

Oct. 5, 1971

TOHRU KITAWAZA

3,609,953

ELASTIC COMPOSITE YARN AND PROCESS FOR MANUFACTURING THE SAME

Filed June 2, 1969

3 Sheets-Sheet 1

Fig. 1

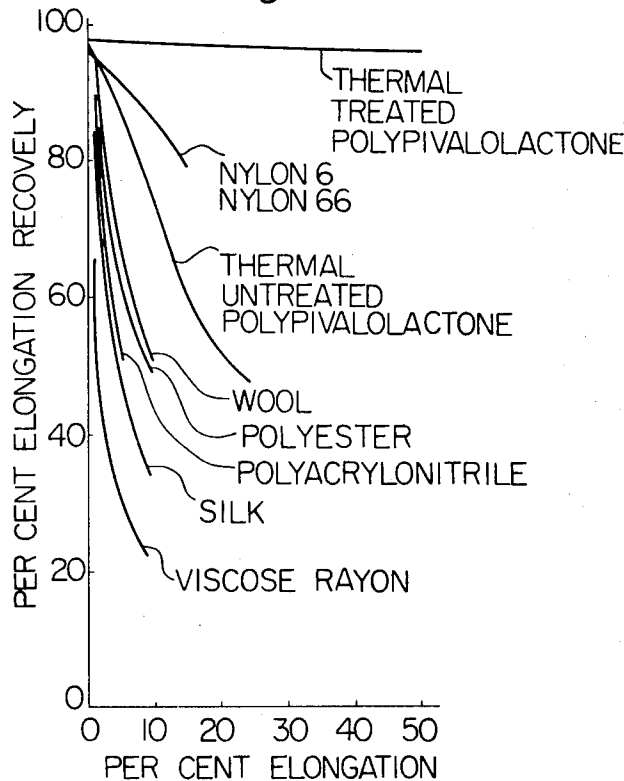


Fig. 2A

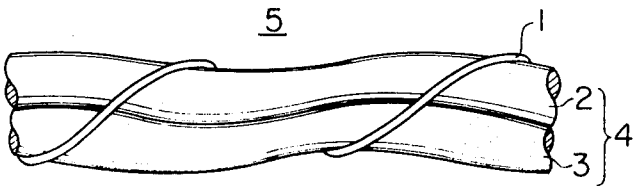
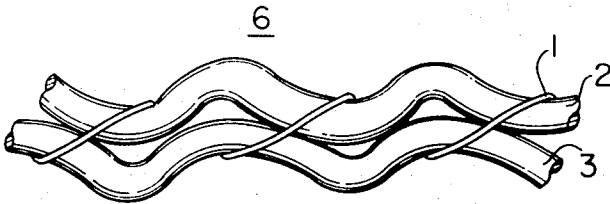


Fig. 2B



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Fig. 3A

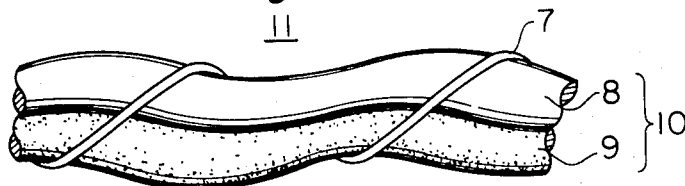


Fig. 3B

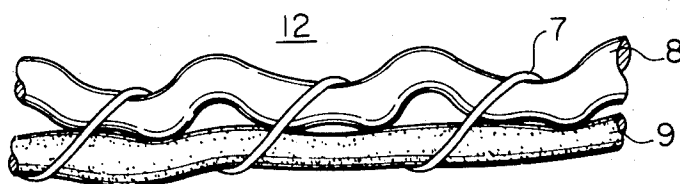


Fig. 4A

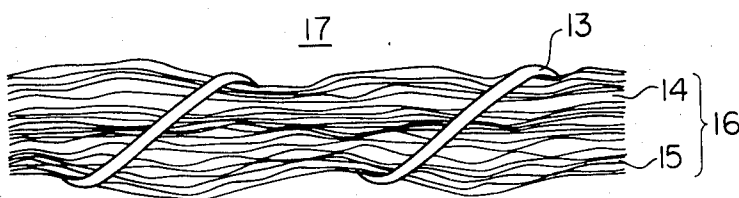
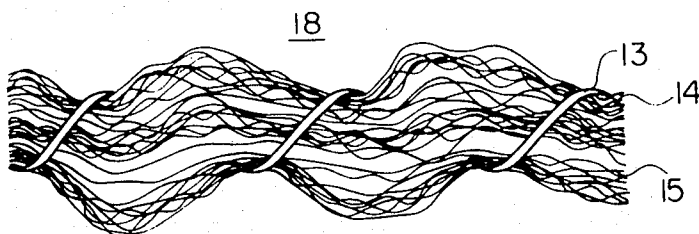


Fig. 4B



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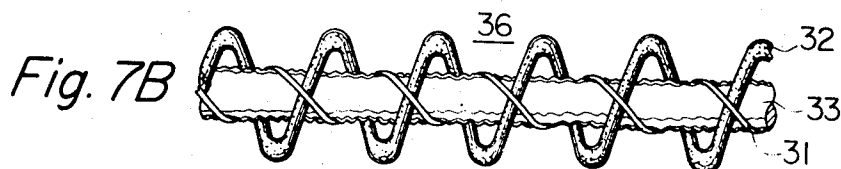
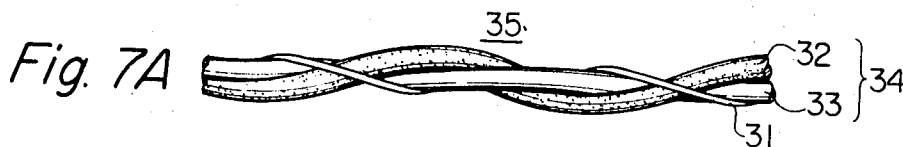
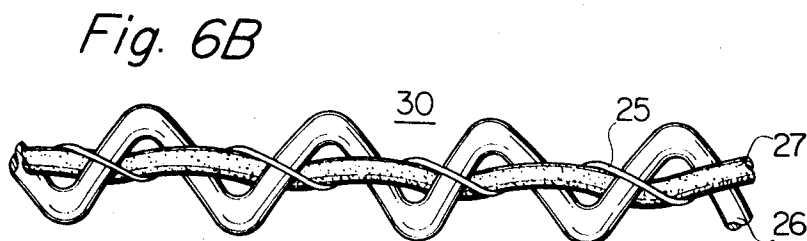
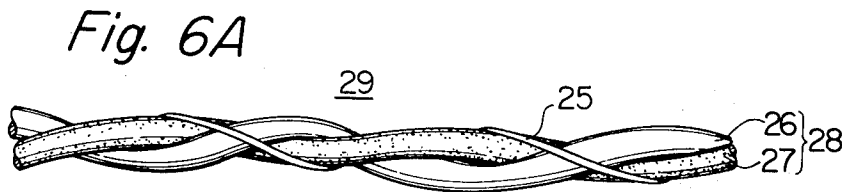
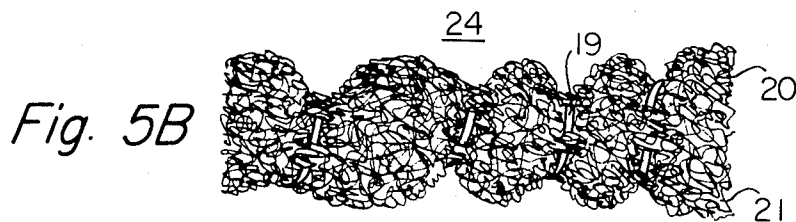
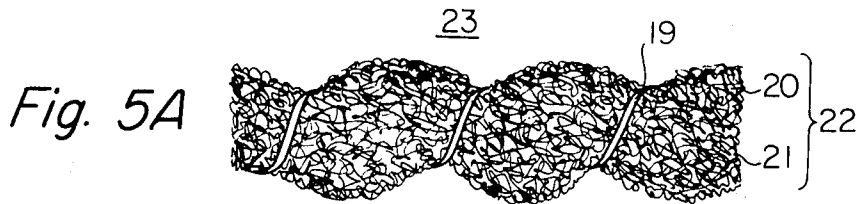
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3,609,953

ELASTIC COMPOSITE YARN AND PROCESS FOR MANUFACTURING THE SAME

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Claims priority, application Japan, June 3, 1968, 43/45,997, 43/45,998, 43/45,999, 43/46,000
43/46,001; June 17, 1968, 43/50,572

Int. Cl. D02g 3/04, 3/38

U.S. Cl. 57—152

21 Claims

ABSTRACT OF THE DISCLOSURE

An elastic composite yarn is provided, in which at least one high elastic filamentary binding yarn of at most 15% by weight consisting essentially of polypivalolactone is combined helically around a ground yarn of at least 85% by weight containing at least one bulked yarn, the bulked yarn extends outwardly in an arc form between adjacent points bound by the binding yarn.

The elastic composite yarn is manufactured by combining the ground yarn containing at least one low heat shrinkable fiber yarn with the binding yarn which is composed of non-elasticized filament and has a shrinkage of at least 10% greater than that of the low heat-shrinkable fiber yarn at a temperature from 100° C. to 220° C. so that the binding yarn is coiled around the ground yarn without elongation, and by heating the resultant composite yarn at a temperature from 100° C. to 220° C.

This invention relates to an elastic composite yarn containing polypivalolactone elastic binding yarn and a process for manufacturing the same. More particularly, this invention relates to an elastic composite yarn which contains (1) at most 15% by weight of at least one high elastic filamentary binding yarn consisting essentially of polypivalolactone and (2) at least 85% by weight of a ground yarn containing at least one bulked yarn which extends outwardly in an arc form between adjacent bound points by the binding yarn, and a process for manufacturing the same.

A desirable stretching characteristic is observed in a conventional crimped yarn of synthetic or artificial fiber formed by means of suitable mechanical crimping such as twisting, heat setting and untwisting or in a conventional crimped composite multifilament yarn manufactured by heat treatment after producing composite multifilament yarn. The term "composite multifilament" as used herein refers to multifilament composed of a plurality of individual filaments, each filament consists of polymers arranged side by side or core-to-sheath and which are mutually adherent along the length of the filament. In the above-described composite filament's lateral cross section, polymers may be arranged either in a mutually equal cross sectional area or in a mutually uneven cross sectional area. In other words, in case of the side by side arrangement, the lateral cross-sectional area of the component polymers may be either equal or not, whereas, in case of the core-to-sheath arrangement, two polymers may be arranged either coaxially or eccentrically. Accordingly a composite yarn made of such yarns can hardly maintain its crimped configuration after repeated stretching operations and its elongation recovery becomes poorer after repeated stretching operations.

In spite of its relatively large elongation and recovery, rubber yarn and a synthetic polyurethane segment elastomer yarn are inferior in their rigidity and tensile recovering force, so that it is rather difficult to obtain a yarn of fine denier. Consequently, an elastic yarn composed

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of such synthetic elastic fibers has an inferior rigidity and a large elongation results even from the application of a relatively small load. Because of such inferior physical characteristics, many processing troubles usually are present in the subsequent yarn knitting or weaving operations, resulting in difficulty in the manufacture of textile products of high and uniform quality. Such drawbacks of the above-mentioned yarn may be mitigated by increasing the composing ratio of the elastic component yarn in the composite yarn and its recovering force may be accordingly enlarged. However, this inevitably entails dilution of desirable characteristics of other component fibers.

Further, such a conventional elastic composite yarn is manufactured by combining the elastic component yarn maintained in a stretched condition with another component yarn. In this connection, a particular yarn feeding device and drafting device are installed as a general requirement so as to precisely control the yarn tension during the stretching.

The finest polyurethane elastomer yarn, which is manufactured and marketed at present, is about 40 denier, but polyurethane elastomer yarn finer than 70 denier is often accompanied by variation in tension or with yarn breakage during the manufacture of the composite yarn due to its inferior rigidity or poor tensile recovering force. For this reason, polyurethane elastomer yarn of 70 denier or larger is generally utilized in the actual production of elastic composite yarn. Consequently, the composing ratio of the polyurethane components within the resulting composite yarn inevitably becomes as large as 15 to 40% by weight. This is also a greater trouble with respect to rubber yarns and the available minimum fineness is about 300 denier in the case of the rubber yarn.

In case the composite yarn is manufactured by using the conventional elastic yarn, particularly in the case where the conventional elastic yarn is composited on an outer portion of the composite yarn, the appearance of the ground yarn composited in an inner portion of the composite yarn is almost covered by the conventional elastic yarn due to a relatively high composing ratio of the conventional elastic yarn with respect to the composite yarn. Therefore, there is the defect that such conventional elastic composite yarns cannot effectively utilize the color, figure and handling of the ground yarn therein.

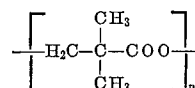
Furthermore, these conventional elastic yarns have not been used on the outer face of the composite yarn because the handling quality is not desirable.

The object of the present invention is to provide an elastic composite yarn having suitable elongation, tensile recovery and bulkiness though having a relatively low composing ratio of elastic binding yarn, and process for manufacturing the same.

Another object of the present invention is to provide a stable elastic composite yarn having a high initial modulus, good form-retention property against repeated stretching, good elastic-retention property which is stable against high temperature accompanied with a relatively low elastic binding yarn composing ratio, and process for manufacturing the same.

Still another object of this invention is to provide an elastic composite in which the elastic binding yarn is coiled around the ground yarn practically without substantially covering the appearance of the ground yarn and which has suitable bulkiness and tensile elasticity, and process for manufacturing the same.

Polypivalolactone in the present invention is a linear ester polymer having the general formula



(1)

and can be easily manufactured by polymerizing hydroxypivalic acid or its ester according to the process disclosed in U.S. Pat. 2,658,055 or by polymerizing pivalolactone according to the process disclosed in British Pat. 766,347.

"Fiber consisting essentially of polypivalolactone" is not limited to fiber in which the component of the fiber-forming polymer is only polypivalolactone as fibers made from copolymers indicated below are also included. That is, a composing ratio of up to 30 mole percent of a copolymer may be present if the fiber has the necessary crystalline property and does not obstruct high orientation. Furthermore, the aforementioned expression includes fibers made of a mixture of polypivalolactone or a copolymer of polypivalolactone and a relatively small quantity of other polymers to the extent where their characteristic features are practically not lost. These fibers form yarns in the form of monofilament, multifilament or staple.

Polypivalolactone differs from polyamide or polyethylene terephthalate, which are representative polyesters being widely utilized commercially as polymers for melt-spinning, as it has very unique characteristics of reaching high crystallinity very rapidly and consequently, special conditions are required in the fiber-making process by melt-spinning. That is, polypivalolactone filament which is very suitable for application of the method of the present invention can be obtained by the first step of melt-extrusion of polypivalolactone having an intrinsic viscosity (μ) of at least 0.7 through a spinneret having hole diameter of 0.5 mm. at a spinning temperature of 240–280° C. as disclosed by the inventors in U.S. patent application No. 634,224, the second step of applying a high draw down while the extruded polymer is still in the molten state or in a plasticized state and making a deformation ratio (A) a value satisfying the equation of

$$A \geq 1367(\mu)^{-5.612} \quad (2)$$

and the third step of drawing the undrawn filament obtained by the aforementioned step at a drawing temperature T (°C.) specified by the equation of

$$T \geq -282 + 1744R - 1605R^2 \quad (3)$$

(where R is the degree of orientation of the undrawn filament) and the equation of

$$200 \geq T \geq 10 \quad (4)$$

Also, the filament having especially superior characteristics suitable for application of the method of the present invention without utilizing the drawing step can be obtained by the first step of melt-extrusion of polypivalolactone having an intrinsic viscosity (μ) of at least 1.1 through a spinneret having a relatively large hole diameter at a spinning temperature of 240–310° C. as disclosed by the inventors in U.S. patent application No. 745,168, the second step of applying a high draw down while said extruded polymer is still in the molten state or in a plasticized state and making the deformation ratio A a value satisfying concurrently the two conditional equations of

$$A \geq 2460(\mu)^{-5.970} \quad (5)$$

$$A \geq 76(\mu)^{-1.599} \quad (6)$$

Such polypivalolactone filament exhibits superior tensile recovery within a certain elongation range, for example, a tensile recovery of at least 90% for 5% elongation even in the spun and drawn condition but such drawn filament has only residual elongation of several tens percentage. And moreover, undrawn filament indicates plastic deformation even with an elongation of only several percentages, and tensile recovering capacity is lost by a large elongation deformation. However, it is possible to increase the tensile recovery tremendously by exposure to a hot atmosphere suitably selected at a yarn temperature of at least 100° C., preferably at least 120° C. and providing at least 95% tensile recovery at 5% elongation, at least 92% at 10%, at least 88% at 15%, at least 85% at 20% and initial modulus of

15–80 g./d., and also converting it to a high elastic filament having a very superior tensile recovery force.

Also, it is possible to manufacture fiber consisting essentially of polypivalolactone with 15–50% heat-shrinkage in a temperature range from 100° C. to 220° C. while maintaining sufficient elastic manifestation by suitably selecting the raw material characteristics for manufacturing filament consisting essentially of polypivalolactone, such as average molecular weight and molecular weight distribution, raw material composition such as the type and quantity of mixing components and the type and quality of the copolymer component, spinning temperature, drawing ratio and heating medium for drawing.

The fiber performance of such high elastic polypivalolactone filament differs somewhat according to the manufacturing condition, i.e. the spinning condition and the drawing condition, but rigidity is considerably higher than that of the conventional elastic filaments such as rubber yarn and synthetic segment polyurethane elastomer filament, and when made elastic by heat treatment, modulus, which is at least 10 times that of the conventional polyurethane elastomer filament and at least 20 times that of rubber yarn, is present. Therefore, even when calculated from modulus, it is necessary to use polypivalolactone yarn in an amount less than $\frac{1}{10}$ of the polyurethane elastomer filament in the composite yarn in order to manufacture elastic composite yarn containing polypivalolactone having a tensile recovery property closely related to that of a certain composite yarn containing polyurethane elastomer.

The present inventor's attention was drawn to polypivalolactone having such very unique properties and succeeded in inventing a commercially advantageous process for manufacturing high elastic composite yarn having superior tensile recovery. By solving previous problems it may be utilized as one component of a composite yarn.

The features of the elastic composite yarn of the present invention are such that (1) it contains at least one high elastic filament binding yarn consisting essentially of polypivalolactone and having a composing ratio of 15% or smaller and (2) it contains a ground yarn present in a composing ratio of 85% or larger containing at least one bulked yarn, (3) said binding yarn is coiled around said ground yarn and (4) said bulked yarn extends outwardly of the composite yarn between the adjacent points bound by said binding yarn.

The composing ratio of the polypivalolactone binding yarn contained in the elastic composite yarn of the present invention is 15% or smaller and as it is a multifilament or monofilament, there is no excessive concealment and the color, shape, and handling quality of the ground yarn are fully manifested. Furthermore, as polypivalolactone binding yarn has a high modulus and resistance against fatigue by repeated stretching as mentioned above, elastic composite yarn, which is suitable for practical use, can be obtained with such a relatively low composing ratio. It is not possible to sufficiently attain the object of the present invention when the composing ratio of the binding yarn is higher than 15% as the concealment of the ground yarn increases. A fiber fineness of below 80 denier, preferably below 40 denier and more preferably below 20 denier, is desirable for the polypivalolactone binding yarn in the composite yarn of the present invention. A composite yarn of such fiber fineness, which can be used with such a low composing ratio and which has sufficient elasticity, was first obtained by the present invention.

The bulked yarn contained in the ground yarn of the composite yarn according to the present invention can be selected suitably from monofilament, multifilament, spun yarn, blended yarn, crimped yarn and multi-component yarn composed of natural fibers such as silk, cotton, linen and wool, regenerated fibers such as viscose rayon

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and cupra, semi-synthetic fibers such as diacetate and triacetate, and synthetic fibers such as polyamide, polyester, poly- α -olefins, polyester ether, polyamino acid, polyvinyl alcohol, polyacrylonitrile and polyether. However, the selection of this bulked yarn must be made such that the relations between heat-shrinkage of the polypivalolactone binding yarn which is to be composited, the heat treating temperature, time and heating medium for making the polypivalolactone binding yarn elastic, and heat-shrinkage and resistance against thermal treatment of the bulked yarn are taken into consideration.

Besides the bulked yarn, the ground yarn of the composite yarn of the present invention may contain elastic yarn. This elastic yarn is a yarn composed of elastic fibers or crimped yarn.

The composite yarn of this invention is manufactured by the following two steps.

(1) The step of manufacturing provisional composite yarn in which at least one non-elasticized, high shrinkable yarn consisting essentially of polypivalolactone having a heat-shrinkage of 10% or more which is higher than that of a low heat-shrinkable yarn at a temperature range of 100 to 220° C. is coiled with a composing ratio of 15% or less practically without stretching, around a ground yarn containing at least one of the low heat-shrinkable fiber yarns at a composing ratio of 85% or more.

(2) The step is one in which this provisional composite yarn is heat-treated at a temperature in a range of 100 to 220° C. However, this heat treatment is carried out on fiber composites beforehand obtained by manufacturing knitted or woven products, nets etc. with this provisional composite yarn.

The tensile elasticity of the binding yarn consisting essentially of polypivalolactone used in the first step has not yet been manifested. In the conventional process of manufacturing composite yarn from rubber yarn or synthetic segment polyurethane elastomer yarn, the elastomer yarns are made into composite yarn with other composition yarns in a condition where it is stretched to the predetermined length and as a result, uneven stretching is produced which frequently causes considerable dimensional instability of the elastomer yarn and yarn breakage. In the manufacturing process of the present invention, however, the binding yarn is not elasticized and can be made into composite yarn with the ground yarn practically without any stretching and consequently, none of the troubles which occur in the conventional method are present.

Also, it is not particularly necessary to apply tension control even when using fine polypivalolactone yarn of 40 denier or finer. Therefore, a special compositing apparatus and drafting apparatus for elastomer yarn, which are necessarily required when manufacturing composite yarn with the conventional elastomer yarn, are entirely unnecessary.

Furthermore, the polypivalolactone binding filament used in the first step must have high thermal shrinkage in a temperature range of 100 to 220° C. That is, this polypivalolactone filament must have a high heat-shrinkage of 10% higher, or more than that of the low heat-shrinkable yarn in the ground yarn at a specific temperature in a range of 100 to 220° C. In other words, the heat treating temperature of the polypivalolactone binding yarn must be selected so that its heat-shrinkage is 10% higher or more than that of the low heat-shrinkable yarn in the ground yarn in a temperature range of 100 to 220° C. The heat-shrinkage of this composite yarn becomes insufficient in the second step when the difference in this heat-shrinkage is below 10% and as a result, the elastic elongation and bulkiness of the composite yarn obtained becomes insufficient.

Polypivalolactone binding yarn is twisted in a spiral form around the ground yarn by the conventional twisting method to bind the ground yarn. In this case, the num-

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ber of twists is suitably selected in accordance with the heat-shrinkage characteristics of the composition yarns, heat treating condition and the object of manufacture, but generally, this is in a range of 100 to 1000 t./m., preferably 200 to 700 t./m.

The heat treating temperature in the second step is suitably selected in a temperature range of 100 to 220° C. in accordance with the heat-shrinkage characteristics of the composition yarns, heat treating apparatus, heat treating time and the object of manufacture. Also, this heat treating temperature is selected in accordance with the heating medium. For example, at the same heating temperature and time, generally heat-shrinkage is smallest when the heating medium is air, the largest when it is hot water and it is intermediate of these when steam is used. Therefore, in order to obtain the desired product, first, binding yarn consisting essentially of polypivalolactone having suitable characteristics is selected in accordance with the composition yarns of the product and object of manufacture, and then a suitable treating condition is selected.

Binding yarn, consisting essentially of polypivalolactone, manifests elasticity and shrinks at the same time by such a heat treatment. The low shrinkable yarn, which is the ground yarn extends outwardly in an arc form between the points bound by the binding yarn, thereby the composite yarn actualizes suitable bulkiness and tensile elasticity. This heat treating step may be carried out with the provisional composite yarn in a freely shrinkable, relaxed state such as hank; or textile, such as knitted goods, woven goods, rope, net, etc., may be manufactured with this provisional composite yarn and then heat-treating these.

A hot air heater, steam heater or hot water heater may be used as the heating apparatus or it may be treated by more than one of these. Also, this heat treatment may be carried out simultaneously with the scouting, bleaching, dyeing and finishing processes.

The heat treating temperature in this second step must be in a range of 100 to 200° C. In case the heat treating temperature is less than 100° C., heat-shrinkage of the binding yarn consisting essentially of polypivalolactone is small and elasticity is not manifested sufficiently and as a result, composite yarn having satisfactory bulkiness and tensile elasticity cannot be obtained. Also, in case the heat treating temperature is above 220° C., there is a possibility of the polypivalolactone becoming soft or melting. The optimum heating temperature depends on the melting point of the binding yarn consisting essentially of polypivalolactone, the critical temperature for actualizing elasticity within the practical time, and the melting point and decomposition point of the fiber contained in the ground yarn.

There is no particular limit to the heat treating time in the second step and this can be selected suitably in accordance with the heat treating temperature, kind of heating medium, construction of the composite yarn, object of manufacture, heat treating apparatus and kinds of composition fibers of the composite yarn.

When the composite yarn in accordance with the present invention contains fibers which can be dimensionally stabilized by heat-setting such as polyester fiber or polyamide fiber, the binding yarn consisting essentially of polypivalolactone actualizes elasticity and heat-shrinkage by heat treatment in this second step and at the same time, the above-mentioned composite fibers are dimensionally stabilized by heat setting in this second step.

In this case, the effective dry heat-setting temperature for polyester fiber and polyamide fiber is 150 to 220° C. but such a high temperature cannot be used for the conventional elastic composite yarn containing rubber yarn or synthetic segment polyurethane elastomer yarn because of the possibility of discoloration and degradation. However, no discoloration or degradation whatsoever is in-

licated with the use of polypivalolactone even with such a high temperature treatment.

The objects, features and advantages of this invention will be better understood by the following description taken in connection with the accompanying drawings.

FIG. 1 is a diagram showing the relation between elongation and tensile recovery of polypivalolactone fiber and other fibers.

FIGS. 2A to 7B are schematic views showing the composition of composite yarns of the present invention, in which A of each figure shows the structure of composite yarn before heat treatment and B of each figure the structure after heat treatment.

FIG. 1 shows the relation between elongation and tensile recovery of polypivalolactone fiber in which elasticity is actualized as a result of heat treatment, polypivalolactone fiber before heat treatment and having not yet been made elastic and other fibers, i.e. nylon 6, nylon 66, wool, polyester fiber, acrylic fiber, silk, and viscose rayon. It can be understood that compared with other fibers, polypivalolactone fiber, which has been made elastic, has good tensile recovery.

Modes of application of the present invention will be better understood from the following examples.

Table 1 shows the manufacturing condition and characteristics of polypivalolactone yarn used as the binding yarn in Examples 1 to 6 and Table 2 shows the composition and manufacturing condition of the composite yarn of Examples 1 to 6.

TABLE 1

Example Number	Bind- ing yarn	Drawing condition		Dry heat-shrinkage		Total denier/ fila- ment	Tenacity in g./ denier	Elonga- tion at break in percent	Initial modulus in g./ denier	Tensile recovery at elongation in percent			
		Temper- ature in ° C.	Drawing ratio	in percent						5% elonga- tion	10% elonga- tion	15% elonga- tion	20% elonga- tion
				150° C.	180° C.								
1-----	A	Undrawn		12.7	13.6	20/6	3.7	151	38	94	87	85	79
2-----	B	190	3.0	21.3	27.5	32/6	4.9	88	46	98	91	88	84
3-----	C	200	4.2	30.4	33.5	15/1	5.6	48	60	99	96	90	87
4-----	D	185	3.0	18.9	28.8	10/1	4.3	160	41	93	90	87	83
5-----	E	150	2.8	25.0	30.1	7/1	4.0	123	42	91	88	84	80
6-----	F	140	3.6	27.5	40.0	10/2	4.2	50	53	95	94	91	86

TABLE 2

	Example Number					
	1	2	3	4	5	6
Binding yarn	A	B	C	D	E	F
Ground yarn:						
Type of composition	Double	Double	Double	Double	Twist	Twist
Material:						
(1)	Worsted	Cotton	Polyester	Nylon 66	Silk	Cupra
(2)	do	Polypivalolactone	do	do	Polypivalolactone	Polypivalolactone
Fineness (count/yarn or denier/filament)						
(1)	48 #/l	30 #/l	120 D/30F	70 F/18F	21D×3	70 D/45F
(2)	48 #/l	180 d/54F	120 D/30F	70 F/18F	110 D/38F	240 D/60F
Number of twist per meter:						
First:						
(1)	500	840	Non		800	240
(2)	500	100	Non		80	Non
Final	Non	Non	Non	Non	500	250
Provisional composite yarn:						
Content of binding yarn (percent)	5	8	6	4	4	3
Twist (T/meter)	300	370	220	260	500	250
Heat treatment:						
Condition of composite yarn	Hank	Hank	Bobbin	Passing through tube heater	Hank	Hank
Temperature (° C.)	150	160	135	170	125	(1) 100. (2) 180.
Time	30 sec	2 min	5 min	30 sec	1 min	(1) 2 min. (2) 5 min.
Heating medium	Steam	Air	Hot water	Air	Steam	(1) Hot water. (2) Air.
Drawing	{ Fig. 2A Fig. 2B	{ Fig. 3A Fig. 3B	{ Fig. 4A Fig. 4B	{ Fig. 5A Fig. 5B	{ Fig. 6A Fig. 6B	{ Fig. 7A Fig. 6B

EXAMPLE 1

This example is explained with reference to FIGS. 2A and 2B. In FIG. 2A, the ground yarn 4 is a double yarn composed of two worsted yarns 2 and 3. Dry heat-shrinkage of the polypivalolactone binding yarn 1 at 150° C. was

12.7% but the dry heat-shrinkage of worsted yarns 2 and 3 could be practically ignored. The polypivalolactone binding yarn 1 was coiled around ground yarn 4 in the S direction with the number of turns being 300 turns/meter to prepare the provisional composite yarn 5. This provisional composite yarn 5 was heat treated in the form of hank for 30 seconds at 150° C. in a continuous steam heater. FIG. 2B shows the form of composite yarn 6 which has been obtained in this manner. Polypivalolactone binding yarn 1 was shrunk by the aforementioned heat treatment and was provided with elasticity. As a result of this, worsted yarns 2 and 3 extend outwardly of the composite yarn in an arc form between adjacent binding points. The composite yarn obtained in this manner had superior bulkiness and tensile elasticity.

EXAMPLE 2

This example is explained with reference to FIGS. 3A and 3B. In FIG. 3A, ground yarn 10 was a double yarn composed of cotton spun yarn 8 and polypivalolactone filament yarn 9. Steaming shrinkages of polypivalolactone binding yarn 7, and polypivalolactone filament yarn 9 and cotton yarn 8 of ground yarn 10 were 22.5%, 11.8%, and 0.8%, respectively, at 160° C. Polypivalolactone binding yarn 7 which has not been elongated is coiled around this ground yarn 10 in the S direction with the number of turns being 370 turns/meter to manufacture provisional composite yarn 11. This provisional composite yarn 11 is heat treated in the form of hank for 2 minutes at 160°

70 C. in a hot air heater. FIG. 3B shows the form of composite yarn 12 obtained in this manner. Polypivalolactone binding yarn 7 and polypivalolactone yarn 9 of a ground yarn 10 are shrunk and also provided with elasticity by the heat treatment. As a result of this, the cotton yarn 8 extends outwardly in an arc form between adjacent bind-

ing points. The composite yarn 12 obtained in this manner has superior bulkiness and elongation elasticity.

EXAMPLE 3

This example is explained with reference to FIGS. 4A and 4B. In FIG. 4A, ground yarn 16 is a double yarn composed of two non-twisted polyester filament yarns 14 and 15. Heat-shrinkages of polypivalolactone binding yarn 13 and the two polyester filament yarns 14 and 15 by hot water treatment at 135° C. were 38.6% and 19.7%, respectively.

Polypivalolactone binding yarn 13 which has not been elongated was coiled around this ground double yarn 16 in the S direction with number of turns of 220 turns/meter to manufacture provisional composite yarn 17. This provisional composite yarn 17 was wound on a bobbin and heat treated as is for 5 minutes in hot water of 135° C. FIG. 4B shows the form of composite yarn 18 obtained in this manner, with tension removed. Polypivalolactone binding yarn 13 was shrunk and was also provided elasticity by the heat treatment. As a result of this, the polyester filament in the ground yarn 16 was extended outwardly in an arc form between the binding points. The composite yarn 18 obtained in this manner had superior bulkiness and tensile elasticity, and the appearance of the binding yarn 13 was practically hidden.

EXAMPLE 4

This example is explained with reference to FIGS. 5A and 5B. In FIG. 5A, the ground yarn 22 is a double yarn composed of false twisted nylon 66 filaments. Heat-shrinkages of this nylon 66 and polypivalolactone binding yarn 19 by dry heat treatment at 170° C. were 3.8% and 26.2%, respectively. Polypivalolactone binding yarn 19, which has not been elongated, was coiled around this ground yarn 22 in a condition of being shrunk 48% with respect to its true length in the S direction with the number of turns being 260 turns/meter to manufacture provisional composite yarn 23. This provisional composite yarn 23 was heat treated with air of 170° C. for 30 seconds while passing through a heater tube. FIG. 5B shows the form of the composite yarn 24 obtained in this manner. Polypivalolactone binding yarn 19 was shrunk and also provided with elasticity by the heat treatment. As a result of this, the nylon 66 crimped filaments were extended outwardly in an arc form between adjacent binding points and the appearance of the binding yarn 19 was practically hidden. The composite yarn 24 obtained in this manner has superior bulkiness and tensile elasticity, and particularly desirable modulus at the initial elongation.

EXAMPLE 5

This example is explained with reference to FIG. 6A and 6B. In FIG. 6A, the ground yarn 28 is a twisted yarn of a silk yarn 26 and polypivalolactone filament yarn 27. This silk yarn 26 and polypivalolactone filament yarn 27 were twisted in the S direction with a twist of 500 t./m. Heat-shrinkages of polypivalolactone binding yarn 25, and polypivalolactone yarn 27 in the ground yarn 28 were 29.5%, and 17.0%, respectively, by steam heat of 125° C. Thermal shrinkage of the silk yarn 26 by steam heat of 125° C. was so small as to be practically ignorable.

Polypivalolactone binding yarn 25 was coiled without being elongated around the ground yarn 28 with a twist of 500 t./m. in the Z direction to manufacture provisional composite yarn 29. The provisional composite yarn was heat-treated in the hank form for 1 minute at 125° C. in a pressurized steamer. FIG. 6B shows the form of the composite yarn 30 obtained in this manner. Polypivalolactone yarns 25 and 27 were shrunk and elasticized by the heat treatment and as a result of this, the silk yarn 26 extends outwardly of the composite yarn in an arc form between adjacent binding points. The composite yarn obtained in this manner had superior bulkiness and tensile elasticity and also stability of form was good.

EXAMPLE 6

This example is explained with reference to FIGS. 7A and 7B. In FIG. 7A, ground yarn 34 was formed from polypivalolactone filament yarn 33 and cuprammonium filament yarn 32. The polypivalolactone filament yarn 33 was a bi-component conjugated yarn and crimps can be produced by heat treatment. Cuprammonium filament yarn 32 is coiled around polypivalolactone bi-component yarn in the S direction with the number of turns being 250 t./m.

Polypivalolactone binding yarn 31 which has not been elongated is coiled around ground yarn 34 in the Z direction with the number of turns being 250 t./m. to form the provisional composite yarn. Heat-shrinkages of polypivalolactone binding yarn 31 and bi-component yarn 33 were 40.0%, and 26.0%, respectively, by dry heat of 180° C. Heat-shrinkage of cuprammonium yarn 32 could be practically ignored, but shrinkage in hot water of 100° C. was 2.8%.

This provisional composite yarn 35 was preheated in the hank form in hot water of 100° C. and then heat-treated for 5 minutes in 180° C. air.

The bi-component yarn 33 actualized crimp by this heat treatment and it also was shrunk and elasticized by this heat treatment. As a result of this, the cuprammonium yarn 32 extends outwardly of the composite yarn in an arc form between adjacent binding joints as shown in FIG. 7B. The composite yarn obtained in this manner had superior bulkiness and elasticity.

In the above examples, the composite yarn was manufactured with the conventional apparatus without any trouble. The composite yarn thus obtained can be used for woven products, knitted products, cords, ropes and nets without any trouble. For example, clothing made from any of the above-mentioned composite yarns fits the body comfortably and are suitable for outer garments, underwear, sports wear and stockings.

What is claimed is:

1. Elastic composite yarn comprising (1) at most 15% by weight of at least one high elastic filamentary binding yarn consisting essentially of polypivalolactone and (2) at least 85% by weight of a ground yarn containing at least one bulked yarn which extends outwardly in an arc form between adjacent bound points by said binding yarn.

2. Elastic composite yarn as claimed in claim 1, wherein said binding yarn has a fineness of at most 80 denier.

3. Elastic composite yarn as claimed in claim 1, wherein said binding yarn is composed of multifilament.

4. Elastic composite yarn as claimed in claim 1, wherein said binding yarn is composed of monofilament.

5. Elastic composite yarn as claimed in claim 1, wherein said ground yarn is composed of a plurality of non-elastic bulked yarns which have been mutually doubled.

6. Elastic composite yarn as claimed in claim 1, wherein said ground yarn is composed of at least one non-elastic bulked yarn and at least one elastic yarn which have been mutually doubled.

7. Elastic composite yarn as claimed in claim 6, wherein said elastic yarn in said ground yarn is composed of an elastic fiber consisting essentially of polypivalolactone.

8. Elastic composite yarn as claimed in claim 1, wherein said bulked yarn is composed of at least one non-elastic multifilament which has a twist of at most 100 t./m.

9. Elastic composite yarn as claimed in claim 1, wherein said bulked yarn is composed of at least one crimped yarn.

10. Elastic composite yarn as claimed in claim 1, wherein said ground yarn is a twisted yarn composed of at least one elastic yarn and at least one non-elastic bulked yarn and said binding yarn is coiled around said ground yarn in a direction opposite a twisting direction of said ground yarn.

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11. Elastic composite yarn as claimed in claim 10, wherein the elastic yarn in said ground yarn is a crimped yarn.

12. Elastic composite yarn as claimed in claim 11, wherein said crimped yarn is a bi-component conjugated elastic yarn composed essentially of polypivalolactone.

13. Process for manufacturing elastic composite yarn, which comprises (1) combining, without elongating, at least 85% by weight of a ground yarn containing at least one low heat-shrinkable fiber yarn with at most 15% by weight of a binding yarn which is composed of at least one non-elasticizing filament consisting essentially of poly-
pivalolactone and having a shrinkage of at least 10% greater than that of the low heat-shrinkable fiber yarn at a temperature between 100° C. and 220° C., to form a composite yarn wherein the binding yarn is coiled helical-
ly around the ground yarn, and (2) heating the resultant composite yarn at a temperature between 100° C. and 220° C.

14. Process as claimed in claim 13, wherein said binding yarn has a fineness at most 40 denier.

15. Process as claimed in claim 13, wherein said binding yarn is composed of multifilament.

16. Process as claimed in claim 13, wherein said binding yarn is composed of monofilament.

17. Process as claimed in claim 13, wherein said ground yarn is a double yarn composed of a plurality of low heat-shrinkable yarns.

18. Process as claimed in claim 13, wherein said ground yarn is a double yarn composed of (1) at least one low heat-shrinkable yarn and (2) at least one filament consisting essentially of polypivalolactone having a

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shrinkage of at least 10% greater than that of the low heat-shrinkable yarn in a temperature between 100 and 220° C.

19. Process as claimed in claim 13, wherein said ground yarn contains at least one low heat-shrinkable multifilament having a twist of at most 100 turns/m.

20. Process as claimed in claim 13, wherein said ground yarn is composed of at least one low heat-shrinkable crimped yarn.

21. Process as claimed in claim 20, wherein said crimped yarn is composed of non-elastic fiber.

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