(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 4 365 344 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
08.05.2024 Bulletin 2024/19

(21) Application number: **22205011.4**

(22) Date of filing: **02.11.2022**

(51) International Patent Classification (IPC):
D04B 1/24 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
D04B 1/24; D10B 2403/032

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
KH MA MD TN

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Remarks:
A request for correction of page 12 of the description has been filed pursuant to Rule 139 EPC. A decision on the request will be taken during the proceedings before the Examining Division (Guidelines for Examination in the EPO, A-V, 3.).

(54) **AN AUTOMATED METHOD FOR KNITTING A TAILORED THREE-DIMENSIONAL GARMENT, A KNIT GARMENT AND A PATTERN DESIGN**

(57) The present invention provides for an automated process for producing knit garments (400) having a tailored look when worn by wearers having different body shapes. Through a combination of woven fibre tailoring techniques, adapted to the domain of knit fabrics, and an innovative approach to programming a three-dimensional seamless garment knitting machine to knit the garment in a new way, a knit garment (400) can be produced which adapts to fit different wearers having different body types while following the wearer's anatomy and providing support where required, thus allowing the same garment to provide a tailored look to different wearers having different body shapes.

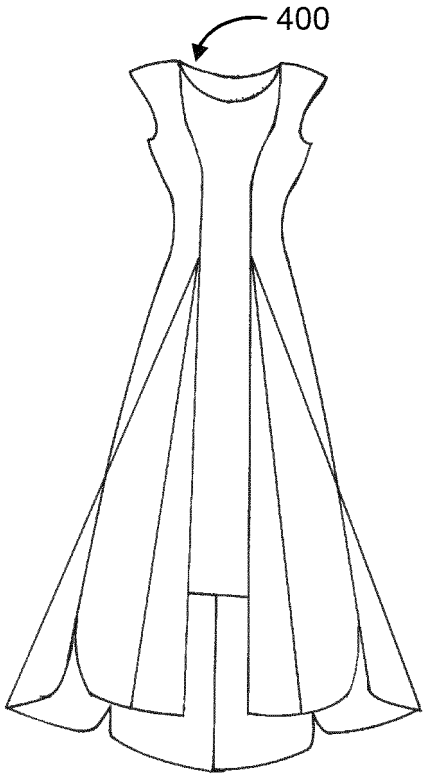

Figure 4A

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Description

TECHNICAL DOMAIN

[0001] The inventive concepts described herein relate generally to the domain of weft knitting processes for the production of fabrics and articles. More particularly, a method for knitting a three-dimensional tailored garment using a 2-bed or 4-bed straight-bar or flat-bed knitting machine is presented, as well as a set of garments which may be produced using the method. Certain aspects described herein relate to techniques for tailor-making garments based on a pattern design, involving the joining together of component parts of the garment.

BACKGROUND

[0002] In the fashion industry, a pattern is a template which is used to trace the outline of the various component parts of a garment onto the fabric from which the garment is to be made. The garment component parts are then cut from the fabric and assembled together, usually by sewing or by other techniques, allowing for overlapping edges of the various component parts to be joined, thus pulling the garment into a three-dimensional shape to fit a wearer.

[0003] Designing a pattern is a highly skilled art which takes many years to master. Highly skilled designers are a rare commodity and the most skillful among them are capable of creating very artistic clothing designs having shape and drape characteristics which preferably enhance the look of the wearer, depending on which types of fabrics are used. Such skills are highly regarded in the industry. Such clothing designs often attract high retail prices. The cut-and-sew techniques which are used when making apparel according to a pattern require that the pattern include a seam allowance so that when the edges of the various component parts of the garment overlap where the seam is to be made, the garment will still fit as intended. Seams are usually bulky in the sense that the garment will be thicker at the seam than at the centre of either of the joined parts due to doubling or bunching of the fabric at the seam, which affects the shape of the garment. Seams may also interfere with the look of the garment or the drape at a particular part of the garment.

[0004] Cut-and-sew techniques are usually best suited to the design and manufacture of garments which are made from woven fabric, especially where the goal is to achieve a tailored, best-fit garment. Woven fabric tends not to deform much and so an important part of tailoring a garment using this technique is to measure the wearer for whom the garment is intended. This leads to a time-consuming process, with garments being tailored to fit one person.

[0005] Knit fabric on the other hand has an advantage in that it has more elasticity than woven fabric. However, when knit fabric is used for cut-and-sew techniques the seams can become very bulky and may affect comfort for the wearer as well as the drape and the general look and fit of the garment. It would be advantageous to be able to use knit fabric in garment design because of the comfort it offers for the wearer and the elastic properties that it offers, through elasticity of the different types of yarn, the stitch type used, the stitch length and the stitch density. Local variations in elasticity can also thus be achieved using knit fabric.

[0006] Recognising the advantages provided by knit fabric for the fashion industry, much work was put into the creation of programmable knitting machines which could knit an entire garment in a single pass without seams, meaning that a seamless, three-dimensional garment, such as a pullover or a dress with sleeves, could be industrially produced in a very short time. For example, European patent publication number EP0533612B1 discloses a flat bar knitting machine capable of knitting a complete three-dimensional garment without seams. Machines such as the one described above usually have two opposing needle beds or four needle beds and are able to create intricate three-dimensional shapes without seams. Starting at the bottom end of the garment, a two-bed or four-bed flat bar knitting machine may be used to knit three separate tubes using three subsets of needle groups across the width of the machine, respectively for the left sleeve, the body and the right sleeve. Knitting of the three tubes continues from the bottom up towards a point where the sleeves should connect to the body of the garment. At the connection point, the two sleeves effectively merge or slide into the body of the garment. Then by performing multiple stitch transfers across the width of the knit fabric over a given number of courses, the tubes' wales decrease in number and the sleeves connect into the body of the garment. The three tubes are thus knit into a single tube towards the top end of the garment to form the shoulders and the neck. Knitting machines which are capable of knitting a complete, ready-to-wear, seamless garment in this way address the problem of waste material produced by cut-and-sew techniques. However, this technique does not allow for the full advantages afforded by the elasticity of knit fabric to be enjoyed because the knitting rows, or courses, of the finished garment lie mostly in the same general direction, i.e. horizontally with respect to how the garment would be worn.

[0007] Other documents describe how separate pieces of knit fabric may be joined by knitting them together in a knitting machine. For example, European patent publication EP2418310B1 describes a method for joining adjacent knit fabric parts, which are aligned in a knitting width direction in a weft knitting machine and which are knit independently.

[0008] European patent publication number EP1652983B1 shows how it is possible to use a flat machine to produce a seamless garment while taking account of a knit pattern and building in three-dimensional effects to the garment, such as the flared skirt disclosed

therein. This cannot be described as tailoring a garment to fit different body shapes, however. The technique is based on calculations for providing the correct flare and for taking account of the pattern.

[0009] European patent publication number EP1444393B1 describes a knit pressure garment, which can be described as tailoring a garment to conform to a wearer's body by following the contours of the wearer's anatomy and providing support where required. The method for producing the garment involves the use of a three-dimensional seamless garment knitting machine, knitting according to instructions which are based on a three-dimensional scan of the wearer's body. This technique is for fabricating knit garments for a particular wearer and would not be suitable for manufacturing many garments which would provide garments having a tailored fit look on a wide variation of different wearers having different body shapes.

[0010] Circular knitting machines are known and may be used to knit garments having a tubular form of a particular diameter. Such machines do not allow for knitting tailored garments having varying diameters over the height of the garment.

BRIEF SUMMARY OF THE INVENTION

[0011] A goal of the present invention, among others, is to create elegant, body-flattering, garment designs which can be made into a garment which self-adapts to different body shapes of different wearers, while simultaneously shaping, using a manufacturing process which is fast enough to allow manufacturers not to overproduce such garments, thus respecting a real customer demand, while minimizing the amount of waste fabric produced during the process. Another goal is to allow the possibility of a maximum number of people to wear tailored garments, providing a "couture" look to people of different body sizes and body shapes without having to use a made-to-measure method for manufacturing the garments. Preferably, a size range of just small, medium and large, for example, should be sufficient to make garments which when worn by wearers of a wide range of different sizes and body shapes, provide the desired tailored look of the garment on the wearer.

[0012] According to a first aspect, there is disclosed herein an automated method for knitting a garment, the method comprising:

using a programmable knitting machine to interpret a predetermined set of knitting instructions to knit a plurality of garment component parts; and

combining the garment component parts to pull them into a three-dimensional form thereby creating a three-dimensional garment;

characterised in that:

the plurality of garment component parts comprises, according to a predetermined pattern design:

a suite of knit fabric panels of geometrical or freeform shape and knit fabric elongate reinforcement structures, said panels each having at least one edge and said reinforcement structures each having a plurality of edges; and

further characterised in that the method further comprises:

successively knitting said plurality of garment component parts by the knitting machine, according to the predetermined knitting instructions; and

linking at least a first part of the garment, said first part having been knit towards the beginning of the method, with at least a second part of the garment, knit towards the end of the method, thus creating a tailored three-dimensional knit garment; wherein

said combining of concerned component parts is done by the knitting machine by progressively knitting abutting edges of respective garment component parts together according to the predetermined knitting instructions as said garment component parts are being knit.

[0013] Linking may be done by sewing or by knitting, the linking thereby creating a final seam on the garment. According to different embodiments, the final seam may be at the back of the garment, at the front of the garment or on one or other sides of the garment. According to an embodiment, linking is also performed towards the top of the garment in order to form shoulder straps.

[0014] The term "freeform", as used here, is merely to indicate that the shapes are not shapes that can be defined by a mathematical equation, as would be the case for geometrical shapes. The term "freeform" does not however mean that the shapes can be freely drawn at random. Neither does it indicate that the shapes may be those which readily appear in nature. On the contrary, the freeform shapes referred to in the context of the present invention are shapes which have been designed expressly by a skilled tailor so that when knit fibre panels having those shapes and knit fibre elongate structures are combined according to the predetermined knitting instructions, they form the desired three-dimensional tailored garment.

[0015] According to another aspect, provision is made for a three-dimensional knit garment fabricated according to the method described above. Such a garment comprises a plurality of garment component parts including a plurality of knit fabric panels of geometric or freeform shape having at least one edge and a plurality of knit fabric elongate reinforcement structures having a plurality of edges, characterised in that adjacent garment component parts are knit together where edges of the corresponding component parts abut with each other.

[0016] According to still another aspect, a pattern design for making a three-dimensional garment is provided.

More specifically, the pattern is for making a knit fabric garment according to the method described above. Such patterns differ from known sewing patterns in that they do not require for any seam allowance to be included because the method for fabricating the garment involves knitting abutting edges of garment component parts without overlapping the edges. As such, the pattern design comprises a plurality of panels of geometrical or freeform shape having at least one edge and a plurality of elongate shapes, and a plurality of elongate shapes having a plurality of edges, the pattern design for making corresponding garment component parts to be combined to form the garment by knitting abutting edges of neighbouring components together according to a predetermined set of knitting instructions for a programmable knitting machine.

[0017] According to yet another aspect, provision is made for a computer-readable medium comprising instructions which, when executed by one or more processors, cause a programmable flat bar weft knitting machine to perform the method described above to make the garment described above.

[0018] Through careful design of a knit garment and its corresponding pattern design, embodiments of the present invention render it possible to create a garment which would give a tailored fit look when worn by different people having quite different body shapes. Embodiments of the present invention allow for advantage to be gained by the preferably body-flattering drape effects possible thanks to the superior elasticity properties of knit fabric in combination with the structure provided by the pattern for allowing parts of the garment to shrink, while at the same time ensuring that sufficient support is provided to allow the garment to maintain its form, without the disadvantage of having obvious seams in the garment where the component parts are attached to each other.

[0019] The invention allows for automated production of garments on industrial scale and at sufficient speed to be able to react quickly to customer demand while respecting the requirement not to generate excess waste fabric. The invention adapts the artistic know how borrowed from the "haute couture" or "couture" industries and transposed for use on knit fabrics, while also adapting the way programmable knitting machines are normally used to allow them to take advantage of the "haute couture" approach and therefore allow for production speed and volume goals to be achieved, without the need for body measurements to be made and for subsequent, time-consuming and labour intensive cut-and-sew techniques to be employed.

[0020] One of the techniques borrowed by the inventor from the domain of "couture" is the "bias cut", technique, which allows designers to create sections of woven fabric which offer stretch, malleability and flowing drape. Cutting woven fabric in a bias cut means cutting the fabric at a diagonal angle across the weave, or grain, of the fabric to give the material more softness and elasticity. To imitate the bias cut applied to woven textiles, embodiments of the present invention, using knit fabric, employ a so-called "bias knit" technique. A panel of knit fabric can be said to be bias knit when the panel includes at least one bias selvage. A bias selvage in a knit fabric panel can be described as a selvage which is aligned in an orientation which is on a bias, or at an angle, with respect to a direction of orientation of a majority of the courses of yarn making up the panel. Embodiments of the present invention make use of such panels, featuring this so-called "bias knit" technique, to imitate the way the bias cut technique is used in the domain of tailoring design to create flowing lines in a garment made using woven fabrics. Embodiments of the present invention therefore allow for some haute couture and/or couture ideas to be applied to the knitting world.

[0021] Examples of knit fabric panels having a shape which features at least one bias selvage include those having a triangular shape or a rhombus or parallelogram shape. Such panels shall be described herein as being bias knit panels or panels which have been bias knit. Use of such panels in embodiments of the present invention affect the drape of the fabric and allow for the expression of flowing lines to be achieved in the garment designs proposed.

[0022] Bias knit panels, as used in embodiments described herein, allow for full advantage of the superior elasticity properties of knit fabric to be exploited, creating softness, suppleness and elasticity and providing for flowing lines in a garment design to be realised. However, bias knit panels also have the disadvantage of introducing instability in that they offer little in the way of support to the garment. Embodiments of the present invention therefore feature the inclusion of elongate reinforcement structures of knit fabric at places on the garment where extra support is required. To provide sufficient support, the yarn used for knitting elongate reinforcement structures is preferably stiffer than yarn used for knitting a panel. The yarn is preferably used in 3-ply or more to provide sufficient rigidity and support.

[0023] Embodiments described herein satisfy the goal of reducing the time it takes to produce a garment when compared to the "cut-and-sew" technique used for making tailored garments. The garments are designed to take full advantage of the elasticity afforded by knit fabric, while providing support where required, to allow for one garment design to fit many different body sizes and types, leading to a reduction in over-production of garments of the "wrong size" and at the same time bringing the world of couture to a larger number of people. Garments described in the present disclosure automatically adapt to different body shapes of different wearers, closely conforming to the wearer's anatomy, without the need for buttons, zippers or other fastening devices which could otherwise interfere with the aesthetic of a garment design.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] The inventive concepts described herein will be better understood thanks to the detailed description which follows, along with the accompanying drawings, in which the following is shown:

figure 1 - a prior art pattern design used in the fashion industry for manufacturing garments according to a cut-and-sew process;
figure 2 - an example of a pattern design according to an embodiment of the present invention;
figure 3A - a pixel-based graphical representation of a predetermined set of knitting instructions, which may be stored on a computer readable medium, according to an embodiment of the present invention, for knitting a three-dimensional tailored knit garment according to an embodiment described herein;
figure 3B - a pixel-based graphical representation of a predetermined set of knitting instructions, which may be stored on a computer-readable medium, according to another embodiment of the present invention, for knitting a three-dimensional tailored knit garment according to an embodiment described herein;
figure 4A - a design sketch of a front view of an example first garment according to an embodiment of the present invention;
figure 4B - a design sketch of a rear view of the example first garment according to an embodiment of the present invention;
figure 4C - a design sketch of a front view of an example second garment according to an embodiment of the present invention;
figure 4D - a design sketch of a front view of an example third garment according to an embodiment of the present invention;
figure 4E - a design sketch of a front view of an example fourth garment according to an embodiment of the present invention;
figure 4F - a design sketch of a front view of an example fifth garment according to an embodiment of the present invention; and
figure 5 - a block diagram of a process for knitting a three-dimensional tailored knit garment according to an embodiment of the present invention.

DETAILED DESCRIPTION

[0025] Figure 1 shows a pattern design **100** allowing for a tailor to cut a number of garment component panels **110, 120, 130, 140** from a piece of fabric to be sewn together to create a three-dimensional garment. The panels have seam allowances between the edges **112, 122, 132, 142** of the panels and a seam line **114, 124, 134, 144** to receive sewing thread for attaching neighbouring panels together to pull them into the required shape to form a three-dimensional garment. Much work goes into the design of a pattern **100** in order to ensure that the finished garment, using the chosen fabric or fabrics, has the desired form and drape.

[0026] Figure 2 shows an example pattern design **200** according to an embodiment of the present invention. Patterns according to embodiments of the invention do not feature seam allowance because the different component parts of a garment created according to embodiments of the invention are joined by knitting abutting edges of respective components together, without overlapping the component parts. The pattern design illustrated in figure 2 may be used, according to an embodiment of the method of the invention, to make a dress having a tailored fit for different wearers having very different body shapes. Other embodiments of pattern design are possible, in keeping with the invention. For example, patterns according to embodiments of the invention may allow for making trousers, jackets, shirts and any garment where a tailored-fitting knit garment is required. Garments may be made for humans or for animals.

[0027] Knitting machine programs comprise needle-by-needle, stich by stitch, row by row instructions which allow the knitting machine to create a knit fabric depending on programmable options dictating when and which yarn or yarns to use, which stitch types to use, stitch lengths and yarn tensions, and so on, to produce a work of knit fabric. Some knitting machine manufacturers offer a pixel-based graphical representation of knitting instructions to make programming of their machines a little more intuitive, especially when visualised on a CAD/CAM programming interface. In such graphical representations, stitch positions are shown horizontally and the sequence of the construction of rows over time is shown vertically, usually with time increasing from bottom to top. Options selected by the program may be illustrated graphically at a different part of the representation. Different colours may be used to show different course directions and/or different stitch properties.

[0028] Programs comprising knitting instructions for creating garments according to embodiments described herein, when visualised in such pixel-based graphical representations, turn out to resemble rather closely the pattern on which the garment construction is based. Figure 3A shows a pixel-based graphical representation of a set of instructions **300** for a programmable knitting machine for knitting a three-dimensional tailored dress according to an embodiment of the present invention. Knitting starts at the bottom of the graphic and proceeds over time, course by course, towards the top of the graphic. The dress may then be linked by attaching stitches created towards the beginning of the program with stitches created towards the end, thereby creating a final seam. Knitting progresses vertically for a garment which will be linked for wearing horizontally. Thus, in figure 3A knitting starts at the left side of the dress, progresses around the body of the dress and ends back at the left side of the dress where the final seam is created during linking.

[0029] Figure 3B shows a pixel-based graphical representation of another set of instructions **310** for a pro-

grammable knitting machine for knitting the same dress as the one above, but where knitting starts and ends at the back of the dress, creating the final seam at the back of the dress.

[0030] Figure 3A and 3B provide just two examples of knitting programs **300, 310** which can be used, along with the corresponding pattern design **200,** for making a dress according to an embodiment of the invention. Other programs are possible for making other garments according to embodiments of the invention, along with their corresponding patterns. For example, programs according to embodiments of the invention may be used for making trousers, jackets, shirts and any garment where a tailored-fitting knit garment is required. Garments may be made for humans or for animals.

[0031] Instructions for a programmable knitting machine may include such characteristics as: the number of courses to knit, the direction of knit for each course, the lengths of the different courses, the types of stitches used for each course or within each course, the lengths of stitches used in a course or within a course, the type of yarn to use, the number of strands of yarn to use (e.g. single ply, 2-ply, 3-ply etc.), the number of different yarns involved in a knit, how to combine (knit) different parts of the garment together, which operation to use when creating a stitch (e.g. knit, tuck, transfer and/or racking, splitting). Course lengths may be increased or decreased during the knit to realise three-dimensional features.

[0032] According to embodiments described herein, knitting machines may be programmed to knit three-dimensional garments in a way in which it was not originally intended, thus allowing a designer of knit fabric garments to exploit many of the "haute couture" techniques available to designers who design using sewing patterns as applied to woven fabrics garments. For example, it is known that a dress design can be made to look supple and flowing when the fabric is cut at a bias to the grain of the woven yarn. Knit fabric already offers an advantage in that it has good elastic properties, but designers do not usually consider making a bias cut on knit fabric. Embodiments of the present invention allow for aspects such as this to be exploited by designers of knitwear garments and on an industrial scale while minimising waste.

[0033] According to embodiments, bias knit panels are proposed to imitate the bias cut in woven fabrics, allowing to design knit garments with soft, supple, flowing lines. Thus, a pattern may be designed, comprising shaped panels of knit fabric, allowing the designer to take advantage of many of the techniques and tricks for designing well-tailored garments, with the added benefit of the elasticity provided by woven fabric, thus allowing to design a garment which adapts itself to different body shapes and types.

[0034] A bias knit panel is a panel of knit fabric comprising courses of knit yarn, wherein at least one selvage of the panel does not line up perpendicular to the direction of the courses. The selvage follows a line which is at an angle to the direction of the courses, for example 45 degrees for a "pure bias", or less for other types of bias. When the selvage is at 90 degrees to the course direction, this is deemed not to be a bias knit.

[0035] Bias knit panels present a disadvantage from the point of their instability, however. They offer little in the way of support to the garment. According to embodiments described herein, it is proposed to reinforce areas of the design which do not have enough stability. Elongate knit fabric reinforcement structures are proposed to provide the required stability.

[0036] According to an embodiment, a pattern is designed, comprising panel shapes and elongate reinforcement structure shapes, and instructions are written for a knitting machine to construct the panels and reinforcement structures and to knit them together as the panels and reinforcement structures are being knit, to pull them into a three-dimensional shape to make a three-dimensional garment. The garment is created in the horizontal direction, beginning at a first point around the body, going around the body and ending back at the beginning point, where the garment is linked by knitting or sewing thus making a seam.

[0037] The following section describes a set of knitting instructions according to an embodiment of the present invention, using the pixel-based graphical representation of the knitting program illustrated in figure 3A as an example. By way of example, the knitting machine for which these instructions apply is a three-dimensional seamless garment V-bed knitting machine, although it is possible to use other types of knitting machines, as long as they can create shaped panels and elongate structures illustrated in the pattern and are capable of knitting the parts together as described.

[0038] In figure 3A, knitting begins by creating reinforcement structure RL1. The elongate reinforcement structure RL1 is knit on a first needle bed over a width of the machine that is defined by the number of needles required to cover the entire length of the dress as it will be worn, that is to say a length extending between the points 7B and 2B at the opposite end of the knit, towards the end of the program. Elongate reinforcement structure RL1 may comprise four rows, or five rows if a more stabilising effect to the finished dress is required. A reinforcement filament may be used, which is a filament which is stiffer than filament which would be used for a panel. Stiffness may be obtained by using 2-ply or 3-ply yarn for example, or by inserting strands of yarn which have stiffer properties. Preferably the structure RL1 uses this reinforcement filament in 3-ply. One of the rows of RL1 may be designated for the linking of the dress construction at the end of the process. Each successive row of RL1 may comprise an extra stitch on the left side, thus forming a sharp point on structure RL1. Any of the elongate reinforcement structures may be provided with a point by adding or subtracting one or more stitches on each successive row, as will be shown below for RL2 and RL3, for example.

[0039] Panel P1 will form the central skirt part of the

left side of the dress. Knitting of panel P1 begins over a length (length of the dress, or width over the machine) extending from point 1A to point 2A. Point 1A will be the main point of the waistline of the dress. Point 2A will be the hemline at the front of the dress. The number of needles involved is gradually and regularly reduced over successive rows on the left side from the beginning of knitting of this panel. Hence, a straight line is created between 1A and 3A at a bias. Meanwhile, one the right side, the number of needles involved is reduced according to the pattern to form a substantially smooth curve between points 2A and 3A. The result is a substantially triangular-shaped, almost freeform, panel, which will form a substantially cone-shaped part on the completed dress having a substantially equalised hemline length. Towards the end of knitting of panel P1, knitting of a second elongate reinforcement structure, RL2, begins, this structure covering the same number of needles involved between point 3A and 1A plus a margin of, for example 3, extra needles. RL2 may have three rows of stitches, or four for more stability, again using 3-ply knit of reinforcement filament, with each successive row having one less stitch, thereby ending up, at point 1B, with the same number of needles as between point 3A and 1A but with one extra if RL2 has three rows. If RL2 has four rows, then knitting would start with the number of needles involved between 3A and 1A plus a margin of 4 extra needles.

[0040] Panel P1 is at its narrowest at point 1A. Due to the small number of stitches involved around this point of the panel, a certain amount of stretch will be built in. However, in the completed dress, stability is provided to this conical part because it is surrounded by two reinforcement structures RL1 and RL2, thus providing a stable base for P1.

[0041] As the distance between lines 1A-2A and 1A-3A gradually increases, so the inherent stretch within the knitwear also increases. The finished garment will therefore become wider in shape with increasing stretch, meaning decreasing stability towards the hemline, resulting in more fluidity between points 2A and 3A.

[0042] Furthermore, this cone-shaped part of the finished dress provides for a gradual shift of the garment flow towards the bias-knit feature of the panels which will be subsequently knit to create line 1B-5A (equivalent to 1C-4B + 4C-13B + 13C-5B) when the different parts will be knit together. Knitting of panel P2, the side panel of the left part of the skirt, begins at point 1B, preferably using 2-ply yarn and in flechage knitting mode to produce line 1B-3B. The final number of needles involved is one needle less than the number of needles used in RL2. Knitting begins with the increase of width on the right to increase the length of the panel by adding the same number of needles to create the straight line 1B-3B. Once the point 3B is reached, the number of the needles remains the same on the right side of the panel until the point 6A is reached. A curved line is created on the right side of the panel P2 by progressively reducing the number of the needles involved to resemble the curved edge shown, as if it were finished by hand. Meanwhile, on the left of the panel, a gradual decrease in the number of needles involved allows for the creation of the straight line 1B-5A. After point 5A is reached, the decrease in needle numbers intensifies and the straight Line 5A-6B is formed. Such reduction of the volume is advantageous for reducing the overall volume of the fitted garment in the skirt area, leaving the volume only needed for the ease of natural flow of the garment below the waistline. Similarly to panel P1, in panel P2 the distance between lines 1B-3B and 1B-5A (where the latter's function is continued with the line 5A-9A) gradually increases, so the stretch inherent in the knitwear does so too. Not only the garment is wider in shape but also is stretcher (less stable) and more fluid towards the hemline (points 3B-6A/6B).

[0043] Reinforcement structure RL3 is created using three rows (or four rows if very light yarn is used or if more stability is required) of back stitch of front stitch 3-ply knit in which reinforcement yarn is inserted. The length of this line is equal to the that which is subtended by the two lines 1B-5A through 5A-6B. Each successive row of RL3 is knit with the addition of two needles to produce the total number of needles required to cover the length of panel P2 and RL3 on the left side together with the geometrically formed cone shape that will appear on the finished dress over panel P1 with RL2 and panel P2 i.e., the area where points 1A and 1B are joined through RL2.

[0044] Panel P3 forms the bust part on the left side of the dress. Knitting of panel P3 begins with the forming of the curved line passing between points 7A and 1C. This is preferably knit using 2-ply yarn in flechage mode, to increase the width of the panel on both sides, starting from the apex, according to the pattern, to enhance the bust shape. Once point 1C is reached, knitting continues between points 1C and 4B, forming the straight bias line. This bias line is preferably a true bias, at 45 degrees. This creates the most instability, prone to provide maximum stretch/shrink characteristics, which is beneficial for the wearer as it will follow the contour of the wearer's anatomy, for different wearers having different body shapes.

[0045] Once point 7A is reached, on the left side of knitting, a point which will later be joined with the centre front part of the dress on future panel P25, the number of stitches is increased to form the neckline as per the pattern. The neckline is therefore continuously knit between points 7A and 8A. Once point 8A is reached, the shape of the shoulder line is formed by decreasing the number of stitches between points 8A and 10A.

[0046] Since a majority of the longest knit rows (knitting rows which involve the largest number of needles) of this panel are knit in the horizontal direction and once the panel is joined with the rest of the structure created, it becomes a stable base part with only one 45-degree line (resembling the fake seam after joining it through RL3, between two Points 1C-4B with the rest of the garment

structure).

[0047] The joint structure of previously knit panels P1 and P2 allows the lower part of the garment be joined at 45-degree angle with this part between at the points 1C-4B. The 45-degree angle "couture bias cut" fake seam line with real life effect of the perfect stretch/shrink and even better envelopment of the body compared to woven garments.

[0048] Panel 4 serves to stabilise the bust part on the left of the garment. This panel may be knit in either 2-ply or 3-ply for additional bust-forming effect and may optionally be knit using reinforcement filament or using yarn including reinforcement filament, thus creating a reinforced envelopment and lifting effect on the bust area. Where 2-ply yarn is used, this can be a direct continuation of the knitting of panel P3 for forming the complete bust area of the dress. The increase in the number of needles involved on the right side of this panel between points 4C and 13B may be a direct continuation of the 45-degree line of P3 i.e. the line 1C-4B.

[0049] At the top left part of panel P4, the extra rows being knit are for the ease of the wearer, providing extended space and subsequently preferred stretch between the bust and underarm area.

[0050] The bias-cut final look of the garment from the centre front part P25, which will be described later, to which points 1C, 1B and 1A are linked through RL2 and RL3, is the couture "bias-cut" technique.

[0051] Panel P5 is the front side part of the left of the garment. This panel begins with the straight line between points 12B and 13C and may be knit using the flechage mode. On the left side the gradual decrease in the number of needles continues between points 12B and 5B to form a straight line. On the other side a gradual increase in the number of participating needles, in flechage mode, provides for another straight line, forming a triangle shape for panel P5.

[0052] The function of line 12B-13C is to provide a stable base to be joined with the bust-forming parts panels P3 and P4. The bias line 13C-5B provides advantageous stretch/shrink properties so that the dimensions from the centre of the garment to the side, through the continuation of line 1C-4B joined with line 4C-13B, joined with diagonal line 1B-5A. This line, in combination with the other parts constructed and fixed within their shapes/stretch they provide, allows a garment to perfectly customise the waist/hip area of each wearer according to their body's particular measurements and characteristics.

[0053] The longest line on panel P5, line 12B-5B is a side line of the dress. This line, due to its long length in this part, being created with the gradual decrease in the number of needles, is the most unstable line of the entire dress. Such instability is beneficial because it provides for the most fluidity and allows for adaptability of the entire garment in key areas of the lower bust/waistline/hip area structure. It provides for a large amount of stretch while the garment is being put on, passing the wider shoulder area of the wearer, thus dispensing with the requirement for any zips, buttons or other fastening devices. Simultaneously it is the most stretchable line required to "mould" this part between very narrow front waist area (area surrounding points 1A, 1B and 1C) and an extremely tight shape around the same waist area at the back of the dress, in a most stable parts, starting with panel P7.

[0054] Once panel P2 is joined to the other parts, panel P3, panel P4 and P5, the front part of the dress has the same properties as a well-tailored garment, where equivalent parts are bias-cut. The benefits of this include: a slim appearance of the dress due to the stitches flowing under the bias-knit effect from the top part of the dress to the seams; maximum stretch/shrink obtained only areas where required for each individual wearer, based on their particular body shape. Benefits include: in the waistline area of a wearer's body, the garment is enveloped closest to the body possible; in the hipline area of the garment it can be stretched as much as desired and is closest to the proportions of the body of the wearer between their waist measurements and their hip measurements. Such bias-knit technique (imitating the bias cut in the domain of couture) allows the garment to envelope and greatly flatter the body of the wearer. A combination of panels P1, P2, P3, P4, P5 and P6 envelope the body of the wearer to a high degree thanks to the bias-knit technique characteristic of embodiments of the present invention; the combination of panels which are joined at the Line 1B-5A provide for a large degree of stretch, preferably the largest amount of which is possible to achieve in the knitwear applying the same overall fabric pattern (thanks to the bias-knit combined with the stretch inherent in the knitwear) while providing the tightest predesigned fit possible (points 1A, 1B and 1C in the front area together with the very tightly-fitted construction on the back). Thanks to this the garment does not require any fastening devices, thus making the final product not only the most fitted item, self-adapted to each individual wearer, but also the most efficiently produced and comfortable in terms of no interference from fastenings.

[0055] The straight line 1B-5A, once it is joined with the three top parts of the garment, panels P3, P4 and P5, forms a diagonal line on the overall garment construction. Consequently, the joining line, appearing as a fake seam, creates an imitation of the bias-cut (45-degree angle) of a conventional couture tailored garment.

[0056] Panel P6 is the lower skirt side front of the dress. This panel is an optional panel and it may be left out or it may be joined with panel P5 to provide a different final effect. Panel P5 may be knit in 3-ply to provide a heightened effect as described below. Otherwise, it may be knit in 2-ply for a lesser effect. Knitting of panel P6 begins with knitting of the full length of the panel in a straight line in the same row, between points 5C and 6C with a slight curve on the hemline between points 6C and 6D as shown in the pattern. Simultaneously, on the left side, the gradual decrease in the number of needles involved in successive rows allows for the creation of straight line 5C-14A.

[0057] Panel P6 connects to panel P2 via line 5C-6C and through reinforcement structure RL3. Panel 6 also connects to panel P5 at point 5C. Once panel P6 is connected to panel P2, the line 5C-14A becomes a continuation of the main diagonal at the front of the dress, 1B-5A.

[0058] Panel P6 provides for the following effects:

due to the line 5B-6C being straight and horizontal during knitting (vertical during wearing), thus providing for the most stable knit, and due to panel P6 being joined with the stretchy and fluid bias line of panel P2 (5A-6B), the gravity of panel P6 shifts panel P2 of the final garment more to the middle of the front of the dress. Thus, through point 5A the entire panel P2 (which is responsible for the most fluid, body enveloping characteristics, of the front part of the garment) becomes adapts itself even more to the contour of the anatomy of the wearer through the added weight/pressure on panel P2 from panel P6, due to the gravity during the wear of the finished garment; the relationship between panel P5 and panel P6 joined through points 5B and 5C, and stabilised on both sides of these two panels by the reinforcement structures RL3 and RL4, is such that during the wearer of the garment, panel P6 stretches panel P5 side line 12B-5B and the entire panel P5 through point 5B. This produces an even stronger body-enveloping effect because the widest part of the most stretchable area of the garment belongs to panel P5 and the overall garment is extremely tightly fitted at the waistline, by stretching panel P5 due to the gravity and weight of panel P6, this waistline area stretches even more, thus making waist looking even thinner and more tightly fitted independently of the body shape of each individual wearer. This makes the garment adapt to each individual wearer.

[0059] Embodiments of the present invention therefore bring industrialised production of tailored complete garment creation within reach of a large number and variety of consumers while reducing the amount of waste involved in the field of garment manufacture.

[0060] Elongated reinforcement structure RL4 is knit using the number of needles covering all of those which were involved in knitting panels P4, P5 and P6 between points 11A-12A and 12B-5B and 5C-14A. This structure represents a side seam of the dress and separates the front from the back of the dress. RL4 is knit in 3-ply backstitch over three rows (or four rows for added stability) using reinforcement filament.

[0061] Panel P7 is the side back part 1 of the left side. This panel is created using the flechage knitting mode in 2-ply horizontal knit. Knitting begins at the bottom of the panel, the hemline side of the garment at point 14B. A straight line is knit between points 14B-5D. After point 5D, the knitting continues by following the tight shape at the narrowing of the waist of the dress. The tightest possible fit is sought, while still allowing the dress to be wearable. To provide for such a tight fit here in woven or knit fabric, without the benefit provided by embodiments of the present invention, would require the use of fastening devices such as buttons or zips. No extra volume or stretch would be able to be provided by any other part of the garment at this point.

[0062] Once point 12C is reached, the panel is knit towards the armhole point 11B. Between points 11B and 15A, the increase in the number of needles involved is applied for the additional length around the armhole towards the central back area of the dress. Once points 15A and 16A on either side have been reached, the knitting of this panel is completed.

[0063] The shapes produced for the front part of the dress, described above, would be impossible to wear without adding fastening devices to the garment without the benefit of embodiments of the present invention. The shoulder and/or hip portions are generally larger than the middle part of a healthy, non-pregnant woman's body. On average about 20% to 30% larger at least, which makes it difficult to achieve tight-fitting garments without fastening devices. Thanks to embodiments of the present invention however, with the contribution of aspects described above, the extra stretch and flexibility and adaptability required is achieved precisely at places on the garment where it is required. When such a garment is worn, the front part compensates for the extremely tightly fitted and knit curved waistline on the stable parts of the back of the garment. This is made possible due to the combination of the properties of well described panel P5 (bias-knit technique allowing for stretch/shrink as a body of the wearer requires in addition to the stretch/shrink property knitwear already may offer) and the added extra volume of panel P7 at the underarm area.

[0064] Panel P8, the side back part 2 of the left of the garment is knit beginning at the top area of the garment on the left side, which is a shoulder area. Preferably, knitting is done using the flechage mode. Point 10B is the outer shoulder point and point 8B is the inner shoulder point. Once a sufficient amount of curve is achieved for the armhole, according to the pattern design, the knitting expands to the full length of the garment (point 16B). Simultaneously the neckline is formed by stitch reduction on the left side of this panel.

[0065] A small curved end may be created at the bottom of the garment by reducing the number of needles engaged between points 17A and 17B. Panel P8 is separated from panel P7 for the two following reasons:

1. With less stretchy yarn being used, additional darts may be created in-between the joining line of these two panels;
2. With more lightweight yarn, if necessary, this panel may be turned to the same angle as panel P5, bottom skirt and knit in the flechage mode with the final result being an even more fluid fit to the body. However, this would add to the garment knitting time (and

thereby to the cost of the garment) for a result which is not easily detectable since the fit is already as near perfect as it can be; only fluidity would be added (perhaps for the ultra-luxury end of the market).

[0066] Panel P9 is the side back part 3 of the left of the garment. Knitting of this panel begins at the bottom part of the back of the garment, preferably using flechage mode. A gradual increase in the number of needles involved allows for the production of the moderate flare of the skirt on the back, sufficient for the ease of flow and movement, creating a straight (godet) line between points 17C and 18B on the left side. Simultaneously, on the right side, a curved hem is created by flechage. After that the straight full-length rows are knit up until the back dart begins to form between points 22A and 23A, the increase of the width of the skirt part continues by knitting extra rows in the area of the skirt between points 24A and 25A. During the knitting of this part the slight increase of the garment width is achieved by adding extra needles on the right side of the panel. Points 19B and 20A are the part of the neckline on the back of the garment.

[0067] The back dart is formed by the gradual decrease in the number of the needles involved from points 22A and 23A. From point 19A towards the bottom edge of the garment, the knitting continues as per the pattern design to create the godet skirt effect with the number of needles decreasing while extra rows knit allows to extend the width of the skirt at the bottom of the garment. Flechage mode is used to elongate slightly the hemline (right side of the panel).

[0068] Panel P10 is the centre back dart panel on the left of the garment. This small panel is designed to provide the centre back dart area with a stable and shaped structure, shaping the waistline of the garment through a decrease in volume in between the joined panels P9 and P11. Knitting of panel 10 begins with the straight line knit in the full panel length from the left side of the garment and the immediate increase in the number of needles involved applied at each successive row on the right side. This creates a smooth flow from the narrow waistline towards the wider top centre back area of this part of the garment. The gap in volume, which resembles the dart, is formed between points of panels P9, P10 and P11, i.e. points 26A/26B, 22A/22B and 23A/23B. Between points 20B and 27A, part of the neckline is formed.

[0069] Knitting of panel P11, the centre back left of the garment, starts from the bottom of the garment using flechage knitting mode to form a godet shape of the skirt between points 25B and 24B. This is done while widening the panel towards the left side, towards the top of the garment. By decreasing the number of stitches from the left side of the panel, the extra volume of the bottom back of the garment is achieved between points 30A and 31A. Flechage mode may be used to slightly elongate the hemline and equalise its edge, at the right side of the panel, at points 25B and 31A.

[0070] Panel P12, the top centre back panel of the left of the garment, serves as a continuation of the dart on the back (a very slim shape for the waist area). This part is made in 2-ply knit starting with a straight line. The decrease in the number of needles engaged in each subsequent knitting row creates the straight line. Points 28B and 32A are the part of the neckline on the back of the garment. The gap in the volume in panels P11, P12, P13 and P14 between points 29A/29B/29C/29D and 30A/30B is the slimmest fitted and tightest area of the centre back resembling the dart.

[0071] Elongate reinforcement structure RL5 is an optional part. It may be used when extra stability is required, for example when very fluid yarn is used, such as silk or viscose. RL5, when used, is made from three rows of 3-ply back or front stitches of reinforcement filament. Additionally, for extremely heavy yarns, the garment knitting process may be separated into two knitting constructions, thus RL5 could be knit on both sides of the centre back of the garment and then a linking step could be done to join the two constructions at a later stage, in which case an extra row of stitches should be provided in order to allow the linking to be done.

[0072] The rest of the garment is symmetrical up to RL9 (just after panel 24) about RL5 when it is used, or about an axis passing between panels P12 and P13 when RL5 is not used. Consequently, the programme may continue in the reverse order until panel 24 (which is the mirror image of panel 1) and RL9 (which is the mirror image of RL1). Then panels 25, 26 and 27 may be created, followed by linking.

[0073] As mentioned, panel P13, the centre back dart on the right side of the garment, is a small panel having exactly the same function as panel P12. It provides the centre back dart area by shaping the waistline of the garment. A gradual increase in the number of engaged needles, using flechage mode knitting, is performed between point 32B (centre back neckline right) and finishing at point 29C once the required length is reached, thus creating a very sharp angle. When is is joined with parts P12 and P11, this creates a smooth gradual decrease in the size of the waist area of the centre back of the garment.

[0074] Knitting of panel P14, the centre back right, starts from the bottom of the garment using the flechage knitting mode between points 31B and 30B when the godet shape of the skirt is created by the widening of the panel towards the centre back (towards the top of the garment). After that point, panel P14 is joined with panel P15 and the full width of this panel is knit (which is a full length of the garment). Thus, the centre back dart is being shaped. Until point 34A, the full length of garment is knit, while simultaneously shaping the hem part of it by decreasing the number of stitches on the right side of this panel. Thereafter, only the godet part of the skirt is left to be knit between points 38A and 39A as per the pattern design.

[0075] Panel P15 is the top centre back right panel. The full length of this panel is knit initially between points 34B and 35B, while connecting with panel P14, the size

of this part is gradually decreased by progressively reducing the number of needles involved in each successive row during the knit process (line 35B-41A). Thus, the centre back side dart is created from the centre back direction. This part of the dart later in combination of the shape produced in panel P16, forms a full right dart of the garment between the Points 41A/B, 35A/B, 36A/B and 37A/B.

[0076] Knitting of panel P16, the side back part on the right of the garment, starts between points 38B and 39B at the bottom of the godet skirt by using flechage mode. When point 38B is reached, the panel width is extended to point 37B, which is the bottom of the right side back dart. From that point, by knitting in flechage mode until point 36B, the side dart deepens. When point 36B is reached, the full length of this part (the full width of the knit panel) is knit from the neckline to the hemline. Simultaneously, the shaped hemline is achieved by the decrease in the number of needles involved on the right side of the panel with the slight curve at the end of the hemline towards point 44A. After points 42A and 43A, which are at the same row have been reached, the remaining godet shape is only knit on the right side of the garment by knitting extra rows with their width decrease in each of the subsequent rows until point 44A is reached.

[0077] Knitting of panel P17 begins with knitting the straight line between points 42B and 44B which immediately follows the line 42A-44A of the previous part, a smooth panel is created with slight ease of flow and movement in the bottom area of the garment. Knitting of panel P17 continues until point 45A is reached on the right side and simultaneously with the slight increase in the number of the needles on the left side to create the shaped conner of the neckline on the back and once point 47A is reached, a gradual decrease in the number of needles allows for shaping of the shoulder line between points 47A and 48A with the simultaneous decrease in the number of needles involved on the right side to shape the top part of the right armhole in the back of the garment.

[0078] Knitting of panel P18, the side back part 1 right, commences with the straight line being knit between points 46B and 45B, which by immediate linking during the knitting process, creates the full part of the right side of the back of the garment. The armhole is fully shaped by the decrease in the number of needles involved on the left side between points 46B and 49A. From point 49A, a curved line is knit creating an extremely tight fit around the bodice and around the waistline using flechage mode knitting and simultaneously the side back seam is formed by widening the skirt area from the hip downwards (towards the right side of this panel). From point 51A the increase in width is equal to that of the panel P19 in the front of the garment, until point 52A is reached.

[0079] The elongate reinforcement structure RL6 is knit in 3-ply yarn with three stabilising rows of back or front stitches using reinforcement filament (or optionally four rows for a further stabilising effect).

[0080] Panel P19, representing the bottom side front right of the dress may be knit in 3-ply yarn. It functions the same way as its corresponding mirror image panel P6. Knitting starts with the increase of knitting length of this panel using flechage mode knitting until the full length of this panel in a straight line is achieved according to the pattern. Simultaneously the slight curve on the hemline is achieved by the stitch decrease to resemble a finished product shape being properly finished by hand in not-knit garments.

[0081] Panel P20 represents the side back body part on the right side of the dress. This panel is knit in flechage mode and functions in the completed construction of this garment in the same way as panel P5 described above. Knitting of panel P20 begins with the increase in proportions by flechage mode according to the pattern of the line created by points 51C-50B. The sharp edge is created by simultaneous decrease of the number of stitches of the right side of this panel according to the line 51C-54A. When the Points 50B and 54A have been reached, knitting of this part ends.

[0082] Panel P21 is the stabilizing bust part on the right of the garment. Knitting of this panel starts with the underarm point 49B, knit in flechage mode. In both directions: line 49B-54B on the right side; and line 49B-56A on the left. After Point 50C is reached on the right side, the full length of this panel is knit until Point 54B. The line 54B-55A is the line which joins with the lower part of the garment construction under 45-degree as described in panel P4. This panel functions in the overall construction of this garment in exactly the same way as panel P4 on the left side of the garment.

[0083] Panel P22 is the mirror image of panel P3. Panel P22 forms the bust panel on the right. Knitting of this part begins at point 48B, the outer corner of the shoulder, which is the front side of the right shoulder line 48-47B. The curve around the armhole is formed using flechage mode knit until point 56B is reached and thereafter the line between points 56B and 55B is knit in the same row. While from the left side the panel is decreased in size for the neckline shape and on the right for the 45-degree line, which is described in the identical mirror image panel P3 on the left side of the garment.

[0084] Elongate reinforcement structure RL7 is the mirror image of RL3. RL7 is knit for the amount of the needles covering a summary of the needles engaged in panel P23 (see below) sum of the needles (58B-51D)+(51D-53C) plus 3 (for RL7 being over 3 rows) or 4 extra needles (for RL7 being over 4 rows). RL7 may be knit in three rows of back (or front) stitch in 3-ply knit with reinforcement filament. Each subsequent row is reduced by 2 needles so the sharp edge will be directly linked to point 58D.

[0085] Panel P23 is the mirror image of panel P2 and functions in the same way. This panel starts to be knit from the bottom opening at point 53C and may be knit in flechage mode in both directions of knit: on the left side the increase continues until point 55D is reached (there-

after same applies to the line between points 51D and 58B), and on the right side until point 53D is reached and then the straight line created by knitting the same amount of needles until point 59A is reached and then the gradual equal in each row decrease of needles engaged is to create the line 59A-58B.

[0086] Elongate reinforcement structure RL8 is the mirror image of RL2. Panel P24 is the mirror image of panel P1. Knitting of panel P24 begins at the hemline point 59B and by using the flechage mode the panel length (knitting width) between points 59B and 58C is created on the left side and the slight curve is created to equalise the hemline on the right side of the garment, line 59B-60A. Elongate reinforcement structure RL9 is the mirror image of RL1.

[0087] Panel P25 is the centre front right of the dress. Knitting of the first left side starts with flechage mode until point 58D is reached and the central middle panel is knit.

[0088] Panel P26 is the central front middle part of the dress. The extremely tight fit of the three panels P25, P26 and P27 is due to the combination of the two side panels which shape the bust area additionally and extremely tightly around the waistline due to the extra gap around points 62 and 65. Knitting starts with the needles necessary between points 61 and 61B and thereafter a gradual decrease in volume around the hip/waistline is produced by the increase of the needles engaged in the left side of the panel until the tightest point 62 with the row which continue to point 63B, neckline. Knitting on the left side is shaping the neckline until point 64A. Thereafter a gradual decrease occurs until point 66.

[0089] Panel P27, the centre front right of the dress, is knit by starting with line 64B-1E, knitting the full length of this panel. Thereafter the shaped curve is created by the decrease in the number of needles engaged on the right side and increase on the left side to shape the neckline towards the left shoulder line until point 7B is reached. The knitting of the garment is completed with this panel. Linking can then begin.

[0090] It is worth noting that garments designed according to embodiments of the present invention, when knit according to embodiments described herein, even using known three-dimensional seamless garment knitting machines, have a shape which remains stable due to the proposed garment parts construction, even though they include panels designed to be worn with the bias grain line. This is achieved by the combination of panels P2, P3, P4, P5, which all are under the angle creating a more fluid, stretchy fit, joined to panels on the back of the garment, these parts being extremely narrow and tight fitted and also being joined to the very stable and central front panel P25.

[0091] Figure 3B illustrates another embodiment of a program, or set of knitting instructions, for a programmable knitting machine, which when used along with a pattern according to an embodiment of the invention, allow for a garment according to an embodiment of the present invention to be created. The instructions are similar to those of figure 3A except that knitting starts and ends at a different place, in this case at elongated reinforcement structure RL5 between panels P12 and P13. Knitting continues in the direction of panels P14, P14, P15 etc until panel P27 is reached, whereupon elongated reinforcement structure RL1 is knit, followed by panel P1 and so on until panel P12 is knit. The process is then concluded by linking at RL5. Other embodiments of programs according to the present invention are possible by beginning knitting at any of a number of different places, depending on any constraints that given makes and models of knitting machines may impose.

[0092] According to an embodiment, elongate reinforcement structures of knit fabric are included at places on the garment where extra support is required. To provide sufficient support, the yarn used for knitting these structures is usually stiffer than yarn used for knitting a panel. The yarn is preferably used in 3-ply or more to provide sufficient rigidity and support.

[0093] Panels used in embodiments of the invention may have different characteristics and contributing functions depending on their shape, size or position on the garment and how they are inter-combined with their neighbouring garment component parts. For example, as already described, panels whose shape includes a selvage which is on a bias with respect to a direction of orientation of a majority of the courses of yarn making up the panel are preferably used for their ability to create flowing lines in the garment design. Other panels may be used to provide more structure. A square panel, for example, may provide more structure. Stability can be provided by the use of heavier yarn or by doubling, tripling or even quadrupling the number of yarns used in one or more courses to provide 2-ply, 3-ply or 4-ply yarn in all or part of a panel, thereby providing extra weight and stability. For example, in a dress according to an embodiment of the present invention, the front section may use 2-ply or 3-ply yarn.

[0094] A garment which is knit using a method according to an embodiment described herein is made from garment component parts which include knit fabric panels and knit fabric elongate reinforcement structures. At some places on the garment, two knit fabric panels may be attached to each other, or otherwise combined, such that they form a junction. Contrary to garments fabricated using cut-and-sew techniques, where junctions between neighbouring panels are readily identifiable in that they present a visible seam, due to overlapping pieces of fabric or bunching of the fabric where it has been sewn, garments according to embodiments of the present invention do not present obvious seams at the junction between neighbouring panels. Each of the participating panels may have a given thickness, but because the panels are knit together as part of the knitting process, according to some embodiments the thickness of the fabric at the junction is substantially equal to the thickness of the panels. Even if the neighbouring panels have different thicknesses, the thickness of the fabric at the junction

will usually not exceed the thickness of the thickest of the corresponding panels.

[0095] Garments which are knit using three-dimensional seamless garment knitting machines do not present seams either since they are not comprised of panels which are sewn together. Moreover, because garments knit on such machines are knit as combined tubes, the courses, or knitting rows, generally run in a horizontal direction with respect to the direction of the tubes, which may be described generally as being a vertical direction. On the other hand, garments knit according to embodiments of the method described herein, although they do not present obvious seams at the junctions between neighbouring panels, under close inspection the knitting direction of the courses on different sides of a junction may run in different directions because although the panels are all created using the same knitting direction, once they are knit together to pull the garment into its desired three-dimensional shape, the courses in the different panels may run in slightly different directions. It is worth noting that even in a garment knit according to the prior art seamless process, a few of the courses which meet near the shoulders, for example, where separate tubes have been knit together, may run in one direction on the body and in another direction on the shoulder, this is different from garments knit according to an embodiment of the method described herein, whose respective neighbouring panels will present a majority of the courses in the different panels running in different directions.

[0096] It is also worth noting that neighbouring panels of a garment knit using the method according to an embodiment of the present invention are combined by knitting abutting edges of the participating panels rather than overlapping the edges.

[0097] According to an embodiment of the present invention, the panels used in assembling a three-dimensional garment are panels which may be described as being two-dimensional panels in that they have a width and a length, or a combination of different widths and different lengths, but that their thickness is not of significance for the design of the finished garment, the three-dimensional aspect of the finished garment being due mainly to the two-dimensional geometry of the panel and the forces involved in the pulling together or the various garment component parts. According to another embodiment, the panels may present a three-dimensional property, adding to the look of the finished fabric. For example, in embodiments where the knitting instructions for knitting a garment component part involve knitting stitches according to a flechage mode of knitting would produce panels which may present a three-dimensional aspect.

[0098] Many different garment designs are possible using the methods described herein. Figures 4A through 4F show examples of dresses **400, 410, 420, 430, 440, 450** which may be made according to embodiments of the invention. As shown, many different variations are possible. For example, different lengths, different hemlines, neck lines, with or without sleeves, different lengths of sleeves where sleeves are present. The bodice can be made to follow the contours of the body. Below the bodice, many different options are available for dress length as well as many different styles of the skirt part of the dress. Additional embellishments around the neckline, collar and/or shoulders are also possible. It is also possible to make garments for men, or even for animals, using an appropriate pattern and a corresponding knitting program with instructions on how to knit the component parts and connect them together for later linking to make the three-dimensional garment.

[0099] Figure 5 illustrates a method **500** for knitting a garment **540** according to an embodiment. At **510** a pattern is provided. At **520** a program is provided to a knitting machine to make the knitting machine **530** sequentially knit panels and elongate reinforcement structures according to the pattern, and to progressively knit the panels and reinforcement structures into each other during the knitting, according to the program, to pull all of the garment component parts (including the panels and the support structures) into a three-dimensional garment designed to provide a tailored look when worn by a wearer. Because of the know how used in the pattern design and the elasticity and shapes of the knit fabric panels and the support provided by the elongate knit fabric reinforcement structures, the finished garment adapts to many different body sizes and types to provide a tailored look to many different wearers.

Claims

1. An automated method for knitting a garment, the method comprising:

using a programmable knitting machine to interpret a predetermined set of knitting instructions to knit a plurality of garment component parts; and

combining the garment component parts to pull them into a three-dimensional form thereby creating the three-dimensional garment;

characterised in that:

the plurality of garment component parts comprises, according to a predetermined pattern design:

a suite of knit fabric panels of geometrical or freeform shape and knit fabric elongate reinforcement structures, said panels each having at least one edge and said reinforcement structures each having a plurality of edges; and

further **characterised in that** the method further comprises:

successively knitting said plurality of garment component parts by the knitting machine, according to the predetermined knitting instructions; and

linking at least a first part of the garment, said first part having been knit towards the beginning of the method with at least a second part of the garment, knit towards the end of the method, thus creating a tailored three-dimensional knit garment; wherein

said combining of concerned component parts is done by the knitting machine by progressively knitting abutting edges of respective garment component parts together according to the predetermined knitting instructions as said garment component parts are being knit.

2. The method according to claim 1, wherein said knitting machine is a programmable flat bar weft knitting machine.

3. The method according to claim 2, wherein the knitting machine is a V-bed knitting machine having either two needle beds or four needle beds.

4. The method according to any of the preceding claims, wherein said linking is done by knitting or by sewing.

5. A three-dimensional knit garment comprising a plurality of garment component parts including a plurality of knit fabric panels of geometric or freeform shape having at least one edge and a plurality of knit fabric elongate reinforcement structures having a plurality of edges, **characterised in that** adjacent garment component parts are knit together where the edges of the corresponding component parts abut with each other.

6. The garment according to claim 5, wherein at least one of the knit fabric panels comprises at least one selvage whose orientation lies at a bias with respect to a direction of a majority of courses of knit fabric within the panel.

7. The garment according to either of claims 5 or 6, wherein one or more of said knit fabric panels has at least one selvage having an orientation which is substantially diagonal to an orientation of a majority of knit courses within the knit fabric panel.

8. The garment according to claim 7, wherein the knit fabric panel having an orientation which is substantially diagonal to an orientation of a majority of knit courses within the knit fabric panel is substantially in the form of a triangle, a parallelogram or a rhombus.

9. The garment according to any of claims 5 to 8, the garment intended to be worn by a wearer having a height, the garment having a height and being intended to be worn by the wearer in an orientation whereby the height of the garment is substantially aligned with the height of the wearer, wherein one or more courses of yarn of one or more garment component parts runs in a direction which substantially coincides with a direction in which the height of the garment is orientated.

10. The garment according to any of claims 5 to 9, said knit fabric panels having a panel thickness, wherein two adjacent panels form a junction at abutting edges, said junction having a thickness which is substantially the same as the thickest of the two adjacent panels.

11. The garment according to claim 10, wherein a majority of knitting courses of a panel on a first side of the junction are oriented in a different direction to a majority of knitting courses of a panel on a second side of the junction.

12. The garment according to any of claims 5 to 11, wherein at least one of said elongate reinforcement structures comprises at least three courses of 3-ply yarn.

13. The garment according to claim 12, wherein the yarn used for the elongate reinforcement structures has a greater stiffness than a yarn used for knitting the knit fabric panels.

14. A pattern design for making a tailored three-dimensional garment, the pattern design comprising a plurality of panels of geometrical or freeform shape each having at least one edge and a plurality of elongate shapes each having a plurality of edges, the pattern design for making corresponding garment component parts to be combined to form the garment by progressively knitting abutting edges of neighbouring component parts together as they are being knit, according to a predetermined set of knitting instructions for a programmable knitting machine.

15. A computer-readable medium comprising instructions which, when executed by one or more processors, cause a programmable flat bar weft knitting machine to perform the method according to any of claims 1 to 4 to make a garment according to any of claims 5 to 13.

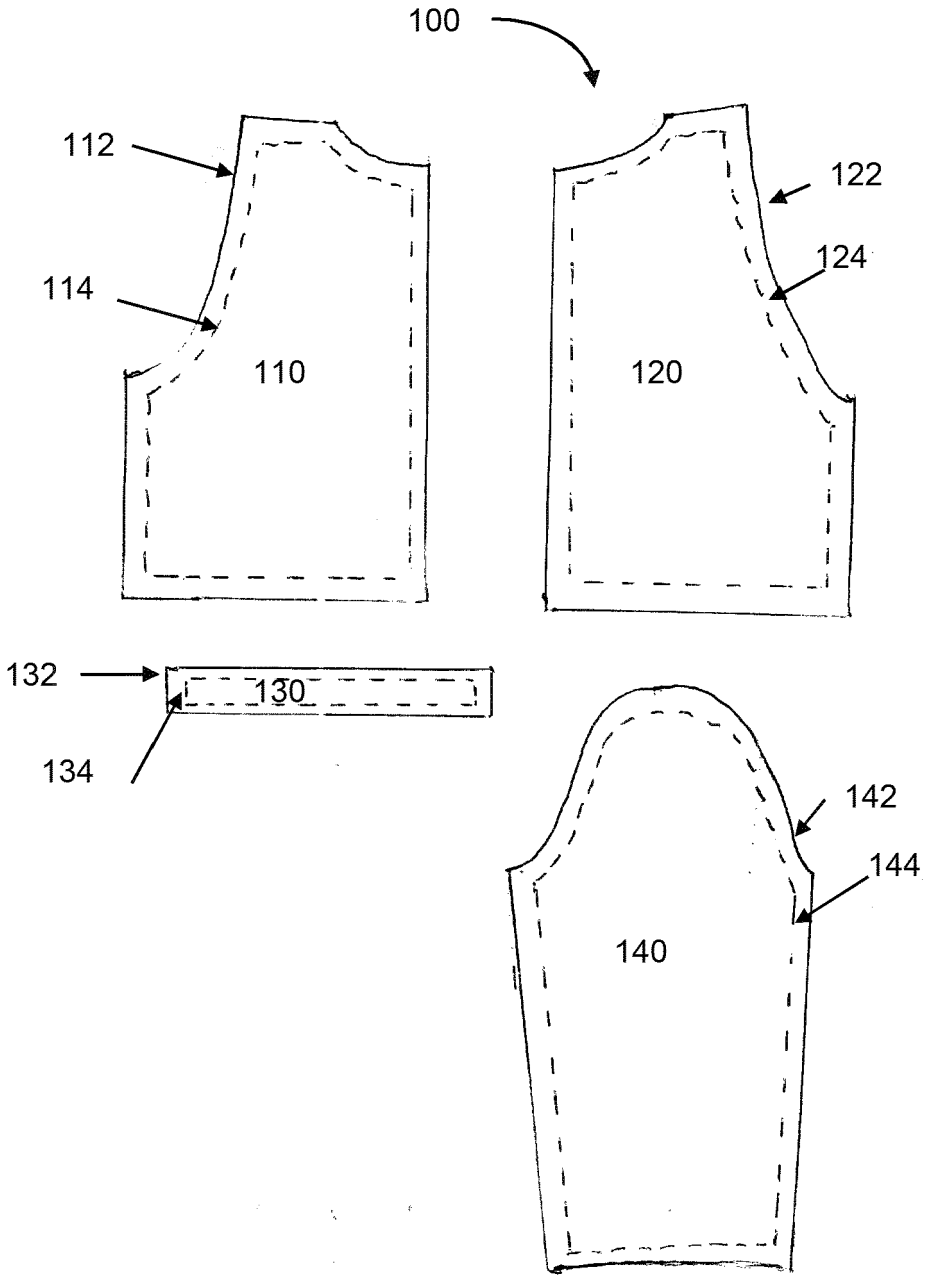

Figure 1

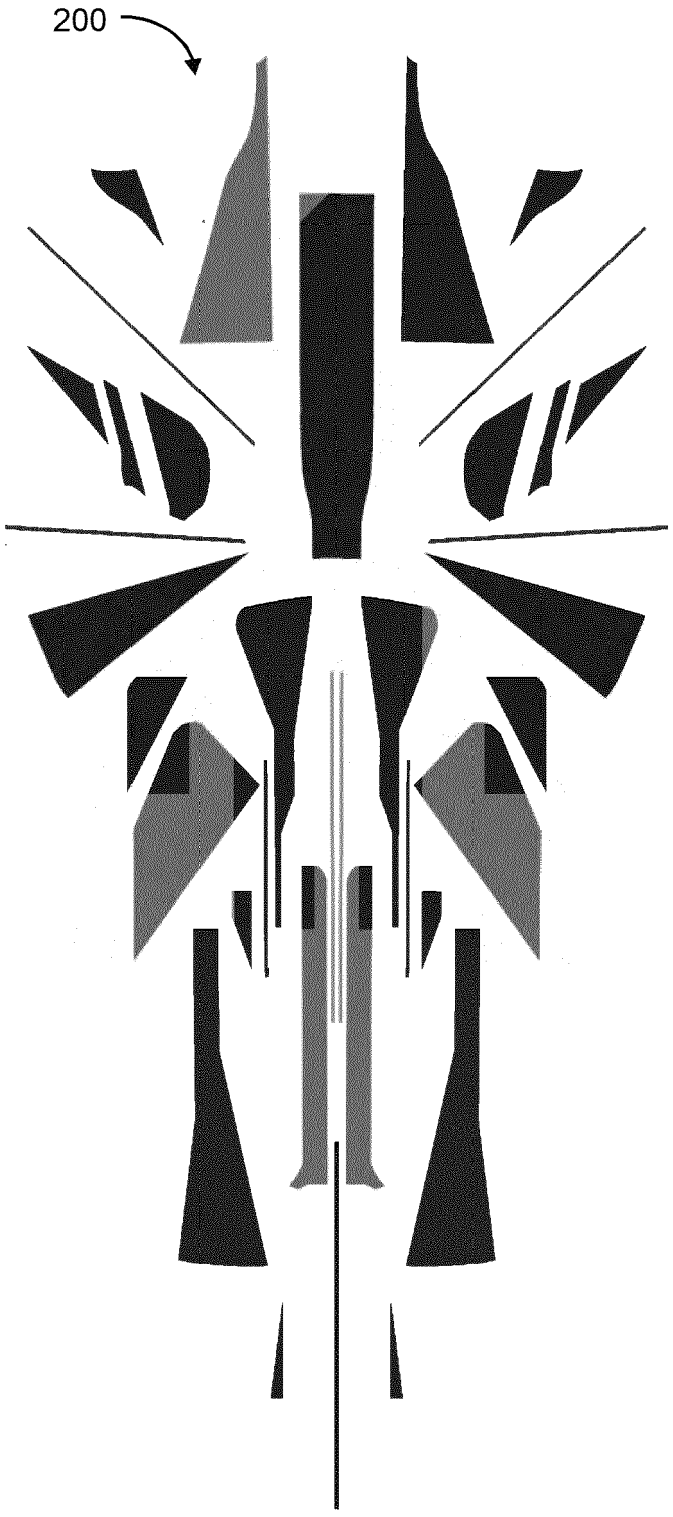

Figure 2

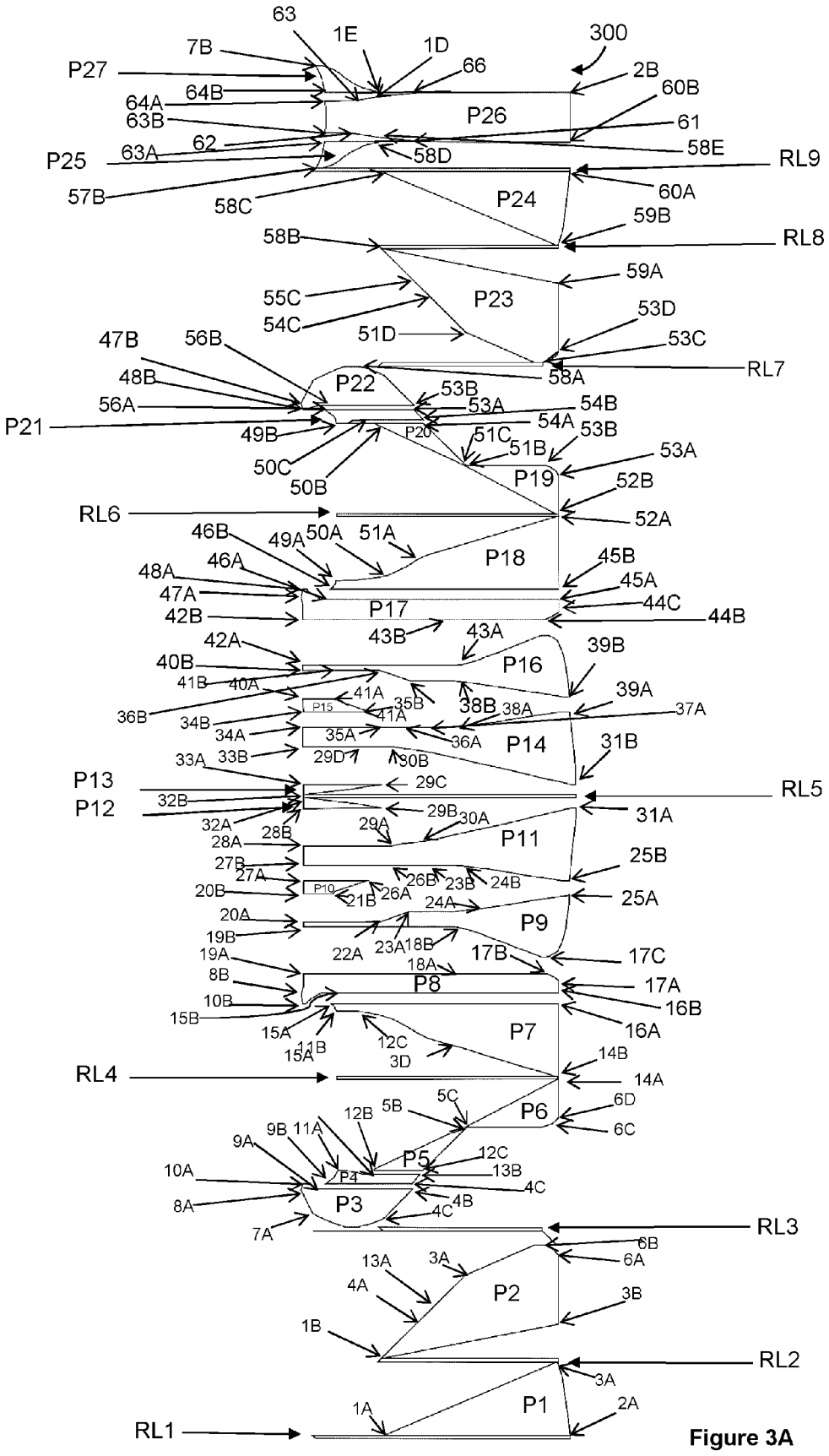

Figure 3A

Newly filed

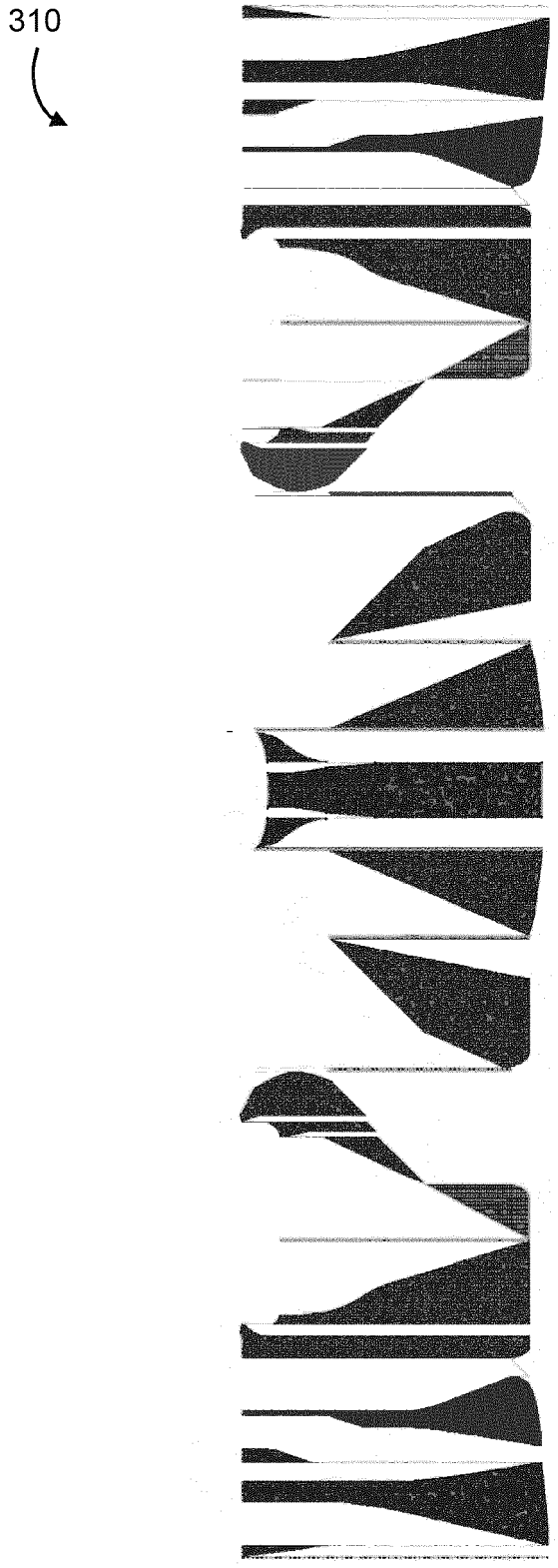

Figure 3B

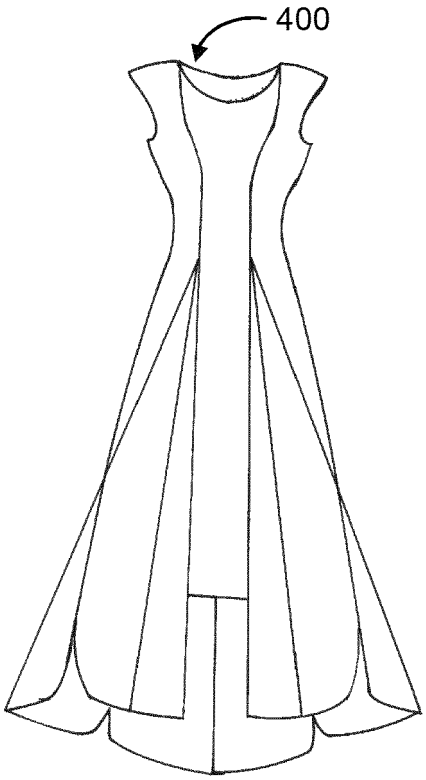

Figure 4A

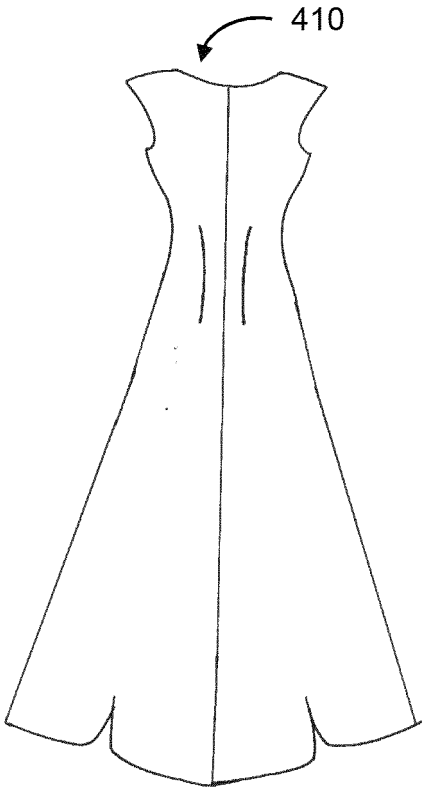

Figure 4B

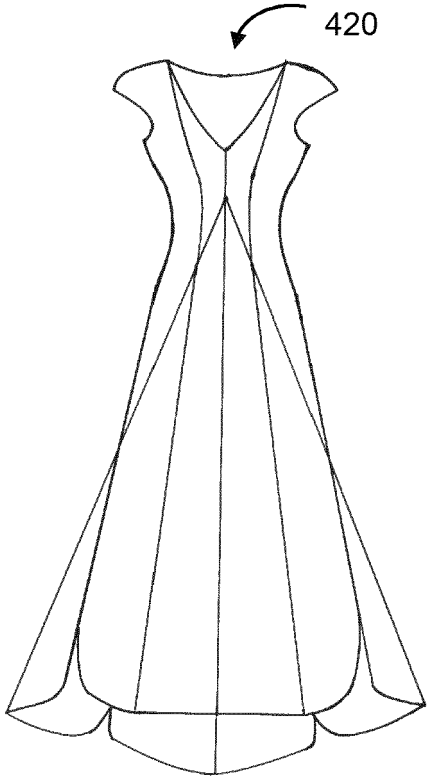

Figure 4C

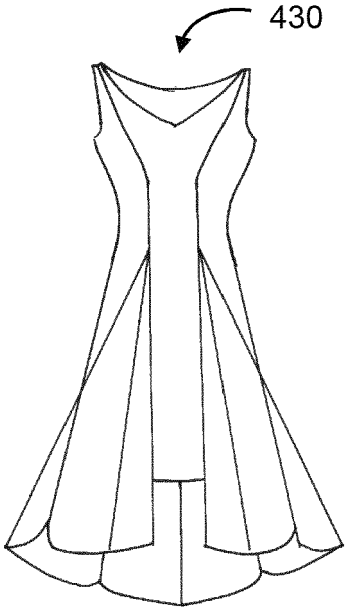

Figure 4D

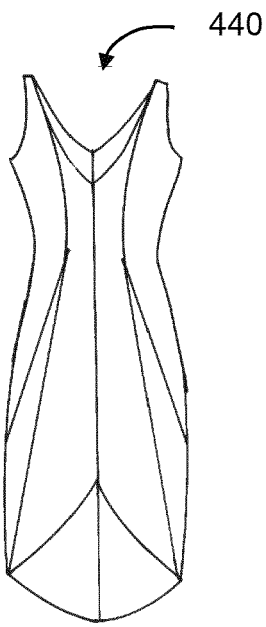

Figure 4E

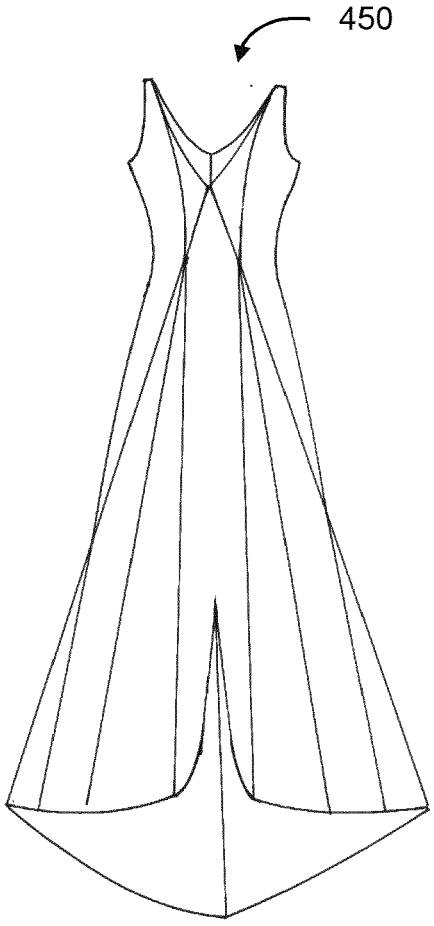

Figure 4F

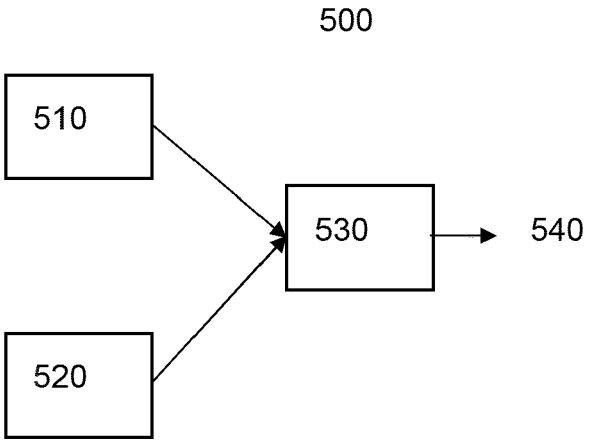

Figure 5

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EUROPEAN SEARCH REPORT

Application Number
EP 22 20 5011

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 4 197 724 A (ROBINSON FRANK [GB] ET AL) 15 April 1980 (1980-04-15)	1-11	INV. D04B1/24
A	* column 2, line 64 - column 8, line 25; claims 1-4; figures 1-4 *	12,13,15	
X	EP 2 759 625 A2 (SHIMA SEIKI MFG [JP]) 30 July 2014 (2014-07-30)	1-7,14, 15	
	* paragraphs [0008], [0010], [0015] - [0032]; figures 1, 5-9 *		
X	WO 2016/018904 A1 (NIKE INNOVATE CV [US]; MEIR ADRIAN [US]) 4 February 2016 (2016-02-04)	5-8,10, 11	
A	* paragraphs [0058] - [0105], [0139], [0163]; claims 2, 13; figures 2, 3, 6, 7, 25, 26, 45 *	2-4	
	* paragraphs [0151] - [0152]; figure 33 *		
A	US 2 120 035 A (NEWBERGER HERMAN H) 7 June 1938 (1938-06-07)	1,5	
	* claim 1; figures 1, 2 *		

TECHNICAL FIELDS SEARCHED (IPC)
D04B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	17 April 2023	Sterle, Dieter

CATEGORY OF CITED DOCUMENTS

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L : document cited for other reasons

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17-04-2023

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4197724 A	15-04-1980	CH 638252 A5	15-09-1983
		DE 2841836 A1	05-04-1979
		FR 2405318 A1	04-05-1979
		GB 2006288 A	02-05-1979
		HK 49684 A	22-06-1984
		IT 1108477 B	09-12-1985
		JP S626028 B2	07-02-1987
		JP S5460039 A	15-05-1979
		US 4197724 A	15-04-1980
EP 2759625 A2	30-07-2014	CN 103966752 A	06-08-2014
		EP 2759625 A2	30-07-2014
		JP 6084047 B2	22-02-2017
		JP 2014141758 A	07-08-2014
		KR 20140095423 A	01-08-2014
WO 2016018904 A1	04-02-2016	AR 101369 A1	14-12-2016
		CN 107072353 A	18-08-2017
		EP 3175026 A1	07-06-2017
		JP 6519648 B2	29-05-2019
		JP 2017522129 A	10-08-2017
		KR 20170040302 A	12-04-2017
		KR 20190059999 A	31-05-2019
		MX 363509 B	25-03-2019
		TW 201609011 A	16-03-2016
		US 2016029736 A1	04-02-2016
		US 2017215515 A1	03-08-2017
		WO 2016018904 A1	04-02-2016
US 2120035 A	07-06-1938	NONE	

EPO FORM P0459

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Patent documents cited in the description

- EP 0533612 B1 **[0006]**
- EP 2418310 B1 **[0007]**
- EP 1652983 B1 **[0008]**
- EP 1444393 B1 **[0009]**