ABSTRACT
Described are uppers for a shoe, particularly a sports shoe. The upper includes a plurality of first portions for receiving at least one toe of the foot, wherein the first portions can be moved substantially independently of each other and wherein the first portions comprise knitwear.
SHOE ADAPTED TO THE SHAPE OF THE FOOT

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application is related to and claims priority benefits from German Patent Application No. DE 10 2013 207 153.1, filed on Apr. 19, 2013, entitled SHOE ADAPTED TO THE SHAPE OF THE FOOT ("the '153 application"). The '153 application is hereby incorporated herein in its entirety by this reference.

FIELD OF THE INVENTION

[0002] The present invention relates to a shoe, in particular a sports shoe.

BACKGROUND

[0003] In general, a shoe comprises a sole and an upper fixed thereto. The sole and the upper are made of leather in case of classic shoes, and, as a rule, of various synthetic materials in case of sport shoes.

[0004] A shoe differs from a sock in that the upper of the shoe provides the foot with much greater stability than a sock does. The foot is fixed much tighter by an upper than it is by a sock. Moreover, the shoe sole protects the foot from injuries and provides cushioning, i.e. the sole absorbs impacts of forces, e.g. during running. By use of a suitable material, e.g. rubber and/or profiling, a shoe sole furthermore provides the necessary static friction with the underground. A sock is not able to fulfill the above-described functions of a shoe.

[0005] In case of a common shoe, the foot of the wearer of the shoe is completely surrounded by the upper and the sole, i.e. the individual toes of the foot sit next to each other. Furthermore, the toes rest on the sole such that each respective toe touches the sole as a whole. It is not possible for a toe to have individual contact to the ground via the sole. While the toes are able to move inside the shoe, they can only exert force on the sole in their entirety.

[0006] This condition may be perceived by the wearer to be disadvantageous and unnatural. From a foot-medical point of view, walking barefoot is considered ideal, wherein the toes are able to move freely to the fullest extent with each toe having direct contact to the ground and being able to feel it.

[0007] Walking barefoot, however, is only possible comfortably and without risk on soft ground. Even small stones are perceived as uncomfortable and involve the risk of injuring the foot, just as pieces of broken glass.

[0008] In addition, especially in winter, the ground outdoors is generally too cold to allow comfortable barefoot walks.

[0009] In order to give the wearer of a shoe a more natural feeling when walking—similar to walking barefoot and to protect the foot from injuries and cold, shoes are known which comprise individual portions for receiving the toes. Each toe may move the portion in which it is placed independently from other portions. This enables each toe to make contact with the ground individually and to feel the ground. Thereby, the walking comfort is similar to the feeling of walking barefoot, but, at the same time, the shoe sole protects the foot from injuries and cold.

[0010] US 2007/0144039 A1, for example, relates to a piece of footwear which allows the independent movement of the toes of the wearer of the piece of footwear while providing comfort, protection and improved haptic feedback.

[0011] However, it has proven disadvantageous with such shoes that the connection between the different portions is perceived as uncomfortable for the toes. The portions are often sewn together or glued together, so that there is a thick and clearly perceptible seam between the toes. This is perceived as uncomfortable and may even cause abrasions in the spaces between the toes.

[0012] DE 10 2011 055 154 A1 refers to a sock for covering a foot as well as the use of firm and cut-resistant yarns for socks. A piece of footwear is provided which is formed in a sock-like manner, surrounds the individual toe areas and consists of a material which is at least partially cut-resistant.

[0013] DE 20 2007 011 165 U1 refers to a piece of footwear which—particularly in the design of a sock or a knee sock—substantially consisting of a formed knee-sock element, at least partially covers the foot as well as a sole element, with the knee sock and the sole element being connected to each other as one piece.

[0014] The solutions suggested by DE 10 2011 055 154 A1 and DE 20 2007 011 165 U1 differ considerably from a shoe or an upper. As was already explained above, a sock is not able to provide the foot—particularly in the field of sports—with the necessary stability. Furthermore, the suggested solutions lack any kind of cushioning, which is especially indispensable during running, in order to protect the joints from jerky impacts of forces.

[0015] The present invention therefore has the aim of providing a shoe—particularly a sports shoe—which confers a walking feeling similar to walking barefoot without causing an uncomfortable sensation in the spaces between the toes.

SUMMARY

[0016] The terms “invention,” “the invention,” “this invention” and “the present invention” used in this patent are intended to refer broadly to all of the subject matter of this patent and the patent claims below. Statements containing these terms should be understood not to limit the subject matter described herein or to limit the meaning or scope of the patent claims below. Embodiments of the invention covered by this patent are defined by the claims below, not this summary. This summary is a high-level overview of various embodiments of the invention and introduces some of the concepts that are further described in the Detailed Description section below. This summary is not intended to identify key or essential features of the claimed subject matter, nor is it intended to be used in isolation to determine the scope of the claimed subject matter. The subject matter should be understood by reference to appropriate portions of the entire specification of this patent, any or all drawings and each claim.

[0017] According to certain embodiments of the present invention, an upper for a shoe comprises a plurality of first portions for receiving at least one toe of a foot, the plurality of first portions being moveable substantially independently of each other, and the plurality of first portions comprising knitwear.

[0018] In some embodiments, the plurality of first portions are formed as one piece. In other embodiments, the plurality of first portions are connected to each other by linking. In additional embodiments, the plurality of first portions are connected to each other substantially seamlessly. In some embodiments, a separate first portion is provided for each toe.
[0019] According to some embodiments, the shoe upper including the plurality of first portions is formed as one-piece knittwear.

[0020] The knittwear may comprise at least one weft-knitted area, which in some embodiments may be weft-knitted three-dimensionally. In some embodiments, the knittwear of the shoe upper is weft-knitted on a flat-knitting machine.

[0021] The knittwear may comprise at least one warp-knitted area, which in some embodiments may be warp-knitted three-dimensionally.

[0022] In certain embodiments, at least one of the plurality of first portions comprises a first area having an elastic yarn. The at least one of the plurality of first portions may further comprise a second area, and wherein the first area comprises a more elastic yarn than the second area. In certain embodiments, two of the plurality of first portions overlap at least partially.

[0023] In some embodiments, at least one of the plurality of first portions comprises a second yarn in addition to a first yarn of the knittwear. According to some embodiments, the second yarn is a melted yarn or a rubberized yarn.

[0024] According to certain embodiments of the present invention, a shoe comprises an upper comprising a plurality of first portions for receiving at least one toe of a foot, the plurality of first portions being moveable substantially independently of each other, and the plurality of first portions comprising knittwear, and a sole which comprises two portions which correspond to the plurality of first portions of the upper and are connected to them.

[0025] In some embodiments, at least a subsection of the sole together with the upper is formed as one-piece knittwear. According to certain embodiments, the sole may be weft-knitted or warp-knitted. In some embodiments, the sole is reinforced by coating and/or by an additional yarn.

[0026] According to some embodiments, the sole comprises a spacer weft-knitted or spacer warp-knitted. The sole may be reinforced depending on a wearer of the shoe. A thickness of the sole may be determined depending on a weight of a wearer of the shoe or depending on the weight and a use of the shoe.

[0027] According to certain embodiments of the present invention, a method of manufacturing an upper comprising a plurality of first portions for receiving at least one toe of a foot, the plurality of first portions being moveable substantially independently of each other, and the plurality of first portions comprising knittwear, the method comprising providing the plurality of first portions for receiving the at least one toe of the foot.

### BRIEF DESCRIPTION OF THE DRAWINGS

[0028] In the following detailed description, embodiments of the invention are described referring to the following figures:

[0029] FIG. 1a is a schematic representation of textile structures, according to certain embodiments of the present invention.

[0030] FIG. 1b is a schematic representation of a weft-knitted fabric with a filler yarn, according to certain embodiments of the present invention.

[0031] FIG. 2 are schematic representations of various interlaces of a warp-knitted fabric, according to certain embodiments of the present invention.

[0032] FIG. 3 are schematic representations of weft-knitted fabrics, according to certain embodiments of the present invention.

[0033] FIG. 4 are illustrations showing a process of stitch forming by latch needles during weft-knitting, according to certain embodiments of the present invention.

[0034] FIG. 5a is a side view of an upper with two connected textile areas, according to certain embodiments of the present invention.

[0035] FIG. 5b is a side view of an upper with two connected textile areas, according to certain embodiments of the present invention.

[0036] FIGS. 6a-6c are cross-sectional views of an upper connected to a shoe sole via adhesive tape, according to certain embodiments of the present invention.

[0037] FIG. 7 are cross-sectional views of fibers for yarns used in knittwear, according to certain embodiments of the present invention.

[0038] FIG. 8 is a front view and a back view of a knittwear, according to certain embodiments of the present invention.

[0039] FIG. 9 is a schematic top view of an upper, according to certain embodiments of the present invention.

[0040] FIG. 10 is a schematic partial view of an upper, according to certain embodiments of the present invention.

[0041] FIG. 11 is a schematic side view of a shoe comprising an upper, according to certain embodiments of the present invention.

[0042] FIG. 12 is a schematic partial view of a shoe comprising an upper, according to certain embodiments of the present invention.

[0043] FIG. 13 is a side view of a shoe comprising an upper, according to certain embodiments of the present invention.

[0044] FIG. 14 is a bottom view of a shoe comprising an upper, according to certain embodiments of the present invention.

### BRIEF DESCRIPTION

[0045] According to certain embodiments of the present invention, an upper for a shoe, in particular a sports shoe, comprises a plurality of first portions for receiving at least one toe of a foot, wherein the first portions may be moved substantially independently of each other, and wherein the first portions comprise knittwear.

[0046] The upper according to certain embodiments of the invention comprises first portions for receiving at least one toe of a foot each. The first portions may be moved substantially independently of each other in order to enable the toes to move freely to a certain extent, i.e. the toes are not restricted in their movement as is the case with a common shoe. Thereby, in case of movement of a portion, neighboring portions may also be moved slightly due to friction or transmission of forces over the upper and/or an existing sole.

[0047] Due to the fact that the first portions are able to move substantially independently, the toes, too, may be moved independently of each other to a large extent. This produces a natural walking feeling similar to walking barefoot. The toes may move freely and have individual contact with the ground and are able to feel it. Moreover, gripping movements of the toes are possible, which are indispensable in certain types of sport, such as climbing.

[0048] Due to the fact that the first portions are formed as knittwear, there is a possibility to avoid thick seams at the joints of the portions. For example, the portions may be manufactured as one-piece knittwear on a corresponding
machine. Thereby, the portions are already joined together without seams during the manufacturing process. Another possibility would be to join the first portions by linking. In this regard, the edges of the portions may be joined together in a coarse-oriented manner, i.e. stitch by stitch, e.g. on a corresponding linking machine without producing thick, irritating seams.

0049 In certain embodiments of the invention, the above-mentioned techniques, which avoid thick, irritating seams, are rendered possible by using knitwear.

0050 In certain embodiments of the invention, the first portions are formed in one piece. Thereby, thick, irritating seams are avoided. One-piece knitwear may be manufactured on a corresponding welt-knitting or warp-knitting machine in a simple, cost-effective, and quick manner. Due to the fact that the first portions are already joined together during the manufacturing process, a corresponding subsequent work step is not necessary.

0051 In additional embodiments of the invention, the first portions are joined together by linking. Linking enables the stitch-oriented joining of the edges of knitwear without creating thick, irritating seams. Linking may be used both in welt-knitted fabrics and in warp-knitted fabrics.

0052 In some embodiments, the first portions are substantially joined without seams, i.e. the joining of the portions between the toes is made without seams. In addition, the knitwear may comprise seams in other areas that are not arranged between the toes (e.g. ornamental seams). With the seamless joints of the first portions, no seams whatsoever are produced in the spaces between the toes, such seams being perceived as irritating to certain wearers.

0053 In some embodiments, an individual first portion is provided for each toe. Thereby, each toe is able to move freely to the fullest extent and may be moved independently of the toes next to it. The walking feeling is hence most similar to walking barefoot.

0054 In certain embodiments, the knitwear comprises at least one welt-knitted area. This may be manufactured, for example, by a welt-knitting machine which allows the simple, cost-effective and fast manufacture of knitwear.

0055 According to certain embodiments, the welt-knitted areas are flat-knitted. In further embodiments, the knitwear is welt-knitted as two layers. In yet other embodiments, the two layers are connected such that on the sides first portions are created.

0056 In certain embodiments of the invention, at least one welt-knitted area is welt-knitted three-dimensionally. Three-dimensional (3D) welt-knitting allows the welt-knitted fabric to be provided with a shape adjusted to the foot directly during the welt-knitting process. Separate cutting is not required. The shape of the toes, the instep or the heel may also be welt-knitted directly into the knitwear.

0057 In certain embodiments of the invention, the upper including the first portions are formed as one-piece knitwear. This allows a simple, cost-effective, and fast manufacture of the whole upper. Subsequent work steps for joining the first portions between each other and with the rest of the upper may not be necessary. In addition, the produced waste is reduced to a minimum.

0058 In certain embodiments of the invention, the knitwear of the upper is made on a circular welt-knitting machine. Circular welt-knitting machines enable the simple manufacture of the first portions, which should follow as far as possible the round shape of the toe and thus, due to their most tubular form possible, may be well suited for being manufactured on a circular knitting machine.

0059 In certain embodiments of the invention, the knitwear comprises at least one warp-knitted area. Warp-knitted fabric may be manufactured cost-effectively and, above all, quickly.

0060 In some embodiments, the at least one warp-knitted area is warp-knitted three-dimensionally. Three-dimensional (3D) warp-knitting allows the warp-knitted fabric to be provided with a shape adjusted to the foot directly during the warp-knitting process. Separate cutting is not required. The shape of the toes, the instep, or the heel may also be warp-knitted directly into the knitwear.

0061 In some embodiments, the knitwear of the upper is welt-knitted on a flat welt-knitting machine. The welt-knitted fabric may be manufactured simply and cost-effectively on a flat welt-knitting machine.

0062 In some embodiments, at least one first portion comprises a first area having an elastic yarn. In further embodiments, the first portion comprises a second area, wherein the first area comprises a more elastic yarn than the second area. In this way, at least one first portion with an elastic area is produced, whereby the first portion may adapt optimally to the toe. An elastic area which is, e.g., arranged in a transversal direction to the toe allows the first portion associated with the toe to adapt to the length of the latter.

0063 In some embodiments, the first portions overlap at least in part. Due to this, an even more comfortable feeling is created between the toes, as they are less spread, this being even more similar to walking barefoot.

0064 In certain embodiments, at least one first portion comprises a second yarn in addition to a first yarn of the knitwear. In some embodiments, the second yarn is a stabilizing yarn. This stabilizes the toes in the longitudinal direction and laterally and the toes are kept in position in relation to a sole. A slipping of the toes beyond the sole is reduced or prevented completely.

0065 According to some embodiments, the second yarn is arranged on a tip of a toe and may further extend to above the toenail and along the side of a toe. In this manner, the second yarn acts like a toe cap which reduces or completely prevents slipping of the toe and protects the latter.

0066 In some embodiments, the second yarn is a melted yarn or a rubberized yarn. A melted yarn or a rubberized yarn may be worked into the knitwear during the manufacturing process, e.g. as an additional yarn. Then, the melted yarn may subsequently be melted by heat, so that it forms reinforced areas when cooling down. The rubberized yarn ensures increased adhesion to the ground surface and increased abrasion resistance.

0067 The necessary stability of the toes which reduces or prevents sliding relative to the sole, may be achieved, in addition or alternatively to the second yarn, by imprinting or coating the first portion. The imprinting or coating may e.g. be polyurethane (PU), a polyester or rubber.

0068 The upper may further comprise an elastic yarn. An elastic yarn worked into the upper allows a simple size adjustment to the respective foot size as well as an overall better fit. Moreover, slipping into the upper is facilitated and lacing may be done without. In some embodiments, lacing, a hook and loop tape, or a strap may additionally be affixed to the upper.

0069 According to certain embodiments of the present invention, a shoe, particularly a sports shoe, comprises an
upper as described above and a sole with second portions that correspond to the first portions of the upper and which are each linked with these. In this regard, the second portions may, but not necessarily, correspond to the first portions with regard to their number. Thus, there may be more first portions than second portions or vice versa. In addition or alternatively, the second portions may correspond to the first portions with regard to their dimensions, with these dimensions not having to be exactly identical. Thus, a first portion may, for example, be smaller than a corresponding second portion and vice versa. Due to the fact that the first and the second portions correspond to each other, a shoe is obtained which allows the greatest possible freedom of movement for the toes and a natural walking feeling, with thick, irritating seams between the toes being avoided.

[0070] In some embodiments, at least a subsection of the sole together with the upper is formed as one-piece knitwear. This allows a simple, cost-effective, and fast manufacture. At the same time, the material waste is reduced to a minimum.

[0071] In some embodiments, the shoe comprises a midsole. In further embodiments, the latter is arranged within the one-piece knitwear. The one-piece knitwear may then form an outer sole in the area of the sole, while the midsole may assume a cushioning function, for example.

[0072] The midsole may be arranged detachably. In this manner, the shoe may e.g. be adjusted to the respective area of application or alternatively or additionally to the weight of the wearer. Moreover, the shoe would be easy to dispose of, by the midsole and the knitwear being disposed of separately.

[0073] In certain embodiments, the sole is weft-knitted or warp-knitted. A weft-knitted or warp-knitted sole may be manufactured cost-effectively on a corresponding machine with a minimum of material waste. By using techniques described below, a weft-knitted or warp-knitted sole may be precisely adapted to the requirements and the field of application of the shoe.

[0074] In some embodiments, the sole is reinforced by coating. This may additionally or alternatively provide the sole with stability in a simple manner. Depending on the coating, the sole may alternatively or additionally also be made water-resistant, abrasion-resistant or firm.

[0075] In some embodiments, the coating is an applied polymer. This may be polyurethane, for example. The polymer may be applied subject to heat and pressure. Alternatively, the polymer may be sprayed on. Alternatively, the coating is a rubber coating. This has high static friction. I.e. good "grip". Moreover, rubber coating is very abrasion-resistant.

[0076] In some embodiments, the sole is additionally or alternatively reinforced by an additional yarn, i.e. in addition to the yarn of the knitwear. In further embodiments, it is a rubber yarn. Alternatively or additionally, it is a monofilament. A yarn may e.g. simply be weft-knitted or warp-knitted into the knitwear of the sole during weft-knitting or warp-knitting.

[0077] In further embodiments, the sole comprises a spacer weft-knitted fabric or a spacer warp-knitted fabric. In this manner, additional cushioning may be achieved or the sole of the shoe may be isolated against cold. The spacer weft-knitted fabric or spacer warp-knitted fabric may be provided with a filling. This may be a particle foam, foam material, or another suitable filling material.

[0078] In further embodiments, the sole is manufactured from a spacer weft-knitted fabric or spacer warp-knitted fabric. In this manner, a sole with cushioning may be obtained in one working step.

[0079] According to some embodiments, the sole is reinforced depending on a wearer of the shoe. In further embodiments, depending on the wearer's running style, the sole is additionally or alternatively reinforced depending on the intended use of a shoe by a wearer. For example, for a runner who touches the ground first with his heel, the heel section of the sole could be specially reinforced in order to allow additional shock absorption.

[0080] In some embodiments, the thickness of the sole is determined depending on the weight of a wearer of the shoe. In further embodiments, the thickness of the sole may additionally or alternatively be determined depending on the use of the shoe by a wearer. This enables the optimum adaptation of the properties of the sole to the requirements of the wearer of the shoe.

[0081] According to certain embodiments of the present invention, a method of manufacturing an upper as described above with the step of providing the plurality of first portions for receiving the at least one toe of the foot.

DETAILED DESCRIPTION

[0082] The subject matter of embodiments of the present invention is described here with specificity to meet statutory requirements, but this description is not necessarily intended to limit the scope of the claims. The claimed subject matter may be embodied in other ways, may include different elements or steps, and may be used in conjunction with other existing or future technologies. This description should not be interpreted as implying any particular order or arrangement among or between various steps or elements except when the order of individual steps or arrangement of elements is explicitly described.

[0083] In the following, embodiments and variations of the present invention are described in more detail on the basis of an upper for a shoe, in particular a sports shoe.

[0084] The use of knitwear allows products such as an upper or a sole of a shoe, such as an insole, strobe sole, midsole and/or outer sole to be equipped with areas having different characteristics and providing different functions with low production effort. The properties include bendability, stretchability (expressed as Young's modulus, for example), permeability to air and water, thermal conductivity, thermal capacity, moisture absorption, static friction, abrasion resistance, hardness, and thickness, for example.

[0085] Various techniques are applied in order to achieve such characteristics or functions, which will be described in the following. Such suitable techniques in manufacturing knitwear include knitting techniques, the selection of fibers and yarns, coating the fibers, yarns or knitwear with polymer or other materials, the use of monofilaments, the combination of monofilaments and polymer coating, the application of fused/melted yarns, and multi-layer textile material. In general, the yarns used for the manufacture of knitwear may be equipped, i.e. coated accordingly. In addition or alternatively, the finished knitwear may be equipped accordingly.

[0086] Another aspect of providing functions concerns the specific use of knitwear for certain areas of a product, for example of an upper or a sole, and the connection of different parts by suitable connection techniques. The mentioned
aspects and techniques as well as other aspects and techniques will be explained in the following.

[0087] The described techniques may be used individually or they may be combined in any manner.

Knitwear

[0088] Knitwear used in the present invention is divided into well-knitted fabrics and single-thread warp-knitted fabrics on the one hand and multi-thread warp-knitted fabrics on the other hand. The distinctive characteristic of knitwear is that it is formed of interlocking yarn or thread loops. These thread loops are also referred to as stitches and may be formed of one or several yarns or threads.

[0089] Yarn or thread are terms for a structure of one or several fibers which is long in relation to its diameter. A fiber is a flexible structure which is rather thin in relation to its length. Very long fibers, of virtually unlimited length with regard to their use, are referred to as filaments. Monofilaments are yarns formed of one single filament, that is, one single fiber.

[0090] In well-knitted fabrics and single-thread warp-knitted fabrics, the stitch formation requires at least one thread or yarn, with the thread running in longitudinal direction of the product, i.e. substantially at a right angle to the direction in which the product is made during the manufacturing process. In multi-thread warp-knitted fabrics, the stitch formation requires at least one warp sheet, i.e. a plurality of so-called warps. These stitch-forming threads run in longitudinal direction, i.e. substantially in the direction in which the product is made during the manufacturing process.

[0091] FIG. 1a shows the basic difference between a woven fabric 10, well-knitted fabrics 11 and 12, and a warp-knitted fabric 13. A woven fabric 10 has at least two thread sheets that are usually arranged at a right angle to one another. In this regard, the threads are placed above or underneath each other and do not form stitches. Weft-knitted fabrics 11 and 12 are created by knitting with one thread from the left to the right by interlocking stitches. View 11 shows a front view (also referred to as the front loop fabric side) and view 12 a back view (also referred to as the back loop fabric side) of a well-knitted fabric 11, 12. The front loop and back loop product sides differ in the run of the legs 14. On the back loop fabric side 12, the legs 14 are covered in contrast to the front loop fabric side 11.

[0092] Certain embodiments of a well-knitted fabric that may be used for the present invention with a filler yarn 15 is shown in FIG. 1b. A filler yarn 15 is a length of a thread placed between two wales in longitudinal direction, which is held by transverse threads of other weave elements. By the combination of the filler yarn 15 with other weave elements, the properties of the well-knitted fabric are influenced or various pattern effects are achieved. Stretchability of the well-knitted fabric in the direction of the wales may for example be reduced by a filler yarn 15.

[0093] Multi-thread warp-knitted fabric 13 is created by warp-knitting with many threads from top down, as shown in FIG. 1a. In doing so, the stitches of a thread are interlocked with the stitches of the neighboring threads. Depending on the pattern according to which the stitches of the neighboring threads are interlocked, one of the seven basic connections (also referred to as “interfaces” in multi-thread warp-knitting) pillar, tricot, 2x1 plain, satin, velvet, atlas and twill are created, for example.

[0094] By way of example, the interlaces tricot 21, 2x1 plain 22, and atlas 23 are shown in FIG. 2. A different interlocking results depending on how the stitches of thread 24, which is highlighted by way of example, are interlocked in the stitches of neighboring threads. In the tricot interlace 21, the stitch-forming thread zigzags through the knitwear in the longitudinal direction and binds between two neighboring wales. The 2x1 plain interlace 22 binds in a manner similar to that of the tricot interlace 21, but each stitch-forming warp skips a wale. In the atlas interlace 23, each stitch-forming warp runs to a turning point in a stairs-shape and then changes direction.

[0095] Stitches arranged above each other with joint binding sites referred to as wales. FIG. 3 shows a wale as an example of a well-knitted fabric 31. The term wale is also used analogously in warp-knitted fabrics. Accordingly, wales run vertically through the mesh fabric. Rows of stitches are arranged next to one another, as shown by way of example for a well-knitted fabric 32 in FIG. 3 are referred to as courses. The term course is also used analogously in warp-knitted fabrics. Accordingly, courses run through the mesh fabric in the lateral direction.

[0096] Three basic well-knitted structures are known in well-knitted fabrics, which may be recognized by the nm of the stitches along a wale. With plain, single Jersey, only back loops may be recognized along a wale on one side of the fabric and only back loops may be recognized along the other side of the product. This structure is created on one row of needles of a knitting machine, i.e. an arrangement of neighboring knitting needles, and also referred to as single Jersey. With rib fabric, front and back loops alternate within a course, i.e. either only front or back loops may be found along a wale, depending on the side of the product from which the wale is considered. This structure is created on two rows of needles with needles offset opposite each other. With purl fabric, front and back loops alternate in one wale. Both sides of the product look the same. This structure is manufactured using latch needles as illustrated in FIG. 4 by stitch transfer. The transfer of stitches may be avoided if double latch needles are used, which comprise both a hook and a latch at each end.

[0097] In many embodiments, a variety of structures and surfaces that may be created with knitwear, which may or may not also be possible with weaving. It is possible to manufacture both very heavy and/or stiff knitwear and very soft, transparent and/or stretchable knitwear with substantially the same manufacturing technique. The parameters by which the properties of the material may be influenced substantially are the pattern of well-knitting or warp-knitting, the used yarn, the needle size or the needle distance, and the tensile strain subject to which the yarn is placed on the needles.

[0098] In certain embodiments of weft-knitting, yarns may be weft-knitted in at freely selectable places. In this manner, selected zones may be provided with certain properties. For example, an upper for a soccer shoe may be provided with zones made from rubberized yarn in order to achieve higher static friction and thus enable the player to better control the ball. With certain yarns being weft-knitted in at selected places, no additional elements have to be applied.

[0099] Knitwear is manufactured on machines in the industrial context. These machines usually comprise a plurality of needles. In well-knitting, latch needles 41 are usually used, which may comprise a moveable latch 42, as illustrated in FIG. 4. This latch 42 closes the hook 43 of the needle 41 so
that a thread 44 may be pulled through a stitch 45 without the needle 41 being caught on the stitch 45. In weft-knitting, the latch needles 41 are usually moveable individually, so that every single needle 41 may be controlled so that it catches a thread for stitch formation.

[0100] A differentiation is made between flat-knitting and circular-knitting machines. In flat-knitting machines, a thread feeder feeds the thread back and forth along a row of needles. In a circular-knitting machine, the needles are arranged in a circular manner and the thread feeding correspondingly takes place in a circular movement along one or more round rows of needles.

[0101] Instead of a single row of needles, it is also possible for a knitting machine to comprise two parallel rows of needles. When looked at from the side, the needles of the two rows of needles may, for example, be opposite each other at a right angle. This enables the manufacture of more elaborate structures or weaves. The use of two rows of needles allows the manufacture of a one-layered or two-layered weft-knitted fabric. A one-layered weft-knitted fabric is created when the stitches generated on the first row of needles are enmeshed with the stitches generated on the second row of needles. Accordingly, a two-layered weft-knitted fabric is created when the stitches generated on the first row of needles are not or only selectively enmeshed with the stitches generated on the second row of needles and/or if they are merely enmeshed at the end of the weft-knitted fabric. If the stitches generated on the first row of needles are loosely enmeshed only selectively with the stitches generated on the second row of needles by an additional yarn, this is also referred to as spacer weft-knitted fabric. The additional yarn, for example a monofilament, is thus guided back and forth between two layers, so that a distance between the two layers is created. The two layers may e.g. be connected to each other via a so-called handle.

[0102] Generally, the following weft-knitted fabrics may thus be manufactured on a weft-knitting machine: If only one row of needles is used, a one-layered weft-knitted fabric may be created. When two rows of needles are used, the stitches of both rows of needles may consistently be connected to each other so that the resulting knitwear comprises a single layer. If the stitches of both rows of needles are not connected or only connected at the edge when two rows of needles are used or are only selectively connected in certain locations, two layers are created. If the stitches of both rows of needles are connected selectively in turns by an additional thread, a spacer weft-knitted fabric is created. The additional thread is also referred to as spacer thread and it may be fed via a separate yarn feeder.

[0103] In certain embodiments, single-thread warp-knitted fabrics may be manufactured by jointly moved needles. In other embodiments, single-thread warp-knitted fabrics needles may be manufactured by fixing the needles and moving the fabric to create the relative motion between the needles and the fabric. In contrast to weft-knitting, the needles are typically not moved individually. Similar to weft-knitting, there are flat single thread warp-knitting and circular single thread warp-knitting machines.

[0104] In multi-thread warp-knitting, one or several coated threads, i.e. threads which are coated next to one another, are used. In stitch formation, the individual warps are placed around the needles and the needles are moved jointly.

[0105] The techniques described herein as well as further aspects of the manufacture of knitwear may be found in “Fachwissen Bekleidung”, 6th ed. by H. Eberle et al. (published with the title “Clothing Technology” in English), in “Textil-und Modelexikon”, 6th ed. by Alfonso Hofer and in “Maschenlexikon”, 11th ed. by Walter Hollhaus, for example.

Three-Dimensional Knitwear

[0106] Three-dimensional (3D) knitwear may also be manufactured on weft-knitting machines and warp-knitting machines, particularly on flat-knitting machines. This is knitwear comprises a spatial structure although it is weft-knitted or warp-knitted in a single process. A three-dimensional weft-knitting or warp-knitting technique allows for spatial knitwear to be manufactured without seams, cut or manufacture in one piece and in a single process.

[0107] Three-dimensional knitwear may, for example, be manufactured by varying the number of stitches in the direction of the wales by partial courses being formed. The corresponding mechanical process is referred to as “needle parking”. Depending on the requirement, this technique may be combined with structural variations and/or variations of the number of stitches in the direction of the course. When partial courses are formed, stitch formation temporarily occurs only along a partial width of the weft-knitted fabric or warp-knitted fabric. The needles which are not involved in the stitch formation keep the half stitches (“needle parking”) until weft-knitting occurs again at this position. In this way, it is possible to form bulges, for example.

[0108] By three-dimensional weft-knitting or warp-knitting, an upper may be adjusted to the cobbler’s last or the foot and a sole may be profiled, for example. The tongue of a shoe may e.g. be weft-knitted into the right shape. Contours, structures, knobs, curvatures, notches, openings, fasteners, loops and pockets may be integrated into the knitwear in a single process.

[0109] Three-dimensional knitwear may be used for the present invention in an advantageous manner.

Functional Knitwear

[0110] According to certain embodiments of the present invention, knitwear and particularly weft-knitted fabric may be provided with a range of functional properties and used in the present invention.

[0111] It is possible using a weft-knitting technique to manufacture knitwear having different functional areas and simultaneously maintaining its contours. The structures of knitwear may be adjusted to functional requirements in certain areas, by the stitch pattern, the yarn, the needle size, the needle distance or the tensile strain subject to which the yarn is placed on the needles being selected accordingly.

[0112] It is possible, for example, to include structures with large stitches or openings within the knitwear in areas in which airing is desired. In contrast, in areas in which support and stability are desired, fine-meshed stitch patterns, stiffer yarns or even multi-layered well-knitting structures may be used, which will be described in the following. In the same manner, the thickness of the knitwear is variable.

[0113] Knitwear having more than one layer provides numerous possible constructions for the knitwear, which provide many advantages. Knitwear with more than one layer, e.g. two, may be weft-knitted or warp-knitted on a weft-knitting machine or a warp-knitting machine with several rows of needles, e.g. two, in a single stage, as described in the
section “knitwear” above. Alternatively, several layers, e.g. two, may be weft-knitted or warp-knitted in separate stages and then placed above each other and connected to each other if applicable, e.g. by sewing, gluing, welding or linking.

[0114] Several layers fundamentally increase solidity and stability of the knitwear. In this regard, the resulting solidity depends on the extent to which and the techniques by which the layers are connected to each other. The same yarn or different yarns may be used for the individual layers. For example, it is possible in a weft-knit fabric for one layer to be weft-knitted from multi-fiber yarn and one layer to be weft-knitted from monofilament, whose stitches are enmeshed. In particular, stretchability of the weft-knitted layer is reduced due to this combination of different yarns. In this construction, a layer made from monofilament may be arranged between two layers made from multi-fiber yarn in order to reduce stretchability and increase solidity of the knitwear. This results in a pleasant surface made from multi-fiber yarn on both sides of the knitwear.

[0115] An alternative of two-layered knitwear is referred to as spacer weft-knitted fabric or spacer warp-knitted fabric, as explained in the section “knitwear”. In this regard, a spacer yarn is weft-knitted or warp-knitted more or less loosely between two weft-knitted or warp-knitted layers, interconnecting the two layers and simultaneously serving as a filler. The spacer yarn may comprise the same material as the layers themselves, e.g. polyester or another material. The spacer yarn may also be a monofilament which provides the spacer weft-knitted fabric or spacer warp-knitted fabric with stability.

[0116] Such spacer weft-knitted fabrics or spacer warp-knitted fabrics, respectively, which are also referred to as three-dimensional weft-knitted fabrics, which are differentiated from the formative 3D weft-knitted fabrics or 3D warp-knitted fabrics mentioned in the section “three-dimensional knitwear” above, may be used wherever additional cushioning or protection is desired, e.g. at the upper or the tongue of an upper or in certain areas of a sole. Three-dimensional structures may also serve to create spaces between neighboring textile layers or also between a textile layer and the foot and thus ensure airing. Moreover, the layers of a spacer weft-knitted fabric or a spacer warp-knitted fabric may comprise different yarns depending on the position of the spacer weft-knitted fabric or the foot.

[0117] The thickness of a spacer weft-knitted fabric or a spacer warp-knitted fabric may be set in different areas depending on the function or the wearer. Various degrees of cushioning may be achieved with areas of various thicknesses, for example. Thin areas may increase bendability, for example, thus fulfilling the function of joints or flex lines.

[0118] Moreover, the layers of a spacer weft-knitted fabric may comprise different yarns depending on the position of the spacer weft-knitted fabric on the foot. In this way, knitwear may be provided with two different colors for the front and the back, for example. An upper made from such knitwear may then comprise a different color on the outside than on the inside.

[0119] Other multi-layered constructions may include pockets or tunnels, in which two textile layers or knitwear weft-knitted or warp-knitted on two rows of needles are connected to each other only in certain areas so that a hollow space is created. Alternatively, items of knitwear weft-knitted or warp-knitted in two separate processes are connected to each other such that a void is created, e.g. by sewing, gluing, welding or linking. It is then possible to introduce a cushioning material such as a foam material, eTPU (expanded thermoplastic urethane), ePP (expanded polypropylene), expanded EVA (ethylene vinyl acetate) or particle foam, an air or gel cushion for example, through an opening, e.g. at the tongue, the upper, the heel, the sole or in other areas. Alternatively or additionally, the pocket may also be filled with a filler thread or a spacer knitwear. It is furthermore possible for threads to be pulled through tunnels, for example as reinforcement in case of tension loads in certain areas of an upper. Moreover, it is also possible for the laces to be guided through such tunnels. Moreover, loose threads may be placed into tunnels or pockets for padding, for example in the area of the ankle. However, it is also possible for stiffer reinforcing elements, such as caps, flaps or bones to be inserted into tunnels or pockets. These may be manufactured from plastic such as polyethylene, TPU, polyethylene or polypropylene, for example.

[0120] A further possibility for a functional design of knitwear is the use of certain variations of the basic weaves. In weft-knitting, it is possible for bulges, ribs or waves to be weft-knitted in certain areas, for example, in order to achieve reinforcement in these places. A wave may, for example, be created by stitch accumulation on a layer of knitwear. This means that more stitches are weft-knitted or warp-knitted on one layer than on another layer. Alternatively, different stitches are weft-knitted fabric on the one layer than on the other layer, e.g. by being weft-knitted fabric tighter, wider or using a different yarn. Thickening is caused in both alternatives.

[0121] Ribs, waves, or similar patterns may, for example, also be used at the bottom of a weft-knitted outer sole of a shoe in order to provide a tread and provide the shoe with better non-slip properties. In order to obtain a rather thick weft-knitted fabric, for example, it is possible to use the weft-knitting techniques “tuck” or “half cardigan”, which are described in “Fachwissen Bekleidung”, 6th ed. by H. Eberle et al., for example.

[0122] Waves may be weft-knitted or warp-knitted such that a connection is created between two layers of a two-layered knitwear or such that no connection is created between the two layers. A wave may also be weft-knitted as a right-left wave on both sides with or without a connection of the two layers. A structure in the knitwear may be achieved by an uneven ration of stitches on the front or the back of the knitwear.

[0123] A further possibility of functionally designing knitwear within the framework of the present invention is providing openings in the knitwear already during weft-knitting or warp-knitting. Embodiments in the course of the present invention, which may be combined with other embodiments, refer to an insole that comprises knitwear. The embodiments may also be applied to a strobol sole, however. The embodiments may equally be applied to an outer sole. An insole, strobol sole, or outer sole is generally arranged above a midsole. The midsole may comprise cushioning properties. The midsole may e.g. comprise a foam material. Other suitable materials are eTPU (expanded thermoplastic urethane), ePP (expanded polypropylene), expanded EVA (ethylene vinyl acetate) or particle foam, for example.

[0124] The knitwear of the insole, strobol sole, or outer sole comprises at least one opening which is weft-knitted or warp-knitted in already during weft-knitting or warp-knitting of the knitwear, respectively. The at least one opening enables the
foot of a wearer of a shoe to be able to directly touch the midsole. This improves the cushioning properties of the shoe on the whole, so that the thickness of the midsole may be reduced.

[0125] In some embodiments, the at least one opening is arranged in the area of the calcaneus. An arrangement in this position has a particularly positive effect on the cushioning properties. A different position of the at least one opening is also possible.

[0126] In certain embodiments, functionally designing knitwear within the framework may include forming laces integrally with the knitwear of an upper. In these embodiments, the upper comprises knitwear and the laces are warp-knitted or weft-knitted as one piece with the knitwear already where the knitwear of the upper is warp-knitted or warp-knitted. In this regard, a first end of a lace is connected to the knitwear, while a second end is free.

[0127] In some embodiments, the first end is connected to the knitwear of the upper in the area of the transition from the tongue to the area of the forefoot of the upper. In these embodiments, a first end of a first lace may be connected to the knitwear of the upper at the medial side of the tongue and a first end of a second lace is connected to the knitwear of the upper at the lateral side of the tongue. The respective second ends of the two laces may then be pulled through lace eyelets for tying the shoe.

[0128] A possibility of speeding up the integral weft-knitting or warp-knitting of laces is having all yarns used for weft-knitting or warp-knitting knitwear end in the area of the transition from the tongue to the area of the forefoot of the upper. In some embodiments, the yarns may end in the medial side of the upper on the medial side of the tongue and form the lace connected on the medial side of the tongue. In certain embodiments, the yarns may end in the lateral side of the upper on the lateral side of the tongue and form the lace connected to the lateral side of the tongue. The yarns may then be cut off at a length that is sufficiently long for forming laces. The yarns may be twisted or intertwined, for example. The respective second ends of the laces may be provided with a lace clip. Alternatively, the second ends are fused or provided with a coating.

[0129] The knitwear is particularly stretchable in the direction of the stitches (longitudinal direction) due to its construction. This stretching may be reduced e.g. by subsequent polymer coating of the knitwear. The stretching may also be reduced during manufacture of the knitwear itself. One possibility is reducing the mesh openings, that is, using a smaller needle size. Smaller stitches generally result in less stretching of the knitwear. Fine-meshed knitwear may e.g. be used at an upper (also referred to as shoe upper). Moreover, the stretching of the knitwear may be reduced by weft-knitted reinforcements, e.g. three-dimensional structures. Such structures may be arranged on the inside or the outside of an upper. Furthermore, non-stretchable yarn, e.g. made from nylon, may be laid in a tunnel along the knitwear in order to limit stretching to the length of the non-stretchable yarn.

[0130] Colored areas with several colors may be created by using a different thread and/or by additional layers. In transitional areas, smaller mesh openings (smaller needle sizes) are used in order to achieve a fluent passage of colors.

[0131] Further effects may be achieved by weft-knitted insets (inlaid works) or Jacquard knitting. Inlaid works are areas which only provide a certain yarn, e.g. in a certain color. Neighboring areas which may comprise a different yarn, for example in a different color, are then connected to each other by a so-called handle.

[0132] During Jacquard knitting, two rows of needles are used and two different yarns run through all areas, for example. However, in certain areas only one yarn appears on the visible side of the product and the respective other yarn runs invisibly on the other side of the product.

[0133] A product manufactured from knitwear may be manufactured in one piece on a weft-knitting machine or a warp-knitting machine. Functionality may then already be manufactured during weft-knitting or warp-knitting by corresponding techniques as described here.

[0134] Alternatively, the product may be combined from several parts of knitwear and it may also comprise parts that are not manufactured from knitwear. In this regard, parts of knitwear may each be designed separately with different functions, for example regarding thickness, isolation, transport of moisture, etc.

[0135] An upper and/or a sole may, for example, be generally manufactured from knitwear as a whole or it may be put together from different parts of knitwear. A whole upper or parts of that may, for example, be separated, e.g. punched, from a larger piece of knitwear. The larger piece of knitwear may, for example, be a circular weft-knitted fabric or a circular warp-knitted fabric or a flat weft-knitted fabric or a flat warp-knitted fabric.

[0136] For example, a tongue may be manufactured as a continuous piece and connected with the upper subsequently, or it may be manufactured in one piece with the upper. With regard to their functional designs, ridges on the inside may e.g. improve flexibility of the tongue and ensure that a distance is created between the tongue and the foot, which provides additional airing. Laces may be guided through one or several weft-knitted tunnels of the tongue. The tongue may also be reinforced with polymer in order to achieve stabilization of the tongue and e.g. prevent a very thin tongue from convolving. Moreover, the tongue may then also be fitted to the shape of the cobbler’s last or the foot.

[0137] In an upper, it is possible for only the front part to be manufactured from knitwear, for example. The remainder of the upper may comprise a different textile and/or material, such as a woven fabric, for example. The front part may e.g. be located only in the area of the toes, extend beyond the toe joints or into the midfoot area. Alternatively, the back part of an upper may be manufactured from knitwear in the area of the heel, for example, and e.g. be additionally reinforced with polymer coating. In general any desired areas of an upper or a sole may be manufactured as knitwear.

[0138] Applications such as polyurethane (PU) prints, thermoplastic polyurethane (TPU) ribbons, textile reinforcements, leather, etc., may be applied to knitwear subsequently. Thus, in an upper which comprises knitwear in its entirety or in parts, a plastic heel or toe cap as reinforcement or logos and eyelets for laces may be applied on the upper, for example by sewing, gluing or welding, as described below.

[0139] Sewing, gluing or welding, for example, constitute suitable connection techniques for connecting individual knitwear with other textiles or with other knitwear. Linking is another possibility for connecting two pieces of knitwear. Therein, two edges of the knitwear are connected to each other according to the stitches (usually stitch by stitch).

[0140] A possibility for welding textiles, particularly ones made from plastic yarns or threads, is ultrasonic welding.
Therein, mechanical oscillations in the ultrasonic frequency range are transferred to a tool referred to as a sonotrode. The oscillations are transferred to the textiles to be connected by the sonotrode under pressure. Due to the resulting friction, the textiles are heated up, softened and ultimately connected in the area of the place of contact with the sonotrode. Ultrasonic welding allows rapidly and cost-effectively connecting particularly textiles with plastic yarns or threads. It is possible for a ribbon to be attached, for example glued, to the weld seam, which additionally reinforces the weld seam and is optically more appealing. Moreover, wear comfort is increased since skin irritations—especially at the transition to the tongue—are avoided.

[0141] Connecting various textile areas may occur at quite different locations. For example, the seams for connecting various textile areas of an upper may be arranged at various positions, as shown in FIGS. 5a and 5b. An upper 51 is shown in FIG. 5a which comprises two textile areas 52 and 53. They are sewn to each other. The seam 54 which connects the two textile areas 52 and 53 runs diagonally from an instep area of the upper to an area of the sole in the transition area from the midfoot to the heel. In FIG. 5b the seam 55 also runs diagonally, but it is arranged more to the front in the direction of the toes. Other arrangements of seams and connecting places in general are conceivable. The seams shown in FIGS. 5a and 5b may each be a thread seam, a glued seam, a welded seam or a linking seam. The two seams 54 and 55 may each be mounted only on one side of the upper 51 or on both sides of the upper.

[0142] In certain embodiments, adhesive tape may be used to connect textile areas. This feature may also be used in addition to an existing connection, e.g. over a sewn seam or a welded seam. An adhesive tape may fulfill further functions in addition to the function of connecting, such as e.g. protection against dirt or water. An adhesive tape may comprise properties which change over its length.

[0143] Embodiments of an upper 51 connected to a shoe sole 61 using adhesive tape are shown in FIGS. 6a, 6b, and 6c. Each of FIGS. 6a, 6b, and 6c shows a cross-section of a shoe depicting different positions of the foot and the resulting deformation of the shoe. For example, tensile forces work on the right side of the shoe in FIG. 6a, whereas compression forces work on the left side.

[0144] The shoe sole 61 may be an outer sole or a midsole. The upper 51 and the shoe sole 61 are connected to each other by a surrounding adhesive tape 62. The adhesive tape 62 may be of varying flexibility along its length. For example, the adhesive tape 62 might be particularly rigid and not very flexible in the shoe’s heel area in order to provide the shoe with the necessary stability in the heel area. This may be achieved by varying the width and/or the thickness of the adhesive tape 62, for example. The adhesive tape 62 may generally be constructed such that it is able to receive certain forces in certain areas along the tape. In this way, the adhesive tape 62 does not only connect the upper to the sole but simultaneously fulfills the function of structural reinforcement.

Fibers

[0145] The yarns or threads, respectively, used for knitwear of the present invention usually comprise fibers. As was explained above, a flexible structure which is rather thin in relation to its length is referred to as a fiber. Very long fibers, of virtually unlimited length with regard to their use, are referred to as filaments. Fibers are spin or twisted into threads or yarns. Fibers may also be long, however, and twisted into a yarn. Fibers may include natural or synthetic materials. Natural fibers are environmentally friendly, since they are compostable. Natural fibers include cotton, wool, alpaca, hemp, coconut fibers or silk, for example. Among the synthetic fibers are polymer-based fibers such as nylon, polyester, elastic, or spandex, respectively, or Kevlar® or other para-aramid synthetic fiber, which may be produced as classic fibers or as high-performance fibers or technical fibers.

[0146] It is conceivable that a shoe may be assembled from various parts, with a welt-knitted or a warp-knitted part comprising natural yarn made from natural fibers and a removable part, e.g. the insole, comprising plastic, for example. In this manner, both parts may be disposed of separately. In this example, the welt-knitted part could be directed to compostable waste, whereas the insole could be directed to recycling of reusable materials, for example.

[0147] The mechanical and physical properties of a fiber and the yarn manufactured therefrom are also determined by the fiber’s cross-section, as illustrated in FIG. 7. These different cross-sections, their properties and examples of materials having such cross-sections will be explained in the following.

[0148] A fiber having the circular cross-section 710 may either be solid or hollow. A solid fiber is the most frequent type, it allows easy bending and is soft to the touch. A fiber as a hollow circle with the same weight/length ratio as the solid fiber has a larger cross-section and is more resistant to bending. Examples of fibers with a circular cross-section are nylon, polyester, and Lyocell.

[0149] A fiber having the bone-shaped cross-section 730 has the property of wicking moisture. Examples for materials for such fibers are acrylic and spandex. The concave areas in the middle of the fiber support moisture being passed on in the longitudinal direction, with moisture being rapidly wicked from a certain place and distributed.

[0150] The following further cross-sections are illustrated in FIG. 7:

[0151] polygonal cross-section 711 with nodes; example: flax;
[0152] oval to round cross-section 712 with overlapping portions; example: wool;
[0153] flat, oval cross-section 713 with expansion and convolution; example: cotton;
[0154] circular, serrated cross-section 714 with partial striations; example: rayon;
[0155] lima bean cross-section 720; smooth surface;
[0156] serrated lima bean cross-section 721; example: Avril™ rayon;
[0157] triangular cross-section 722 with rounded edges; example: silk;
[0158] trilobal star cross-section 723; like triangular fiber with shinier appearance;
[0159] clubbed cross-section 724 with partial striations; sparkling appearance; example: acetate;
[0160] flat and broad cross-section 731; example: acetate in another design;

[0161] star-shaped or concertina cross section 732;
[0162] cross-section 733 in the shape of a collapsed tube with a hollow center; and
[0163] Square cross-section 734 with voids; example: Anso™ nylon.

[0164] Individual fibers with their properties which are relevant for the manufacture of knitwear for the present invention will be described in the following:
aramid fibers: good resistance to abrasion and organic solvents; non-conductive; temperature-resistant up to 500° C.

para-aramid fibers: known under trade names Kevlar®, Techron®, and Twaron®; outstanding strength-to-weight properties; high Young’s modulus and high tensile strength (higher than with meta-aramides); low stretching and low elongation at break (approx. 3.5%); difficult to dye.

meta-aramides: known under trade names Nomon®, Teijincomex®, New Star®, X-Fiber™.

dyneema fibers: highest impact strength of any known thermoplastics; highly resistant to corrosive chemicals, with exception of oxidizing acids, extremely low moisture absorption; very low coefficient of friction, which is significantly lower than that of nylon and acetate and comparable to Teflon®; self-lubricating; highly resistant to abrasion (15 times more resistant to abrasion than carbon steel); nontoxic.

carbon fiber: an extremely thin fiber about 0.005-0.010 mm in diameter, composed substantially of carbon atoms; highly stable with regard to size; one yarn is formed from several thousand carbon fibers; high tensile strength; low weight; low thermal expansion; very strong when stretched or bent; thermal conductivity and electric conductivity.

glass fiber: high ratio of surface area to weight; by trapping air within them, blocks of glass fibers provide good thermal insulation; thermal conductivity of 0.05 W/(m·K); the thinnest fibers are the strongest because the thinner fibers are more ductile; the properties of the glass fibers are the same along the fiber and across its cross-section, since glass has an amorphous structure; correlation between bending diameter of the fiber and the fiber diameter; thermal, electrical and sound insulation; higher stretching before it breaks than carbon fibers.

Yarns

A plurality of different yarns may be used for the manufacture of knitwear according to certain embodiments in the present invention. As was already defined, a structure of one or several fibers which is long in relation to its diameter is referred to as a yarn.

Functional yarns are capable of transporting moisture and thus of absorbing sweat and moisture. They may be electrically conducting, self-cleaning, thermally regulating and insulating, flame resistant, and UV-absorbing, and may enable infrared radiation. They may be suitable for sensors. Antibacterial yarns, such as silver yarns, for example, prevent odor formation.

Stainless steel yarn contains fibers made of a blend of nylon or polyester and steel. Its properties include high abrasion resistance, high cut resistance, high thermal abrasion, high thermal and electrical conductivity, higher tensile strength and high weight.

In textiles made from knitwear, electrically conducting yarns may be used for the integration of electronic devices. These yarns may, for example, forward impulses from sensors to devices for processing the impulses, or the yarns may function as sensors themselves, and measure electric streams on the skin or physiological magnetic fields, for example. Examples for the use of textile-based electrodes may be found in European patent application EP 1 916 523.

Melted yarns may be a mixture of a thermoplastic yarn and a non-thermoplastic yarn. There are substantially three types of melted yarns: a thermoplastic yarn surrounded by a non-thermoplastic yarn; a non-thermoplastic yarn surrounded by thermoplastic yarn; and pure melted yarn of a thermoplastic material. After being heated to the melting temperature, thermoplastic yarn fuses with the non-thermoplastic yarn (e.g. polyester or nylon), stiffening the knitwear. The melting temperature of the thermoplastic yarn is determined accordingly and it is usually lower than that of the non-thermoplastic yarn in a case of a mixed yarn.

A shrinking yarn is a dual-component yarn. The outer component is a shrinking material, which shrinks when a defined temperature is exceeded. The inner component is a non-shrinking yarn, such as polyester or nylon. Shrinking increases the stiffness of the textile material.

A further yarn for use in knitwear are luminescent or reflecting yarns and so-called “intelligent” yarns. Examples of intelligent yarns are yarns which react to humidity, heat or cold and alter their properties accordingly, e.g. contracting and thus making the stitches smaller or changing their volume and thus increasing permeability to air. Yarns made from piezo fibers or yarn coated with a piezo-electrical substance are able to convert kinetic energy or changes in pressure into electricity, which may provide energy to sensors, transmitters or accumulators, for example.

Yarns may furthermore generally be reworked, e.g. coated, in order to maintain certain properties, such as stretching, color or humidity resistance.

Polymer Coating

Due to its structure, weft-knitted or warp-knitted knitwear is considerably more flexible and stretchable than woven textile materials. For certain applications and requirements, e.g. in certain areas of an upper or a sole according to the present invention, it is therefore necessary to reduce flexibility and stretchability in order to achieve sufficient stability.

For that purpose, a polymer layer may be applied to one side or both sides of knitwear (weft-knit or warp-knit goods), but generally also to other textile materials. Such a polymer layer causes a reinforcement and/or stiffening of the knitwear. In an upper it may e.g. serve the purpose of supporting and/or stiffening and/or reducing elasticity in the toe area, in the heel area, along the lace eyelets, on lateral and/or medial surfaces or in other areas. Furthermore, elasticity of the knitwear and particularly stretchability are reduced. Moreover, the polymer layer protects the knitwear against abrasion. Furthermore, it is possible to give the knitwear a three-dimensional shape using the polymer coating by compression-molding.

In the first step of polymer coating, the polymer material may be applied to one side of the knitwear. It may also be applied on both sides, however. The material may be applied by spraying, knife coating, laying, printing, sintering, ironing or spreading. If it is polymer material in the form of a film, the latter is placed on the knitwear and connected with the knitwear by heat and pressure, for example. Spraying may be carried out by a tool similar to a hot glue gun. Spraying enables the polymer material to be applied evenly in thin layers. Moreover, spraying is a fast method. Effect pigments such as color pigments, for example, may be mixed into the polymer coating.
According to certain embodiments, the polymer is applied in at least one layer with a thickness of 0.2-1 mm. One or several layers may be applied, with it being possible for the layers to be of different thicknesses and/or colors. Between neighboring areas with polymer coating of various thicknesses there may be continuous transitions from areas with a thin polymer coating to areas with a thick polymer coating. In the same manner, different polymer materials may be used in different areas, as will be described in the following.

During application, polymer material attaches itself to the points of contact or points of intersection, respectively, of the yarns of the knitwear, on the one hand, and to the gaps between the yarns, on the other hand, forming a closed polymer surface on the knitwear after the processing steps described in the following. However, in case of larger mesh openings or holes in the textile structure, this closed polymer surface may also be intermittent, e.g. so as to enable airing. This also depends on the thickness of the applied material: The more thinly the polymer material is applied, the easier it is for the closed polymer surface to be intermittent. Moreover, the polymer material may also penetrate the yarn and soak it and thus contributes to its stiffening.

After application of the polymer material, the knitwear is pressed in a press under heat and pressure. The polymer material liquefies in this step and fuses with the yarn of the textile material.

In a further optional step, the knitwear may be pressed into a three-dimensional shape in a machine for compression-molding. For example, the area of the heel or the area of the toes of an upper may be shaped three-dimensionally over a cobbler's last. Alternatively, the knitwear may also be directly fitted to a foot.

After pressing and molding, the reaction time until complete stiffening may be one to two days, depending on the used polymer material.

The following polymer materials may be used: polyester; polyester-urethane pre-polymer; acrylate; acetal; reactive polyolefins; co-polyester; polyamide; co-polyamide; reactive systems (mainly polyurethane systems reactive with H₂O or O₂); polyurethanes; thermoplastic polyurethanes; and polymeric dispersions.

A suitable range for viscosity of the polymer material is 50-80 Pa s (pascal second) at 90-150°C, which may further include a range of 15-50 Pa s (pascal second) at 110-150°C.

A suitable range for the hardness of the hardened polymer material is 40-60 Shore D. Depending on the application, other ranges of hardness are also conceivable.

The described polymer coating may be used sensibly wherever support functions, stiffening, increased abrasion resistance, elimination of stretchability, increase of comfort and/or fitting to prescribed three-dimensional geometries are desired. It is also conceivable to fit e.g. an upper to the individual shape of the foot of the person wearing it, by polymer material being applied to the upper and then adapting to the shape of the foot under heat.

Monofilaments for Reinforcement

As was already defined, a monofilament is a yarn formed by one single filament, that is, one single fiber. Therefore, in certain embodiments, stretchability of monofilaments is considerably lower than that of yarns which are manufactured from many fibers. This also reduces the stretchability of knitwear that is manufactured from monofilaments or include monofilaments and which are used in the present invention. Monofilaments are typically made from polyamide. However, other materials, such as polyester or a thermoplastic material, would also be conceivable.

So whereas knitwear made from a monofilament is considerably more rigid and less stretchable, this knitwear may not include the desired surface properties, such as e.g. smoothness, colors, transport of moisture, outer appearance and variety of textile structures as usual knitwear has. This disadvantage is overcome by the knitwear described in the following.

FIG. 8 depicts a weft-knitted fabric having a weft-knitted layer made from a first yarn, such as a multi-fiber yarn, for example, and a weft-knitted layer made from monofilament. The layer of monofilament is weft-knitted into the layer of the first yarn. The resulting two-layered knitwear is considerably more solid and less stretchable than the layer made from yarn alone. If a monofilament melts slightly, the monofilament fuses with the first yarn even better.

FIG. 8 particularly depicts a front view 81 and a back view 82 of a two-layered knitwear 80. Both views show a first weft-knitted layer 83 made from a first yarn and a second weft-knitted layer 84 made from monofilament. The first weft-knitted layer 83 made from a first yarn is connected to the second weft-knitted layer 84 by stitches 85. Thus, the greater solidness and smaller stretchability of the second weft-knitted layer 84 made from the monofilament is transferred to the first weft-knitted layer 83 made from the first yarn.

A monofilament may also be melted slightly in order to connect with the layer of the first yarn and limit stretching even more. The monofilament then fuses with the first yarn at the points of contact and fixes the first yarn with respect to the layer made from monofilament.

Combination of Monofilaments and Polymer Coating

The weft-knitted fabric having two layers described in the preceding section may additionally be reinforced by a polymer coating as was already described in the section “polymer coating”. The polymer material is applied to the weft-knitted layer made from monofilament. In doing so, it does not connect to the material (e.g. polyamide material) of the monofilament, since the monofilament has a very smooth and round surface, but substantially penetrates the underlying first layer of a first yarn (e.g. polyester yarn). During subsequent pressing, the polymer material therefore fuses with the yarn of the first layer and reinforces the first layer. In doing so, the polymer material has a lower melting point than the first yarn of the first layer and the monofilament of the second layer. The temperature during pressing is selected such that only the polymer material melts but not the monofilament or the first yarn.

Melted Yarn

For reinforcement and for the reduction of stretching, the yarn of the knitwear which is used according to the invention may additionally or alternatively also be a melted yarn that fixes the knitwear after pressing. There are substantially three types of melted yarns: a thermoplastic yarn surrounded by a non-thermoplastic yarn; a non-thermoplastic yarn surrounded by thermoplastic yarn; and pure melted yarn of a thermoplastic material. In order to improve the bond
between thermoplastic yarn and the non-thermoplastic yarn, it is possible for the surface of the non-thermoplastic yarn to be texturized.

**[0198]** In certain embodiments, pressing takes place at a temperature ranging from 110 to 150°C, and may further be approximately 130°C. The thermoplastic yarn melts at least partially in the process and fuses with the non-thermoplastic yarn. After pressing, the knitwear is cooled, so that the bond is hardened and fixed. The melted yarn may be arranged in the upper and/or the sole.

**[0199]** In some embodiments, the melted yarn is weft-knit into the knitwear. In case of several layers, the melted yarn may be weft-knit into one, several or all layers of the knitwear.

**[0200]** In certain embodiments, the melted yarn may be arranged between two layers of knitwear. In doing so, the melted yarn may simply be placed between the layers. Arrangement between the layers has the advantage that the mold is not stained during pressing and molding, since there is no direct contact between the melted yarn and the mold.

### Thermoplastic Textile for Reinforcement

**[0201]** A further possibility for reinforcing knitwear that is used for the present invention, for example in an upper and/or a sole, is the use of a thermoplastic textile. This is a thermoplastic woven fabric or thermoplastic knitwear. A thermoplastic textile melts at least partially when subjected to heat and stiffens as it cools down. A thermoplastic textile may, for example, be applied to the surface of an upper or a sole, which may comprise knitwear, for example, by applying pressure and heat. When it cools down, the thermoplastic textile stiffens and specifically reinforces the upper or the sole in the area in which it was placed, for example.

**[0202]** The thermoplastic textile may be specifically manufactured for the reinforcement in its shape, thickness and structure. Additionally, its properties may be varied in certain areas. The stitch structure, the knitting stitch, and/or the yarn used may be varied such that different properties are achieved in different areas.

**[0203]** According to certain embodiments, a thermoplastic textile is a weft-knit fabric or warp-knit fabric made from thermoplastic yarn. Additionally, the thermoplastic textile may also comprise a non-thermoplastic yarn. The thermoplastic textile may be applied to an upper or a sole of a shoe, for example, by pressure and heat.

**[0204]** A woven fabric whose wefts and/or warps are thermoplastic are other embodiments of a thermoplastic textile. Different yarns may be used in the weft direction and the warp direction of the thermoplastic woven fabric, so as to achieve different properties, such as stretchability, in the weft direction and the warp direction.

**[0205]** A spacer weft-knit fabric or spacer warp-knit fabric made from thermoplastic material are other embodiments of a thermoplastic textile. In this regard, e.g. only one layer may be thermoplastic, e.g. so as to be attached to an upper or a sole. Alternatively, both layers are thermoplastic, e.g. in order to connect the sole to the upper.

**[0206]** A thermoplastic weft-knit fabric or warp-knit fabric may be manufactured using the manufacturing techniques for knitwear described in the section “knitwear”.

**[0207]** A thermoplastic textile may be connected with the surface to be reinforced only partially subject to pressure and heat so that only certain areas or only a certain area of the thermoplastic textile connects to the surface. Other areas or another area do not connect, so that the permeability for air and/or humidity is maintained there, for example. The function and/or the design of e.g. an upper or a sole may be modified by this.

### Upper

**[0208]** FIG. 9 shows a schematic top view of an upper 51, according to certain embodiments of the present invention. The upper 51 comprises a plurality of first portions 91 that are suitable for receiving at least one toe of a foot each. The toes of a wearer of a shoe provided with an upper 51 according to embodiments of the invention are positioned in the first portions 72 while the shoe is worn.

**[0209]** The upper 51 in FIG. 7 comprises five first portions 91, which means that for each toe, there is an individual first portion of the plurality of portions 91. However, it is also conceivable that two or more toes are allocated to one single first portion.

**[0210]** For example, the big toe could be allocated to an individual first portion, while the remaining toes are allocated to a mutual first portion. The upper 51 would hence comprise two first portions in total.

**[0211]** A toe may also be allocated to none of the first portions. Openings in the upper 51 could, for example, make one or several toes visible from outside.

**[0212]** The upper 51 is configured such that the first portions 91 may be moved substantially independently of each other in order to enable the toes to move freely to a certain extent, i.e. the toes are not restricted in their movements as is the case with a normal shoe. The toes may create individual contact with the ground via the sole. In this regard, in case of movement of a portion, neighboring portions may indeed be moved along slightly due to friction or transmission of forces over the upper 51 and/or an existing sole.

**[0213]** Due to the substantially independent freedom of movement of the first portions 91, the toes, too, may be moved largely independently from each other. This produces a natural walking feeling similar to walking barefoot. The toes may move freely and have individual contact with the ground and are able to feel it. A gripping movement of individual toes is also possible.

**[0214]** The first portions 91 in FIG. 9 are formed as knitwear, which may be manufactured as explained in the section “knitwear”. In the example of FIG. 9, the forefoot area 92, which comprises the first portions 91, is formed as knitwear. The remaining area 93 of the upper 51 does not have to be formed as knitwear, since seams are perceived as less disturbing in this area. In certain embodiments, this area 93 may be formed as a thicker, elastic woven fabric or as another conventional shoe material for example.

**[0215]** In other embodiments, the first portions 91 of the upper 51 may be formed as knitwear and no further area of the upper 51. In yet other embodiments, the whole upper 51 may be formed as knitwear. For example, the forefoot area 92 could be weft-knit, whereas the remaining area 93 is warp-knit, or vice versa.

**[0216]** In certain embodiments, the upper 51 may be formed as knitwear in one piece. For example, the upper 51 may be weft-knit or warp-knit continuously. In this case, there are no differing areas 92 and 93 with regard to the use of knitwear. In this case, however, the areas 92 and 93 may differ with regard to their weft-knit or warp-knit structure or the used yarns. A more open stitch structure may be used for airing on the toes in the forefoot area 92, whereas a
tighter weft-knitted fabric may be used on the sides in order to increase stability. Reinforcements such as e.g. ribs, tunnels, pockets, etc. may be weft-knitted or warp-knitted into areas 92 or 93 in order to receive reinforcements or the like. Ribbons may be weft-knitted on.

[0217] The first portions 91 may each be manufactured individually as knitwear and then be joined together by linking. During linking, the edges of the portions of knitwear are joined together in a course-oriented manner, i.e. linked together stitch by stitch, so that no thick seam is produced. This may e.g. be done on a linking machine.

[0218] In certain embodiments, the first portions 91 may be manufactured as one-piece knitwear. For example, the portions 91 may be weft-knitted on a circular knitting machine. The manufacture on a flat knitting machine or a warp knitting machine is also possible. On a flat weft-knitting machine, an upper layer and a bottom layer of the knitwear may e.g. be weft-knitted at the same time, with a respective row of needles being used for each of the two layers, as described in the section "knitwear". The two layers may only be connected to each other along the contour of the shoe and thus form a cavity for the foot. The two layers may also not be fully flat weft-knitted, but may be weft-knitted three-dimensionally, so that the final shape corresponds to the foot, as described in the section "three-dimensional knitwear".

[0219] By linking or manufacturing in one piece the first portions 91, no seams are produced between the first portions 91. This means that joining of the first portions 91 between the toes is made without seams. The knitwear may comprise seams in other areas which are not arranged between the toes.

[0220] The first portions 91 may overlap at least in part, as is shown in FIG. 10. Here, for example, the first portion for the big toe 91a partially overlaps the neighboring first portion 91b, which, in turn, partially overlaps the neighboring first portion 91c, etc.

[0221] Not all first portions 91 necessarily overlap each other. The at least partially overlapping first portions 91 may e.g. be manufactured by the smallest first portion 91e being weft-knitted or warp-knitted first. Subsequently, the next bigger first portion 91d is weft-knitted or warp-knitted such that it at least partially overlaps the smaller first portion 91e. This process is repeated until the largest first portion 91a is reached. These overlapping first portions 91 may also be weft-knitted simultaneously on a flat weft-knitting machine or three-dimensionally weft-knitted into shape, for example.

[0222] The at least partial overlap of the first portions 91 causes an even more pleasant sensation between the toes, since the toes are spread apart less and a “lumpy” feeling between the toes is reduced further or prevented.

[0223] The first portions 91 may comprise an additional yarn which, for instance, may be directly weft-knitted or warp-knitted into the knitwear. Alternatively, the additional yarn may be worked into the knitwear afterwards, for example, by sewing in or embroidering (on). The additional yarn may e.g. be a stabilizing yarn, which improves the support of the toes in the first portions 91 and thus reduces or prevents the toes slipping forward or towards the sides beyond the sole. The additional yarn may be a melted yarn, a rubberized yarn, a yarn with less stretchability or a thicker yarn. There may also be several stabilizing yarns which are twisted, for example. A melted yarn may, e.g. be fused by heat and hardens when cooling down. Thereby, a stiffened, reinforced area is formed. A rubberized yarn has a rubber-like surface and a correspondingly high static friction and thus increases adhesion to the ground surface and increased abrasion resistance.

[0224] The additional yarn may be arranged on a tip of a toe and so as to extend above the toenail and along the side of a toe. In this manner, the additional yarn acts like a toe cap that reduces or completely prevents slipping of the toe and protects the latter. The additional yarn does not have to be processed in a sheet-like manner. It may also be processed in a line-like manner, for example, such as weft-knitted in.

[0225] In FIG. 7, a first area 94 in the first portion 91 of the big toe is shown which may comprise an elastic yarn. Due to this, the first portion 91 is particularly elastic in this area. The first portion 91 hence simply adapts itself to the shape and size of the toe, particularly to the length of the toe. It is conceivable that also other first portions of other areas of the upper are formed by an elastic yarn. The elastic yarn may, for example, be directly weft-knitted or warp-knitted into the knitwear. Alternatively, the elastic yarn may be worked into the knitwear afterwards, for example, by sewing (on) or well-knitting (on).

Shoe

[0226] FIG. 11 shows a shoe 111 with an upper 51 according to the invention. Besides the upper 51, the shoe 111 comprises a sole 61. The sole may be made of leather, rubber, or a synthetic material such as ethylene vinyl acetate (EVA), for example. The sole 61 may also be weft-knitted or warp-knitted, i.e. also be formed of knitwear. The upper 51 is fixed to the sole 61, for example, by bonding, welding or sewing. The sole 61 comprises two portions 112 that correspond to the first portions of the upper 91 and are connected to them.

[0227] The top view of FIG. 12 shows that each of the first portions 91 of the upper corresponds to one of the second portions 112 of the sole. In certain embodiments, several first portions of the upper may correspond to one single second portion of the sole. For example, the first portion for the big toe alone may correspond to a second portion, whereas the remaining first portions for the other toes merely correspond to a further second portion of the sole. The shoe would then have an upper with five first portions and a sole with two second portions.

[0228] In case of the shoe 111 shown in FIG. 10 and FIG. 11, a subsection of the sole 61 together with the upper 51 may be formed as one-piece knitwear. Alternatively, the entire sole 61 and the entire upper 61 may be jointly formed as one-piece knitwear. The manufacture of such a shoe 111 may occur on a weft-knitting machine or a warp-knitting machine. With regard to the manufacture of knitwear, reference is made to the section "knitwear", for example.

[0229] The sole 61 and the upper 51 may also be weft-knitted or warp-knitted separately and then joined together, e.g. by linking, gluing, weft-knitting together, welding, etc.

[0230] The sole 61 may be additionally reinforced, as described in the sections "polymer coating", "monofilaments for reinforcement", "combination of monofilaments and polymer coating", melted yarn" and "thermoplastic textile for reinforcement", i.e. for example, by an applied polymer, a rubber coating, a yarn, a spacer warp-knitted fabric and/or a spacer weft-fabric.

[0231] The reinforcement may be effected depending on the running style of a wearer of the shoe. For a runner who, for example, prefers touching the ground with the heel first, the heel area of the sole 61 may be reinforced correspondingly.
[0232] The thickness of the sole 61 may be determined depending on the weight of a wearer of the shoe 111. For a wearer who weighs more, a thicker sole 61 may e.g. be used than for a lighter wearer.

[0233] Alternatively or additionally, the thickness of the sole 61 may be determined depending on the use of the shoe 111 by a wearer. For example, a thicker sole 61 providing additional cushioning may be used for a running shoe than is the case for a climbing shoe or a casual shoe.

[0234] FIG. 13 shows a side view of a shoe 111 that comprises an upper 51, according to certain embodiments of the invention. The shoe 111 shown in FIG. 13 comprises a sole 61 to which the upper 51 is fixed. The upper 51 has a forefoot area 92 made of knitwear. The area 92 comprises first portions 91 for receiving the toes of a wearer of the shoe 111. The first portions 91 are formed as knitwear. The area 93 of the upper may be manufactured from elastane, nylon, spandex, neoprene or Lytra. The areas 92 and 93 may be joined by a seam 131. In principal, other techniques for joining may also be used, such as sewing, gluing, welding, linking, for example.

[0235] The first portions 91 are coated partially with a foil 132 for reinforcing and improving the abrasive properties. The foil 132 is thermoplastic and is applied to the first portions 91 by heat and pressure. Alternatively, an abrasion-resistant yarn may be weft-knitted in and additionally or alternatively, a coating, e.g. a polymer coating, a PU print or a rubberized print may be applied. A melted yarn may also be weft-knitted in or embroidered on afterwards. Instead of a foil, other techniques of the ones described above may also be used for reinforcing.

[0236] In certain embodiments, the area 93 is partially printed on, e.g. by a PU print (for example by the company Kurim, which specializes in PU coatings e.g. for the shoe industry), in order to improve stability. Equally, the area 92, the first portions 91 or the sole 61 may be printed on for improving stability or for optical enhancement.

[0237] FIG. 14 shows a view of the bottom of a shoe 111 comprising an upper 51, according to certain embodiments of the invention. The shoe 111 comprises a sole 61 with second portions 112, which are overlapped by corresponding first portions (not visible in FIG. 14) of the upper. The sole 61 may be formed as a separate part and connected, e.g. glued to, the upper 51. The sole 61 may also be sprayed (e.g. as TPU) or vulcanized (e.g. rubber) directly onto the upper 51. The sole 61 may be formed as a coating of the upper 51. The sole 61 may also be a part of the weft-knit fabric or warp-knit fabric of the upper 51 and weft-knit in or warp-knit in e.g. as a rubberized yarn or melted yarn.

[0238] The sole 61 is provided with a profile in order to improve the traction of the shoe 111. The profile can, in principle, be adapted to the field of application of the shoe 111. A shoe which is to be used in the country could comprise a coarser and deeper profile than a shoe which is worn in town.

[0239] In some embodiments, the sole shown in FIG. 12 furthermore includes an area where the sole 61 is thinner than in other areas. This area 141 is located between the area of the toes and the area of the ball of the toes and extends along the foot’s flex lines. Since the sole 61 is thinner in this area 141, the second portions 112 of the sole 61, which are connected to the first portions of the upper, are easier to snap with regard to the remainder of the sole 61. The overall freedom of movement of the toes is thus increased.

[0240] The sole 61 shown in FIG. 14 furthermore comprises grooves 142 and 143. The grooves 142 run substantially in the longitudinal direction of the sole 61, whereas the grooves 143 run substantially in the lateral direction of the sole 61. The grooves 142, 143 generally correspond to the foot’s natural flex lines, but another path of the grooves is also possible.

[0241] The grooves 142 and 143 have the effect that the sole 61 as a whole becomes more flexible, adapts better to the shape of the foot and allows a more natural walking feeling similar to that of walking barefoot.

[0242] In the following, further examples are described to facilitate the understanding of the invention:

[0243] 1. Upper (51) for a shoe, in particular a sports shoe, comprising:

[0244] a. a plurality of first portions (91) for receiving at least one toe of a foot;

[0245] b. the first portions (91) being moveable essentially independently of each other; and

[0246] c. the first portions (91) comprising knitwear.

[0247] 2. Upper (51) according to example 1, wherein the first portions (91) are formed as one piece.

[0248] 3. Upper (51) according to example 1, wherein the first portions (91) are connected to each other by means of linking.

[0249] 4. Upper (51) according to any one of the preceding examples, wherein the first portions (91) are connected to each other essentially seamlessly.

[0250] 5. Upper (51) according to any one of the preceding examples, wherein a separate first portion (91) is provided for each toe.

[0251] 6. Upper (51) according to any one of the preceding examples, wherein the knitwear comprises at least one weft-knit area.

[0252] 7. Upper (51) according to example 6, wherein the at least one weft-knit area is weft-knit three-dimensionally.

[0253] 8. Upper (51) according to any one of the preceding examples, wherein the shoe upper (51) including the first portions is formed as one-piece knitwear.

[0254] 9. Upper (51) according to one of the preceding examples, wherein the knitwear further comprises at least one warp-knit area.

[0255] 10. Upper according to example 9, wherein the at least one warp-knit area is warp-knit three-dimensionally.

[0256] 11. Upper (51) according to any one of examples 1 through 8, wherein the knitwear of the shoe upper (51) is weft-knit on a flat-knitting machine.

[0257] 12. Upper (51) according to any one of the preceding examples, wherein at least one first portion (91) comprises a first area (94) having an elastic yarn.

[0258] 13. Upper according to example 12, wherein the first portion (91) comprises a second area and wherein the first area (94) comprises a more elastic yarn than the second area.

[0259] 14. Upper (51) according to any one of the preceding examples, wherein at least one first portion (91) overlaps at least partially.

[0260] 15. Upper (51) according to any one of the preceding examples, wherein at least one first portion (91) comprises a second yarn in addition to a first yarn of the knitwear.
[0261] 16. Upper (51) according to example 15, wherein the second yarn is a melted yarn or a rubberized yarn.

[0262] 17. Shoe (111), in particular a sports shoe, comprising:

[0263] a. an upper (51) according to any one of the preceding examples; and

[0264] b. a sole (61) which comprises two portions (112) which correspond to the first portions (91) of the shoe upper (51) and are connected to them.

[0265] 18. Shoe (111) according to example 17, wherein at least a subsection of the sole (61) together with the upper (51) is formed as one-piece knitwear.

[0266] 19. Shoe (111) according to example 17 or 18, wherein the sole (61) is well-knitted or warp-knitted.

[0267] 20. Shoe (111) according to any one of examples 17 through 19, wherein the sole (61) is reinforced by coating.

[0268] 21. Shoe (111) according to any one of examples 17 through 20, wherein the sole (61) is reinforced by an additional yarn.

[0269] 22. Shoe (111) according to any one of examples 17 through 21, wherein the sole (61) comprises a spacer well-knitwear or spacer warp-knitwear.

[0270] 23. Shoe (111) according to any one of examples 17 through 22, wherein the sole (61) is reinforced depending on a wearer of the shoe (111).

[0271] 24. Shoe (111) according to any one of examples 17 through 23, wherein the thickness of the sole (61) is determined depending on the weight of the wearer of the shoe (111) or depending on the weight and the use.

[0272] 25. A method of manufacturing an upper (51) in accordance with one of examples 1 through 16, with the step of providing a plurality of first portions (91) for receiving at least one toe of the foot, wherein the upper (51) is formed such that the first portions (91) can be moved substantially independently of each other and wherein the portions (91) comprise knitwear.

[0273] Different arrangements of the components depicted in the drawings or described above, as well as components and steps not shown or described are possible. Similarly, some features and sub-combinations are useful and may be employed without reference to other features and sub-combinations. Embodiments of the invention have been described for illustrative and not restrictive purposes, and alternative embodiments will become apparent to readers of this patent. Accordingly, the present invention is not limited to the embodiments described above or depicted in the drawings, and various embodiments and modifications may be made without departing from the scope of the claims below.

That which is claimed is:

1. An upper for a shoe comprising:

(a) a plurality of first portions for receiving at least one toe of a foot;

(b) the plurality of first portions being moveable substantially independently of each other; and

(c) the plurality of first portions comprising knitwear.

2. The upper according to claim 1, wherein the plurality of first portions are formed as one piece.

3. The upper according to claim 1, wherein the plurality of first portions are connected to each other by linking.

4. The upper according to claim 1, wherein the plurality of first portions are connected to each other substantially seamlessly.

5. The upper according to claim 1, wherein a separate first portion is provided for each toe.

6. The upper according to claim 1, wherein the knitwear comprises at least one well-knitted area.

7. The upper according to claim 6, wherein the at least one well-knitted area is well-knitted three-dimensionally.

8. The upper according to claim 1, wherein the shoe upper including the plurality of first portions is formed as one-piece knitwear.

9. The upper according to claim 1, wherein the knitwear further comprises at least one warp-knitted area.

10. The upper according to claim 9, wherein the at least one warp-knitted area is warp-knitted three-dimensionally.

11. The upper according to claim 1, wherein the knitwear of the shoe upper is well-knitted on a flat-knitting machine.

12. The upper according to claim 1, wherein at least one of the plurality of first portions comprises a first area having an elastic yarn.

13. The upper according to claim 12, wherein at least one of the plurality of first portions comprises a second area, and wherein the first area comprises a more elastic yarn than the second area.

14. The upper according to claim 13, wherein two of the plurality of first portions overlap at least partially.

15. The upper according to claim 1, wherein at least one of the plurality of first portions comprises a second area in addition to a first area of the knitwear.

16. The upper according to claim 15, wherein the second area is a melted yarn or a rubberized yarn.

17. A shoe comprising:

(a) an upper comprising

(i) a plurality of first portions for receiving at least one toe of a foot;

(ii) the plurality of first portions being moveable substantially independently of each other; and

(iii) the plurality of first portions comprising knitwear;

(b) a sole which comprises two portions which correspond to the plurality of first portions of the upper and are connected to them.

18. The shoe according to claim 17, wherein at least a subsection of the sole together with the upper is formed as one-piece knitwear.

19. The shoe according to claim 17, wherein the sole is well-knitted or warp-knitted.

20. The shoe according to claim 17, wherein the sole is reinforced by coating.

21. The shoe according to claim 17, wherein the sole is reinforced by an additional yarn.

22. The shoe according to claim 17, wherein the sole comprises a spacer well-knitwear or spacer warp-knitwear.

23. The shoe according to claim 17, wherein the sole is reinforced depending on a wearer of the shoe.

24. The shoe according to claim 17, wherein a thickness of the sole is determined depending on a weight of a wearer of the shoe or depending on the weight and a use of the shoe.

25. A method of manufacturing an upper comprising (i) a plurality of first portions for receiving at least one toe of a foot, (ii) the plurality of first portions being moveable substantially independently of each other, and (iii) the plurality of first portions comprising knitwear, the method comprising providing the plurality of first portions for receiving the at least one toe of the foot.

* * * * *