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(71) Applicant: **Calik Denim Tekstil San. Ve Tic. A.S. Istanbul (TR)**

(72) Inventors:
- **KARADUMAN, Ahmet Serhat Yesilyurt/Malatya (TR)**
- **ÖZKUL, Deniz Yesilyurt/Malatya (TR)**
- **CIRIK, Yasin Yesilyurt/Malatya (TR)**
- **TEMEL, Mustafa Önder Yesilyurt/Malatya (TR)**

(74) Representative: **Schmid, Nils T.F.**
Boehmert & Boehmert
Anwaltspartnerschaft mbB
Pettenkoferstrasse 22
80336 München (DE)

(54) **COMPOSITE YARN, FABRIC COMPRISING THE COMPOSITE YARN, METHOD FOR PRODUCING A COMPOSITE YARN AND ARRANGEMENT FOR PRODUCING A COMPOSITE YARN**

(57) The invention relates to a composite yarn (1) in particular for weaving, comprising at least one fibrous core (3) made of a core material comprising recycled fibers, in particular recycled cellulosic fibers and/or recycled synthetic fibers, and a sheath (5) surrounding the fibrous core, the sheath being made of a sheath material, in particular a sheath material comprising cellulosic fibers and/or synthetic fibers, having a greater axial strength than the core material.

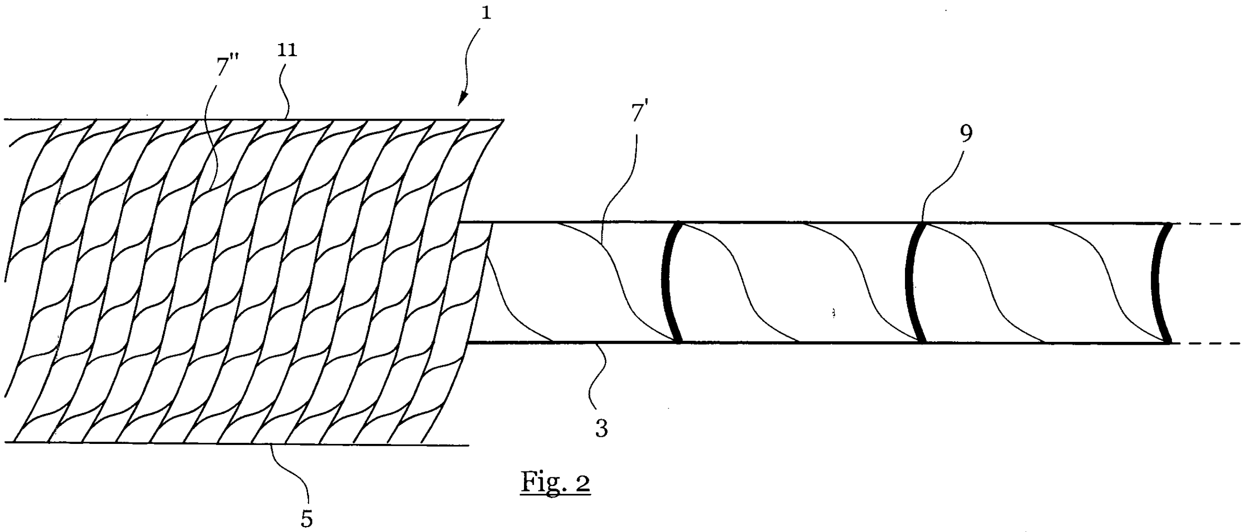


Fig. 2

EP 3 725 923 A1

Description

[0001] The invention refers to a composite yarn in particular for weaving. Further, the invention refers to a fabric, in particular a woven fabric, comprising at least one composite yarn. Further, the invention refers to a method for producing a composite yarn and to an arrangement for producing a composite yarn.

[0002] Yarns are typically produced by spinning fibers of wool, flex, cotton, polyester, elasthane or other materials to achieve long strands which shall be called yarns or threads. Particularly, the composite yarn according to the invention shall be used for manufacturing fabrics, such as woven fabrics or knitted fabrics. The fabric according to the invention shall particularly be used for manufacturing of clothes, preferably jeans fabric, denim or dungaree.

[0003] There are a lot of spinning technologies known in the art for spinning fibers into yarns, such as ring spinning, open-end spinning, air-jet spinning and friction spinning. However, before the yarn can be produced, the fibers have to be provided. Fibers in the meaning of the present invention shall incorporate staple fibers having a definite length and filaments having an indefinite length. In the case of fibers in the form of staple fibers, they can for example be provided from natural sources, such as cotton or wool. Fibers in the form of filaments, such as nylon filaments or polyester filaments, can for example be produced by melt spinning. However, in any case, the part of providing suitable fibers for spinning the fibers to a yarn requires energy, natural resources and causes costs. In order to reduce costs, energy and/or natural resources for providing the fibers, it is desirable to use recycled fibers for the yarn production.

[0004] Within the meaning of the present invention, recycled fibers shall be staple fibers having a length of maximally 25 mm, 23 mm, 22 mm or 20 mm and/or of at least 2 mm, 4 mm, 6 mm, 8 mm, 10 mm, 12 mm or 15 mm, in particular of an average length between 20 and 25 mm. Recycled fibers can for example be provided by cutting and/or separating them from textile products, such as from woven fabrics or knitted fabrics, in particular in the form of slivers. In particular, recycled fibers being provided from slivers usually have a high amount, in particular at least 30 %, 50 %, 70 %, 90 % or 95 %, of fibers with a fiber length between 10 mm and 25 mm, in particular between 20 mm and 25 mm. A problem arising when using recycled fibers for the yarn production is that the resulting yarn has a low axial strength due to the short fiber length. Because of the low axial strength of the yarns being produced from recycled fibers, yarns having a high percentage of recycled fibers, such as at least 20 %, 25 %, 30 % or 35 %, can particularly not be used for fabrics, in particular not for clothes such as jeans fabric, denim or dungarees. The high percentage of fibers having a low fiber length in recycled fibers, leads to a low percentage of recycled fibers that can be used for yarn production.

[0005] It is an object of this invention to provide a yarn overcoming the above-mentioned disadvantages, particularly a yarn comprising recycled fibers, in particular an increased content of recycled fibers, wherein the yarn has an increased axial strength, particularly has enough axial strength to be processed in fabric manufacturing processes, such as weaving, knitting and dyeing. It is further an object of this invention to provide a method and an arrangement for producing a composite yarn comprising recycled fibers, in particular an increased content of recycled fibers, having an increased axial strength, particularly having enough axial strength to be processed in fabric manufacturing processes, such as weaving.

[0006] The object is solved by the features of the independent claims.

[0007] According to a first aspect of the present invention, a composite yarn in particular for weaving is provided, comprising at least one fibrous core made of a core material comprising recycled fibers, in particular recycled cellulosic fibers and/or recycled synthetic fibers, and a sheath surrounding the fibrous core, the sheath being made of a sheath material, in particular a sheath material comprising cellulosic fibers and/or synthetic fibers, having a greater axial strength than the core material.

[0008] A fibrous core in the meaning of the present invention is a core comprising staple fibers. Staple fibers are fibers of a definite length, in particular a length greater than 2 mm, 5 mm or 10 mm and/or a length of maximally 500 mm, 200 mm, 150 mm, 100 mm, 80 mm, 60 mm, or 45 mm. Preferably, staple fibers shall include fibers with a fiber length between 10 mm and 45 mm. Preferably, the core material consists of staple fibers. However, the core material can also comprise filaments in addition to the staple fibers. In particular, the fibrous core can consist of at least 30%, 50%, 70%, 90%, 95% or 100% of staple fibers and/or to less than 30%, 20%, 10%, 5% or 2% of filaments.

[0009] Unless otherwise specified, values declared in percent shall be understood as mass percent within the meaning of the present invention.

[0010] Within the meaning of the present invention, the terms core material and sheath material particularly relate to the fibers being part of the core material. In order to compare the axial strength of the core material and the sheath material, the core material and the sheath material shall be compared with each separated from the composite yarn. The axial strength of the core material can for example be measured by measuring the axial strength of the fibrous core before the fibrous core becomes surrounded by the sheath. Alternatively, the strength of the core material can be measured by separating the fibrous core from the already produced composite yarn. Subsequently the strength of the core material can be measured by measuring the strength of the at least one fibrous core.

[0011] The strength of the sheath material can also be measured by separating the fibers forming the sheath material from the composite yarn, forming the sheath material to a sheath yarn and measuring the axial strength of the sheath yarn. However, it shall be considered that the production of the composite yarn as well as the separation of the sheath material from the composite yarn can influence the axial strength of the sheath material and the axial strength of the core material.

[0012] The strength of the sheath material can particularly be measured by using the arrangement for surrounding the fibrous core with the sheath for producing a yarn only consisting of the sheath material. A preferred arrangement for producing such a sheath yarn for the measurement of the axial strength of the sheath material is a ring spinning arrangement, which is described in detail below.

[0013] Within the meaning of the present invention, the axial strength of the core material and of the sheath material is the strength of the respective material in longitudinal direction of the fibers forming the respective material. Particularly, the strength of the core material and of the sheath material can be compared by the breaking force of the respective material. In particular, the material having the greater breaking force is the material having the greater breaking force. The breaking force is the force being applied to the respective material or in axial direction which leads to the breaking of the respective material. Breaking within the meaning of the present invention particularly means that the respective material breaks into two parts.

[0014] There are many testing methods and testing devices known in the art to measure the breaking force of fibers, filaments, yarns and rovings. For instance, the USTER TENSOR RAPID-3 device (Uster, Switzerland) is able to measure elasticity, breaking force, etc. of yarns or filaments. An example of said testing device is described in WO 2012/062480 A2 which shall be incorporated hereinto by reference.

[0015] In a preferred embodiment of the invention, the axial strength is indicated by the breaking tenacity. The breaking tenacity can be calculated by dividing the breaking force through the linear density of the sheath material and respectively of the core material. According to this preferred embodiment of the invention, the material having the greater breaking tenacity is the material having the greater axial strength. The tenacity is usually measured in grams per Denier. Thereby, the unit "grams" indicates the strength being applied for breaking the yarn, and the unit "Denier" represents the linear density. Of course, the linear density can also be measured by other units, such as tex, Nm, Ne, etc. The skilled person knows how to adapt the formula for calculating the breaking tenacity depending on the units indicating the linear density.

[0016] Because the yarn count affects the axial strength of the resulting yarn, it is preferred to compare the axial strength of the core material and of the sheath material by comparing yarns having the preferred yarn count as in the resulting hybrid yarn. As indicated below, a preferred yarn count for the at least one fibrous core is 30 Ne and a preferred yarn count for the hybrid yarn is 10 Ne. For the comparison of the axial strength of the core material and of the sheath material, it is therefore preferred to compare the axial strength of a core yarn having a yarn count of 30 Ne with the axial strength of a sheath yarn having a yarn count of 10 Ne. In order to make the results comparable, it is preferred to compare the axial strength by the Tenacity, in particular by the breaking tenacity.

[0017] Further, because the spinning technology being used for the yarn production particularly affects the axial strength of the resulting yarn, it is preferred to compare the core material and the sheath material by a respective core yarn and a respective sheath yarn being produced by the spinning technology which is preferred for the hybrid yarn production. As described below, the preferred spinning technology for the at least one fibrous core yarn is the open-end spinning technology and the preferred spinning technology for spinning the sheath around the at least one core yarn is the ring spinning technology. Accordingly, it is preferred to compare a core yarn being produced by open-end spinning with a sheath yarn being produced by ring spinning.

[0018] According to a preferred embodiment of the invention, the axial strength of the sheath material is at least 25%, 50%, 75%, 100%, 125% or 150% greater than the sheath material strength. Preferably, the axial strength of the core material is between 2 cN/tex and 12 cN/tex, in particular between 4 cN/tex and 10 cN/tex, more particular between 6 cN/tex and 8 cN/tex. Alternatively or additionally, the axial strength of the sheath material is between 8 cN/tex and 20 cN/tex, in particular between 10 cN/tex and 18 cN/tex, more particular between 12 cN/tex and 16 cN/tex. Alternatively or additionally, the axial strength of the composite yarn is between 6 cN/tex and 20 cN/tex, in particular between 9 cN/tex and 17 cN/tex, more particular between 11 cN/tex and 15 cN/tex.

[0019] The axial strength being indicated in cN/tex preferably relates to the breaking tenacity. The difference in axial strength being indicated in % preferably relates to the comparison of the breaking tenacity of the core material and of the sheath material. Of course, when considering the differences in yarn count of the sheath material and of the core material, the differences in the axial strength can be even greater. For instance, a sheath material having a yarn count of 10 Ne corresponds to a yarn count of 60 tex wherein a yarn count of the core material of 30 Ne corresponds to a yarn count of about 20 tex. Accordingly a sheath material having a breaking tenacity of 6 cN/tex and a yarn count of 30 Ne particularly has a breaking strength of 120 cN. A sheath material having a breaking tenacity of 12 cN/tex and a yarn count of 10 Ne would have a breaking strength of 720 cN. In this example, the sheath material would have a breaking tenacity being 100 % greater than the breaking tenacity of the core material. However, the total breaking strength of the sheath material would be 500 % greater than the total breaking strength of the core material. The skilled person will know how to calculate the differences regarding the total axial strength on the basis of the later described preferred yarn counts of the sheath material and the core material.

[0020] The inventor of the present invention has surprisingly found that surrounding the fibrous core with a sheath, which sheath material has a greater axial strength than the core material, increases the overall axial strength of the composite yarn. It has surprisingly been found that with the inventive concept, even composite yarns comprising a high content of recycled fibers, such as up to 20%, 25%, 30% or 35% of recycled fibers, can be produced having still enough overall axial strength to be manufactured to fabrics, such as woven fabrics. It has been found that the axial strength of the sheath material can be increased by decreasing the content of short fibers, in particular recycled fibers, in the sheath material and/or by increasing the average fiber length of the sheath material. Further, it has been found that the overall axial strength of the composite yarn can be increased by producing the at least one fibrous core by open-end spinning. Therefore, it is particularly preferred to combine the following second, third and/or fourth aspect of the present invention with the first aspect of the present invention and vice-versa.

[0021] Cellulosic fibers are in particular fibers made with ethers or esters of cellulose, which can be obtained from the bark, wood or leaves of plants, or from other plant-based material. In addition to cellulose, the fibers may particularly comprise hemicellulose and lignin. The used cellulosic fibers can particularly be natural cellulosic fibers or manufactured cellulosic fibers. For instance, natural cellulosic fibers in the form of cotton fibers, silk fibers and/or linen fibers can be used. Manufactured cellulose fibers are particularly fibers being produced by processing plants into a pulp and then extruding the pulp in the same ways as synthetic fibers, such as polyester or nylon. For instance, manufactured cellulose fibers can be used in the form of rayon fibers and/or viscose fibers.

[0022] Synthetic fibers are particularly fibers made by humans with chemical synthesis. In general, synthetic fibers are created by extruding fiber-forming materials through spinnerets into air and water for forming the fiber. Synthetic fibers can for instance be made from crudes and intermediates including petroleum, coal, limestone and water. As synthetic fibers, for instance nylon fibers, polyester fibers, acrylic fibers, spandex fibers, aramid fibers, T400 and/or glass fibers can be used.

[0023] Due to the increased axial strength of the composite yarn, the composite yarn can be processed with pretreatment processes, such as dyeing, prior to weaving the yarns. In a preferred embodiment of the invention, the composite yarn is processed to yarns that are raw, sulphur, dyed, reactive dyed, indigo (ring) dyed, pigment dyed, direct dyed, indanthrene dyed, acid dyed, natural dyed, etc. Preferably, the core material can be colored or raw. Additionally or alternatively the sheath material can be dyed, in particular indigo dyed, before the sheath material is surrounded around the fibrous core.

[0024] According to a second aspect of the present invention a composite yarn in particular for weaving is provided, comprising at least one fibrous core made of a core material comprising recycled fibers, in particular recycled cellulosic fibers and/or recycled synthetic fibers, and a sheath surrounding the at least one fibrous core, the sheath being made of a sheath material, in particular a sheath material comprising cellulosic fibers and/or synthetic fibers, having a lower content of recycled fibers than the core material.

[0025] A lower content of recycled fibers can in particular also include the absence of recycled fibers at all in the sheath material. However, it has been found that even sheath material comprising recycled fibers can increase the axial strength of the composite yarn, if the content of recycled fibers in the sheath material is lower than the content of recycled fibers in the core material.

[0026] The content of the recycled fibers in the core material and in the sheath material is preferably measured in weight percentage.

[0027] The content of the recycled fibers in the core material and in the sheath material can particularly be measured by weighing the amount of recycled fibers being intended for the core material for a specific length, for instance 1000 m, of a composite yarn and weighing the amount of recycled fibers being intended for the sheath material or the same length of the composite yarn.

[0028] In order to increase or decrease a content of recycled fibers in the core material or in the sheath material, fresh fibers, such as staple fibers being longer than recycled fibers or filaments, can be introduced into the core material or the sheath material.

[0029] In a preferred embodiment of the present invention, the sheath material consists at least to 30%, 50%, 70%, 90%, 95% or 100% of filaments, i.e. fibers with indefinite length, or of staple fibers having a longer length than the recycled fibers.

[0030] It has surprisingly been found that even a content of up to 30% of recycled fibers in the sheath material can lead to a sufficient axial strength of the composite yarn for being processed in weaving technology when the remaining part of the sheath material comprises long fibers, such as fibers having a length of more than 25 mm, 30 mm, 35 mm or 40 mm and/or as filaments.

[0031] In order to provide a composite yarn with a high amount of recycled fibers, it has been found advantageous to provide a fibrous core which core material consists to 100% of recycled fibers. In such an embodiment, it is preferred that the sheath material is particularly free of recycled fibers.

[0032] According to a preferred embodiment of the present invention, the core material consists to at least 30%, 50%, 70%, 90%, 95% or 100% of recycled fibers, preferably of recycled fibers having a fiber length of maximally 25 mm, 20 mm, 15 mm or 10 mm. Additionally or Alternatively, the sheath material consists to less than 30%, 20%, 10%, 5% or 2% of recycled fibers, in particular is free of recycled fibers, preferably of recycled fibers having a fiber length of maximally 25 mm, 20 mm, 15 mm or 10 mm.

[0033] In embodiments in which the core material consists to less than 100% of recycled fibers, the remaining part can comprise or consist of fibers being longer than the recycled fibers or of filaments.

[0034] The second aspect of the present invention can advantageously be combined with the first aspect of the present invention to increase the axial strength of the core material and thereby increase the axial strength of the composite yarn.

[0035] According to a third aspect of the present invention, a composite yarn in particular for weaving is provided, comprising at least one fibrous core made of a core material comprising recycled fibers, in particular recycled cellulosic fibers and/or recycled synthetic fibers, and a sheath surrounding the at least one fibrous core, the sheath being made of a sheath material, in particular a sheath material comprising cellulosic fibers and/or synthetic fibers, having a greater average fiber length than the core material.

[0036] The greater average fiber length of the sheath material can for instance be realized by the second aspect of the present invention, namely by providing a sheath material having a lower content of recycled fibers than the core material. For instance, the sheath material can be free of recycled fibers wherein the core material can consist to 100% of recycled fibers, such that the average fiber length of the sheath material is greater than the average fiber length of the core material. This can particularly lead to a sheath material having a greater axial strength than the core material. However, independently of the content of the recycled fibers, an increased axial strength of the composite yarn can in particular also be achieved by using a sheath material having a greater average fiber length than the core material. For instance, both the sheath material and the core material may consist to the same content of recycled fibers, such as to 30%. Thereby, the greater average fiber length of the core material can be realized by using fibers of a greater average fiber length for the remaining part of the sheath material. Alternatively, or additionally, the greater average fiber length of the sheath material can be realized by using recycled fibers of a greater average fiber length for the sheath material than the fiber length of the recycled fibers of the core material.

[0037] However, it is preferred to use a core material substantially consisting of fibers with a fiber length within a low fiber length range and to use a sheath material substantially consisting of fibers with a fiber length within a high fiber length range. Substantially means in this context at least 70%, 90%, 95% or 100% of the fibers. Preferably, the low fiber length range is between 5 mm and 32 mm, more preferably between 10 mm and 28 mm, most preferably between 20 mm and 25 mm. Preferably, the high fiber length range starts from at least 26 mm, more preferably from 28, 30 mm or 32 mm, most preferably from 34 mm or from 36 mm. Preferably, the sheath consists to at least 30%, 50%, 70%, 90%, 95% or 100% of fibers or of filaments.

[0038] According to a preferred embodiment, the core material has an average fiber length of less than a length between 26 mm and 32 mm, preferably an average fiber length of less than 26 mm, 24 mm or 22 mm. Additionally or alternatively, the sheath material has an average fiber length of more than a length between 26 mm and 32 mm, preferably an average fiber length of more than 26 mm, 28 mm, 30 mm, 32 mm, 34 mm or 36 mm.

[0039] In particular in combination with the subsequently described fourth aspect of the present invention, it has surprisingly been found that the use of fibers having an average fiber length less than a length between 26 mm and 32 mm, preferably an average fiber length of less than 26 mm, 24 mm or 22 mm, leads to an increased axial strength of the fibrous core compared to a fibrous core which core material has a greater average fiber length. It has surprisingly been found that even the use of fibers having an average fiber length between 10 mm and 15 mm, for the at least one axial core can, in particular in combination with the fourth aspect of the invention, particularly lead to a composite yarn having enough axial strength to be processed in weaving technologies.

[0040] Therefore, it is particularly advantageous to combine the third aspect of the present invention with the subsequently described fourth aspect of the present invention.

[0041] According to a preferred embodiment, the composite yarn has an average fiber length of at least 2 mm, 5 mm or 10 mm. This is of particular importance because when using two short fibers, the production of a yarn from these fibers becomes more difficult and the axial strength of the resulting fibrous core becomes particularly low.

[0042] According to a fourth aspect of the present invention, a composite yarn in particular for weaving is provided, comprising at least one fibrous core made of a core material comprising recycled fibers, in particular recycled cellulosic fibers and/or recycled synthetic fibers, the core being produced by open-end spinning and a sheath being made of a sheath material, in particular a sheath material comprising cellulosic fibers and/or synthetic fibers, the sheath being surrounded around the at least one fibrous core by spinning, in particular by ring spinning. It has surprisingly been found that by producing the at least one fibrous core by open-end spinning, the strength of the fibrous core can significantly be increased compared to other spinning technologies. In particular, it has been fund that upon using the open-end spinning technology for producing the fibrous core, a greater amount of recycled fibers can be used compared to other spinning technologies, such as ring spinning, leading to the same or even to an increased axial strength of the at least one fibrous core. Further, it has surprisingly been found that by the open-end spinning technology, the axial strength can be increased by using recycled fibers of a lower length than it would be required for other spinning technologies, such as ring spinning. For instance, for producing a fibrous core by ring spinning, normally the length of the fibers in the core material shall particularly be between 26 mm and 45 mm. It has surprisingly been found that in particular producing a fibrous core by open-end spinning from a core material comprising or consisting of fibers having a fiber length of less than 26 mm, 24 mm or 22 mm, and/or of at least 10 mm, 15 mm or 20 mm, leads to a fibrous core having a greater axial strength than when using fibers having a greater fiber length, such as a fiber length being greater than 26 mm, 28 mm, 30 mm, 32 mm, 34 mm or 36. Particularly good results could be achieved by using a core material according to the first, the second and/or the third aspect of the present invention, in particular of their preferred embodiments, for the open-end spinning.

[0043] It has been found that in order to spin the sheath around the at least one fibrous core, the fibrous core needs a minimum axial strength because the fibrous core is usually tensioned during the spinning of the sheath around the core. If the axial strength of the at least one fibrous core is not high enough, the fibrous core particularly breaks upon trying to spin the sheath around the fibrous core due to the tension stress. In this regard, it has surprisingly been found that upon using the open-end spinning technology, even a fibrous core consisting of up to 100% of recycled fibers and/or having an average fiber length between 10 mm and 15 mm can be produced with a sufficient axial strength for being processed to a composite yarn in the subsequent spinning action.

[0044] However, even the axial strength of the at least one fibrous core achieved by the open-end spinning technology might not be sufficient for processing the fibrous core in weaving manufacturing steps, such as the weaving itself and pre-treatment steps, such as dyeing of yarns.

[0045] Therefore, the fibrous core is surrounded by the sheath to provide a composite yarn having enough axial strength to be processed for the manufacturing of fabrics, such as woven fabrics. The sheath material particularly has a greater axial strength than the core material such that the axial strength of the composite yarn is increased by surrounding the fibrous core by the sheath.

[0046] In particular, the axial strength of the composite yarn can substantially be provided by the sheath surrounding the core. In particular, the sheath serves for two purposes. The first is to increase the axial strength of the composite yarn such that the composite yarn can be processed in fabric manufacturing processes, such as in dyeing processes and in weaving processes. The second is particularly to surround the fibrous core in such a way, that even in case the core breaks upon the processing of the composite yarn, the fibers of the core remain in the composite yarn. In particular, the term surrounding shall be understood as enclosing or encapsulating the fibrous core in circumferential direction to the length of the fibrous core. In particular, the sheath holds the fibrous core, in particular compresses the core, to prevent the core from breaking and/or from being separated from the composite yarn upon processing the composite yarn.

[0047] Due to the inventive aspects of the present invention, the fibrous core particularly only needs to provide enough axial strength so as not to break during the process step of surrounding the core with the sheath material, in particular during spinning, more particularly, during ring spinning. Once the at least one core is surrounded by the sheath material, the axial strength of the composite yarn can substantially be provided by the sheath material. When using the term substantially in this regard, it is meant that most of the axial strength of the composite yarn, in particular at least 70%, 90%, 95% or even 100% is provided by the composite yarn. In particular, the at least one fibrous core can even weaken the composite yarn due to its relatively low axial strength, which weakening can be compensated by the sheath surrounding the core.

[0048] It has surprisingly been found that it is particularly of advantage to use fibers of a low fiber length, such as the previously described fiber lengths for the core material, for the open-end spinning of the fibrous core, and to use fibers having a greater average fiber length, such as the previously described fiber lengths for the sheath material, or filaments for spinning the sheath around the fibrous core, in particular by ring spinning.

[0049] Ring spinning and open-end spinning is described in more detail below in relation to the method according to the fifth aspect of the present invention and in relation to the arrangement according to the sixth aspect of the present invention. It shall be clear that the inventive composite yarn according to the first, the second, the third and/or the fourth aspect of the invention can be produced and structured according to the method according to the fifth aspect of the present invention and/or according to the arrangement according to the sixth aspect of the present invention.

[0050] According to a preferred embodiment of the invention, the at least one fibrous core has a yarn count of 40 $\pm$ 20 Ne, preferably of 30 $\pm$ 10 Ne, more preferably of 30 $\pm$ 5 Ne, most preferably of 30 $\pm$ 3 Ne or of 30 $\pm$ 1 Ne. Alternatively or additionally, the sheath has a yarn count of 20 $\pm$ 15 Ne, preferably of 15 $\pm$ 10 Ne, more preferably of 15 $\pm$ 5 Ne, most preferably of 15 $\pm$ 3 Ne or of 15 $\pm$ 1 Ne. Alternatively or additionally, the composite yarn has a yarn count of 15 $\pm$ 14 Ne, preferably of 10 $\pm$ 9 Ne, more preferably of 10 $\pm$ 5 Ne, most preferably of 10 $\pm$ 3 Ne or of 10 $\pm$ 1 Ne.

[0051] It has surprisingly been found that in particular a higher yarn count of the fibrous core compared to the yarn count of the sheath leads to an increased strength of the composite yarn. Within the meaning of the present invention, the higher yarn count means a higher value in the unit Ne (Number English). This is particularly surprising because the axial strength of a yarn being produced by spinning, in particular by open-end spinning, is usually anti-proportional to the yarn count in Ne. In particular, usually the axial strength of a yarn increases when the yarn count in Ne of the yarn decreases. However, this surprising effect might be explained by the particularity of the present invention, in which it is rather the sheath providing the axial strength of the composite yarn than the fibrous core. By decreasing the yarn count, the mass per length of the sheath material can particularly be increased, thereby increasing the axial strength of the sheath material, particularly without affecting the desired yarn count of the composite yarn. This particularly contributes to the particularity of the present invention, according to which rather the sheath than the at least one fibrous core provides the axial strength of the composite yarn. This is of particular advantage in combination with the fourth aspect of the present invention in which the production of the at least one fibrous core by open-end spinning allows the production of a fibrous core having enough axial strength to be processed in the subsequent operation for surrounding the at least one core with the sheath even if the at least one fibrous core has a relatively high yarn count in Ne, such as 40 ± 20 Ne, 30 ± 10 Ne, 30 ± 5 Ne, 30 ± 3 Ne or 30 ± 1 Ne.

[0052] According to a preferred embodiment of the present invention, the composite yarn consists to at least 20%, preferably at least 30%, more preferably at least 35%, of the core material. Additionally, or alternatively, the composite yarn consists to maximally 80%, preferably maximally 70%, more preferably maximally 65% of the sheath material. It has surprisingly been found that with the present invention, composite yarns having up to 35% of the core material can be produced which still has enough axial strength to be processed to fabrics, particularly by weaving. Since due to the present invention even fibrous cores consisting to 100% of recycled fibers can be produced and surrounded by a sheath, composite yarns can be provided having up to 35% of recycled fibers. In particular in combination with the fourth aspect of the present invention, even composite yarns can be provided having 35% of recycled fibers having an average fiber length of less than a length between 10 mm and 15 mm or of an average fiber length within a range of 10 mm to 15 mm or within a range of 20 mm to 25 mm, wherein the composite yarn particularly has still enough axial strength to be processed to a fabric, in particular by weaving.

[0053] According to a preferred embodiment of the present invention, the sheath material consists to at least 50%, 70%, 90%, 95% or 100% of staple fibers and/or of filaments. In particular, the sheath material can be a combination of staple fibers and filaments. For instance, the sheath material can comprise to 95 % of staple fibers and to 5 % of filaments, such that the filaments particularly increase the axial strength of the core material. The staple fibers of the sheath material preferably have a greater average fiber length than the recycled fibers as particularly stated abore and below. Preferably the staple fibers of the sheath

[0054] In a preferred embodiment of the invention, the composite yarn comprises at least one sub-sheath surrounding the at least one fibrous core, the sub-sheath being made of a sub-sheath material, in particular a sub-sheath material comprising cellulosic fibers and/or synthetic fibers, wherein the sub sheath preferably surrounds the at least core such that the sub-sheath is encompassed by the at least one fibrous core and the sheath. Additionally or alternatively, the sub-sheath material preferably consists to at least at least 50%, 70%, 90%, 95%, or 100% of staple fibers or of filaments. The sub-sheath can for example be surrounded around the fibrous core prior to surrounding the fibrous core by the sheath material such that the sub-sheath is particularly encompassed by the at least one fibrous core and the sheath. This can for instance be of advantage when a fibrous core has a relatively low axial strength being not sufficient for surrounding a sheath material having relatively high linear density, such as a yarn count of 15 Ne, around the fibrous core. In such a case, the fibrous core can previously be surrounded by a sub-sheath material having lower linear density, such as a yarn count of 30 Ne, to increase the axial strength of the fibrous core by the sub-sheath material. Subsequently, the fibrous core with the increased axial strength can particularly be surrounded with a sheath material having a greater linear density, such as yarn count of 15 Ne.

[0055] According to a preferred embodiment of the present invention, the composite yarn comprises at least two, three, four or five of the at least one fibrous core made of a core material comprising recycled fibers, wherein preferably the core material of each fibrous core consists to at least 30%, 50%, 70%, 90%, 95% or 100% of recycled fibers, preferably of recycled fibers having a fiber length of maximally 25 mm, 20 mm, 15 mm or 10 mm. In one embodiment, each of the fibrous cores comprise substantially to the same content of recycled fibers. Within the meaning of the present invention, the term substantially the same content shall particularly contain deviations of up to ±10 %, 5% or 3%. However the fibrous cores can also have different contents of recycled fibers. Alternatively or additionally, the fibrous cores can have a substantially the same or a different yarn count.

[0056] In particular, one, more or all of the fibrous cores can be produced and/or structured according to the previously and subsequently described at least one fibrous core. However, if using more than one fibrous core, it is particularly of advantage to adapt the yarn count such that a group of the fibrous cores have substantially the same yarn count as the preferred yarn count of one fibrous core. The fibrous cores can particularly be aligned substantially parallel to each other or twisted around each other. When using more than one fibrous core, one or more of the fibrous cores can be surrounded by a sub-sheath prior to aligning or twisting the fibrous cores to each other. In embodiments in which the fibrous cores are surrounded by sub-sheaths, the sub-sheath can, particularly after aligning or twisting the cores around each other, form the sheath around the fibrous cores. However, preferably even if the fibrous cores are surrounded by a sub-sheath, the fibrous cores are preferably further surrounded by a sheath. Thereby, the axial strength of the resulting composite yarn can particularly be increased and/or the fibrous cores can be prevented from being separated from each other during fabric manufacturing processes.

[0057] According to a preferred embodiment of the present invention, the composite yarn further comprises at least one, in particular at least two, three, four or five, additional core. The at least one additional core is particular at least one additional filament core, such as at least one elastic filament core and/or at least one inelastic filament core. Alternatively or additionally, the at least one additional core is particular at least one additional fibrous core being made of an additional core material, wherein the additional core material comprises a lower content of recycled fibers than the core material, comprises a lower average fiber length than the core material and/or consists to at least 50%, 70%, 90%, 95%, or 100% of staple fibers having a greater fiber length than the recycled fibers or of filaments.

[0058] A filament core within the meaning of the present invention is a core consisting of one filament. A filament within the meaning of the present invention is particularly a single fiber of indefinite length, for instance produced by melt spinning. An additional core material can particularly comprise staple fibers and/or filaments. Additional cores comprising filaments can particularly comprise a plurality of filaments, such as at least one, two, three or four filaments being aligned with each other, in particular substantially parallel, or twisted around each other. In particular some of the filaments being comprised in the additional core material can be aligned with each other while others of the filaments being comprised in the additional core material can be twisted around the aligned filaments.

[0059] An elastic filament within the meaning of the present invention shall be particularly be capable of stretching at least about two times of its initial length, i.e. package length. After having stressed an elastic filament by stretching at least about two times of its initial length, an elastic recovery of at least 90 % up to 100 % arises. The elastic recovery is a parameter for the elastic filament. The elastic recovery in percent represents a ratio of the length of the elastic filament following the release of tension stress with respect to the length of the elastic filament prior to be subjected to said tension stress (package length). An elastic recovery having a high percentage, i.e. between 90 % and 100 %, is to be considered as providing an elastic capability of returning substantially to the initial length after the stress was applied. In this regard, an inelastic filament is defined by a low percentage elastic recovery, i.e. the inelastic filament will not be able to return substantially to its initial length, if a stretching of at least two times of its initial length is realized.

[0060] Said percent elastic recovery of filaments can be tested and measured according to the standard ASTMD3107, the entire content of which is expressively incorporated hereinto by reference. Said test method ASTMD3107 is a testing method for a fabric made from yarns. Of course, it is possible to deviate from the test results of the fabric the elastic recovery for the yarn itself. However, a yarn testing method and testing device can be used for individual measuring filaments and/or yarns. For instance the previously mentioned USTER TENSOR RAPID-3 device (Uster, Switzerland) can be used for measuring percentage of elastic recovery of filaments and/or yarns.

[0061] Typical examples for an elastic filament are a polyurethanic fiber such as elastane, spandex and those filaments that have similar elastic properties. In general, an elastic filament within the meaning of the invention particularly may be stretched at least 300 % or 400 % of the package length (e.g. as elongation at break). Package length shall be understood as the initial or original length of the elastic filament while essentially no tensile tension is applied. Examples of elastic filaments within the meaning of the invention include but are not limited to, Dowxla, Dorlastan (Bayer, Germany), Lycra (Invista, USA), Clerrspan (Globe Mfg. Co., USA), Glospan (Globe Mfg. Co., USA), Spandaven (Gomelast C.A., Venezuela), Rocia (Asahi Chemical Ind., Japan), Fujibo Spandex (Fuji Spinning, Japan), Kanebo LooBell 15 (Kanebo Ltd., Japan), Spantel (Kuraray, Japan), Mobilon (Nisshinbo Industries), Opelon (Toray-DuPont Co. Ltd.), Espa (Toyoba Co.), Acelan (Teakwang Industries), Texlon (Tongkook Synthetic), Toplon (Hyosung), Yantai (Yantei Spandex), Linel, Linetex (Fillatice SpA). In general, these elastic filaments provide as a basis of the yarn sufficient elastic properties. It is noted that also elastic filaments made of polyolefin could be used

[0062] An inelastic filament within the meaning of the present invention is a filament being not capable of being stretched beyond a maximum length without permanent deformation, said maximum length being less than 1.5 times of its package length. Typical material for the inelastic control filament or a respective example for such a filament are T400, PBT, polyester, nylon, etc.

[0063] The addition of at least one additional filament core in the inventive composite yarn particularly serves to increase the axial strength of the composite yarn. In one embodiment of the present invention, the at least one filament core can be an elastic filament core. Alternatively or additionally to the increasing of the axial strength of the composite yarn, the use of an additional elastic filament core can particularly serve to increase the elastic behavior of the composite yarn. Alternatively or additionally, the at least one additional filament core can be an inelastic filament core. Alternatively or in addition to the increasing of the axial strength of the composite yarn, the use of an inelastic filament core particularly serves to restrict the elongation of the composite yarn in axial direction in reaction to a force being applied in axial direction to the composite yarn. The at least one additional filament core, in particular in the form of an inelastic filament core or an elastic filament core, can be aligned, in particular substantially parallel, to the at least one fibrous core and/or twisted around the at least one fibrous core. Additionally or alternatively, at least two filament cores, for instance two elastic filament cores, can be twisted around each other and be aligned in their twisted form substantially parallel to the at least one fibrous core. Additionally, or alternatively, two elastic filament cores can be twisted around one inelastic filament core and be aligned in their twisted form to the at least one fibrous core. The use of at least two elastic filament cores and of at least two elastic filament cores in combination with at least one inelastic filament core is described in EP 3 061 856 A1 which is incorporated hereinto by reference. The incorporation of EP 3 061 856 A1 particularly relates to the filamentary core being described therein and the advantages being achieved with respect to the elasticity and strength of a yarn in which such filamentary core is comprised. Further, the incorporation of EP 3 061 856 A1 includes the methods and apparatus described therein for producing such filamentary core and for surrounding such filamentary core with a sheath. It shall be clear that the incorporation of EP 3 061 856 A1 relates to the addition of such filamentary core to the at least one fibrous core within the meaning of the present invention.

[0064] Preferably, the inventive composite yarn is a core spun yarn, in particular a core spun yarn with at least one fibrous core and a sheath comprising staple fibers and optionally filaments. The sheath of the core spun yarn can particularly be a fibrous sheath which can incorporate staple fibers and filaments or a staple fiber sheath consisting to 100 % of staple fibers.

[0065] The invention also relates to a fabric, in particular a woven fabric, comprising at least one composite yarn according to the invention. The composite yarn being comprised in the inventive fabric can either be specified by one or more of the first to the fourth aspects of the invention and/or by being produced by the method according to the fifth aspect of the invention and/or by being produced with the arrangement according to the sixth aspect of the invention.

[0066] The fabric can particularly consist to 20%, 40%, 60%, 80%, 90%, 95% or 100% of the inventive composite yarn. Additionally, or alternatively, the inventive composite yarn can be used as a weft yarn and/or as a warp yarn of a woven fabric. Additionally, or alternatively, the inventive composite yarn can be used for each, every second, every third, every fourth or every fifth warp yarn and/or weft yarn of the fabric.

[0067] According to a fifth aspect of the present invention, a method is provided for producing a composite yarn in particular for weaving, comprising the steps of providing recycled fibers, in particular recycled cellulosic fibers and/or recycled synthetic fibers, open-end spinning the recycled fibers into at least one fibrous core, providing sheath fibers, in particular cellulosic sheath fibers and/or synthetic sheath fibers, and spinning, in particular ring spinning, the sheath fibers around the at least one fibrous core to produce a sheath surrounding the core.

[0068] The inventive method enables the production of an inventive composite yarn. It shall be clear that the inventive method can be conducted such that the inventive composite yarn as described above and below can be produced.

[0069] A fibrous core within the meaning of the present invention may particularly be defined as a continuous collection of fibers held together by twisting the fibers around each other. The twist can in general be produced by different spinning technologies, such as ring spinning and open-end spinning. Ring spinning and open-end spinning as well as differences and advantages of the respective spinning technology are described below.

[0070] It has particularly been found advantageous to provide recycled fibers of an average fiber length of less than a length between 26 mm and 32 mm, preferably an average fiber length of less than 26 mm, 24 mm or 22 mm for the open-end spinning of the fibrous core. It has surprisingly been found that particularly using recycled fibers having an average fiber length of at least 10 mm, 15 mm or 20 mm and/or of less than 26 mm, 24 mm or 22 mm, leads to a greater axial strength of the resulting fibrous core than when using longer fibers for the open-end spinning.

[0071] Regarding providing the sheath fibers, it has been found advantageous to use fibers having an average length of more than the length between a length between 26 mm and 32 mm, preferably an average fiber length of more than 26 mm, 28 mm, 30 mm, 32 mm, 34 mm or 36 mm, and/or an average fiber length of less than 80 mm, 60 mm or 45 mm.

[0072] According to a sixth aspect of the present invention, an arrangement for producing a composite yarn in particular for weaving is provided, comprising an open-end spinning arrangement for spinning recycled fibers, in particular recycled cellulosic fibers and/or recycled synthetic fibers, into a core yarn, and a further spinning arrangement, in particular a ring spinning arrangement, for spinning a sheath, in particular a sheath being made of a sheath material comprising cellulosic fibers and/or synthetic fibers, around the core yarn.

[0073] The inventive arrangement can be designed such that the inventive method for producing the inventive composite yarn can be conducted. Further, the inventive method can be defined such that it can be conducted with the inventive arrangement.

[0074] A ring spinning arrangement particularly comprises a fiber supply, such as a sheath material supply or a core material supply, a drafting system, a ring, and a driven spindle to wind the spun yarn around the spindle, in particular to form a yarn package. The fiber supply can be in the form of a roving being wound around a fiber supply spindle. In particular, the roving is unwound from the fiber supply spindle and drafted by the drafting system. Thereby, the weight per length of the roving is particularly reduced, such that the yarn count in Ne is increased. This is particularly realized by a drafting zone within the drafting system comprising front-drafting rolls and back-drafting rolls, wherein the surface speed of the front-drafting rolls is greater than that of the back-drafting rolls. The draft of the roving within the meaning of the present invention particularly describes the reduction of the fibers in the cross-section of the roving. For instance, a roving having 20,000 fibers in the cross-section prior to the drafting system and of two fibers after leaving the drafting system could be expressed in a draft of 10,000.

[0075] The front-drafting rolls particularly deliver a continuous cohesive stream of fibers, which becomes twisted immediately into a yarn. This transformation is particularly accomplished by the interaction of the spindle, the ring and a traveller. The spindle is particularly rotated by a spindle drive. The rotation of the spindle particularly causes twists to be inserted into the stream of fibers delivered by the front rolls. The winding is particularly accomplished when the yarn passes the traveller and becomes wound onto the spindle. The traveller particularly travels in axial direction parallel to the spindle axis in order to distribute the yarn along the spindle axis.

[0076] In particular, a stationary ring is provided around the spindle which holds the traveller. The roving is particularly drawn from the drafting system, passes the traveller and is led to the spindle where it is wound to a yarn package. In order to wind the twisted yarn on a spindle, the traveller particularly cooperates with the spindle. The traveller particularly moves on the ring without physical drive but is carried along by the yarn. The rotation rate of the traveller is particularly lower than the rotation rate of the spindle,wherein and this difference particularly enables the winding of the yarn on the spindle.

[0077] Ring spun yarns and open-end spun yarns can particularly be destinguished from each other by one or more of the following differences. In particular, the fibers in a ring spun yarn are more parallel to each other than the fibers in an open-end spun yarn. In particular, a ring spun yarn has a compact structure, with essentially no wrapper fibers or hooked fibers. In particular the intensive fiber migration, which in turn is influenced by the triangular geometry of the spinning zone of an ring spinning arrangement, and in particular the high spinning tensions lead to a self-locked structure of ring-spun yarns resulting to a relativ high axial strength of ring-spun yarns, in particular to a higher axial strength than that of open-end spun yarns.

[0078] Compared to ring spun yarns, rotor spun yarns particularly have a greater twist, in particular a twist being 10 to 15 % greater. Further, the elongation of rotor spun yarns is particularly greater compared to ring spun yarns. Further, open-end spun yarns are particularly more uniform regarding their axial strength along the yarn length. Further, open-end spun yarns are particularly more even than ring-spun yarn. Further, open-end spun yarns are particularly less hairy than open end spun yarns. Further, open-end spun yarns particularly comprise less waste, such as fibers being shorter than 2 mm or powder, than ring spun yarns. Further, open-end spun yarns have particularly better abrasion properties than ring-spun yarns. Further, open-end spun yarns are a particularly harder, in particular in touch, than ring spun yarns. Further, open-end spun yarns particularly have less neps than ring-spun yarns. On the other hand, the axial strength of open-end spun yarns are particularly lower than of ring spun yarns, in particular between 10 % to 20 % lower. Further, open-end spun yarns are particularly more bulky than open-end spun yarns. In particular with regard to a fabric, it has been found that ring-spun yarns have a more dull appearance.

[0079] The spindle particularly provides three functions. First, it particularly provides a location to wind the yarn to form a yarn package. Secondly, by rotating the yarn spindle, the spindle particularly causes a twist to be inserted into the yarn being formed at the front rolls. Thirdly, the rotation of the spindle particularly causes the yarn to pull the traveller around the ring, such that an additional twist can be inserted into the strand of yarn being formed at the front roll.

[0080] The production of ring spun yarns particularly depends on the spindle speed, the front roll speed and/or the traveller speed. Thereby, economic limitations arise with ring spinning being related to the energy consumption and the package size. In particular, the energy consumption required to rotate the package is greater than that needed to insert twists to yarn being formed at the front-drafting rolls. A drawback particularly arising upon ring spinning is the increase of yarn imperfection, such as inconsistent yarn count and/or numbers of twists per meter along the yarn length, in particular of up to ± 25 %, when increasing the production speed. Further, the Hairiness of ring spun yarns is particularly increased compared to open-end spun yarns.

[0081] The basic difference between ring spun yarns and open-end spun yarns is particularly in the way they are formed. By ring spinning, the yarn is produced by inserting twists into a continuous strand of cohesive fibers delivered by the front-drafting rolls. Contrary thereto, upon open-end spinning, the yarn is formed from individual fibers directly collected from the inside surface of a rotor by twist forces. Accordingly, one particular difference is that a ring spun yarn is formed from the outside in, while an open-end yarn is formed from the inside out.

[0082] The open-end spinning arrangement particularly comprises a fiber supply, such as a core material supply, a drafting system, a twisting system and a packaging system for winding the open-end spun yarn onto a spindle.

[0083] The fiber supply particularly comprises a feed roller for feeding the open-end spinning arrangement with a sliver, the sliver comprising recycled fibers. In particular, the fiber supply further comprises a feed plate, in particular a spring loaded feed plate, confining a passage for the sliver from the fiber supply to the drafting system. In particular, the feed plate urges the sliver against the feed roller. A sliver shall particularly be understood as a sliver of an already used textile, also known as post-consumer textile. The feed roller particularly urges a fiber beard of the sliver to project into the drafting system. The sliver is particularly urged from a can beneath the open-end spinning arrangement via a feed trumpet to the feed roller. The feed roller particularly grips the sliver and urges it into the region of the opening roller. Particularly, a spring is provided urging the feed plate towards the feed roller and thereby particularly the sliver to towards the feed roller. In the event of an end-break, the fiber supply is particularly stopped either by stopping the feed roller rotation or by pivoting the trumpet, such that the feeding of the sliver is particularly automatically stopped. Therefore, a yarn-sensing arm can be provided. The drafting system particularly comprises a mechanical drafting system and a pneumatic drafting system. The pneumatic drafting system is particularly arranged downstream the mechanical drafting system.

[0084] In conventional spinning processes, such as ring spinning, the fiber supply, in particular in form of a roving, is maintained as a coherent structure and is merely attenuated during spinning. In open-end spinning, the fiber supply, in particular in form of a sliver, is particularly opened to individual fibers. This task is particularly performed mainly by the opening roller. The opening roller particularly combs through the fiber beard projecting into the drafting system and transports the plucked fibers to the transport tube.

[0085] Preferably, the mechanical drafting system comprises an opening roller for opening the sliver. The opening roller particularly comprises a cylindrical body on the circumferential of which needles or saw-like teeth are provided for combing fibers out of the sliver, which is also known as opening. In particular, the opening roller combs through the fiber beard projecting into the drafting system and thereby pulls fibers out of the sliver. Thereby rear, such as powder and fibers being shorter than 10 mm, 8 mm, 6 mm, 4 mm or 2 mm are also opened from the opening roller and can be spun into the open end spun yarn which can cause defects in the open-end spun yarn. In order to increase the quality of the resulting open-end spun yarn, it has been found advantageous to use slivers having a high level of cleanliness, in particular a maximum amount of waste of less than 10 %, 5 %, 3 %, 1 %, preferably of less than 0,5 % or of less than 0,1 %. In order to further decrease the amount of waste in the resulting open-end spun yarn, it has been found advantageous to open slivers having a high amount of fibers having a low fiber length, in particular of less than 26 mm, 24 mm or 22 mm. Alternatively or additionally, a waste output can be provided to separate the waste from the fibers to be used for the open-end spun yarn in the twisting system.

[0086] In the open-end spinning arrangement, a pneumatic drafting system can be arranged downstream the mechanic drafting system. The pneumatic drafting system can particularly comprise a transport tube through which the fibers are transported to the twisting system. Preferably, the pneumatic drafting system is an air drafting system. Thereby, fibers can particularly be affected by turbulence as they flow through the transport tube, causing poor orientation of the fibers. Poor orientation can particularly weaken the resulting open-end spun yarn, such that it is desirable to avoid poor fiber orientation. A poor orientation shall particularly be understood as an orientation deviating from a preferred substantially parallel alignment of the fibers. It has been found that short fibers, in particular fibers having a fiber length of less than 26 mm, 24 mm or 22 mm, are less vulnerable for disorientation than long fibers, such that particularly upon using slivers with short fibers, the orientation of the fibers in the transport tube can be increased. An increased orientation shall particularly be understood as an orientation of fibers in which the fibers are oriented more parallel to each other. Further, it has been found that orientation of the fibers can be increased by designing the drafting system such that the air flow velocity in the transport tube is greater than the surface speed of the opening roller. It has been found particularly advantage to design the drafting system such that the air flow velocity is between 50% and 300% greater than the surface speed of the opening roller. To obtain such a fast airflow, the inside of the rotor of the twisting system can particularly be run under reduced atmospheric pressure (i.e. a partial vacuum) which may be achieved by designing the rotor with radial holes to allow the rotor to generate its own vacuum (self-pumping effect). Alternatively, an external pump can be used for generating a vacuum in the rotor. Additionally or alternatively, the transport tube can be designed in a shape that is tapered towards the rotor to allow acceleration of the fibers as they approach the rotor inside surface. Thereby, the fiber disorientation in the transport tube can particularly be further decreased.

[0087] Preferably, successive layers of fibers are laid into the inside surface of the rotor, which is also known as "doubling" or "back doubling" as explained below. Such doubling particularly decreases, in particular evens out, minor irregularities in the yarn. In particular, doubling contributes to the low irregularity and greater uniformity of open-end spun yarn.

[0088] The separation of the drafting action and the twisting action in open-end spinning, compared to ring spinning, particularly contributes to the uniform quality of open-end spun yarns. If a rotor spun yarn is observed under a microscope, it will particularly be noticed that along the yarn axis there are many fibers that are not completely tied into the yarn. These fibers have a free end that wraps itself around the yarn periphery. This is a characteristic that is particularly peculiar to open-end spun yarns. These fibers are commonly called "fiber belts" or "wrapper fibers". Although wrapper fibers are technically a defect, it has been found that they can form a tight belt around the open-end spun yarn that can give the open-end spun yarn greater strength and a smoother surface.

[0089] In the transport tube, in particular an air stream is needed for further transporting the fibers to the rotor.

The air stream can particularly be generated by a fan that draws air by suction air through holes in the rotor. To facilitate generation an under pressure, the rotor is preferably hermetically sealed as far as possible. The air stream in the transport tube particularly lifts the fibers off the surface of the opening roller and leads them to the rotor. Preferably, this fiber movement is accelerated by a convergent (tapered) form of the transport tube. Thereby, the fibers are particularly additionally drafted. Moreover partial straightening of the fibers is particularly achieved upon the air stream. A third draft can particularly arise upon arrival of the fibers on the wall of the rotor by adjusting the peripheral speed of the rotor to several times the speed of the fibers in the transport tube. This particularly contributes arrange the fibers substantially parallel to each other. Another straightening of the fibers particularly occurs as the fibers slide down the rotor wall into a rotor groove under the influence of the centrifugal forces caused by the rotor.

[0090] The opening roller can particularly be driven by 5.000 to 10.000 rotations per minute. The rotor can particularly be driven by 50.000 to 200.000 rotations per minute or by about 100.000 rotations per minute. The delivery speed, namely the speed with which the open-end spun yarn is drawn out of the rotor can particularly be set to 50 to 500 m/min, 100 to 400 m/min or to 150 to 250 m/min. The number of twists per meter in an open-end spun yarn can particularly be set to 150 to 300 twists per meter, in particular to 200 to 250 twists per meter. The Draft of the open-end spun yarn can particularly be adjusted between 25 and 400. The rotor diameter can particularly be chosen between 32 to 65 mm.

[0091] In particular, one difference between open-end spun yarns and ring spun yarns is a tighter fiber control due to a higher spinning tension. As a result, less fiber migration occurs in rotor spinning, resulting in a more uniform fiber orientation in the yarn structure which produces smoother, more uniform yarns, however having a lower relative axial strength, in particular a lower breaking tenacity. The impact of fiber friction in the rotor groove particularly results in some fibers that are only partially twisted, which particularly contributes to a lower yarn strength compared to ring spun yarns.

[0092] The inventors of the present invention have surprisingly found that surrounding a fibrous core being produced by open-end spinning with a sheath increases the overall strength of the resulting composite fiber in such a way that it can particularly be processes in weaving technologies.

[0093] Due to the combination of the mechanical drafting system and of the pneumatic drafting system, the number of fibers can particularly be reduced from 20.000 in the cross section of sliver to 5 to 10 in the cross section of the output of the transport tube. This represents a draft of 4.000 to 5000. In order to produce an open-end spun yarn having about 100 yarns, the fibers have to be laid in successive layers in the rotor (back doubling). Thereby, the overall draft can be increased compared to the draft from the sliver to the output of the transport tube. The overall draft shall be particularly understood as the ratio between the number of fibers in the sliver and the number of yarns in the resulting open-end spun yarn. For example, an open-end spun yarn having 100 fibers in its cross section, being produced from a sliver having 20.000 fibers in its cross section has a draft of 200.

[0094] The twisting system of the open end spinning arrangement particularly comprises a rotor. In the rotor, the fibers are particularly mechanically twisted to a continuous yarn. The torque causing the respective twist insertion is particularly applied by the rotation of the rotor with respect to the point of the yarn tail contacting the rotor navel. The amount of twist (turns per meter) is determined by the ratio between the rotor speed (rpm) and the take up speed (meter/min).

[0095] The packaging in open-end spinning is particularly completely separate from the drafting and the twisting operations. The separation between packaging and twisting particularly allows the formation of larger yarn packages than those in ring spinning.

[0096] A particular advantage of an open-end spinning system is that fibers of a shorter length can be spun to a yarn compared to a ring spinning arrangement. In particular for ring spinning, fibers of a length between 26 mm and 45 mm are required. Contrary thereto, with open-end spinning, fibers having a length of 10 mm to 45 mm, in particular of 20 mm to 25 mm, can be spun to a yarn. This is of particular advantage because recycled fibers being provided from already used fabrics, so-called post-consumer fabrics, often have a high amount of fibers between 20 mm and 25 mm. Therefore, the open-end spinning technology enables utilizing a high amount of recycled fibers being provided from already used fabrics.

[0097] Ring spinning particularly comprises three operations, namely drafting, twisting and winding. However, prior to the ring spinning, fresh fibers particularly have to be pretreated, such as by passing the fresh fibers through a blow room particularly for opening and cleaning the fibers, a carding frame, a drawing frame and/or a flyer particularly for the separation of individual fibers, for the parallelization of fibers and/or for the formation of a fiber tape. Contrary thereto, open-end spinning using recycled fibers particularly directly starts with the drafting from the sliver such that costs and energy can be reduced.

[0098] Preferred embodiments of the invention are described in the dependent claims. Further advantages, features, and characteristics of the invention become apparent by the subsequent description of the preferred embodiments in which are dedicated in:

Fig. 1 a fibrous core in side view;

Fig. 2 a composite yarn in side view, wherein the sheath is partially blended out to show the fibrous core being surrounded by the sheath;

Fig. 3 a schematic side view of a composite yarn;

Fig. 4 a schematic top view on the composite yarn of Fig. 3;

Fig. 5 a schematic side view on a manufacturing process step for making the composite yarn shown in Fig. 3 and 4;

Fig. 6 a schematic side view of a composite yarn comprising three fibrous cores;

Fig. 7 a schematic top view on the composite yarn of Fig. 6;

Fig. 8 a schematic side of a manufacturing process step for producing a composite yarn as shown in Figs. 6 and 7;

Fig. 9 a schematic side view of a composite yarn comprising a fibrous core and two filament cores;

Fig. 10 a schematic top view on the composite yarn shown in Fig. 9;

Fig. 11 a schematic side view of a manufacturing process step for producing a composite yarn as shown in Fig. 9 and 10;

Fig. 12 a schematic side view of a composite yarn comprising a naked fibrous core and two fibrous cores with sub-sheaths being twisted throughout the naked core;

Fig. 13 a schematic top view on the composite yarn shown in Fig. 12;

Fig. 14 a schematic side view of a manufacturing process step for producing a composite yarn as shown in Fig. 12 and 13;

Fig. 15 a schematic view on an open-end spinning arrangement;

Fig. 16 a schematic view of a ring spinning arrangement for manufacturing a composite yarn as shown in Fig. 1 and 2 and in Fig. 3 and 4;

Fig. 17 a schematic view of a ring spinning arrangement for producing a composite yarn as shown in Fig. 6 and 7 or Fig. 9 and 10; and

Fig. 18 a schematic view of a ring spinning arrangement for manufacturing a composite yarn as shown in Fig. 12 and 13.

[0099] For an easier legibility, similar or the same components are designated in the following with similar or the same reference signs. Composite yarns are designated with reference sign 1.

[0100] The at least one fibrous cores is designated with reference sign 3. The sheaths is designated with reference sign 5. Fibers being comprised in the at least one core yarn 5 are designated with reference sign 7'. Fibers being comprised in the sheath 5 are designated with reference sing 7"

[0101] Fig. 1 shows schematically a fibrous core 3 being spun from fibers 7' by open-end spinning (rotor spinning). It shall be noted that fibers 7', 7" in the Figures are only schematically shown. The differences in length between recycled fibers and staple fibers having a greater length than recycled fibers shall not be derived from the Figures. As can be seen in Fig. 1, the fibers 7' of core yarns 3 being spun by open-end spinning are particularly connected to each other by so-called belt fibers (wrapping fibers) 9. Contrary thereto, the fibers 7' of fibrous cores being produced by ring spinning (not shown) do particularly not comprise belt fibers 9. In particular, fibers of ring spun fibrous cores form smooth helical windings 11 around the yarn axis and are arranged substantially parallel.

[0102] Figure 2 shows a composite yarn 1 in particular for weaving, comprising a fibrous core 3 consisting of a core material comprising recycled fibers 7' and a sheath 5 surrounding the fibrous core 3, the sheath comprising a sheath material. The fibrous core 3 shown in Figure 2 is spun by open-end spinning which can particularly be recognized by the belt fibers 9 surrounding the fibrous core 3 in circumferential direction. The sheath 5 of the composite yarn 1 has been wound around the fibrous core 3 by ring spinning, which can particularly be seen by the helical windings 11 in the form of which the sheath 5 is wound around the fibrous core 3.

[0103] Figure 3 illustrates a schematic side view of a composite yarn 1 comprising a fibrous core 3 and a sheath 5, wherein the helical winding 11 of the sheath 5 around the fibrous core 3 is not shown. As indicated by the fibers 7", the sheath 5 shown in Figure 3 preferably consists of staple fibers 7". Even though it is not apparent from the Figures 3 to 14 that the fibrous core 3 is produced by open-end spinning and that the sheath 5 is produced by rotor spinning, it shall be clear that these are the preferred manufacturing methods for the composite yarn 1 shown therein.

[0104] Figure 4 illustrates a top view on the composite yarn 1 of Figure 3. In Figure 4, the cross section 13' of the fibrous core 3 is schematically shown by the circle 13'. The cross-section 13" of the sheath 5 is schematically shown by the circle 13". The fibers 7' being comprised in the cross-section of the fibrous core 3 are illustrated by the points 7'. Contrary thereto, the fibers 7" comprised in the cross section 13" of the sheath 5 are illustrated by the surfaces 7". It shall be clear that the cross-sections 13', 13" as well as the number of fibers 7', 7" in the Figures 3 to 14 shall only illustrate how to differentiate between the cross section 13" of the sheath and the cross section 13' of the fibrous core 3 and the fibers 7', 7" comprised therein. However, neither preferred numbers of the fibers 7', 7" comprised within the cross sections 13', 13" nor relations between the number of fibers 7', 7" in the cross-sections 13', 13" can be derived from these illustrations.

[0105] The process step of Figure 5 illustrates the merging of a fibrous core 3 with sheath material in the form of a drafted roving 19. In the merging station 17, the drafted roving 19 is wound around the fibrous core 3 to surround the fibrous core 3. In particular, the drafted roving 19 is helically twisted around the fibrous core 3 by twist insertion 15 to form helical windings 11 around the fibrous core 3.

[0106] Figure 6 and 7 schematically illustrate a composite yarn 1 differing from the composite yarn 1 shown in Figure 3 and 4 in that three fibrous cores 3 are comprised in the composite yarn 1 instead of one fibrous core 3.

[0107] Figure 8 schematically illustrates a manufacturing process step for manufacturing the composite yarn 1 shown in Figure 6 and 7. Therefore, three separate fibrous cores 3 are merged in the merging station 17 with a drafted roving 19. Of course, in an alternative embodiment, the fibrous cores 13 can also be merged together in a not shown previous merging station and subsequently be merged with the drafted roving 19.

[0108] It shall be clear that the invention is not limited to composite yarns 1 with one or more identical fibrous cores 3. For instance, the fibrous cores 3 can consist to different percentage of recycled fibers. It is also possible to provide a composite yarn comprising for instance one fibrous core 3 consisting of recycled fibers and one or more fibrous cores consisting of fresh staple fibers 7. Further, in embodiments shall be comprised by the invention, in which at least one fibrous core 3 is combined with at least one filament core 21, such as an elastic or an inelastic filament core.

[0109] As shown in Figure 6 and 7, the fibrous cores and/or at least one fibrous core and the at least one filament core 21 can be aligned substantially parallel to each other. Thereby, the fibrous cores 3 can contact each other as illustrated in Figure 6 and 7 or being spaced from each other within the composite yarn 1. Further, the fibrous cores 3 can be twisted around each other.

[0110] Figure 9 and 10 illustrate an embodiment of the present invention in which two filament cores 21 are twisted around one fibrous core 3. The filament cores 21 can be inelastic or elastic filament cores. It shall be clear that also one or more than two filament cores 21 can be wound around the fibrous core 3 or around one or more fibrous core 3. Further, the invention shall also incorporate embodiments in which one or more filament cores are twisted around more than one fibrous core 3 or around at least one fibrous core 3 and at least one filament core 21 being aligned substantially parallel to the fibrous core 3.

[0111] Figure 11 illustrates a process manufacturing step for producing a composite yarn 1 as shown in Figure 9 and 10.

[0112] Figure 12 and 13 illustrate a composite yarn 1 similar to the composite yarn shown in Figure 9 and 10, however differing in that the filament core 21 is surrounded by a sub-sheath 23. Preferably, the sub-sheath 23 comprises or consists of staple fibers 7. The use of sub-sheaths 23 is only illustrated in the example shown in Figure 12 and 13. However, it shall be clear that sub-sheaths 23 can also be applied to one or more fibrous cores and/or to one or more filament cores being aligned substantially parallel to the fibrous core 3 or being twisted around the fibrous core 3. In particular, one or more of the filament cores 21 or fibrous cores 3 previously and subsequently described can be provided with a sub-sheath 23.

[0113] Figure 14 illustrates a process step for manufacturing a composite yarn 1 as shown in Figure 12 and 13. As can be seen therein, the sub-sheath material 25 can be surrounded around the filament core 21 in the sub-sheath merging stations 27. Thereby, the sub-sheath material 25 can be, for instance, provided in form of a drafted roving 19. The sub-sheath material 25 can be twisted around the filament cores 21 to produce a filament cores 21 having a sub-sheath 25 surrounding the filament cores 21 by helical windings. After the sub-sheaths 25 have been winded around the filament cores 21, the filament cores 21 can be merged with the fibrous core 3 and a drafted roving 19 in the merging station 17.

[0114] Figure 15 schematically illustrates an open-end spinning arrangement 29 which is also known as rotor spinning arrangement. The open-end spinning arrangement 29 particularly comprises a fiber supply 31, a drafting system 33, a twisting system 35 and a packaging system 37.

[0115] The fiber supply 31 serves to feed the open-end spinning arrangement 29 with a sliver 39 comprising recycled fiber 7'. The sliver 39 can be a carded or a drawn sliver. Preferably, a drawn sliver is used. For feeding the open-end spinning arrangement 29, a feed roller 41 is provided transporting the sliver 39 to the drafting system 33. Therefore, the feed roller 41 particularly cooperates with a feed plate 43, preferably being spring loaded (not shown). The feed plate 43 and the feed roller 41 particularly confine a sliver passage 45 through which the sliver 39 is passed from the fiber supply 31 to the drafting system 33.

[0116] The drafting system 33 particularly comprises a mechanical drafting system 47 and a pneumatic drafting system 49. The mechanical drafting system 47 particularly comprises an opening roller 51 which opens the sliver 39 by combing the fibers 7' out of the sliver 39. The opening roller 51 particularly comprises a cylindrical body 53 on the circumferential of which teeth 55 are provided for combing out the fibers 7' from the sliver 39. It has been found advantageous to use an opening roller 51 having a teeth density of 15 to 20 teeth/cm^2, preferably about 18,5 teeth/cm^2. The opening roller 51 particularly provides two effects. The first is the mechanical drafting of the sliver 39 which is also known as opening of the sliver 39. Thereby, the rapidly rotating opening roller 51 combs out the leading ends of the fibers and conveys the resulting drafted sliver to the pneumatic drafting system 49. The second effect is to separate waste within the sliver 39 which shall not be used for the production of the open-end yarn. Said waste can comprise very short staple fibers, such as staple fibers being shorter than 10 mm, 8 mm, 6 mm, 4 mm or 2 mm, and/or powder. For the second effect, a waste output is provided for separating the waste 59 from the fibers 7' being mechanically drafted from the sliver 39. However, the opening roller 51 does not only separate waste 59 from recycled fibers 7'. Due to the friction between the opening roller 51 and the fibers 7', waste 59 is produced during the opening of the sliver 39. The waste 59 being produced by the opening action particularly depends on the fiber length. As the fiber length increases, the force acting on the fibers 7' increases. This can result in shortening of fibers and in abrasion powder which has to be separated as waste. Therefore, in order to receive as much and preferably as clean recycled fibers 7' as possible from the sliver 39, the length of the fibers 7' in the sliver 39 needs to be carefully controlled. In this regard, it has particularly been found advantages to provide slivers with a high content of fibers 7' having a fiber length of less than 26 mm, 24 mm or 22 mm an preferably being greater than 10 mm. Thereby, fibers 7' having a fiber length being still long enough to be processed in open-end spinning can be provided and at the same time the waste production upon opening can be significantly reduced. Further, the wear of the opening roller 51 upon the friction between the fibers 7' and the opening roller 51 can be reduced. Further, since the waste output 57 cannot guarantee all waste 59 to be separated from the fibers 7', the control of the fiber length for reducing the waste production is also of importance for reducing the waste content in the resulting yarn. This is particularly because fine waste can accumulate in the subsequently described rotor 63 and thereby causes yarn defects.

[0117] In order to further increase the quality of the resulting open-end spun yarn 3, it is recommended to use a sliver 39 having less than 0,1 % of waste 59 prior to being inserted into the open-end spinning arrangement 29.

[0118] The waste output 57 can particularly lead the waste 59 to a collecting chamber (not shown) from which it can be removed.

[0119] After the drafting of the sliver 39 within the mechanical drafting system, the opened fibers 7' are pneumatically drafted by the pneumatic drafting system 49. Therefore, the pneumatic drafting system 49 particularly comprises a transport tube 61 in which the fibers 7' are subjected to a pneumatic draft. Therefore, the transport tube 61 is particularly tapered so as to create an accelerated air stream which straightens the fibers 7'. These two subsequent draft operations produce an amount of draft that is height enough to reduce the numbers of fibers 7' from 20.000 in the cross-section of the sliver to less than 50 fibers 7', preferably between two and ten fibers 7', when leaving the transport tube 61.

[0120] From the drafting system 33, in particular from the transport tube 61, the drafted fibers 7' are particularly fed into the twisting system 35. The twisting system 35 particularly comprises a rotor 63 being rotated around a rotor axis 65. The rotor is particularly disc shaped. In radial direction, the rotor 63 is particularly bordered by a rotor wall 67. Due to the rotation of the rotor around the rotor axis 65, the fibers 7' being fed into the rotor 63 are particularly pushed against the rotor wall 67 by centrifugal forces. The rotor wall 67 particularly comprises a rotor groove in which the fibers 7' become accumulated.

[0121] As illustrated in Figure 15, the fibers are preferably directly deposited from the transport tube 61 into the rotor groove 61. The rotor groove can particularly be v-shaped. By the accumulation of the fibers 7' in the rotor groove 69, the fibers 7' form a fibrous ring 71 within the rotor groove 69. Within the rotor 63, the fibers 7' are merged with a yarn tail 73 protruding into the rotor 63. The fibers 7' in the fibrous ring 71 are connected with the yarn tail 73 via twist insertion 15. Thereby, the yarn tail 73 protrudes into the fibrous ring 71, where the fibers 7' become accumulated with the yarn tail 73. Downstream, the yarn tail 73, the open-end spun yarn 3, which becomes later the fibrous core 3 and is therefore also designated with the reference number 3, is drawn by the packaging system 37 through a duffing tube 75. Therefore, the packaging system 37 particularly comprises drafting rolls 77 drafting the open-end spun yarn 3 out of the rotor 69 and conveys the open-end spun yarn 3 to a spindle (not shown) where the open-end spun yarn 3 is packed, in particular wound onto the spindle.

[0122] The amount of twists (turn per meter) of the resulting open-end spun yarn 3 is particularly determined by the ratio between the rotor speed (rotation per minute) and the take up speed (metres per minute) in which the open-end spun yarn 3 is delivered out of the rotor 63 by the take-up rollers 77. In particular, every turn of the rotor inserts a twist into the resulting open-end spun yarn 3.

[0123] As can be seen from the above, the drafting of the fibers 7' from the sliver 39 to the rotor 63 is independent from the twist insertion 15 which is conducted by the rotor 63. Further, the twist insertion 15 can be controlled independently from the delivery speed. For instance, the delivery speed can be held constant while the amount of twist (metre per minute) can be increased by increasing the rotations per minute of the rotor 63. Alternatively, the amount of twists (turns per metre) can be increased by decreasing the delivery speed while maintaining the rotational speed of the rotor 63. Due to the separation of the twisting and the drafting, the total draft can either be changed by controlling the rotor speed and the delivery speed or by controlling the draft being applied to the sliver by the opening roller and the transport channel. The total draft within the meaning of the present invention shall be understood as the ratio between the number of fibers 7' in the sliver 39 being fed into the open-end spinning arrangement 29 and of the resulting open-end spun yarn 3. For instance, upon using the open-end spinning technology, it is possible to reduce the total draft by the so called back-doubling. Back-doubling particularly means that the number of fiber 7' within a cross-section being reduced in the drafting system 33 becomes increased again in the twisting system 35. The number of doublings can particularly be described by the ratio N/n wherein N is the number of fibers 7' in the cross-section 13' of the resulting open-end spun yarn 3 and n is the number of fibers 7' in the output cross-section of the transport tube 61.

[0124] Figure 16 illustrates a ring spinning arrangement 79 for manufacturing a composite yarn as shown in Figures 1 and 2 and Figures 3 and 4. Ring spinning arrangements are in the following designated with reference sign 79. The ring spinning arrangement 79 comprises a sheath material supply 81 and a core material supply 83. The core material supply 83 preferably comprises an open-end spun yarn 3 being wound onto a spindle 85. The sheath material supply 81 preferably comprises a roving consisting of staple fibers 7 being wound onto a spindle 87. The ring spinning arrangement 79 further comprises a core material drafting system comprising a core back drafting roll 89 and a core front drafting roll 91. Further, the ring spinning arrangement 79 comprises a sheath material drafting system comprising a sheath back drafting roll 93 and a sheath front drafting roll 95. In order to produce the inventive composite yarn 1, the fibrous core 3 is drawn from the core material supply 83 and conveyed via the core back drafting role 89 and the core front drafting role 91 to a merging station 17. Further, a roving 97 is drawn from the sheath material supply 81 via the sheath back drafting roll 93 and the sheath front drafting roll 95 to the merging station 17. Within the merging station 17, the sheath material, in particular in form of a drafted roving 19, is wound around the fibrous core 3 by twist insertion 15. The resulting composite yarn 1 comprises the fibrous core 3 and the sheath 5 surrounding the fibrous core 3, in particular by helical windings 11.

[0125] In the Figures 16 to 18 the twist insertion is represented by reference sign 15. The person skilled in the art knows how to perform the twist insertion 15 by means of rotor spinning. In particular, the twist insertion 15 can be conducted by rotation of the spindle 99 onto which the composite yarn 1 is wound. Therefore, the spindle 99 can be rotated by a spindle drive (not shown) while a traveller (not shown) travels in axial direction parallel to the spindle access, in order to distribute the composite yarn around the spindle axis. The composite yarn 1 being wound around the spindle 99 particularly forms the yarn package 101.

[0126] Preferably, the surface speed of the sheath front drafting roll 95 is greater than the surface speed of the sheath back drafting roll 93 such that the roving 97 becomes drafted between the sheath back drafting roll 93 and the sheath front drafting roll 95. Upon the difference between the surface speed of the sheath front drafting roll 95 and the sheath back drafting roll 93, the draft of the roving 97 can be adjusted. In the same way, namely by controlling the surface speed of the core back drafting roll 89 and the core front drafting roll 91, the draft of the fibrous core 3 can be adjusted. Upon the use of separated drafting systems for the fibrous core 3 and for the sheath material, the draft can be independently adjusted for the fibrous core and for the sheath material 97. However, it shall be clear that the present invention is not limited to arrangement and methods where the fibrous core 3 and the sheath material 97 are subjected to different drafts. It might also be possible to produce a composite yarn by a single drafting mechanism drafting the fibrous core 3 and the sheath material 97 to the same extent prior to the twist insertion 15 in the merging station 17. The ring spinning arrangement 79 may further comprise a conditioning device 103 for instance for wetting or heating the sheath material and/or the core material prior to twist insertion 15 and/or prior to the drafting.

[0127] Figure 16 illustrates a ring spinning arrangement for manufacturing a composite yarn 1 as shown in Figure 6 and 7 or in Figure 9 and 10. The ring spinning arrangement 79 shown in Figure 17 is substantially identical to the ring spinning arrangement 79 shown in Figure 16, however, differing in that two additional core material supplies 83' are provided. The additional core material supplies 83' can comprise fibrous cores 3 or additional cores 3', 21, such as additional fibrous cores 3' and/or additional filament cores 21 as previously described, being wound on additional spindles 87'. In the following, Figure 17 is described by the example of an additional core material supplies 83' comprising additional filament cores 21. From the additional core material supply 83', filament cores 21 can be drawn and conveyed to the merging station 17. As illustrated in Figure 17, the additional filament cores 21 can be drafted in between by the same core back drafting roll 89 and core front drafting roll 91 as the filament core 3. In such an arrangement, different drafts to the different cores 3, 21 could be applied by additionally driving bars 107 of the additional core material supplies 83'. However, it is of course also possible to draft each core 3, 21 by its own drafting mechanism.

[0128] Figure 18 illustrates a ring spinning arrangement 79 for producing a composite yarn as shown in Figures 12 and 13. As in Figure 17, three core material supplies 83, 83' are provided in the ring spinning arrangement 79 shown in Figure 18. The ring spinning arrangement 79 shown in Figure 18 differs from the one shown in Figure 17 in that two additional sheath material supplies 81' are provided. The two additional sheath material supplies 81' preferably comprise additional rovings 97' being wound around spindles 109, 111. As shown in Figure 18, the additional rovings 97' can be drafted by the same sheath back drafting roll 93 and sheath front drafting roll 95. Of course, the additional rovings 97' might also be drafted by separate drafting mechanisms. Downstream, the sheath front drafting roll 95, the additional rovings 91' are merged with the additional filament cores 21 in a sub-sheath merging stations 27. Additionally or alternatively to the additional filament cores 21, additional fibrous cores 3' or fibrous cores 3 can be used. In the sub-sheath merging stations 27, the additional rovings 97' are wound around the additional filament cores 21 by twist insertion 15. Downstream the sub-sheath merging stations 27, the additional filament cores 21 are surrounded by a sub-sheath 23. In the subsequent merging station 17, the additional filament cores 21 together with their sub-sheath 23 are merged with the fibrous core 3 and the drafted roving 19 by twist insertion 15. Of course, it is also possible to amend the ring spinning arrangement 79 in that in addition or alternatively a sub-sheath is wound around the fibrous core 3 prior to the merging station 17.

[0129] The features disclosed in the above description, the Figures and the claims may be significant for the realisation of the invention in its different embodiments individually as in any combination.

Reference signs:

[0130]

1	composite yarn
3	fibrous core
3'	additional fibrous core
5	sheath
7'	fibers of the fibrous core
7"	fibers of the sheath
9	wrap fibers/belts
11	helical windings
13'	cross section of the fibrous core
13"	cross section of the sheath
15	twist insertion
17	merging station
19	drafted roving
21	filament core
23	sub sheath
25	sub sheath material
27	sub sheath merging station
29	open-end (rotor) spinning arrangement
31	fiber supply
33	drafting system
35	twisting system
37	packaging system
39	sliver
41	feed roller
43	feed plate
45	passage
47	mechanical drafting system
49	pneumatic drafting system
51	opening roller
53	cylindrical body
55	teeth
57	waste output
59	waste
61	transport tube
63	rotor
65	rotor axis
67	rotor wall
69	rotor groove
71	fibrous ring
73	yarn tail
75	duffing tube
77	take up rolls
79	ring spinning arrangement
81	sheath material supply
81'	additional sheath material supply
83	core material supply
83'	additional core material supply
85, 87	spindle
89	core back drafting roll
91	core front drafting roll
93	sheath back drafting roll
95	sheath front drafting roll
97	roving
97'	additional roving
99	spindle
101	yarn package
103	conditioning device
107	driving bars
109	spindle
111	spindle

Claims

1. A composite yarn (1) in particular for weaving, comprising:

   - at least one fibrous core (3) made of a core material comprising recycled fibers, in particular recycled cellulosic fibers and/or recycled synthetic fibers; and
   - a sheath (5) surrounding the fibrous core (3), the sheath (5) being made of a sheath material, in particular a sheath material comprising cellulosic fibers and/or synthetic fibers, having a greater axial strength than the core material.

2. The composite yarn (1) according to claim 1, wherein the axial strength of the sheath material is at least 25%, 50%, 75%, 100%, 125% or
   150% greater than the sheath material strength, and/or
   the axial strength of the core material is between 2 cN/tex and 12 cN/tex, in particular between 4 cN/tex and 10 cN/tex, more particular between 6 cN/tex and 8 cN/tex, and/or
   the axial strength of the sheath material is between 8 cN/tex and 20 cN/tex, in particular between 10 cN/tex and 18 cN/tex, more particular between 12 cN/tex and 16 cN/tex, and/or

the axial strength of the composite yarn (1) is between 6 cN/tex and 20 cN/tex, in particular between 9 cN/tex and 17 cN/tex, more particular between 11 cN/tex and 15 cN/tex.

3. A composite yarn (1) in particular according to one of the preceding claims in particular for weaving, comprising:

    - at least one fibrous core (3) made of a core material comprising recycled fibers, in particular recycled cellulosic fibers and/or recycled synthetic fibers; and
    - a sheath (5) surrounding the at least one fibrous core (3), the sheath (5) being made of a sheath material, in particular a sheath material comprising cellulosic fibers and/or synthetic fibers, having a lower content of recycled fibers than the core material.

4. The composite yarn (1) according to one of the preceding claims, wherein
the core material consists to at least 30%, 50%, 70%, 90%, 95% or 100% of recycled fibers, preferably of recycled fibers having a fiber length of maximally 25 mm, 20 mm, 15 mm or 10 mm, and/or the sheath material consists to less than 30%, 20%, 10%, 5% or 2% of recycled fibers, in particular is free of recycled fibers, preferably of recycled fibers having a fiber length of maximally 25 mm, 20 mm, 15 mm or 10 mm.

5. A composite yarn (1) in particular according to one of the preceding claims in particular for weaving, comprising:

    - at least one fibrous core (3) made of a core material comprising recycled fibers, in particular recycled cellulosic fibers and/or recycled synthetic fibers; and
    - a sheath (5) surrounding the at least one fibrous core (3), the sheath (5) being made of a sheath material, in particular a sheath material comprising cellulosic fibers and/or synthetic fibers, having a greater average fiber length than the core material.

6. The composite yarn (1) according to one of the preceding claims, wherein
the core material has an average fiber length of less than a length between 26 mm and 32 mm, preferably an average fiber length of less than 26 mm, 24 mm or 22 mm, and /or wherein the sheath material has an average fiber length of more than a length between 26 mm and 32 mm, preferably an average fiber length of more than 26 mm, 28 mm, 30 mm, 32 mm, 34 mm or 36 mm.

7. A composite yarn (1) in particular according to one of the preceding claims in particular for weaving, comprising:

    - at least one fibrous core (3) made of a core material comprising recycled fibers, in particular recycled cellulosic fibers and/or recycled synthetic fibers, the core being produced by open-end spinning; and
    - a sheath (5) being made of a sheath material, in particular a sheath material comprising cellulosic fibers and/or synthetic fibers, the sheath (5) being surrounded around the at least one fibrous core (3) by spinning, in particular by ring spinning.

8. The composite yarn (1) according to one of the preceding claims, wherein
the at least one fibrous core (3) has a yarn count of 40 $\pm$ 20 Ne, preferably of 30$\pm$ 10 Ne, more preferably of 30 $\pm$ 5 Ne, most preferably of 30 $\pm$ 3 Ne or of 30 $\pm$ 1 Ne, and/or wherein the composite yarn (1) has a yarn count of 15 $\pm$ 14 Ne, preferably of 10$\pm$ 9 Ne, more preferably of 10 $\pm$ 5 Ne, most preferably of 10 $\pm$ 3 Ne or of 10 $\pm$ 1 Ne.

9. The composite yarn (1) according to one of the preceding claims, wherein
the composite yarn (1) consists to at least 20%, preferably to at least 30%, more preferably to at least 35%, of the core material and/or
to maximally 80%, preferably maximally 70%, more preferably maximally 65% of the sheath material.

10. The composite yarn (1) according to one of the preceding claims, wherein
the sheath material preferably consists to at least at least 50%, 70%, 90%, 95%, or 100% of staple fibers or of filaments, and/or wherein
the composite yarn (1) comprises at least one sub-sheath surrounding the at least one fibrous core (3), the sub-sheath being made of a sub-sheath material, in particular a sub-sheath material comprising cellulosic fibers and/or synthetic fibers, wherein the sub sheath preferably surrounds the at least one fibrous core (3) such that the sub-sheath is encompassed by the at least one fibrous core (3) and the sheath (5), and/or wherein
the sub-sheath material preferably consists to at least at least 50%, 70%, 90%, 95 %, or 100% of staple fibers or of filaments.

11. The composite yarn (1) according to one of the preceding claims, comprising at least two, three, four or five of the at least one fibrous core (3) made of a core material comprising recycled fibers, wherein preferably the core material of each fibrous core (3) consists to at least 30%, 50%, 70%, 90%, 95% or

100% of recycled fibers, preferably of recycled fibers having a fiber length of maximally 25 mm, 20 mm, 15 mm or 10 mm.

12. The composite yarn (1) according to one of the preceding claims, further comprising at least one, in particular at least two, three, four or five, additional core (3', 21), in particular
at least one additional filament core (21), such as at least one elastic filament core and/or at least one inelastic filament core, and/or
at least one additional fibrous core (3') being made of an additional core material, wherein the additional core material comprises a lower content of recycled fibers than the core material, comprises a lower average fiber length than the core material and/or consists to at least 50%, 70%, 90%, 95 %, or 100% of staple fibers having a greater fiber length than the recycled fibers or of filaments.

13. A fabric, in particular a woven fabric, comprising at least one composite yarn (1) according to one of the preceding claims.

14. A method for producing a composite yarn (1) particularly according to one of the claims 1 to 12 in particular for weaving, comprising the steps of:

- providing recycled fibers, in particular recycled cellulosic fibers and/or recycled synthetic fibers;
- open-end spinning the recycled fibers into at least one fibrous core (3);
- providing sheath fibers, in particular cellulosic sheath fibers and/or synthetic sheath fibers; and
- spinning, in particular ring spinning, the sheath fibers around the at least one fibrous core (3) to produce a sheath (5) surrounding the core.

15. An arrangement for producing particularly according to claim 14 a composite yarn (1) in particular according to one of the claims 1 to 12 in particular for weaving, comprising:

- an open-and spinning arrangement (29) for spinning recycled fibers, in particular recycled cellulosic fibers and/or recycled synthetic fibers, into a core yarn; and
- a further spinning arrangement, in particular a ring spinning arrangement (79), for spinning a sheath (5), in particular a sheath being made of a sheath material comprising cellulosic fibers and/or synthetic fibers, around the core yarn.

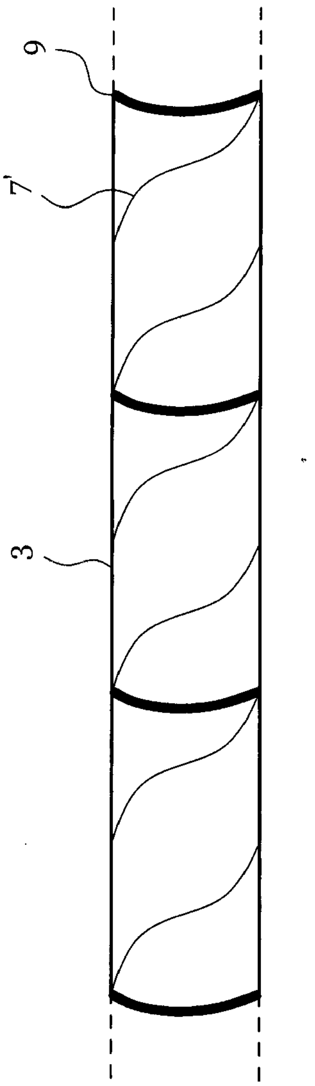


Fig. 1

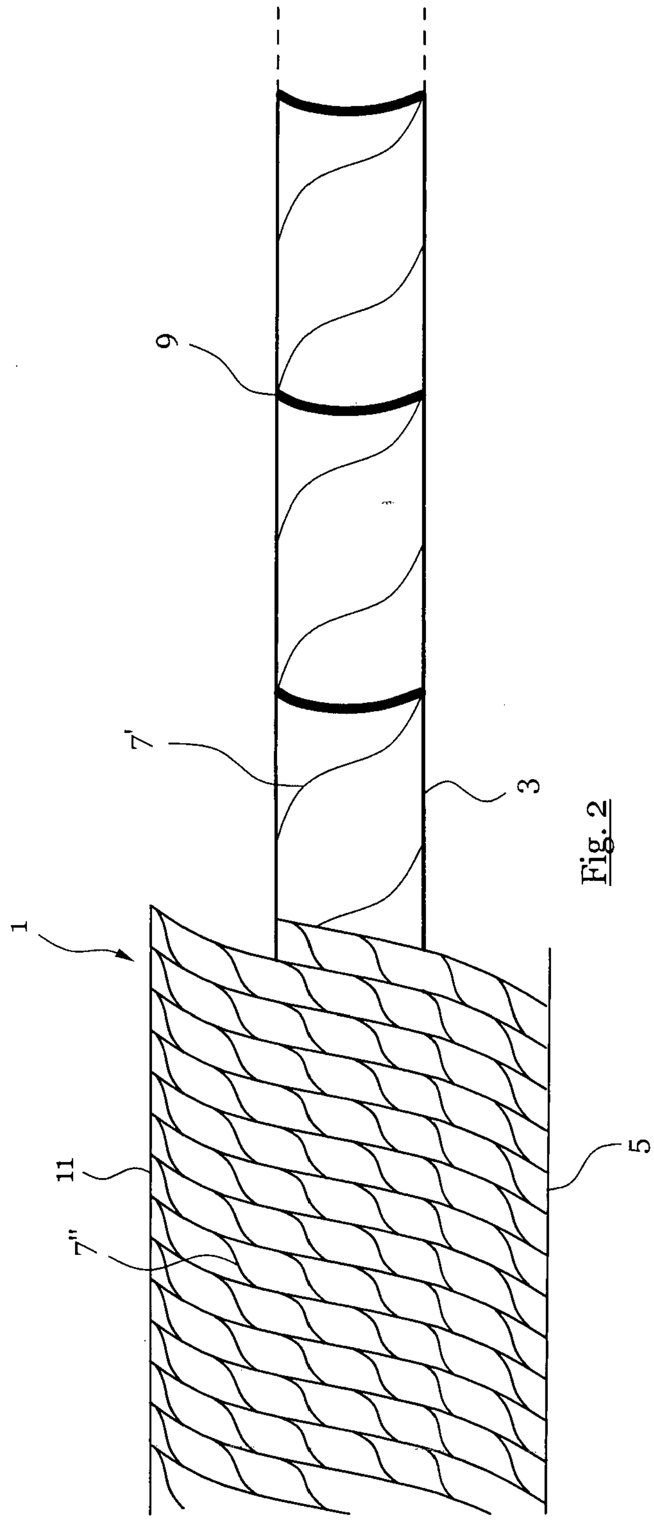


Fig. 2

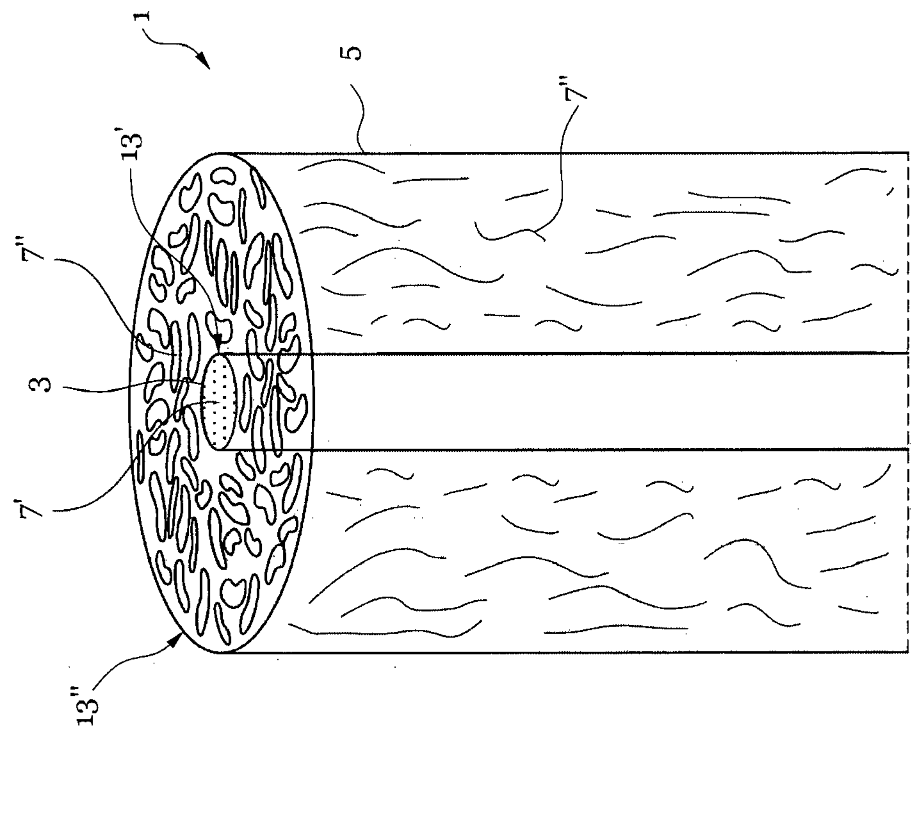


Fig. 3

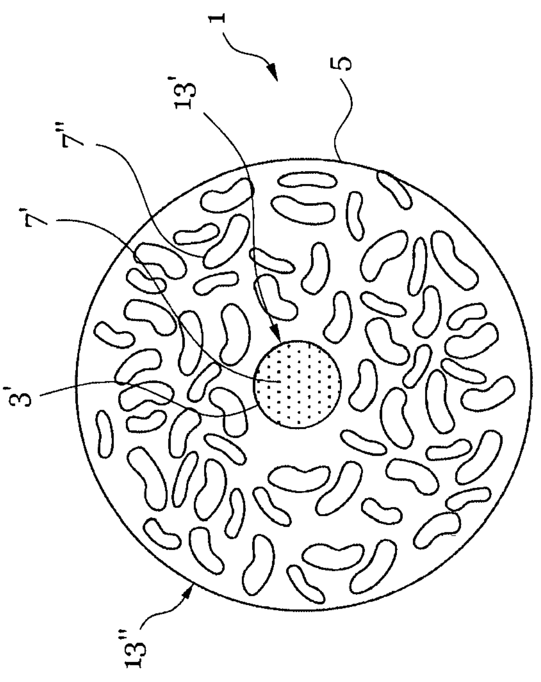


Fig. 4

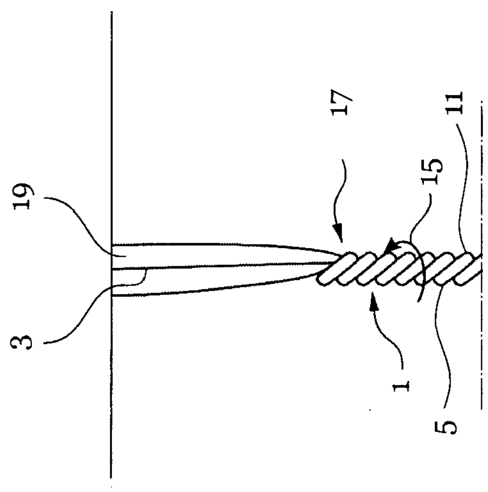


Fig. 5

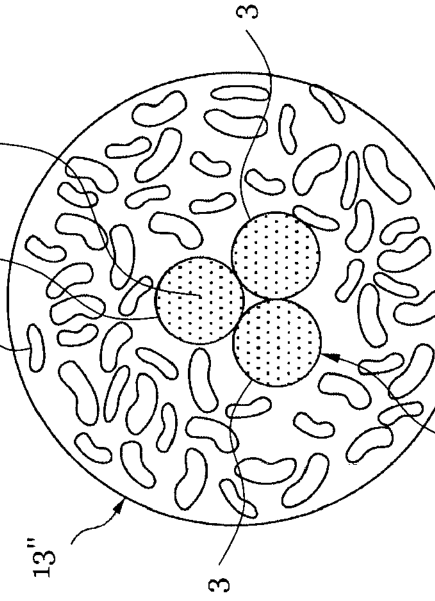


Fig.7

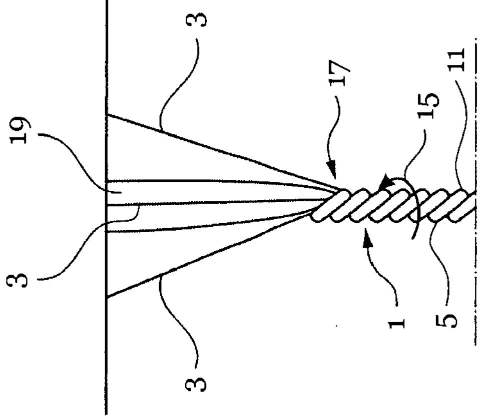


Fig. 8

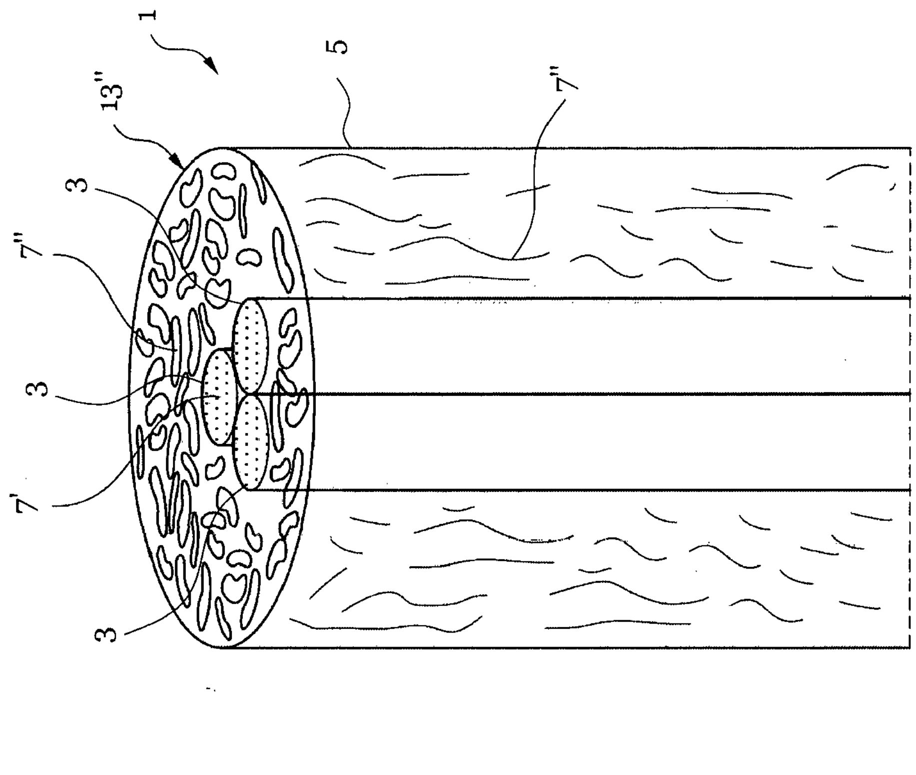


Fig. 6

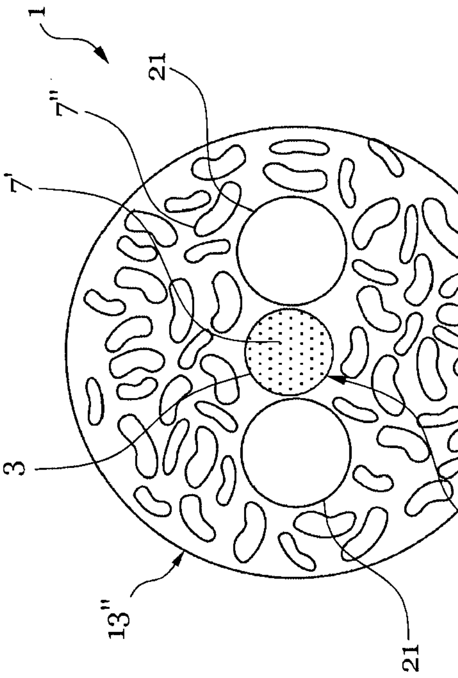


Fig. 10

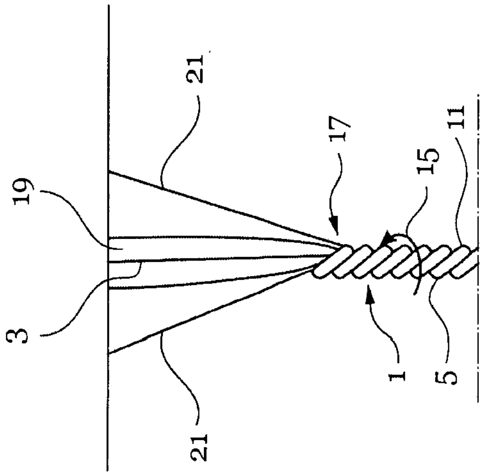


Fig. 11

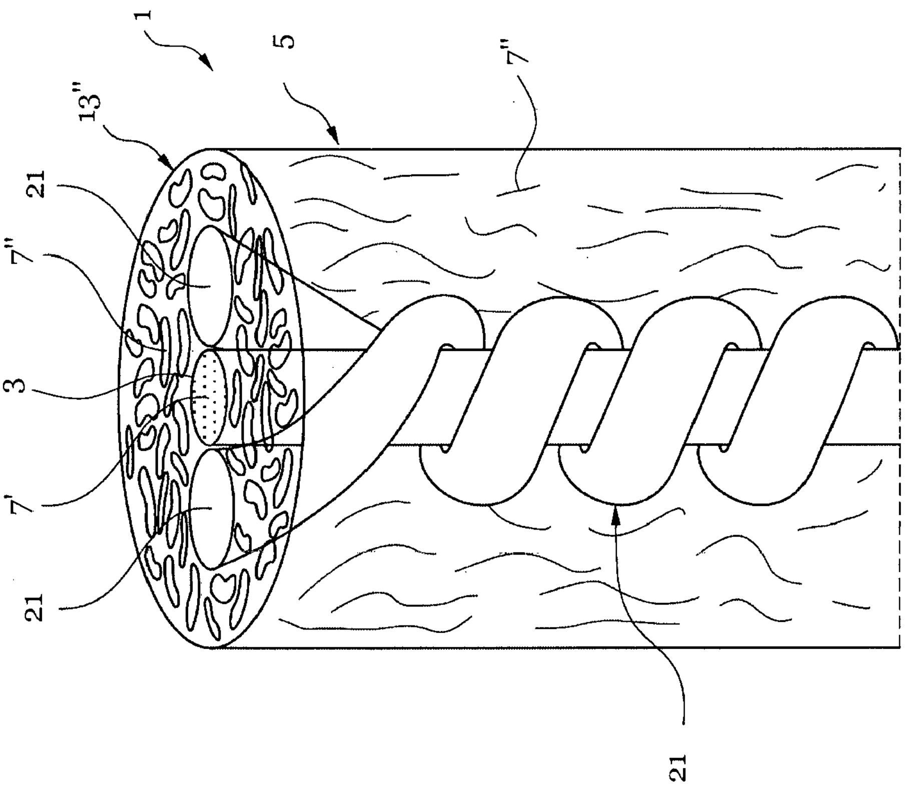


Fig. 9

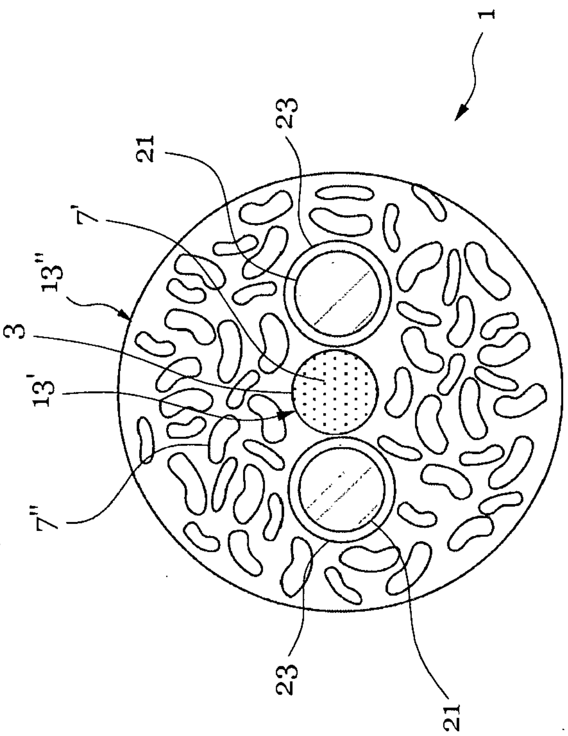


Fig. 13

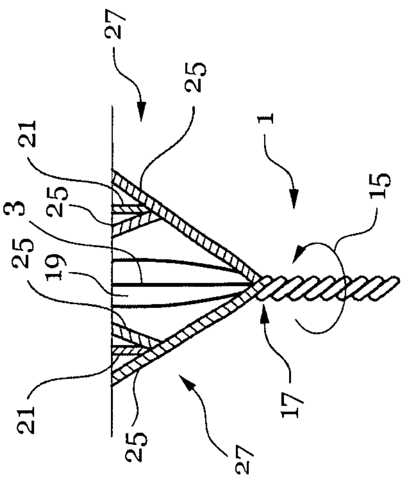
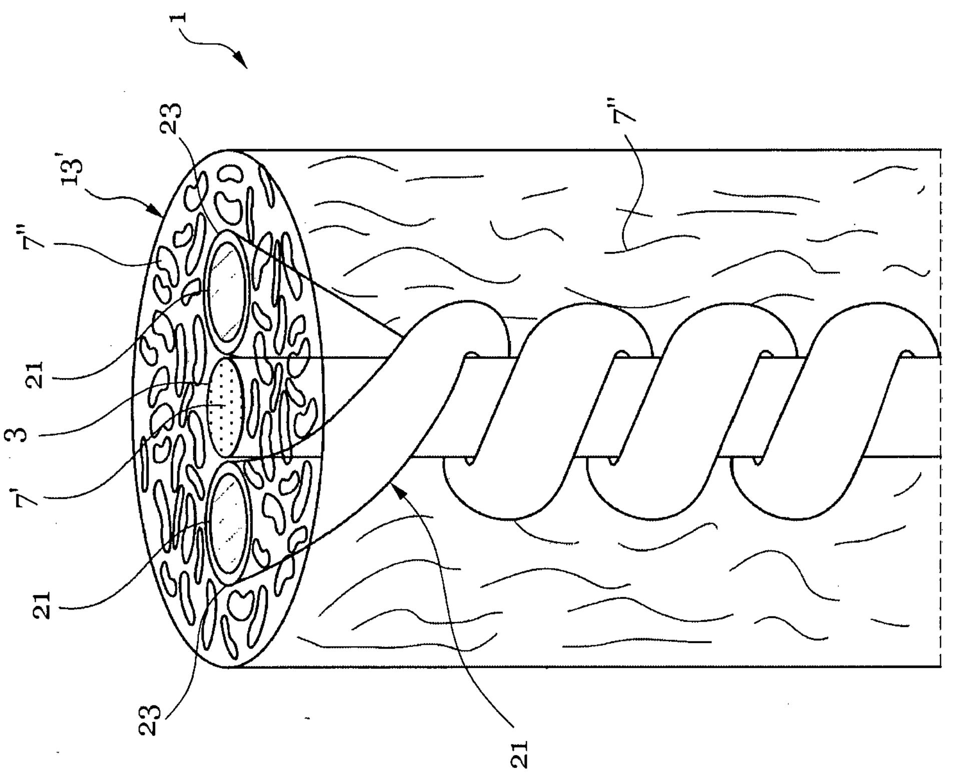


Fig. 14



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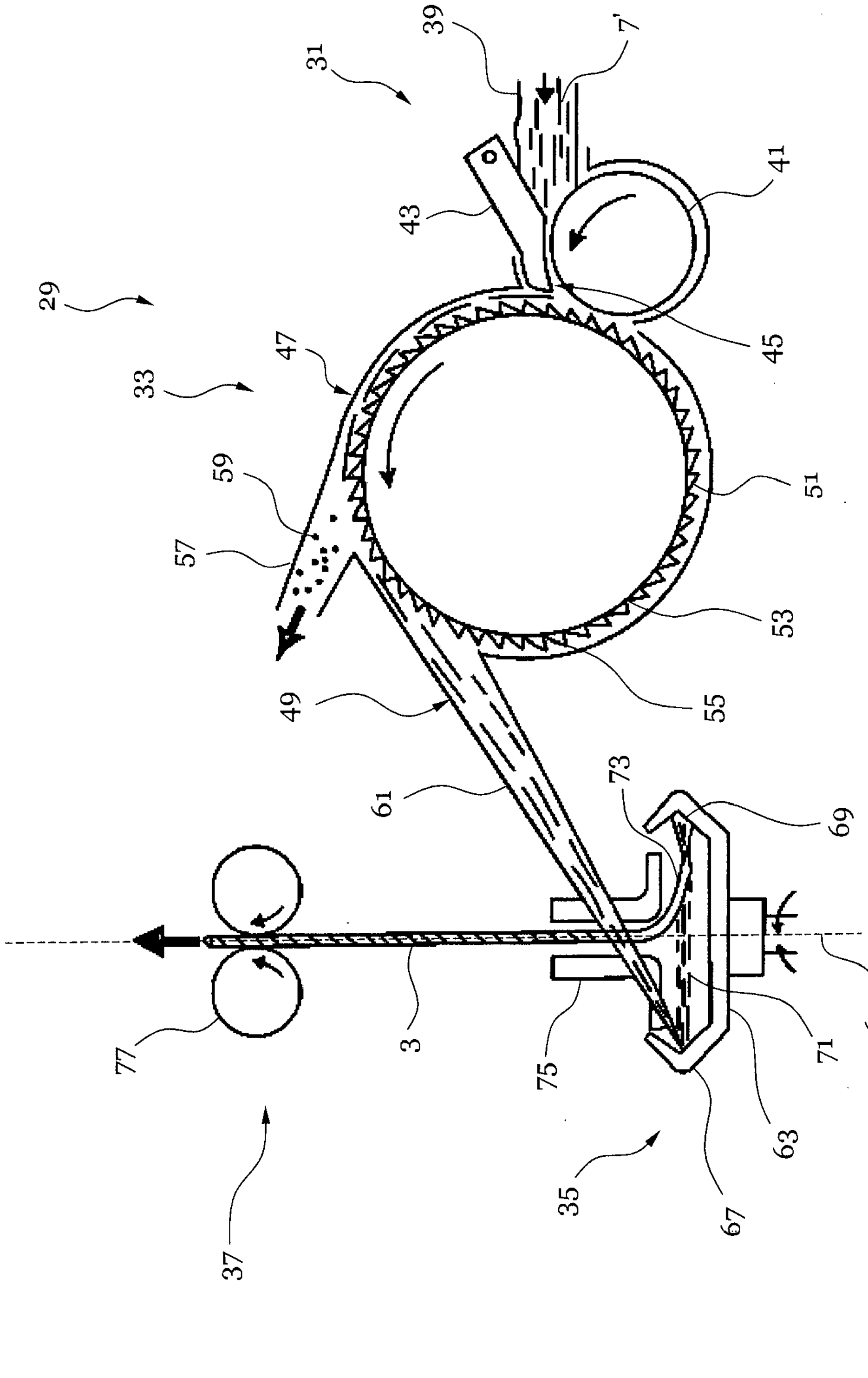
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Fig. 15

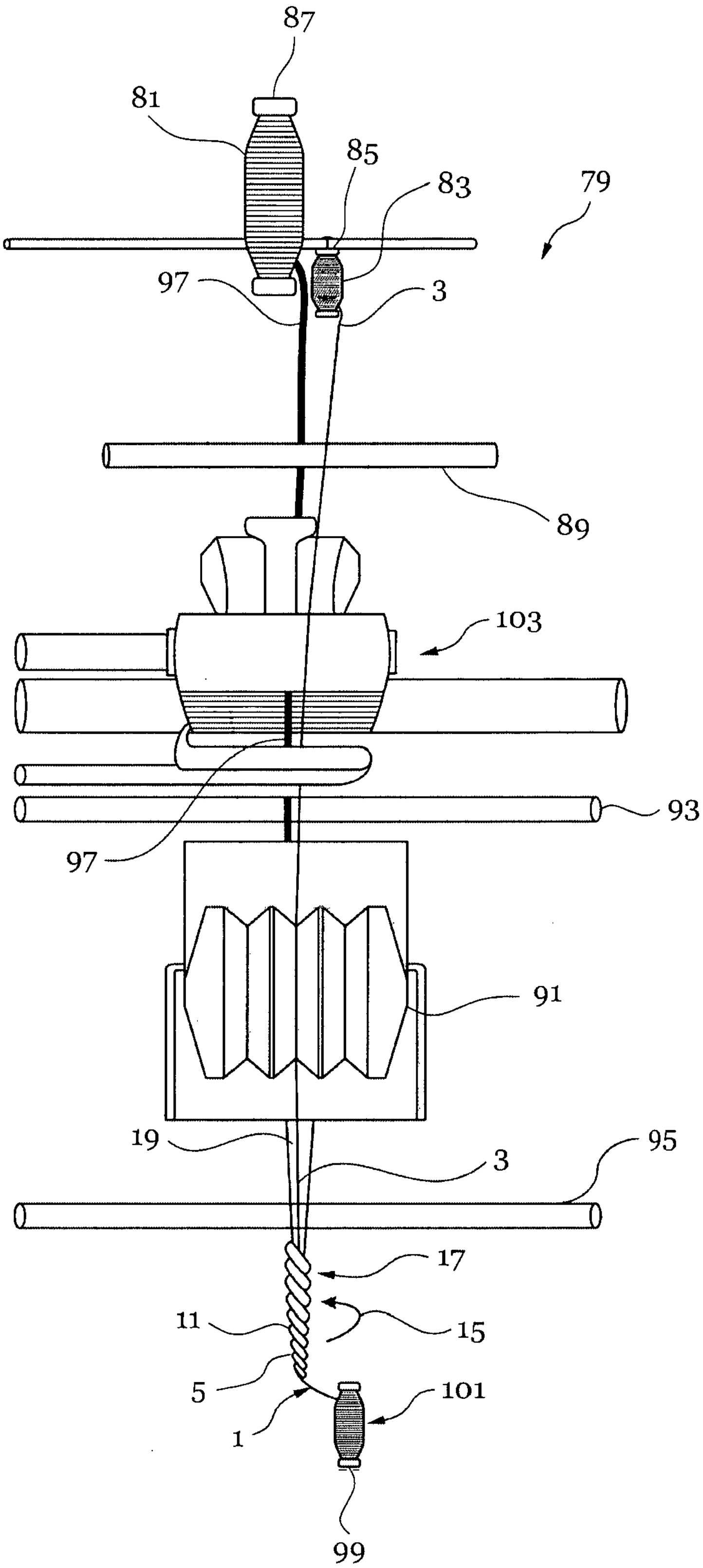

Fig. 16

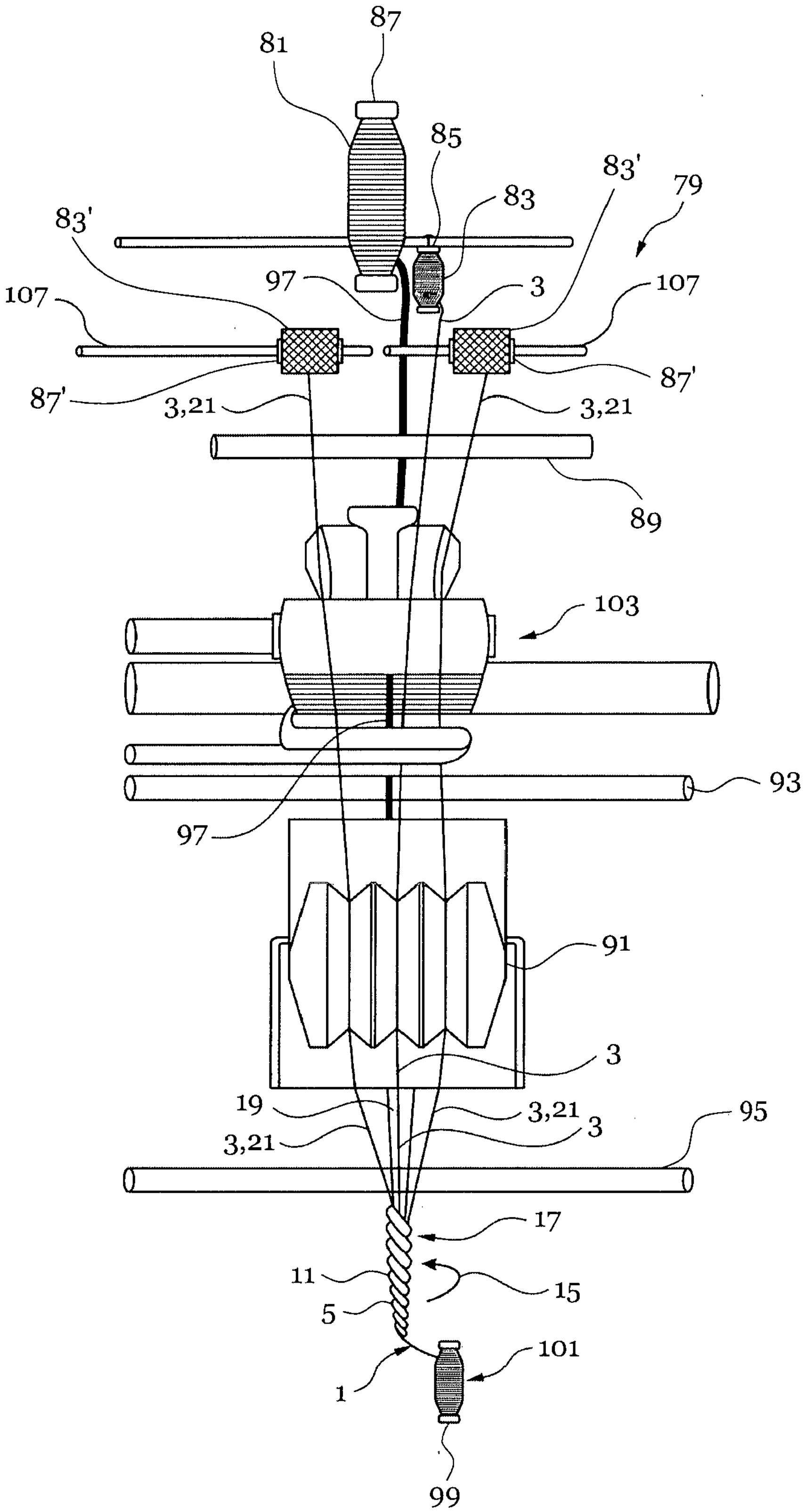
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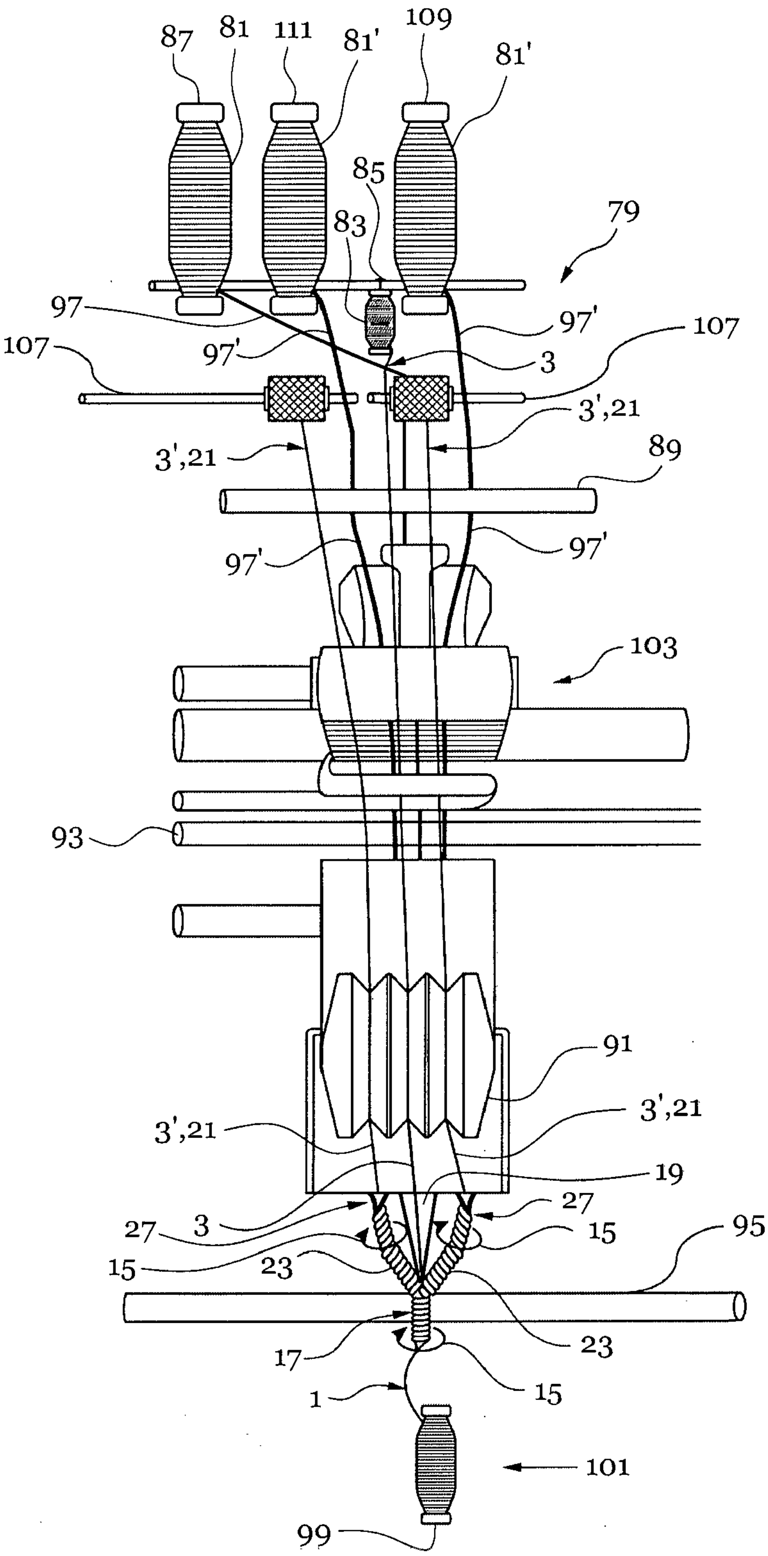
Fig. 17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101
99

Fig. 18

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EUROPEAN SEARCH REPORT

Application Number
EP 19 00 0188

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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	10 February 2020	Pollet, Didier

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