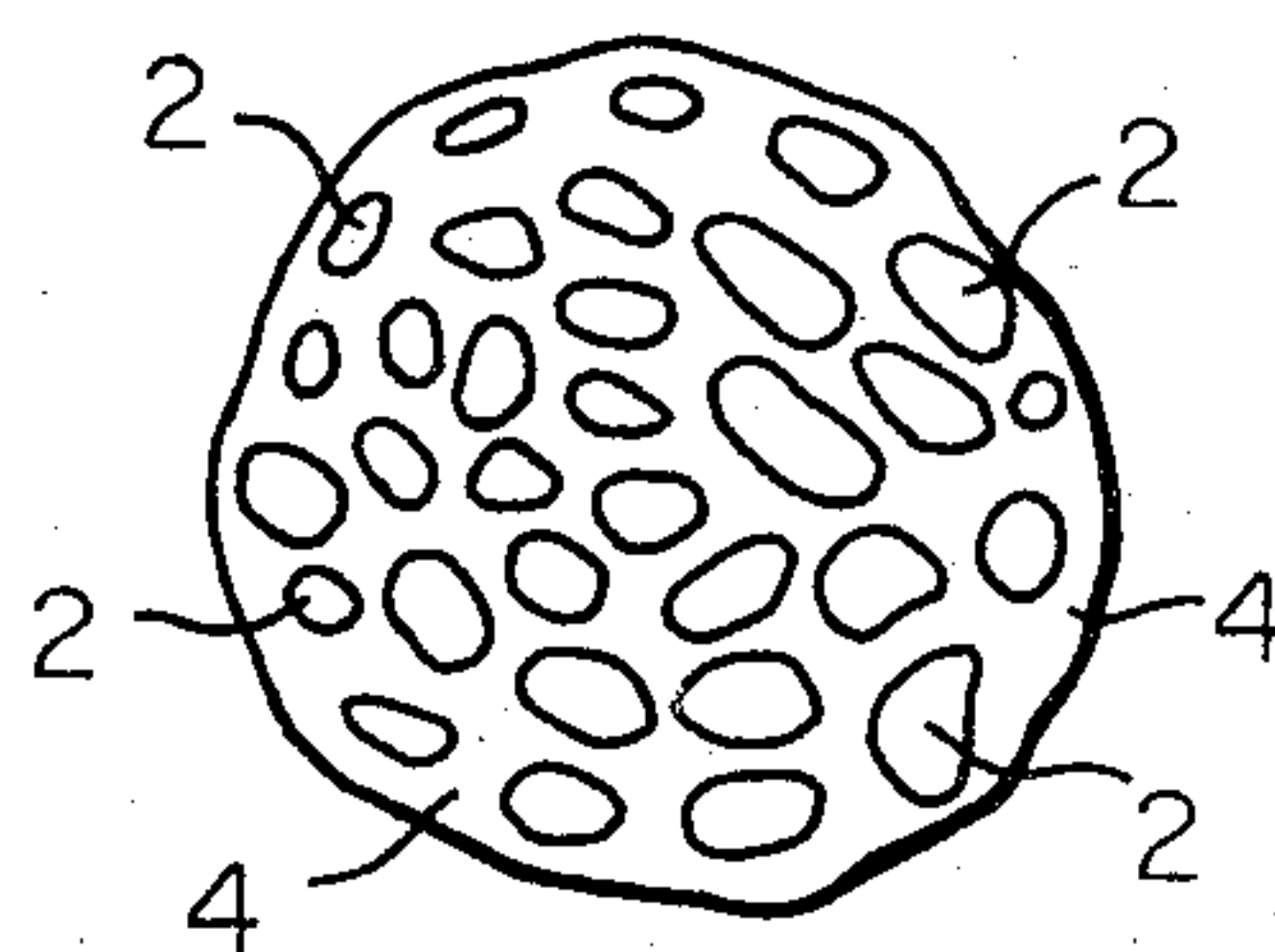
*Fig. 1A*



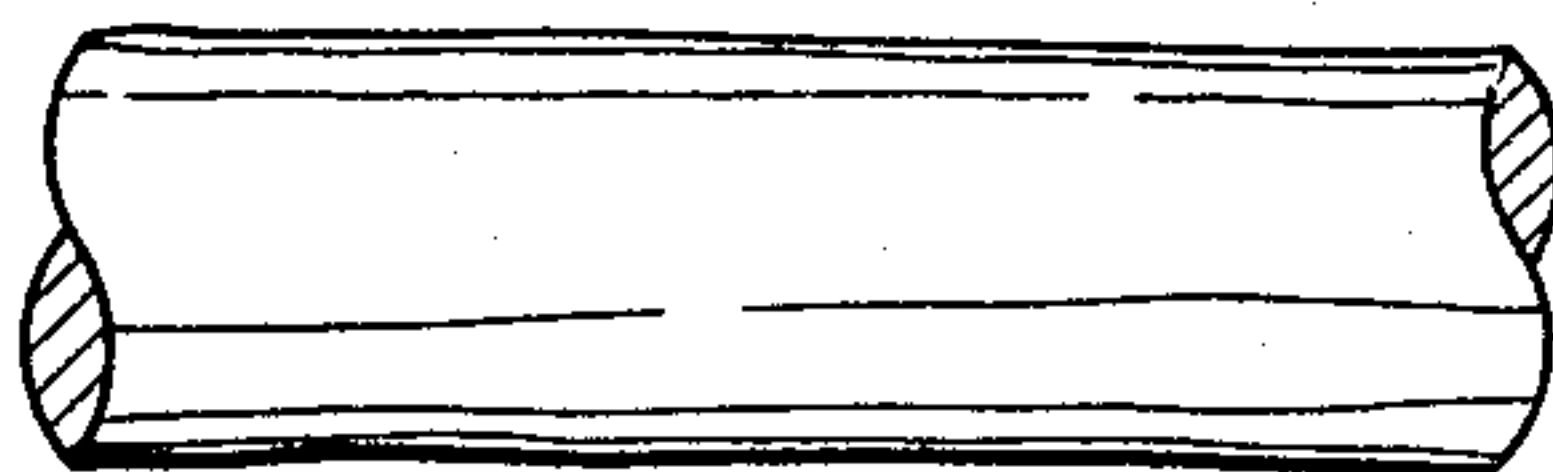
*Fig. 1B*



*Fig. 2*



*Fig. 3A*



*Fig. 3B*

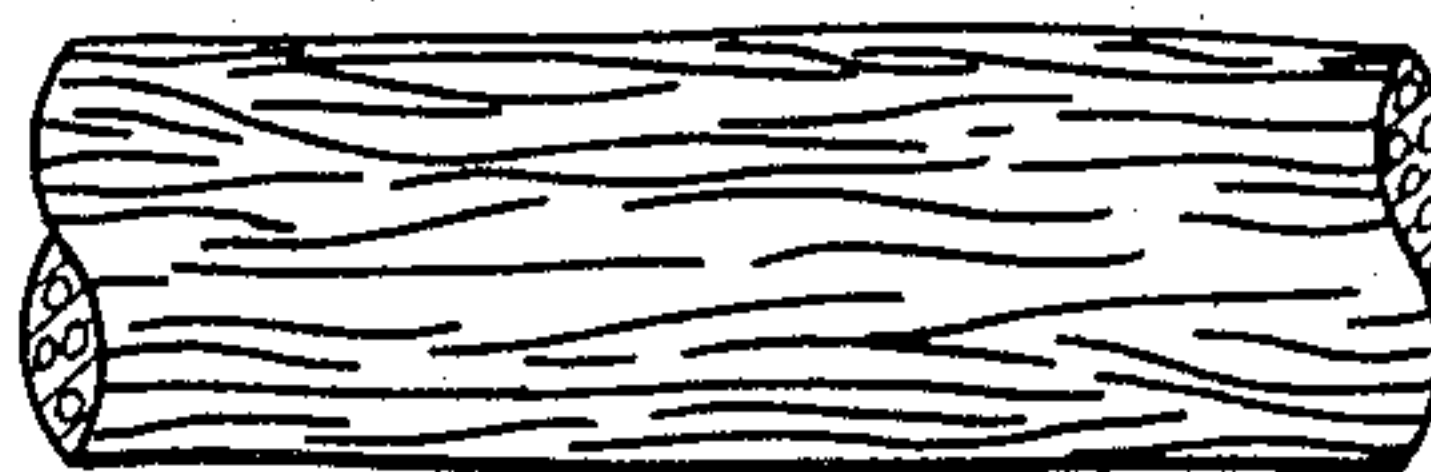


Fig. 4

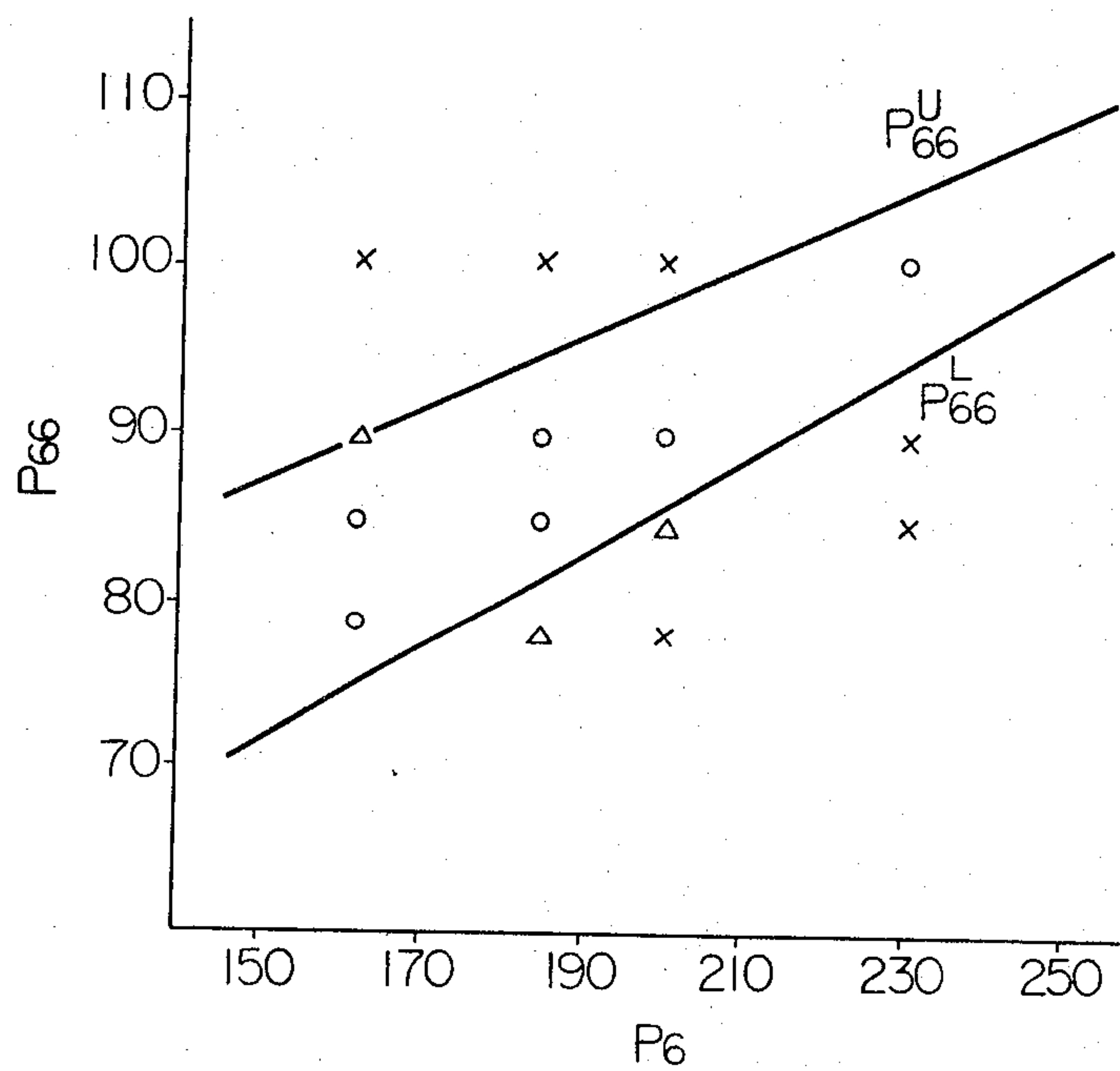


Fig. 7

Fig. 5

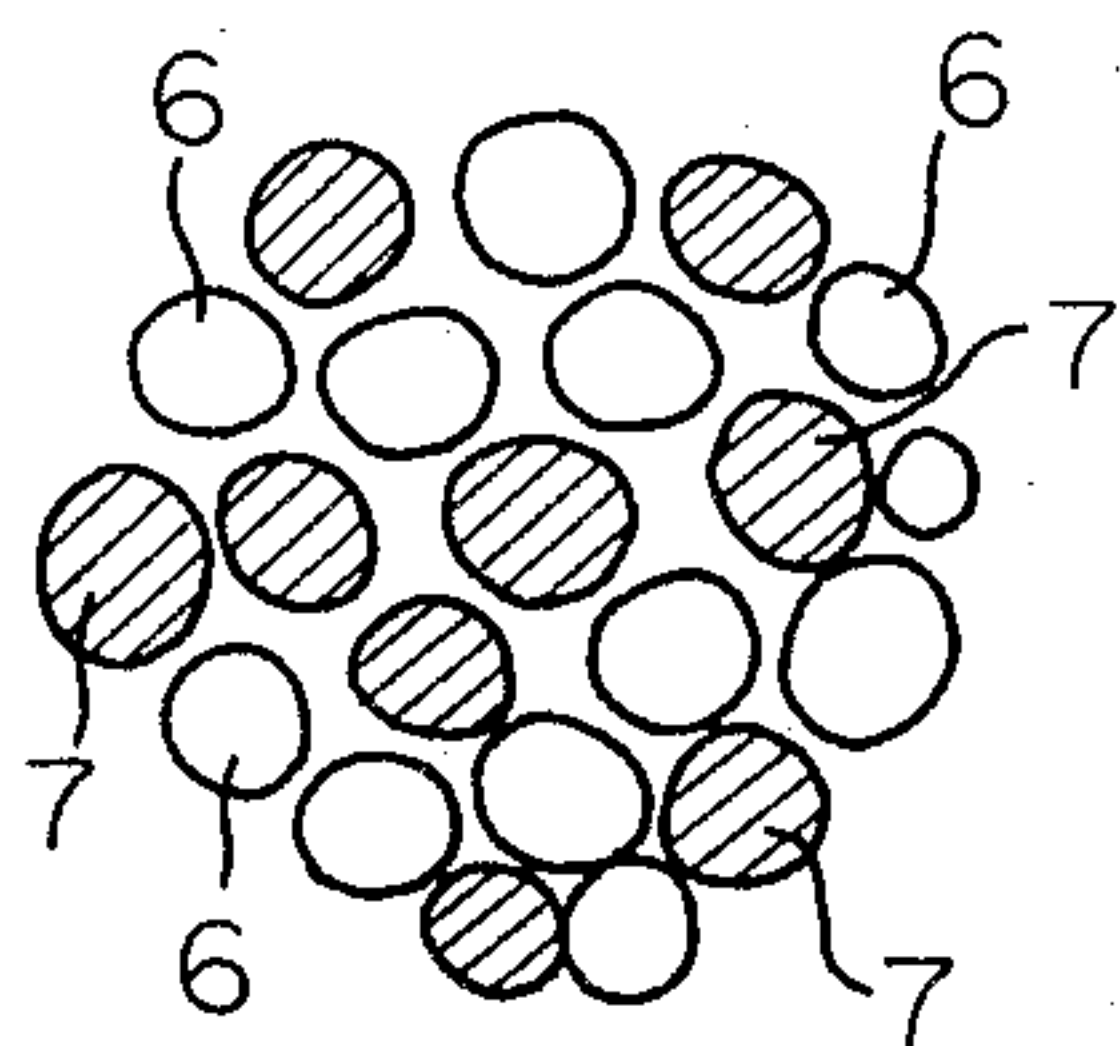
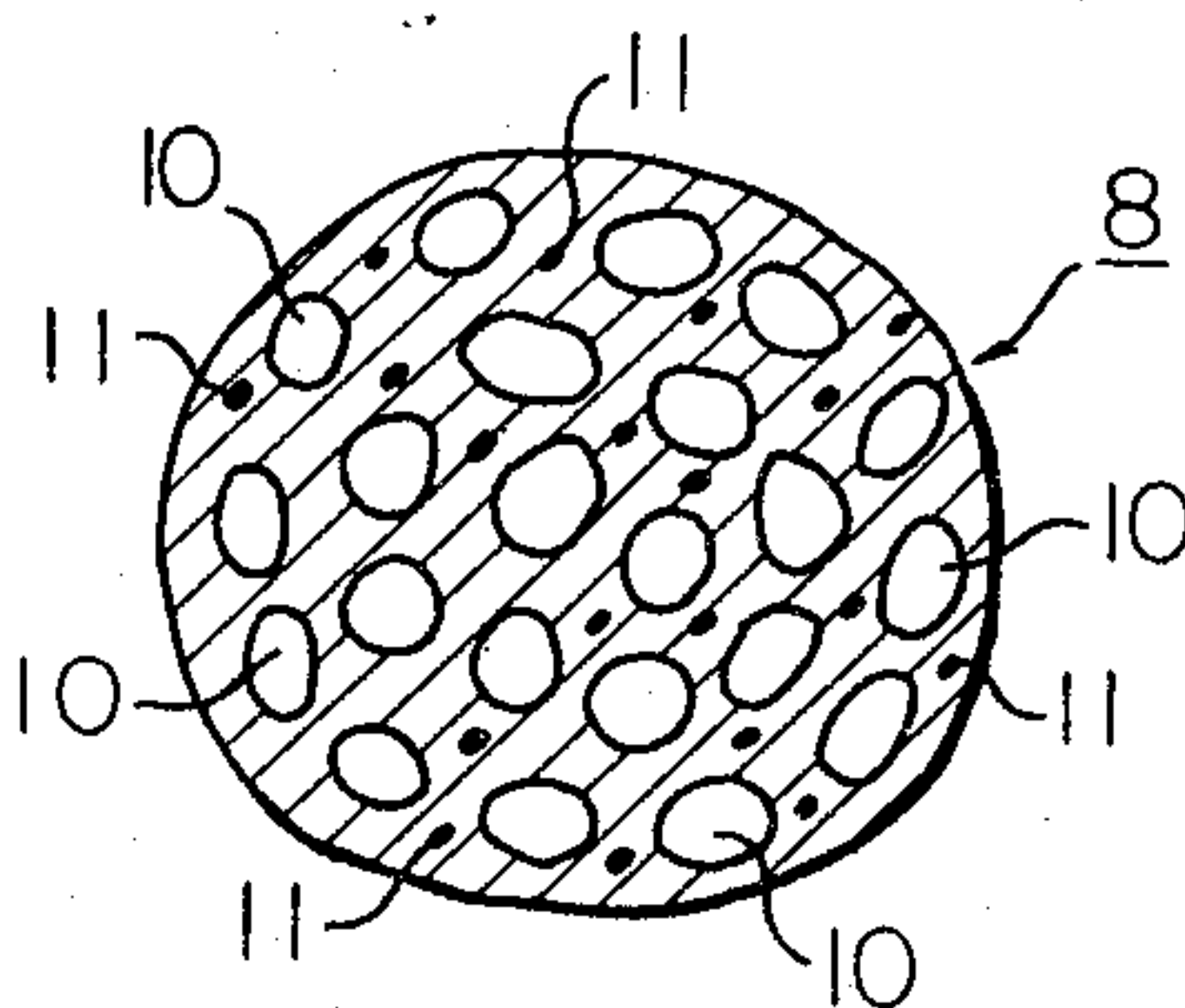


Fig. 6





# METHOD FOR MANUFACTURING SYNTHETIC MULTICORE ELEMENTS

## BACKGROUND OF THE INVENTION

The present invention relates to a method for manufacturing improved bonded filament yarn and more particularly relates to a method for manufacturing bonded filament yarn composed of a matrix component and a plurality of island components which is particularly used for industrial use such as chafer fabric of tires, manufactured synthetic filament yarn and industrial products produced of it.

Remarkable inroads have been made by synthetic fibers, both in the form of filament yarns and spun yarns, into the field of industrial use, particularly into the field of reinforcements for various types of tires. For instance, they have been favorably used for the carcass portion of a tire in a form of tire cords, for the chafing strip portion or for the cushion portion of a tire in the form of a woven cloth.

However, such application of conventional synthetic fibers for reinforcement of tires was accompanied by several drawbacks due to the configurational characteristics of fibers used in the reinforcement. As is well known, the conventional synthetic tire cord was made of a twisted multifilament yarn or a twisted bundle of spun yarns. When such a tire cord is immersed into dirty water, which usually happens with a tire, dirt in the water is easily soaked into the configuration of the tire cord together with water on account of capillarity due to the presence of a plurality of fine filaments or fibers in the yarn and is left there after the water has evaporated. Consequently, this often caused quick and easy contamination of the tire cord. This is the first defect of the tire cord made of the conventional synthetic yarns.

When such synthetic multifilament yarn is used for the chafing strip of a tubeless tire, this capillarity due to the presence of a plurality of fine filaments or fibers in the yarn also causes leakage of air contained within the tire through the multifilament yarn positioned in the bead portion of the tire. Such leakage of air is liable to cause quick lowering of internal pressure of the tire and easy formation of spots within the carcass portion of the tire, both of which often result in unexpected accident when the car is running.

When such synthetic reinforcing member is used for the chafing strip portion of a tire, it is subjected to severe friction and repeating impact, which is usually the case with a tire, resulting in separation and breakage of the component fibers or filaments. This separation and breakage of the component fibers and filaments causes quick deterioration of the bead portion of the tire and finally quick wearing-out of the tire. This is the defect of the chafer fabric made of the conventional synthetic yarns.

In order to avoid such troubles encountered in the conventional synthetic chafer fabric of a tire, several methods have been proposed. Use of bonded filament yarns instead of multifilament yarns or spun yarn is one of method for eliminating troubles due to capillarity. However chafer fabric made of a bonded filament yarn could not be provided with good flexibility. Moreover, when a cloth for chafer is made of bonded filament yarns, the thickness at the intersection of the component bonded filament yarns becomes larger than the other portions, which is theoretically twice as thick as that of the other portions and the concentration of stress upon these thickened intersections causes quick wearing-out of the netted cloth starting from these intersections. Besides, there often has been observed unfavorable irregular arrangement of yarns in the construction of the cloth made of bonded filament yarns caused by slippage of yarn having smooth surface. Application of resin finishing upon the multifilament cloth for chafer is another example of an attempt to prevent leakage of air. But, this resin treatment has two drawbacks, the first of these is that it is difficult for the resin solution to penetrate into the multifilament and the second is the separation of resins from the filaments in the cloth during actual use of the cloth.

As is well-known, polyamide filament yarn has been favorably used as a material for industrial use such as tire cords or reinforcements for tires. Conventionally, manufacture of highly oriented polyamide bonded filament was performed by extruding molten polyamide polymer through fine holes of a spinneret, instantaneously cooling the extruded filaments with a cooling medium such as water and applying stretching operation upon the cooled filaments while taking up onto a package. In case stretched filaments of higher than 40 denier was required, which is generally the case when used as a material for industrial use, it was necessary to use water as the cooling medium in order to obtain good result in the stretching process. However, in case of the water cooling system, the spinning speed of the filament years was limited to from 30 to 50 meters/min. and further limited to lower than 30 meters/min. in case the stretched bonded filament yarn of larger denier was required. This is mainly because of the fact that an overstretching of the filaments takes place due to the flow resistance of the cooling water when the filaments are passed through the water bath at a high-processing speed. Consequently, it was very much difficult to obtain a stretched filament yarn of larger denier by processing the filament at a spinning speed the same as that of the usual melt-spinning process, that is at a spinning speed from 300 to 1,000 meters/min. Moreover, it was difficult to obtain good orientation and crystallization of the material polymer by the usual stretching process when the stretched filament of larger denier is required, and such poor orientation and crystallization of the material polymer upon stretching resulted in lowered strength of the manufactured bonded filament, which usually ranged between 5 and 6 g./denier.

The principal object of the present invention is to provide an improved synthetic bonded filament yarn provided with good flexibility, with high strength, and resistance against impact loading, chemicals, mildew, aging and damage by wetting.

Another object of the present invention is to provide an improved synthetic filament yarn particularly used for industrial use such as reinforcement of a tire bead provided with good flexibility of the synthetic multifilament yarn or synthetic spun yarn conventionally used for the same purpose while eliminating the drawbacks encountered in these conventional synthetic yarns.

A still further object of the present invention is to provide an improved method for making synthetic reinforcing cloth for tires which can withstand long use and repeated impact loading by effectively preventing the concentration of stress upon the intersections of the component filament yarns and the slippage of yarns in the construction of the cloth.

A still further object of the present invention is to provide a novel method for manufacturing a synthetic filament yarn of larger denier provided with high orientation and crystallization of the material polymers.

A still further object of the present invention is to provide an economical method for manufacturing a synthetic bonded filament yarn having high strength at a high-production speed almost equal to that of the conventional melt-spinning process.

In accordance with the above-described objects of the invention, the method of the present invention is characterized by forming a unit composite from at least one kind of an island or core component and at least one kind of a matrix component whose melting point is different from that of the island component, assembling a plurality of the unit composites thus formed into a bundle and melting the matrix component of all unit composites by heating.

The synthetic filament yarn manufactured by the method of the present invention is characterized by having a cross-sectional profile composed of mutually continuous matrix portion and a plurality of island portions almost uniformly distributed within the matrix portion.

In the following explanation of the present invention, the description will be made mainly by referring to the case of



polyamide polymer as the material for the synthetic filament yarn of the present invention because of the fact that the polyamide filament yarn is generally and favorably used as a material for industrial use such as in a tire. However, the polymer material used for the purpose of the present invention can also be chosen, in accordance with the requirements of the end use, from a group composed of polycaprolactam, polyhexamethylene-adipoamide, polyethylene terephthalate, polypropylene, polyethylene, polyacetal, polyvinyl chloride, polystyrene, copolymers of these polymers, blended polymers of these polymers and blocked polymers of these polymers.

With respect to the combination of these material polymers, the combination of polyhexamethylene-adipoamide as the island component with polycaprolactam as the matrix component or the combination of polyethylene terephthalate as the island component with polycaprolactam as the matrix are preferably for the purpose of the present invention.

The cross-sectional profile of the unit composite of the present invention is characterized by being composed of at least one kind of an island component and at least one kind of a matrix component.

One typical example of the unit composite is obtained in the form of a sheath-core configuration wherein the island component is positioned in the core portion and the matrix component is positioned in the sheath portion surrounding the core portion in a substantially concentric arrangement. Another example of the unit composite is obtained in a form of a multifilament yarn which contains a plurality of fine island component filaments and a plurality of fine matrix component filaments in a randomly bundled condition. In some cases, it is also possible to have both components in a so-called bimetal-like configuration within the cross section of the unit composite.

Further features and advantages of the present invention will be apparent from the ensuing description with reference to the accompanying drawings to which, however, the scope of invention is in no way limited.

FIGS. 1A and 1B are diagrammatical cross-sectional view of an embodiment of a unit composite having so-called sheath-core configuration,

FIG. 2 is a diagrammatical cross-sectional view of a bonded filament yarn of the present invention,

FIGS. 3A and 3B are side views of a conventional bonded filament yarn and a bonded filament yarn manufactured by the method of the present invention, respectively,

FIG. 4 is a graphical representation of the relation between the degree of polymerizations of nylon 6 and nylon 66 which can be used favorably in the method of the present invention,

FIG. 5 is a diagrammatical cross-sectional view of another embodiment of a unit composite having the so-called multifilamentlike configuration,

FIG. 6 is a diagrammatical cross-sectional view of a bonded filament yarn made of a plurality of unit composites shown in FIG. 5,

FIG. 7 is a cross-sectional view of a tubeless tire wherein a reinforcing cloth made of the bonded filament yarns of the present invention is used.

#### UNIT COMPOSITE OF SHEATH-CORE CONFIGURATION;

#### ITS MECHANISM, MANUFACTURE, UTILIZATION AND EXAMPLES.

As mentioned above, one typical example of the unit composite of the present invention is obtained by putting the island and matrix components in a sheath-core arrangement wherein the island component is completely surrounded by the matrix component in a substantially concentric condition.

The manufacturing method of the polyamide bonded filament yarn composed of this type of unit composite is characterized by composite spinning the polyamide sheath component of lower melting point together with the polyamide

core component, whose melting point is at least 15° C. higher than that of the sheath component, through a spinneret, stretching the composite filaments thus obtained, doubling a plurality of the stretched filaments into a bundle of filaments and heating the bundle of filaments at a heating temperature which is higher than the melting point of the sheath component and lower than that of the core component, thereby melting the sheath components of each composite filament and converting the bundle of the composite filaments into a bonded filament whose cross section is composed of mutually continuous matrix portion which is made of the sheath components and a plurality of island portions which are made of the core components almost uniformly distributed within the matrix portion.

In the above-mentioned procedure, the cross-sectional profile of the unit composite can be obtained both in a concentric arrangement and in an eccentric arrangement. Both of the arrangements can be employed suitably for the purpose of the present invention in so far as the core component is completely surrounded by the sheath component.

The composite spinning of this type of composite filament is carried out, for example, by melting both of the component polymers independently using the respective melting apparatus and extruding both of the molten polymers simultaneously through the same spinneret especially designed for sheath-core composite spinning.

The formation of a bonded filament yarn from a bundle of composite filaments is generally performed by heating the bundle of composite filaments just after stretching and doubling as above described. However, in special cases, heat treatment can also be applied to the textile products made of them, thereby melting the sheath components contained in the multifilament yarns forming the cloth or the screen sheet. Moreover, for the purpose of uniform melting of the sheath components contained in the multifilament yarn, it is also recommended that twists from 50 turns/meter to 500 turns/meter be applied to the multifilament yarn prior to heat treatment.

The heating temperature employed in this heat treatment should be adjusted according to the degree of flexibility required for the manufactured bonded filament yarn. In case a high degree of flexibility is required for the manufactured bonded filament yarn, it is desirable to form numerous air cells in the structure of the bonded filament yarn by heating the multifilament yarn at a relatively low temperature.

As the heating medium used for the heat treatment of the present invention, any one of such mediums as heated air, heated inert gas, highly pressurized steam and superheated steam can be favorably used, while in some special case, a chemical medium such as a polyamide solvent can also be used. In case a dry medium such as heated air is used, the temperature of the heating medium must generally be maintained higher than the melting point of the sheath polyamide polymer. While in case of wet heating, the heating temperature should be higher than the temperature 80° C. below the melting point of the sheath polyamide polymer. For example, when the melting point of the sheath polyamide polymer is 210° C., it is possible to melt the sheath polyamide polymer by using a high-pressured steam maintained at a temperature higher than 130° C. As a special case, when a roughened surface condition is required for the manufactured bonded filament yarn, a chemical medium such as heated phenol solution can be effectively utilized. This kind of chemical heating medium is favorably used especially when a polyamide copolymer is used as the sheath component.

As to the material polymer used for both of the components, the method of the present invention is characterized by using the same kind of polymers in order to obtain a stronger coherency between components after heating and transparency of the manufactured bonded filament yarn. The use of different kind of polymers for respective component will be accompanied by poor coherency and lower transparency. However, by the requirement of the end use, the



bonded filament yarn of the present invention can contain delustering agents such as titanium dioxide, light-resisting agents such as a manganate or copper salt, optical bleaching agents and heat-resisting agents such as copper iodide, copper chloride, copper bromide, copper benzoate and copper acetate.

When deciding the difference in the melting point of both component polyamide polymers, it should be noted that the component polyamide polymer with the higher melting point should not be damaged by the heat treatment for melting the component polyamide polymer with the lower melting point, that is, the difference in the melting point should be more than at least 15° C., and more preferably more than 25° C. However there is an upper limit in the difference. The difference in the melting point is dependent upon the combination of component polymers. In case the manufactured bonded filament yarn is used as a material for a brush for cleaning at a high temperature, it is necessary to select a sheath component polymer having relatively high-melting point. While in case the heat treatment is applied to manufactured bonded filament yarn for the purpose of improving the heat-shrinking property, it is necessary to select a sheath component polymer whose melting point does not differ too much from the processing temperature of the heat treatment for the sake of easiness in the actual production process. Consequently, it can be concluded that the melting point of the sheath component polyamide polymer should preferably be higher than at least 160° C. in accordance with the purpose of the present invention.

With respect to the content of both components within the manufactured bonded filament yarn, it is desirable that the sheath component should be more than 10 percent by weight, more preferably the content of the sheath component should range between 20 and 40 percent by weight. Also, the content of the core component should be less than 90 percent by weight, more preferably it should range between 60 and 80 percent by weight. However, in case high strength is particularly required for the manufactured bonded filament yarn, it is desirable to make the content of the sheath component smaller.

The thickness of the unit composite filament of the present invention ranges between 2 and 30 denier, and more preferably between 5 and 15 denier. After being extruded through the spinneret, a plurality of those unit composite filaments are bundled together in the form of a multifilament yarn and, if necessary, twisted. The number of the unit composite filaments contained within a multifilament yarn is determined according to the requirement of the end use, for instance, it is obtained as a multifilament of 420 denier containing 40 filaments, 840 denier containing 80 filaments or 840 denier containing 96 filaments.

The sheath component polyamide polymer used in the present invention can favorably be chosen from a group composed of poly- $\epsilon$ -caproamide (nylon 6), polycaprylicamide (nylon 8), polyundecanoamide (nylon 11), polydodecanoamide (nylon 12), polyhexamethylene-cebacamide (nylon 610), polyamide copolymer of  $\epsilon$ -caprolactum with hexamethylene-diammonium-adipate (nylon 6/6666), polyamide copolymer of  $\epsilon$ -caprolactum with hexamethylene-diammonium-isophthalate (nylon 6/6I), polyamide copolymer of  $\epsilon$ -caprolactum with hexamethylene-diammonium-terephthalate (nylon 6/6T), polyamide copolymer of  $\epsilon$ -caprolactum with hexamethylene-diammonium-cebacate (nylon 6/610), polyamide copolymer composed of any three of  $\epsilon$ -caprolactum, hexamethylene-diammonium-adipate, hexamethylene-diammonium-cebacate, hexamethylene-diammonium-isophthalate and hexamethylene-diammonium-terephthalate (for instance nylon 6/66/610). The composition of the sheath component polyamide copolymer can be changed as required in accordance with the melting point of the core component polyamide polymer combined with it.

As to the core component polymer,  $\epsilon$ -caproamide and polyhexamethylene-adipamide can favorably be used, how-

ever any other polyamide polymers can be used without departing from the purpose of the present invention in accordance with the combination of the components.

Favorable combinations of both components can be obtained, for instance, by combining nylon 6 as the sheath with nylon 66 as the core, copolymerized nylon 6/nylon 66 as the sheath with nylon 6 as the core, copolymerized nylon 66/nylon 6 as the sheath with nylon 66 as the core, nylon 12 as the sheath with nylon 6 as the core, nylon 11 as the sheath with nylon 6 as the core, nylon 11 as the sheath with nylon 66 as the core, nylon 12 as the sheath with nylon 66 as the core, nylon 610 as the sheath with nylon 66 as the core and copolymerized nylon 66/nylon 610 as the sheath with nylon 66 as the core.

Referring to FIG. 1A, a cross section of an embodiment of the unit composite of the present invention is diagrammatically shown. In this embodiment, the cross section of the unit filament composite 1 is composed of a core component 2 and a sheath component 3 surrounding the core component 2 in a concentric arrangement. Another embodiment of the cross section is shown in FIG. 1B, wherein both of the components 2 and 3 are arranged in an eccentric arrangement. The bonded filament yarn of the present invention can be obtained by heating a bundle of a plurality of such unit composite filaments, thereby melting the sheath component of all unit composite filaments. By melting the sheath component of all unit composite, all of the sheath components adhere mutually to form a continued matrix component of the manufactured bonded filament yarn, as shown in FIG. 2, wherein the core components 2 are positioned within the matrix component 4 in an uniformly distributed condition.

In FIG. 3A, a photographic representation of a side view of the conventional polyamide bonded filament yarn is shown, while in FIG. 3B, a photographic representation of a side view of a polyamide bonded filament yarn of the present invention is shown. As is clearly shown in the drawing of FIG. 3A, the conventional polyamide bonded filament yarn is provided with a smooth surface due to a substantially circular cross-sectional profile. However, usually, there is little demand for bonded filament yarns having such smooth surface, that is, in most cases, it is required to positively roughen the surface of the bonded filament yarn for the purpose of the prevention of yarn slippage within the structure of a product made of them, such as a fishing net or a gut of a tennis racket. The bonded filament yarn of the present invention differs from such a conventional bonded filament yarn as it is provided with a rough surface during its manufacture due to non-circular cross-sectional profile as clearly shown in FIGS. 2 and 3B. This is one of the outstanding features of the bonded filament yarn manufactured by the method of the present invention.

As the bonded filament yarn of the present invention is provided with such a rough surface, it can be used suitably even for fishing lines, guts of rackets, fasteners, screens, belts and bristles, for which the conventional bonded filament yarns could not be used on account of their smooth surface condition.

The following examples are illustrative of the present invention, but are not to be construed as limiting the same.

#### EXAMPLE 1

Nylon 6 having a relative viscosity of 2.7 and nylon 66 having a relative viscosity of 2.75, both with respect to 1 percent solution of 98% sulfuric acid, were used as the material polyamide polymers. Chips of both material polymers were dried at 110° C. for 18 hours and melted independently by heating at 285° C. Molten polymer of nylon 6 was supplied to a spinneret at a feeding rate of 43 g./min. while molten polymer of nylon 66 was also supplied to the spinneret but at a feeding rate of 100 g./min. The spinneret was provided with 80 spinning holes. After being extruded through the spinneret, the multifilament yarn, which is composed of 30 percent by weight of nylon 6 and 70 percent by weight of nylon 66, was taken up at



a processing speed of 300 meters/min. Then the multifilament yarn was stretched at a stretching ration of 5.2 while being subjected to heat treatment by a heating member maintained at 180° C. and converted into a bonded filament yarn of the present invention. The stretched bonded filament yarn of 860 denier thus obtained was provided with a breaking strength of 8.2 g./denier and a breaking elongation of 18.6 percent.

#### COMPARATIVE EXAMPLE 1

Nylon 66 having a relative viscosity of 2.75 with respect to sulfuric acid was melted at 285° C. The molten polymer was extruded through a spinneret at a spinning rate of 33 g./min. in the form of a bonded filament yarn and was cooled by with water at a position 10 cm. under the spinneret. After taking up at a processing speed of 35 meters/min., the bonded filament yarn was stretched at a stretching ratio of 4.5 in hot water maintained at 60° C. The stretched bonded filament yarn of 900 denier thus obtained was provided with a breaking strength of 5.1 g./denier and a breaking elongation of 20.4 percent.

#### EXAMPLE 2

Nylon 12 having a relative viscosity of 2.0 and nylon 6 having a relative viscosity of 2.4 both with respect to sulfuric acid were used as the material polyamide polymers. Chips of both material polymers were melted independently by heating at 250° C. and were extruded through a spinneret in the form of a plurality of unit composite filaments of sheath-core configuration. After taking up at a processing speed of 400 meters/min., the multifilament yarn, which is composed of 20 percent by weight of nylon 12 and 80 percent by weight of nylon 6, was stretched at a stretching ratio of 4.2 without heating. The stretched multifilament yarn of 880 denier/80 filaments thus obtained was provided with a breaking strength of 6.5 g./denier and breaking elongation of 26.1 percent.

#### EXAMPLE 3

A polyamide copolymer (nylon 6/nylon 66) obtained by copolymerization reaction carried out at a temperature of 257° C. for 19 hours under pressure from a solution composed of 15 percent by weight of hexamethylene-diammonium-adipate and 85 percent by weight of  $\epsilon$ -caprolactum. The relative viscosity of the polyamide copolymer obtained was 3.0 with respect to sulfuric acid and the melting point measured by the optical method was 198° C. Nylon 6 polymer having a relative viscosity of 2.8 and a optical melting point of 220° C. was obtained as the result of polymerization of  $\epsilon$ -caprolactum. The optical melting point herein used was obtained by exposing a piece of the specimen polymer to polarized light, heating the specimen at a heating rate of 1° C./min. while immersing in silicone in order to prevent oxidation of the specimen polymer by heating, and measuring the temperature when the luminous aspect of the specimen has disappeared. Then the polymers obtained were melted independently by heating at 270° C. and extruded through a spinneret designed for sheath-core composite spinning. The resulting content of nylon 6 polymer was of 75 percent by weight and 25 percent was for nylon 6/nylon 66 copolymer, and the cross-sectional profile of the obtained unit composite filament yarn was a slightly eccentric arrangement. After being taken up at a processing speed of 500 meters/min., the multifilament yarn was stretched at a stretching ratio of 4.6 while heating with a heating member maintained at 180° C. The stretched filament yarn of 600 denier/40 filaments thus obtained was provided with a breaking strength of 7.6 g./denier and a breaking elongation of 24.8 percent.

#### EXAMPLE 4

Chips of nylon 6 and nylon 66 were prepared in the same manner as in Example 1 with the only exception that copper benzoate was added to both polymer chips so that the content of copper in the polymer was 100 p.p.m. After composite

spinning followed by stretching while heating in the same manner as in Example 1, the stretched filament yarn of 860 denier/80 filaments thus obtained was provided with a breaking strength of 8.1 g./denier and a breaking elongation of 19.0 percent.

#### EXAMPLE 5

After obtaining a multifilament yarn composed of nylon 6 and nylon 66 in the same manner as in Example 1, 200 turns/meter of S-twists were imparted to the multifilament yarn. Next, the twisted multifilament yarn was heated in a heating chamber maintained at 230 $\pm$ 5° C. for 45 seconds without stretching, thereby the nylon 6 sheath components of all the unit composite filament were melted completely and a bonded filament yarn as shown in FIG. 3B was obtained. The bonded filament yarn obtained having an apparent thickness of 920 denier was provided with a breaking strength of 5.7 g./denier and a breaking elongation of 18.5 percent. A plurality of wrinkles were observed on the surface of the bonded filament yarn obtained and resembled the surface of a multifilament yarn made of nylon 66 only. As an example of actual utilization, a fishing line made of the bonded filament yarn of the present example was provided with stronger knot-strength than a fishing line made of a bonded filament yarn manufactured by the conventional method.

#### EXAMPLE 6

After obtaining a multifilament yarn composed of nylon 12 and nylon 6 in the same manner as in Example 2, 100 turns/meter of S-twists were imparted to the multifilament yarn. Next, the twisted multifilament yarn was subjected to continuous heating in hot air maintained at 200 $\pm$ 5° C. for 30 seconds while being stretched 2 percent, and was taken up at a processing speed of 50 meters/min. The bonded filament yarn of 900 denier thus obtained was provided with a breaking strength of 5.2 g./denier, breaking elongation of 22.6 percent and had excellent transparency. As an example of actual utilization, a bristle brush made of the bonded filament yarns of the present example was had with excellent flexibility and high degree of resilience, and it was confirmed that such a brush was especially suitable for painting on account of good conformity to paints.

#### EXAMPLE 7

After obtaining a multifilament yarn composed of copolymerized nylon 6/nylon 66 and nylon 6 in the same manner as in Example 3, 200 turns/meter of primary Z-twists were imparted to the multifilament yarn. Then, two of the primarily twisted multifilament yarns were doubled and again imparted 200 turns/meter of secondary S-twists. A bonded filament yarn was obtained by heating the twisted multifilament yarn with saturated steam maintained at 130° C. for 1 second. The bonded filament yarn of 1,300 denier thus obtained was provided with a breaking strength of 5.3 g./denier and a breaking elongation of 20.0 percent. The density of the bonded filament yarn obtained was 1.130 while that of the unstretched multifilament yarn was 1.142. By comparing the densities, it was inferred that the bonded filament yarn obtained contained some air cells.

#### EXAMPLE 8

After obtaining a multifilament yarn composed of nylon 6 and nylon 66 in the same manner as in Example 4, 200 turns/meter of S-twists were imparted to the multifilament yarn. After heating in hot air of 220° C., the bonded filament yarns obtained by heating were woven into a woven-cloth of plain weave having a weaving density of 7 yarns/cm. Then the woven-cloth was again subjected to heating at 230° C. for 45 seconds without stretching. The fishing net obtained was provided with firmly melt-fixed intersections of component bonded filament yarns, resulting in less slippage of yarns in the net construction during actual use.



## EXAMPLE 9

A plurality of unit composite filaments, which are composed of nylon 6 as the sheath components and nylon 66 or polyethylene terephthalate as the core components, were bundled and heated in order to form a bonded filament yarn. The bonded filament yarns obtained were suitable as material of the reinforcing cloth used for the chafing strip portion of a tire. As a result of the application of the bonded filament of the present invention, effective prevention of lowering of the inner pressure of the tire due to leakage of air could be attained, together with excellent flexibility of the reinforcing cloth.

## EXAMPLE 10

A bonded filament yarn of the present invention was obtained in the same manner as in Example 9. The bonded filament yarns obtained were suitable as material of the reinforcing member of a V-belt. By using the bonded filament yarn of the present invention, the side portion of the V-belt was so effectively reinforced that it could withstand severe and frequent contact with a pulley, while a V-belt reinforced with the conventional multifilament yarns was easily damaged by severe and frequent contact with a pulley on account of the separation and breakage of individual filaments within the yarn. Beside, the reinforcing member made of the bonded filament yarn of the present invention could easily be bonded to the rubber portion of the belt only by using such a bonding agent as RFL because the outer surface of the bonded filament yarn of the present invention was completely covered with nylon 6. This is one of the outstanding features of the bonded filament yarn of the present invention in case it is used as a reinforcing member of articles made of rubber.

## EXAMPLE 11

A bonded filament yarn of the present invention composed of polyethylene terephthalate as the island components and polycaprolactum as the matrix component was used for a bowstring. The bowstring obtained was used for a long times with less formation of fluffs due to the breakage of component filaments and with less contamination by dirt, and such mechanical properties of the bowstring as stress-strain property were almost the same with those of a bowstring made of the conventional polyethylene terephthalate multifilament yarn.

## COMPARATIVE EXAMPLE 2

Nylon 6 having a relative viscosity of 3.0 with respect to sulfuric acid was melted at 285° C. The molten polymer solution was extruded through a spinneret at a spinning rate of 50 g./min. in the form of a bonded filament and was cooled with water at a position 10 cm. under the spinneret. After taking up at a processing speed of 33 meters/min., the bonded filament yarn was stretched at a stretching ratio of 4.5 within hot water maintained at 65° C. and, next, heated at 170° C. for 30 second while bestowing 12 percent relaxation to the processing bonded filament yarn. The bonded filament yarn of 1,320 denier thus obtained was provided with a breaking strength of 4.5 g./denier and a breaking elongation of 35.2 percent.

The following examples are illustrative of the actual utilizations of the filament yarn of the present invention, but are not to be construed as limiting the same.

## EXAMPLE 12

Bonded filament yarns of the present invention composed of nylon 66 as the island components and nylon 6 as the matrix component was used for a gut of a racket. The gut obtained was provided with better flexibility and higher strength than the gut made of the conventional bonded filament yarn, together with moderate elongation and resilience.

# DEFINITION OF DEGREE OF POLYMERIZATION OF POLYAMIDE POLYMERS USED IN THE PRESENT INVENTION

In the manufacture of the unit composite filament of the present invention having so-called sheath-core configuration, the condition of the sheath-core configuration of the unit composite filament obtained is dependent upon the difference in viscosity of the material polymers used for both components. In case the difference in viscosity is too large, the spinning condition will be considerably disturbed and it becomes difficult to obtain a stable and refined sheath-core configuration of the unit composite filament manufactured. The formation of such a disturbed sheath-core configuration can be effectively prevented by making the viscosities of both of the molten polymers substantially equal at the spinning temperature. After repeated researches, the inventors of the present invention have reached a conclusion that adjustment of viscosity of polymers can be attained satisfactorily by adjusting the degree of polymerization (hereinafter abbreviated as DP.) of polymers. In the following description, reference will be made mainly to a case wherein nylon 6 is used as the sheath component and nylon 66 is used as the core component of a unit composite filament of the present invention.

In accordance with the above-described purpose of the present invention, DP. of polymers used in the present invention should preferably be defined by the following equations;

$$P_{66}^U = 0.23P_6 + 51.5$$

$$P_{66}^L = 0.29P_6 + 28.0$$

$$150 < P_6 < 300$$

where  $P_{66}^U$  = Upper limit of DP. of nylon 66 core component polymer

$P_{66}^L$  = Lower limit of DP. of nylon 66 core component polymer

$P_6$  = DP. of nylon 6 sheath component polymer

In the above equations, DP. of the polymers is given in the form of number average degree of polymerization which is generally estimated by end-group measurement. However, the following method can be favorably employed instead in the present invention, that is, DP. of polymers can be calculated from the following equation, wherein  $\eta_r$  is relative viscosity of the specimen polymer with respect to 1 percent solution of 98 percent sulfuric acid.

$$P_6 = 100 (\eta_r - 1.05)$$

$$P_{66} = 50 (\eta_r - 1.05)$$

DP. of the component polymers used in the present invention refers to DP. of a multifilament yarn after extrusion from a spinneret of a melt spinning machine and just before being subjected to heating. In case DP. of the polymer chip is given, it must be noted that DP. of the polymer chip is changed while it is passing through the melt spinning machine, depending upon the spinning temperature and the processing time. Consequently, a suitable adjustment of the DP. is necessary in this case. For instance, when nylon polymer having an approximately equal quantity of amino-end groups and carboxyl-end groups is processed at a spinning temperature of 280° C., the relative viscosity  $\eta_r$  of the nylon multifilament yarn obtained changes as follows depending upon the length of the processing time  $t$ , provided that  $t$  is not longer than 30 minutes.

$$\eta_r = \eta_{r0} + 0.013t$$

where  $\eta_{r0}$  = viscosity of nylon polymer when  $t = 0$

By defining DP. of the component polymers as above-described, it becomes possible to apply the same spinning tem-



perature to both of the component polymers which makes the mechanical construction of the melt spinning machine simple. This is one of the outstanding features of the above-described definition of DP. of the component polymers.

Generally, when a filament yarn of the conventional type is composed of two components of different material polymers, the behavior of the two components during stretching is different. In other words, each of the components has its own optimum stretching condition and thus, it is difficult or almost impossible for such a filament yarn to be stretched under an optimum stretching condition, that is, it is quite difficult to find a stretching condition which is suitable for both of the components. Such difficulties in stretching often results in lower strength of the filament yarn manufactured. However, by applying the method of the present invention, both component polymers can be processed under an approximately identical processing condition within the melt spinning machine and this results in almost similar behavior of both component during stretching. Consequently it becomes possible to obtain a filament yarn whose core component (nylon 66) is highly oriented by stretching. This is another outstanding features of the above-described definition of DP. of the component polymers.

Moreover, the manufacture of the bonded filament yarn by heating the multifilament yarn can proceed at a processing speed from 300 to 500 meters/min. Such a high-production speed of the process of the present invention assures high-production efficiency in the production of bonded filament yarn particularly used for industrial use. This is still other outstanding features of the above described definition of DP. of the component polymers.

The following examples are illustrative of the effect resulting from the definition of DP. of the component polymers.

#### EXAMPLE 13

Sheath-core-type unit composite filaments were produced by a composite melt spinning machine having two independent heat plate-type melting devices, gear pumps and a common spinneret for composite spinning. Using acetic acid as a viscose stabilizer, a variety of poly-ε-caproamide (nylon 6) and polyhexamethylene-adipamide (nylon 66) having different viscosities was obtained. Polymerization of nylon 6 was carried out under atmospheric pressure, while polymerization of nylon 66 was carried out under a pressure of 7.5 kg./cm.<sup>2</sup>. The spinning temperature was adjusted in accordance with DP. of nylon 6, that is, the spinning temperature of 280° C. was used for  $P_6 < 180$ , 290° for  $180 \leq P_6 < 220$  and 300° C. for  $P_6 \geq 220$ . It was confirmed that the spinning condition was not affected very much by the fluctuation of the spinning temperature if it is less than  $\pm 10^\circ$  C. A multifilament yarn of 1,000 denier/24 filaments, which is composed of 30 percent by weight of nylon 6 and 70 percent by weight of nylon 66, was manufactured at a spinning speed of 400 meters/min. by extruding the material molten polymers through a spinneret designed for composite spinning and which is provided with a plurality of spinning holes of 1.0 mm. diameter and intervening distance of 0.5 mm. Then the multifilament yarn obtained was stretched at a stretching ratio from 4.8 to 5.0 while heating with a heating plate maintained at 180° C. The cross-sectional condition of the obtained bonded filament yarn is given in Table 1 and FIG. 4 for a series of combinations of material polymers, wherein the symbol (o) represents a substantially concentric arrangement of the cross section, the symbol (x) represents a random arrangement of the cross section and the symbol (Δ) represent an intermediate arrangement of the cross section.

TABLE 1

$P_{66}$	78	85	90	101
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$P_6$				
162	o	o	Δ	x
185	Δ	o	o	x
201	x	Δ	o	Δ
230	—	x	x	o

The stress-strain property of the bonded filament yarn obtained is shown in Table 2 for some typical combinations of polymers shown in Table 1.

TABLE 2

$P_6$	$P_{66}$	Breaking strength in g./denier	Breaking elongation in %
162	78	7.6	22.5
185	78	7.5	20.8
201	78	7.0	25.3
162	90	7.7	22.6
185	90	8.3	18.5
201	90	8.4	19.1
230	90	7.5	23.1

As a result of an experiment, it was confirmed that poor arrangement of the cross section of the bonded filament yarn manufactured often results in poor stress-strain property because of the fluctuation of the cross-sectional condition of the unit composite filament yarn.

#### EXAMPLE 14

Nylon 66 having a relative viscosity of 2.8 and nylon 6 having a relative viscosity of 3.0 both with respect to sulfuric acid were used as the material polyamide polymers. 0.03 percent by weight of potassium iodide and 0.03 percent by weight of copper iodide were added to the chips of nylon 6 and nylon 66, respectively, before spinning. A multifilament yarn of 4,000 denier/96 filaments, which is composed of 25 percent by weight of nylon 6 and 75 percent by weight of nylon 66, was manufactured at a spinning speed of 400 meters/min. by extruding the material molten polymers through the some spinneret as that used in the preceding example. Then the multifilament yarn obtained was stretched at a stretching ratio of 5.2 while heating with a heating plate maintained at 180° C. After stretching, the filament yarn obtained was provided with a breaking strength of 8.2 g./denier and a breaking elongation of 17.9 percent. Next, 200 turns/meter of S-twists were imparted to the stretched filament yarn. Then the twisted filament yarn was heated at 230° C. for 15 seconds without stretching. The bonded filament yarn of the present invention thus obtained was provided with a cross section wherein a plurality of nylon 66 island components were distributed uniformly within the nylon 6 matrix component formed by heat melting the nylon 6 sheath component of all unit composite filament contained within the multifilament yarn before stretching. By using such bonded filament yarns as the material for a reinforcing cloth of a chafing strip portion of a tubeless tire, it was possible to provide the tubeless tire with better conformity to rubber and less leakage of air as compared with a tubeless tire made of the conventional bonded filament yarn.

#### UNIT COMPOSITE OF MULTIFILAMENTLIKE CONFIGURATION:

#### ITS MECHANISM, MANUFACTURE, UTILIZATION AND EXAMPLES

In the foregoing descriptions, references were made to a unit composite having sheath-core configuration, however there is still another typical example of the unit composite of the present invention. This example of the unit composite is obtained in the form of a bundle of filaments which contains a plurality of fine island component-filaments and matrix component filaments.



The manufacturing method of the polyamide bonded filament yarn composed of this type of unit composites is characterized by simultaneously spinning more than two kinds of molten polymers whose melting point differs from each other through a spinneret which is provided with a plurality of spinning holes in such a manner that holes for one polymer and holes for another polymer are uniformly distributed, doubling a plurality of the unit composite filaments thus obtained into a multifilament yarn and heating the multifilament yarn at a heating temperature higher than the melting point of one of the material polymer, thereby melting one of the component polymers of each composite filament and converting the multifilament yarn into a bonded filament yarn whose cross section is composed of mutually continuous matrix portion and a plurality of island portions almost uniformly distributed within the matrix portion.

There is another process for carrying out the method of the present invention, that is, after spinning both of the component polymers independently into the respective filaments having almost a similar cross-sectional area, these filaments are bundled into a multifilament yarn and mixed together uniformly while stretching the multifilament yarn. Next the multifilament yarn is heated in order to melt one of the component polymer of each filament and converting the multifilament yarn into a bonded filament yarn. Heating of the multifilament yarn can be performed by utilizing the dry heating system, the wet heating system, high frequency heating system and infrared heating system.

As the material polymers used in the present invention, any combination of polymers can be employed in so far as there is a distinct difference in the melting points of polymers. This difference in the melting point should preferably be larger than 10° C. The content of both component polymer is dependent upon the requirement of the end use. In case high degree of strength is specially required for the bonded filament yarn manufactured, the content of the component polymer having a lower melting point must be larger than that of the component polymer having a higher melting point. However this combination must be reversed in case good flexibility and excellent resistance against friction is especially required for the bonded filament yarn manufactured. In order to satisfy both requirements, the content of the component polymer having the lower melting point should range between 10 and 60 percent by weight.

The multifilament yarn of the present invention can be made of filaments whose thickness differs from each other and, if necessary, suitable twist can be imparted into the bonded filament yarn. Needless to say, the heating temperature of the multifilament yarn should be lower than the melting point of the component polymer having the higher melting point so as not to cause its melting by heating.

Referring to FIG. 5, a cross section of an embodiment of a unit composite of the present invention is shown. In the drawing, the unit composite 5 of the present invention is presented in a form of a bundle of filaments composed of a plurality of component core filaments 6 of higher melting point and a plurality of component filaments 7 of lower melting point. By bundling a plurality of such unit composites 5 into a multifilament yarn, imparting twists if necessary and heating the multifilament yarn at a temperature between the melting point of both component polymers to effect melting of component filaments 7, it is possible to obtain a bonded filament yarn having a cross section shown in FIG. 6. In the drawing, the bonded filament yarn 8 of the present invention is composed of a matrix component 9, a plurality of island or core components 10 randomly distributed in the matrix component 9 and a plurality of air cells 11 formed during the manufacture of the bonded filament yarn. It can be clearly understood that the island component 10 of the bonded filament yarn 8 corresponds to the component filament 6 of the unit composite 5, while the matrix component 9 of the bonded filament yarn 8 corresponds to the component filament 7 of the unit composite 5.

It should be noted that the presence of the plurality of air cells 11 plays an important role in the determination of the flexibility of the bonded filament yarn manufactured, and this is one of the characteristic features of the bonded filament yarn of the present invention. The larger the number of such air cells in the cross section of the bonded filament yarn, the higher is the flexibility of the bonded filament yarn obtained.

Although it is provided with an apparent surface similar to that of a conventional bonded filament yarn, the bonded filament yarn of the present invention is provided with high flexibility and good resilience which can not be expected of the conventional type of bonded filament yarns. Besides, the resulting properties of the bonded filament yarn manufactured can be varied over a wide range in accordance with the requirement of the end use by adjusting the content of component polymers, changing the combination of the component polymers or by adjusting the number of air cells in the cross section of the yarn. And such a wide range of property results in a wide range of utilization of the bonded filament yarn produced such as reinforcing cloths of tires, reinforcing cords of V-belts, guts of rackets and bowstrings.

The following examples are illustrative of the present case of the invention.

#### EXAMPLE 15

Nylon 6 was used as the lower melting point component polymer and nylon 66 was used as the higher melting point component polymer. The unit composite of 144 denier obtained was composed of randomly mixed 24 component filaments half of which are nylon 6 component filaments of 6 denier and the remaining half of which are nylon 66 components filaments of 6 denier. Then seven of such unit composites were doubled into a multifilament yarn and 20 turns/10 cm. of S-twists were imparted to the doubled multifilament yarn. Prior to heating, the twisted multifilament yarn was immersed into an RFL solution for the purpose of providing a stronger bonding ability to rubber. After squeezing, the multifilament yarn was heated by a dry hot air maintained at 235° C. for 45 seconds without stretching, thereby nylon 6 component filaments were melted to adhere to each other and the multifilament yarn was converted into a bonded filament yarn. Using the polyamide bonded filament yarns thus obtained, a woven cloth having the following construction was produced.

$$\frac{144^d/7 \times 144^d/7}{39 \times 39} \text{ (ends or picks/5 cm.)}$$

The woven cloth obtained was used as a reinforcing cloth of a chafing strip of a tubeless tire, by which air leakage was reduced and has high resistance against friction.

#### EXAMPLE 16

Nylon 6 was used as the lower melting component polymer point and polyethylene terephthalate was used as the higher melting point component polymer. The unit composite of 144 denier obtained was composed of randomly mixed 24 component filaments half of which are nylon 6 component filaments of 6 denier and remaining half are polyethylene terephthalate component filaments of 6 denier. Then, six of such unit composites were doubled together and twisted in the Z direction at a twisting rate of 10 turns/10 cm. Next, two of the primary twisted yarns were doubled together and twisted into the S-direction at a twisting rate of 20 turns/10 cm. Finally, three of the secondary twisted yarns were further doubled together and again twisted in the Z-direction at a twisting rate of 10 turns/10 cm. in order to form a cable cord. The cable cord obtained heated by a dry hot air maintained at 240° C. for 60 seconds without stretching while treating with an RFL solution for the purpose of stronger bonding ability to rubber.

The cable cord obtained was used as a reinforcing member of a V-belt with excellent bonding ability to rubber and less separation of cords.



## EXAMPLE 17

The polyamide bonded filament yarn obtained in Example 15 was used as guts of rackets. The gut obtained was provided with high flexibility and strength and moderate elongation and resilience.

In most of the foregoing examples, it was necessary for the filament yarn of the present invention to be converted from a multifilament yarn to a bonded filament yarn by heating the multifilament yarn and melting the lower melting point component filaments. However, in case the filament yarn of the present invention is used for a woven cloth or a netted cloth which does not have knot portions, it is desirable to use the multifilament yarn without positively converting it into a bonded filament yarn by heating.

Such a netted cloth can be manufactured from the multifilament yarns of the present invention by weaving them into a woven-cloth or by netting them into a netted cloth which does not have knot portions. This manufactured woven or netted cloth is next heated at a temperature between the respective melting points of the component polymers of the unit composite contained within the multifilament yarn. Then the component polymer of lower melting point is melted by heating and the surface of the cloth is almost completely covered with a layer of the molten component polymer of the lower melting point.

Consequently, a cloth made of the multifilament yarn of the present invention can preferably be used as a reinforcing cloth of a tubeless tire chafer with air leakage eliminated effectively. This is one of the outstanding features of the bonded filament yarn of the present invention. Besides the intersections of the yarns do not become as thick as in case of bonded filament yarns, because the filament yarn of the present invention is constructed into cloth while it is still in the form of multifilament yarns. This is because the cross-sectional profile of the multifilament yarn can be deformed more easily by stressing, which is usually the case with weaving or netting, than that of a bonded filament yarn. By heating the cloth as already mentioned, such intersections of yarns are also melted and fixed to each other while each of the multifilament yarn maintains its deformed cross-sectional profile. As a result of this, there will be only a small difference in thickness between the intersections and the other portions of the cloth. Such small difference in thickness can result in effective elimination of stress concentration upon the intersections of yarns which often causes quick wearing out of a tire. This is another outstanding feature of the bonded filament yarn of the present invention.

With respect to the thickness of filament yarns, the thickness of a multifilament yarn ranges between 210 and 3,360 denier, while the thickness of a component filament is preferably smaller than 10 denier for the purpose of effective prevention of air leakage. The number of meshes of the net should range between 100 and 50,000 meshes/10 cm.<sup>2</sup>.

The following examples are illustrative of the multifilament of the present invention.

## EXAMPLE 18

Unit composites containing 60 percent by weight of nylon 66 as the core component ( $\eta_r=2.6$ ) and 40 percent by weight of nylon 6 as the sheath component ( $\eta_r=3.6$ ) were bundled into a multifilament yarn of 840 denier/136 filaments by using this multifilament yarn. A woven cloth having following construction was produced.

$$\frac{840 \text{ denier}/1 \times 840 \text{ denier}/1}{39 \times 39} \text{ (ends or picks/5 m.)}$$

After this was heated at 230° C. for 45 seconds using heated air without stretching, the cloth was immersed into an RFL solution for the purpose of improving the bonding ability to rubber and further baked at 150° C. for 2 minutes. The cloth obtained was used for the chafing strip portion of a tire, by which leakage of air was very small throughout the time the tire was actually used. The resulting properties of the cloth manufactured are shown in Table 3.

TABLE 3

	Along warp direction	Along filling direction
Yarn density in ends or picks/5 cm.	44 (warp yarn)	40 (filling yarn)
Thickness in mm.	0.69	
Weight in g./m. <sup>2</sup>	1.85	
Breaking strength in kg./3 cm.	105	89
Breaking elongation in %	19.5	21.3
Dry heat* shrinkage in %	0	0

\*150° C. × 30 min.

## EXAMPLE 19

The same kind of woven cloth was obtained by the same method as in the preceding example with only exception that the baking treatment was carried out at 100° C. for 2 minutes. However in the present case, the heat treatment for melting component filaments of lower melting point was applied to the cloth after the baking treatment. The cloth obtained was used for the chafing strip portion of a tire, by which leakage of air was very small throughout the time the tire was actually used. The resulting properties of the cloth manufactured are shown in Table 4.

TABLE 4

	Along warp direction	Along filling direction
Breaking strength in kg.	4.2 (warp)	3.8 (filling)
Breaking elongation in %	21.0 (warp)	22.9 (filling)
Residual strength After 2 × 10 <sup>5</sup> times of bending in %	92	—
Bond strength by H-test in kg./¼ inch	4.0	3.5

## EXAMPLE 20

Unit composites containing 70 percent by weight of nylon 6 as the core component and 30 percent by weight of copolymerized nylon 6/nylon 66 as the sheath component were bundled into a multifilament yarn of 840 denier/96 filaments. The melting point of nylon 6 polymer was 218° C. while the melting point of nylon 6/nylon 66 copolymer was 202° C. Using the multifilament yarn, a woven cloth having the same construction as that of Example 18 was produced. After heating with heated air of 210° C. for 45 seconds without stretching, the cloth was immersed into an RFL solution for the purpose of improving the bonding ability to rubber and further subjected to baking treatment at 150° C. for 2 minutes. The cloth obtained was used for the chafing strip portion of a tire, by which leakage of air was very small throughout the time the tire was actually used. The resulting properties of the cloth manufactured are shown in Table 5.

TABLE 5

	Along warp direction	Along filling direction
Yarn density in ends or picks/5 cm.	44 (warp yarn)	40 (filling yarn)
Thickness in mm.	0.68	
Weight in g./m. <sup>2</sup>	1.81	



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Breaking strength in kg./3 cm.	138	109
Breaking elongation in %	19.5	22.0
Bond strength by H-test in kg./¼ inch	4.1	—
Amount of the bonding agent bestowed in %	3.3	—
Residual strength after $2 \times 10^3$ times of bending in %	89	—

## EXAMPLE 21

Unit composites containing 70 percent by weight of polyethyleneterephthalate as the core and 30 percent by weight of nylon 6 as the sheath component were bundled into a multifilament yarn of 210 denier/24 filaments. Using the multifilament yarn, a woven cloth having the following construction was produced.

$$\frac{210 \text{ denier}/4 \times 210 \text{ denier}/4}{39 \times 39} \text{ (ends or picks/5 cm.)}$$

After receiving the heating and bonding treatments as in the preceding examples, the cloth obtained was used with good results for the chafing strip portion of a tire, by which leakage of air was very small throughout the time the tire was actually used. The resulting properties of the cloth manufactured are illustrated in Table 6.

TABLE 6

	Along warp direction	Along filling direction
Yarn density in ends or picks/5 cm.	44 (warp yarn)	40 (filling yarn)
Thickness in mm		0.69
Weight in g./m. <sup>2</sup>		210
Breaking strength in kg./3 cm.	105	97
Breaking elongation in %	18.6	19.0

As was repeatedly described above, the filament yarn of the present invention can be used suitably for tire, especially for tubeless tire, in the form of both bonded filament yarn and multifilament yarn. In the utilization of the filament yarn of the present invention, it is required to melt the matrix components of lower melting point by heating the filament yarn at a temperature between the melting points of both components while the filament yarn is still in the form of multifilament yarns or after the filament yarn is woven into a cloth. However it is also applicable, in accordance with the purpose of the invention, to melt the matrix components of the filament yarns after the reinforcing cloth made of them is attached to the tire by carrying out the vulcanization of rubber at a vulcanizing temperature between the melting points of both components. By thus heating the tire during vulcanization, the molten matrix components completely cover the islands components and all molten matrix component is adhered to each other to become continuous. This covering and continuously adhering condition of the matrix component can be fixed over the entire reinforcing cloth by cooling the tire after vulcanization and consequently, the surface of the reinforcing cloth is completely covered with a matrix component which prevents leakage of air therethrough.

The presence of air cell, rubberpiece or bonding agent within the molten matrix component will not cause any leakage of air therethrough.

Referring to FIG. 7, an embodiment of the utilization of the reinforcing cloth of the present invention to a tubeless tire is shown. In the drawing, a tubeless tire 12 is disposed to a rim, and the reinforcing clothes 14 of the present invention are disposed to the chafing strip portion 15 of the tire 12.

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In order to avoid separation of both components within the filament yarn manufactured by dynamic deformation subjected to the yarn during actual utilization of the tire, the combination of the component polymers must be selected in such a manner that the mutual bonding ability of both components is strong enough to withstand such a severe dynamic deformation. Generally, the combination is preferably chosen from a group composed of polyamide polymers. As the material polymer of the matrix components, the polyamide polymer should be selected such that its melting point is lower than the ordinary vulcanizing temperature of the tire, which ranges between 150° and 190° C. Nylon 12 made of  $\omega$ -lauriclactum or a copolymerized polyamide containing at least 80 percent by weight of  $\omega$ -aminoundecan acid and  $\omega$ -lauriclactum are usually used for the matrix components of the present invention, by which less damage by chemicals and excellent adaptability to the actual processing processes result.

With respect to the content of the components in the present case, the content of the matrix component ranges from 10 to 60 percent by weight while the corresponding content of the island component ranges from 90 to 40 percent by weight, more preferably the content of the former ranges from 20 to 60 percent by weight while the corresponding content of the latter ranges from 80 to 20 percent by weight.

The following examples are illustrative of the actual utilization of the filament yarn of the present invention as a reinforcing cloth of a tubeless tire.

## EXAMPLE 22

Unit composites containing 70 percent by weight of nylon 6 as the core component and 30 percent by weight of copolymerized  $\omega$ -lauriclactum/ $\epsilon$ -caprolactum as the sheath component were bundled into a multifilament yarn of 840 denier/60 filaments. The copolymer was composed of 90 percent by weight of  $\omega$ -lauriclactum and 10 percent by weight of  $\epsilon$ -caprolactum and the melting point of the copolymer measured by the optical method was 170° C. The multifilament yarn obtained was provided with a breaking strength of 8.0 g./denier and a breaking elongation of 18.5 percent after stretching. Then the reinforcing cloth made of the multifilament yarns was disposed to the chafing strip portion of a tubeless tire having a size of 7.00-13. The tubeless tire was then subjected to vulcanization treatment. Vulcanization of the tire was carried out by B.O.M. vulcanizing machine by heating the tire for 15 minutes in such a manner that the inside of the tire was heated with hot water maintained at a temperature of 185° C. and a pressure of 20 kg./cm.<sup>2</sup> and the outside of the tire was heated with steam of 175° C. The tubeless tire obtained was had with excellent resistance against friction with less leakage of air therethrough.

## EXAMPLE 23

Unit composites having an ordinary bimetallike configuration and containing 50 percent by weight of nylon 12 and 50 percent by weight of nylon 6 were bundled into a multifilament yarn of 840 denier/96 filaments. The optical melting point of nylon 12, which was obtained by polymerizing  $\omega$ -lauriclactum monomers, was 180° C. and the relative viscosity of the polymer was 2.20 with respect to 1 percent solution of 98% sulfuric acid, while the relative viscosity of nylon 6 was 3.3. The multifilament yarn obtained was provided with a breaking strength of 8.3 g./denier and a breaking elongation of 17.5 percent after stretching. Then the multifilament yarns were disposed to the chafing strip portion of a tubeless tire and then vulcanization treatment was applied by heating the tire for 10 minutes in such a manner that the inside of the tire was heated at 190° C. and outside at 185° C. The tubeless tire obtained was provided with excellent resistance against friction with less leakage of air therethrough.

While the invention has been described in conjunction with certain embodiments thereof, various changes and modifications may be made without departing from the spirit and scope of the invention.



What is claimed is:

1. A method of manufacturing synthetic multicore filaments comprising: providing a plurality of individual filament composites each comprising a core component composed of synthetic polymeric material having a given melting point temperature and a sheath component surrounding said core component composed of synthetic polymeric material having a melting point temperature lower than said given melting point temperature; bundling together said plurality of individual filament composites to form a bundle of multifilament composites; imparting from 50 to 500 twists per meter length to said bundle of multifilament composites; and melting the sheath components of the twisted bundle of multifilament composites at a temperature between the melting point temperatures of said core and sheath components into a common matrix component containing therein said core components whereby a multicore filament is obtained.

2. A method according to claim 1, wherein said synthetic polymeric materials are selected from a group consisting of polycaprolactam, polyhexamethylene-adipamide, polyethylene terephthalate, polypropylene, polyethylene, polyacetal, polyvinylchloride, polystyrene, copolymer of these polymers, blended polymers of said polymers, and block copolymers of said polymers.

3. A method according to claim 1, wherein the combination of said sheath component and core component polymeric materials is selected from a group consisting of sheath-forming polycaprolactam with core-forming polyhexamethylene-adipamide and sheath-forming polycaprolactam with core-forming polyethylene-terephthalate.

4. A method according to claim 1, wherein said melting point temperature of said core component is higher than that of said sheath component by at least 15° C.

5. A method according to claim 4, wherein said core component is composed of nylon 66 and said sheath component is composed of nylon 6.

6. A method according to claim 5, wherein the degrees of polymerization of said two polymeric materials are defined by the following formula:

$$P_{66}^U = 0.23P_6 + 51.5$$

$$P_{66}^L = 0.29P_6 + 28.0$$

$$150 < P < 300$$

wherein

$P_{66}^U$  = upper limit value of degree of polymerization of nylon 66

$P_{66}^L$  = lower limit value of degree of polymerization of nylon 66

$P_6$  = degree of polymerization of nylon 6.

7. A method according to claim 1, wherein said heat-treating step includes maintaining said twisted bundle of multifilament composites free of slack during their heat treatment.

8. A method according to claim 1 including heat-treating said twisted bundle of multifilament composites at a low enough temperature to develop a plurality of air pockets in said common matrix component to effectively increase the flexibility of the multicore filament.

9. A method according to claim 1 further including weaving a plurality of said multicore filaments into a tubeless tire chafer strip.

10. A method of manufacturing a tubeless tire reinforcing chafer strip composed of synthetic multicore filaments comprising: providing a plurality of individual filament composites each comprising a core component composed of synthetic polymeric material having a given melting point temperature and a sheath component surrounding said core component composed of synthetic polymeric material having a melting point temperature lower than said given melting point temperature; bundling together said plurality of individual filament composites to form a bundle of multifilament composites; imparting from 50 to 500 twists per meter length to said bundle of multifilament composites; weaving a plurality of such bundles of multifilament composites into a chafer strip configuration; and heat-treating said chafer strip at a temperature between the melting point temperatures of said core and sheath components for a sufficient time to effect melting of individual ones of said sheath components of each twisted bundle into a common matrix component containing therein said core components.

11. A method according to claim 10 including, prior to said heat-treating step, disposing said chafer strip within a tubeless tire; and wherein said heat-treating step is carried out during vulcanization of said tubeless tire.

12. A method of manufacturing synthetic multicore filaments comprising: providing a plurality of bundles of filaments wherein each bundle comprises a first plurality of filaments composed of synthetic polymeric material having a given melting point temperature and a second plurality of core filaments composed of synthetic polymeric material having a melting point temperature lower than said given melting point temperature randomly interspersed with said first plurality of filaments; twisting together said plurality of bundles of filaments to obtain a multifilament composite; and heat-treating said multifilament composite at a temperature between the melting point temperatures of said first and second pluralities of filaments for a sufficient time to effect melting of said second plurality of filaments into a common matrix component containing uniformly dispersed therein said core filaments.

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