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(54) **METHODS OF FORMING A PROSTHETIC KNIT AND THE PROSTHETIC KNITS FORMED THEREFROM**

(57) The present disclosure is directed to methods of forming implantable prosthetic knits including one or more loops and/or grip members of a controlled height and/or shape, and the implantable prosthetic knits formed therefrom.

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Description

Technical Field

[0001] The present disclosure relates to prosthetic knits including one or more loops and/or grip members of a controlled height and/or shape, as well as methods of forming such prosthetic knits.

Background

[0002] To obtain a textile with grips, i.e., self-gripping textile, it is known in some instances to first form a textile featuring loops on an outer surface thereof and obtained during a knitting process. However, current methods for producing such textiles are limited to forming a single loop profile and limited in ability to vary a height and/or shape of the loop. The height and/or shape of a loop, and possibly the future grip formed therefrom, can be parameters determinant of the gripping capabilities of the self-gripping textile.

[0003] FIG. 1 depicts a prior art knitting pattern suitable for producing a loop on a textile and/or a self-gripping textile, wherein a single loop profile is produced without the ability to vary the height and/or shape of the loop. As shown, the knitting pattern 1 represents a loop yarn 10 forming a loop stitch 14 between a first bond stitch 12 on a first weft side (e.g., right side in FIG. 1) of the loop stitch 14 and a second bond stitch 16 on a second weft side (e.g., left side in FIG. 1) opposite the first weft side. As a result, the height and/or shape of any loop formed by the loop stitch 14 is generally limited to the single needle 5 upon which the loop stitch 14 is formed and because the single needle 5 always pulls the loop stitch 14 (and/or loop yarn 10) the same way every time, all the loops resulting therefrom are identical in height and/or shape. Although the knitting pattern 1 of FIG. 1 may produce a satisfactory self-gripping textile, the limited ability to control the height and/or shape of any loop formed therewith may restrict the gripping capabilities of the textile, and/or may restrict the materials, or combinations of materials, utilized in forming such self-gripping textiles. Thus there remains a need to control the height and/or shape of a loop (and possibly a future grip formed therefrom) on a prosthetic knit in order to enhance the gripping capabilities of the knit and/or expand upon the various combinations of suitable materials for forming such knits.

SUMMARY

[0004] The present disclosure relates to methods of producing a prosthetic knit wherein the height of a loop and/or a grip-member produced thereon can be controlled by the process of knitting.

[0005] In some embodiments, methods of producing a prosthetic knit include knitting a loop yarn, a first ground yarn, and a second ground yarn on at least three guide bars to form a looped knit. The three guide bars include a first ground guide bar, a second ground guide bar, and a loop guide bar. The first ground guide bar includes the first ground yarn and the second ground guide bar includes the second ground yarn to form a ground structure of the knit. The loop guide bar includes the loop yarn to form one or more loops extending from a face of the ground structure of the knit. The loop yarn forms a loop stitch between a first bond stitch and a second bond stitch. The first and second bond stitches are formed on the same side of the loop stitch in a weft direction.

[0006] The looped knit can be further processed to be thermoset and/or transformed into a self-gripping prosthetic knit including a plurality of grip members. The loops may be transformed by pressing the looped knit flat across a cylinder maintained at a temperature which results in melting of a head of the loop into the plurality of grip members.

[0007] In some embodiments, the first and second ground guide bars are rear guide bars of a knitting machine and the loop guide bar is a front guide bar of the knitting machine.

[0008] The loop stitch can be formed within a predetermined needle distance of the first and second bond stitches. In some embodiments, the loop stitch may be formed within a needle distance of one, two, or four of at least one of the first and second bond stitches.

[0009] The loop yarns and ground yarns can be made of suitable biocompatible material. In some embodiments, the loop yarn may be made of a first biocompatible material having a first elasticity and one or both of the first or second ground yarns is made of a second biocompatible material having a second different elasticity. The first elasticity may be lower than the second elasticity.

[0010] In some embodiments, the methods include the loop guide bar following one of the following knitting patterns:

0-1/2-1/0-1/2-1/0-1/2-1//,
0-1/3-2/0-1/3-2/0-1/3-2//,
0-1/5-6/0-1/5-6/0-1/5-6//, or
1-2/7-6/3-2/6-5/0-1/4-5//.

[0011] In some embodiments, the methods include the first and second ground guide bars following the following knitting

patterns:

First Ground Guide Bar: 3-2/3-4/1-0/3-4/3-2/5-6//
Second Ground Guide Bar: 3-4/3-2/5-6/3-2/3-4/1-0//

[0012] In some embodiments, the methods include the loop guide bar and the first and second ground guide bars following the following knitting patterns:

Loop Guide Bar: 2-3/7-6/3-2/0-1/2-3/7-6/3-2/0-1/2-3/7-6/3-2/0-1//
First Ground Guide Bar: 3-2/3-4/1-0/3-4/3-2/5-6/3-2/3-4/1-0/3-4/3-2/5-6//
Second Ground Guide Bar: 3-4/3-2/5-6/3-2/3-4/1-0/3-4/3-2/5-6/3-2/3-4/1-0//, or
Loop Guide Bar: 2-3/7-6/3-2/1-0/2-3/5-4/9-10/5-4/7-8/5-6/0-1/4-5//
First Ground Guide Bar: 3-2/3-4/1-0/3-4/3-2/5-6/3-2/3-4/1-0/3-4/3-2/5-6//
Second Ground Guide Bar: 3-4/3-2/5-6/3-2/3-4/1-0/3-4/3-2/5-6/3-2/3-4/1-0//.

[0013] The present disclosure also relates to prosthetic knits including a ground structure of a knit and at least one loop extending therefrom. The ground structure of the knit is defined by an arrangement of yarns including a first ground yarn and a second ground yarn. The ground structure defines a first face and an opposite second face of the looped knit. The at least one loop (and/or loop yarn) extends and/or protrudes from the first face of the ground structure. The loop (and/or loop yarn) is derived from a loop stitch and extends between a first bond stitch within the ground structure and a second bond stitch. The first and second bond stitches being positioned on the same side in a weft direction of the loop and/or loop stitch.

[0014] The loop and/or loop stitch can be formed within a predetermined needle distance of the first and second bond stitches. In some embodiments, the loop and/or loop stitch may be formed within a needle distance of one, two, or four of at least one of the first and second bond stitches.

[0015] In some embodiments, the prosthetic knits described herein, either looped or self-gripping, may include a loop yarn knitted following one of the following knitting patterns:

0-1/2-1/0-1/2-1 /0-1/2-1//,
0-1/3-2/0-1/3-2/0-1/3-2//,
0-1/5-6/0-1/5-6/0-1/5-6//, or
1-2/7-6/3-2/6-5/0-1/4-5//.

[0016] In some embodiments, the prosthetic knits described herein, either looped or self-gripping, may include first and second ground yarns knitted following the knitting pattern:

First Ground Guide Bar: 3-2/3-4/1-0/3-4/3-2/5-6//
Second Ground Guide Bar: 3-4/3-2/5-6/3-2/3-4/1-0//.

[0017] In some embodiments, the prosthetic knits described herein, either looped or self-gripping, may include loop yarns and ground yarns knitted together the following knitting patterns:

Loop Guide Bar: 2-3/7-6/3-2/0-1/2-3/7-6/3-2/0-1/2-3/7-6/3-2/0-1//
First Ground Guide Bar: 3-2/3-4/1-0/3-4/3-2/5-6/3-2/3-4/1-0/3-4/3-2/5-6//
Second Ground Guide Bar: 3-4/3-2/5-6/3-2/3-4/1-0/3-4/3-2/5-6/3-2/3-4/1-0//, or
Loop Guide Bar: 2-3/7-6/3-2/1-0/2-3/5-4/9-10/5-4/7-8/5-6/0-1/4-5//
First Ground Guide Bar: 3-2/3-4/1-0/3-4/3-2/5-6/3-2/3-4/1-0/3-4/3-2/5-6//
Second Ground Guide Bar: 3-4/3-2/5-6/3-2/3-4/1-0/3-4/3-2/5-6/3-2/3-4/1-0//.

[0018] Self-gripping prosthetic knits are also provided. The self-gripping prosthetic knits may include a ground structure and at least one pair of grip members. The ground structure of the prosthetic knit includes an arrangement of yarns including at least a first ground yarn and a second ground yarn. The ground structure define a first face and an opposite second face of the knit. The plurality of grip members being derived from a common loop stitch of a loop yarn. The grip members extend from the first face of the ground structure. In some embodiments, a first grip member of pair of grip members can be secured to the ground structure by a first bond stitch and a second grip member of the pair secured to the ground structure by a second bond stitch. The first and second bond stitch being positioned on the same side in a weft direction of the pair of grip members.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate embodiments of the disclosure and, together with a general description of the disclosure given above, and the detailed description of the embodiments given below, serve to explain the principles of the disclosure.

FIG. 1 is a schematic representation of a knitting pattern of a prior art self-gripping textile:
FIGS. 2A-2B are each a schematic representation of a knitting pattern of multiple guide bars for producing a prosthetic knit according to at least one embodiment of the present disclosure;
FIGS. 3A-3B are each a schematic representation of a knitting pattern of multiple guide bars for producing a prosthetic knit according to at least one embodiment of the present disclosure;
FIGS. 4A-4B are each a schematic representation of a knitting pattern of multiple guide bars for producing a prosthetic knit according to at least one embodiment of the present disclosure;
FIGS. 5A-5B are each a schematic representation of a knitting pattern of multiple guide bars for producing a prosthetic knit according to at least one embodiment of the present disclosure;
FIGS. 6A-6B are each a schematic representation of a knitting pattern of multiple guide bars for producing a prosthetic knit according to at least one embodiment of the present disclosure;
FIGS. 7A-7B are each a schematic representation of a knitting pattern of multiple guide bars for producing a prosthetic knit according to at least one embodiment of the present disclosure;
FIGS. 8 is a schematic representation of transforming loops into grip members as described in at least one embodiment herein.
FIG. 9A is a schematic representation of a looped prosthetic knit formed from the knitting patterns of FIGS. 2A-2B according to at least one embodiment of the present disclosure;
FIG. 9B is a schematic representation of a looped prosthetic knit formed from the knitting patterns of FIGS. 3A-3B according to at least one embodiment of the present disclosure;
FIG. 9C is a schematic representation of a looped prosthetic knit formed from the knitting patterns of FIGS. 4A-4B according to at least one embodiment of the present disclosure;
FIG. 9D is a schematic representation of a looped prosthetic knit formed from the knitting patterns of FIGS. 5A-5B according to at least one embodiment of the present disclosure;
FIG. 9E is a schematic representation of a looped prosthetic knit formed from the knitting patterns of FIGS. 6A-6B according to at least one embodiment of the present disclosure;
FIG. 9F is a schematic representation of a looped prosthetic knit formed from the knitting patterns of FIGS. 7A-7B according to at least one embodiment of the present disclosure;
FIGS. 10A-10F are each a schematic representation of a self-gripping prosthetic knit formed from the looped prosthetic knits of FIGS. 9A-9F, respectively;
FIGS. 11A-11C are each a schematic representation of a looped prosthetic knit, thermoset looped prosthetic knit, and self-gripping prosthetic according to at least one embodiment of the present disclosure.

DETAILED DESCRIPTION

[0020] The present disclosure is directed to methods of forming prosthetic knits including one or more loops (i.e., looped prosthetic knits) and/or grip members (i.e., self-gripping prosthetic knits) of a controlled height or shape, and the prosthetic knits formed therefrom.

I. Methods of Forming a Prosthetic Knit

[0021] The methods described herein for producing a prosthetic knit generally include a) forming a looped prosthetic knit including one or more loops of a controlled dimension (e.g., height and/or shape) extending from at least one face of the knit; b) thermosetting the looped prosthetic knit; and c) cutting and/or melting one or more of the loop(s) into a plurality of grip members extending from the face to form a self-gripping prosthetic knit. Each loop produced on the knit according to the present disclosure can be cut as a consequence of its melting and thus gives rise to two grip members or grip members protruding outwards from the face of the knit on which the loop is present.

Ia. forming a looped prosthetic knit

[0022] The prosthetic knits and/or looped prosthetic knits of the present disclosure can be produced on a warp knitting machine including at least three guide bars. The three guide bars include a loop guide bar GB1 dedicated to knitting a loop yarn of the knit, a first ground guide bar GB2 dedicated to knitting a first ground yarn of the knit, and a second ground guide

bar GB3 dedicated to knitting a second ground yarn of the knit. In some embodiments, a fourth guide-bar may also be included GB4.

[0023] The prosthetic knits and/or looped prosthetic knits of the present disclosure are produced along the warp direction of the machine by means of three or four guide bars operating together and each repeating a knitting pattern defining an evolution of the yarns. The evolution of a yarn from one needle to another is called a course. The needles extend along the width of the machine, which corresponds to the weft direction of the knit produced. The knitting pattern corresponds to the smallest number of courses whereby the whole yarn evolution can be described. The knitting pattern therefore involves a determined number of needles, which corresponds to the total number of needles used for the yarn to complete its whole evolution.

[0024] A first aspect of the present disclosure is depicted in Figs. 2A-2B which illustrate a first knitting pattern suitable for forming a prosthetic knit and/or looped prosthetic knit as described herein. The warp direction Wa, the weft direction We, the loop yarns 60 (threaded in the loop guide bar GB1), the first ground yarns 70 (threaded in the first ground guide bar GB2), and the second ground yarns 80 (threaded in the second ground guide bar GB3) are represented.

[0025] FIG. 2A depicts the specific knitting pattern of each of the three guide-bars (and/or yarns) separately. As shown, in some embodiments, the knitting pattern repetition unit for the loop guide-bar GB**1** may include a displacement of the loop yarns 60 over two (2) alternating neighboring needles along six (6) courses (corresponding to the displacement referred to as A-B-C-D-E-F in FIG. 2A). As further shown, the knitting pattern repetition unit for the ground guide-bars GB**2** and GB**3** may include a displacement of the ground yarns 70, 80 over six (6) needles along six (6) courses (corresponding to the displacement referred to as A'-B'-C'-D'-E'-F' or A"-B"-C"-D"-E"-F" in FIG. 2A). The overall pattern repetition size of the knitting pattern of FIGS. 2A-2B is six (6) courses. The evolution of the yarns 60, 70, 80 collectively at the seventh course is the same as at the first course.

[0026] As further shown in FIG. 2A, in some embodiments, the loop yarns 60 (threaded in the loop guide bar GB1) form only open stitches (e.g., open bond stitches and open loop stitches), the first ground yarns 70 (threaded in the first ground guide bar GB2) and the second ground yarns 80 (threaded in the second ground guide bar GB3) form only closed stitches, or both, in forming a prosthetic knit as described herein.

[0027] The specific knitting pattern of FIG. 2B depicts each of the three guide-bars (and/or yarns) collectively. As shown, the first ground guide bar GB2 (threaded with the first ground yarn 70) and the second ground guide bar GB3 (threaded with the second ground yarn 80) form a ground structure or base of the prosthetic knit including an arrangement of yarns. The arrangement of yarns include at least the first and second ground yarns 70, 80, respectively, forming a plurality of first and second ground stitches 72, 82, respectively, such as closed first and second ground stitches 72, 82.. In addition to the ground yarns 70, 80 and/or stitches 72, 82, the first and second ground guide bars GB2, GB3, respectively, further include one or more free knitting needles 55 being free of any ground stitches 72, 82 and bond stitches 62, 66 throughout the knit pattern.

[0028] In some embodiments, the knitting pattern and/or ground guide bars may include a plurality of free knitting needles 55 spaced at regular intervals 56 in a weft direction. In some embodiments, the regular interval 56 for spacing between each of the free knitting needles may be 3 needles in a weft direction.

[0029] As further depicted in FIG. 2B, the loop guide bar GB1 (threaded with the loop yarn 60) forms: a first bond stitch 62 interacting (i.e., interlocking and/or binding) with one of the first or second ground stitches 72, 82; a loop stitch 64 on a free knitting needle 55 creating a loop extending from and free of the ground structure (due to the unraveling of the loop stitch being free of any ground stitches on the free knitting needle); and, a second bond stitch 66 interacting (i.e., interlocking and/or binding) with another of the first or second ground stitches 72, 82. The second bond stitch 66 is formed in a direction opposite to the loop guide bar GB1 direction when forming the loop stitch 64 in order to create and/or position both loop bond stitches, e.g., the first and second bond stitches 62, 66, respectively, on the same side in a generally weft direction of the loop stitch 64 (and/or loop).

[0030] In some embodiments, as further shown at least in Fig. 2B, the first and second bond stitches 62, 66, respectively, may interact with the first and second ground stitches 72, 82, respectively, in an alternating manner (e.g., first bond stitch 62 interacts with the first ground stitch 72, then the second bond stitch 66 interacts with the second ground stitch 82, then the next first bond stitch 62a interacts with another first ground stitch 72a, etc.).

[0031] Using the loop guide bar GB1 first (i.e., as a front guide bar) and the ground guide bars GB2, GB3, following thereafter (i.e., as rear guide bars), ensures the flange of the loop stitch 64 is free of the ground structure. In this way, it is possible to favorize the forming of the loop extending from the back side or flange side of the textile, as well as control one or more dimensions (e.g., height or shape) of the loop by choosing the free knitting needle position at a different distance of the bond stitches. For example, as shown in FIG. 2B, it is possible to form a loop stitch 64 (and/or loop) within one needle distance ND in a weft direction of the bond stitches 62, 66.

[0032] In some embodiments, the loop guide bar GB1, first ground guide bar GB2, and second ground guide bar GB3 are single threaded one full, two empty, according to the following knitting pattern (as represented in FIG. 2B) according to the standard ISO 11676 (publication year 2014):

Loop Guide Bar GB1: 0-1/2-1/0-1/2-1/0-1/2-1//

Ground Guide Bar GB2: 3-2/3-4/1-0/3-4/3-2/5-6//

Ground Guide Bar GB3: 3-4/3-2/5-6/3-2/3-4/1-0//.

[0033] A second aspect of the present disclosure is depicted in Figs. 3A-3B which illustrate a second knitting pattern suitable for forming a prosthetic knit and/or looped prosthetic knit as described herein. The warp direction Wa, the weft direction We, the loop yarns 60' (threaded in the loop guide bar GB1), the first ground yarns 70 (threaded in the first ground guide bar GB2), and the second ground yarns 80 (threaded in the second ground guide bar GB3) are represented collectively in FIG. 3B. Since the knitting pattern of the first ground yarns 70 (threaded in the first ground guide bar GB2) and the second ground yarns 80 (threaded in the second ground guide bar GB3) is the same as depicted in FIGS. 2A, only the knitting pattern of the loop yarn 60' (threaded in the loop guide bar GB1) is individually represented in FIG. 3A.

[0034] As shown in FIG. 3A, the knitting pattern repetition unit for the loop guide-bar GB1 may include a displacement of the loop yarns 60' over three (3) needles per course in alternating weft directions along six (6) courses (corresponding to the displacement referred to as A-B-C-D-E-F in FIG. 3A). Although it is envisioned that a loop stitch and/or loop can be formed within any needle distance ND in a weft direction of the bond stitches, in some embodiments as shown in FIG. 3A, the loop stitch 64' (and/or loop) may be particularly formed within a needle distance ND of two (2) in a weft direction of the bond stitches 62', 66'.

[0035] The specific knitting pattern of FIG. 3B depicts each of the three guide-bars (and/or yarns) collectively. In addition to the ground yarns 70, 80 and/or stitches 72, 82, the first and second ground guide bars GB2, GB3, respectively, further include one or more free knitting needles 55 being free of any ground stitches 72, 82 and bond stitches 62, 66. The plurality of free knitting needles 55 spaced at regular intervals 56 in a weft direction by 3 needles.

[0036] As further depicted in FIG. 3B, the loop guide bar GB1 (threaded with the loop yarn 60) forms: a first bond stitch 62' interacting with (i.e., interlocking and/or bonding with) one of the first or second ground stitches 72, 82; a loop stitch 64' on the free knitting needle 55 creating a loop extending from and free of the ground structure (due to the unraveling of the loop stitch being free of any ground stitches on the free knitting needle); and, a second bond stitch 66' interacting with (i.e., interlocking and/or bonding with) another of the first or second ground stitches 72, 82. The second bond stitch 66' is formed in opposition to the loop guide bar GB1 direction when forming the loop stitch 64 in order to create and/or position both loop bond stitches, e.g., the first and second bond stitches 62', 66', respectively, on the same side in a generally weft direction of the loop stitch 64' (and/or loop).

[0037] In some embodiments, the loop guide bar GB1, first ground guide bar GB2, and second ground guide bar GB3 are single threaded one full, two empty, according to the following knitting pattern (as represented in FIG. 3B) according to the standard ISO 11676 (publication year 2014):

Loop Guide Bar GB1: 0-1/3-2/0-1/3-2/0-1/3-2//

Ground Guide Bar GB2: 3-2/3-4/1-0/3-4/3-2/5-6//

Ground Guide Bar GB3: 3-4/3-2/5-6/3-2/3-4/1-0//.

[0038] A third aspect of the present disclosure is depicted in Figs. 4A-4B which illustrate a third knitting pattern suitable for forming a prosthetic knit and/or looped prosthetic knit as described herein. The warp direction Wa, the weft direction We, the loop yarns 60" (threaded in the loop guide bar GB1), the first ground yarns 70 (threaded in the first ground guide bar GB2), and the second ground yarns 80 (threaded in the second ground guide bar GB3) are represented collectively in FIG. 4B. Since the knitting pattern of the first ground yarns 70 (threaded in the first ground guide bar GB2) and the second ground yarns 80 (threaded in the second ground guide bar GB3) are the same as depicted in FIGS. 2A-2B, only the knitting pattern of the loop yarn 60" (threaded in the loop guide bar GB1) is individually represented in FIG. 4A.

[0039] As shown in FIG. 4A, the knitting pattern repetition unit for the loop guide-bar GB1 may include a displacement of the loop yarns 60" over five (5) needles per course in alternating weft directions along six (6) courses (corresponding to the displacement referred to as A-B-C-D-E-F in FIG. 4A). As shown in FIG. 4B, in some embodiments, the loop stitch 64" (and/or loop) may be particularly formed within a four needle distance ND of the bond stitches 62", 66".

[0040] The overall pattern repetition size of the knitting patterns of FIGS. 3A-4B is six (6) courses. The evolution of the yarns 60' (or 60"), 70, 80 collectively at the seventh course is the same as at the first course.

[0041] In some embodiments, the loop guide bar GB1, first ground guide bar GB2, and second ground guide bar GB3 are single threaded one full, two empty, according to the following knitting pattern (as represented in FIG. 4B) according to the standard ISO 11676 (publication year 2014):

Loop Guide Bar GB1: 0-1/5-6/0-1/5-6/0-1/5-6//

Ground Guide Bar GB2: 3-2/3-4/1-0/3-4/3-2/5-6//

Ground Guide Bar GB3: 3-4/3-2/5-6/3-2/3-4/1-0//.

[0042] As depicted in FIGS. 2A-4B, in some embodiments, the needle distance between the loop stitching and the bond stitching may remain constant throughout the knit and/or may produce loop stitches and/or loops of a constant dimension throughout the looped prosthetic knit.

[0043] As further depicted in FIGS. 2A-4B, in some embodiments, the knitting pattern and/or ground guide bars may include a plurality of free knitting needles 55 spaced at a regular interval 56 of 3 needles in a weft direction, while the needle distance between the loop stitching and the bond stitching may vary between 1 and 4 needles in a weft direction and/or 1 needle in the warp direction.

[0044] A fourth aspect of the present disclosure is depicted in Figs. 5A-5B which illustrate a fourth knitting pattern suitable for forming a prosthetic knit and/or looped prosthetic knit as described herein. The warp direction Wa, the weft direction We, the loop yarns 60 (threaded in the loop guide bar GB1), the first ground yarns 70 (threaded in the first ground guide bar GB2), and the second ground yarns 80 (threaded in the second ground guide bar GB3) are represented.

[0045] FIG. 5A depicts the specific knitting pattern of each of the three guide-bars (and/or yarns) separately. As shown, in some embodiments, the knitting pattern repetition unit for the loop guide-bar GB**1** may include a displacement of the loop yarns 160 over seven (7) needles along six (6) courses (corresponding to the displacement referred to as A-B-C-D-E-F in FIG. 5A). As further shown, the knitting pattern repetition unit for the ground guide-bars GB**2** and GB**3** may include a displacement of the ground yarns 170, 180 over six (6) needles along six (6) courses (corresponding to the displacement referred to as A'-B'-C'-D'-E'-F' or A"-B"-C"-D"-E"-F" in FIG. 5A).

[0046] As further shown in FIG. 5A, in some embodiments, the ground yarns 170, 180 may form only closed stitches, the loop yarns 160 may form a combination of open and closed stitches (i.e., open bond stitches 162, closed bond stitches 166, and open loop stitches 164), or both in forming a prosthetic knit as described herein.

[0047] The specific knitting pattern of FIG. 5B depicts each of the three guide-bars (and/or yarns) collectively. As shown, the first ground guide bar GB2 (threaded with the first ground yarn 170) and the second ground guide bar GB3 (threaded with the second ground yarn 180) knit a ground structure or base including an arrangement of yarns including at least the first and second ground yarns 170, 180, respectively, forming a plurality of first and second ground stitches 172, 182, respectively, and in some instances particularly closed first and second ground stitches 172, 182. In addition to the ground yarns 170, 180 and/or stitches 172, 182, the first and second ground guide bars GB2, GB3, respectively, further include one or more free knitting needles 155 being free of any ground stitches 172, 182 and bond stitches 162, 166.

[0048] In some embodiments, the knitting pattern and/or ground guide bars may include a plurality of free knitting needles 155 spaced at regular intervals 156 in a weft direction. In some embodiments, the regular interval 156 for spacing between each of the free knitting needles may be 3 needles.

[0049] As further depicted in FIG. 5B, the loop guide bar GB1 (threaded with the loop yarn 160) forms: a first bond stitch 162 interacting (i.e., interlocking and/or binding) with a second ground stitch 182a; a loop stitch 164 on the free knitting needle 155 creating a loop extending from and free of the ground structure (due to the unraveling of the loop stitch being free of any ground stitches on the free knitting needle); and, a second bond stitch 166 interacting with (i.e., interlocking and/or bonding with) another of the second ground stitches 182b. The second bond stitch 162 is formed in opposition to the loop guide bar GB1 direction when forming the loop stitch 164 in order to create and/or position both loop bond stitches, e.g., the first and second bond stitches 162, 166, respectively, on the same side in a generally weft direction of the loop stitch 164 (and/or loop).

[0050] In some embodiments, as further shown at least in Fig. 5B, the first and second bond stitches 162, 166, may only interact with the second ground stitches 182a, 182b, respectively, and/or the first ground stiches 172 may be free of any bond stitches. In addition, in some embodiments, the first bond stitches 162 may be only first open bond stitches 162 and the second bond stitches 166 may be only second closed bond stitches 166.

[0051] In some embodiments, as further shown in FIGS. 5A-5B (and unlike the knits represented in FIGS. 2A-4B), the loop stitches 164 and the bond stitches 162, 166 may not simply alternate in a warp direction. Rather, in some embodiments, the second closed bond stitch 166 may be positioned between the open loop stitch 164 and the first open bond stitch 162.

[0052] In some embodiments, as further shown in FIGS. 5A-5B (and unlike the knits represented in FIGS. 2A-4B), the needle distance ND between the loop stitch 164 and each of the bond stitches 162, 166 (in the weft direction) are not equal and/or symmetrical. Rather, the needle distance ND_1 (in the weft direction) between the loop stitching 164 and the first open bond stitch 162 (e.g., ND_1 is five (5) needles) may be different than the needle distance ND_2 (in the weft direction) between the loop stitching 164 and the second closed bond stitching 166 (e.g., ND_2 is four (4) needles).

[0053] In some embodiments, the loop guide bar GB1, first ground guide bar GB2, and second ground guide bar GB3 are

single threaded one full, two empty, according to the following knitting pattern (as represented in FIGS. 5A and 5B) according to the standard ISO 11676 (publication year 2014):

Loop Guide Bar GB1: 1-2/7-6/3-2/6-5/0-1/4-5//

Ground Guide Bar GB2: 3-2/3-4/1-0/3-4/3-2/5-6//

Ground Guide Bar GB3: 3-4/3-2/5-6/3-2/3-4/1-0//.

[0054] A fifth aspect of the present disclosure is depicted in Figs. 6A-6B which illustrate a fifth knitting pattern suitable for forming a prosthetic knit and/or looped prosthetic knit as described herein. The warp direction Wa, the weft direction We, the loop yarns 160' (threaded in the loop guide bar GB1), the first ground yarns 170 (threaded in the first ground guide bar GB2), and the second ground yarns 180 (threaded in the second ground guide bar GB3) are represented. FIG. 6B depicts the knitting pattern of each of the three guide-bars (and/or yarns) collectively.

[0055] The knitting pattern of the first ground yarns 170 (threaded in the first ground guide bar GB2) and the second ground yarns 180 (threaded in the second ground guide bar GB3) are the same as depicted in FIGS. 5A. The knitting pattern of the loop yarn 160' (threaded in the loop guide bar GB1) is different, as well as the knit pattern repetition.

[0056] As shown in FIG. 6A, the the knitting pattern repetition unit for the loop guide-bar GB**1** may include a displacement of the loop yarns 160' over seven (7) needles per course along twelve (12) courses. The overall pattern repetition size of the knit being twelve (12) courses. The evolution of the yarns at the thirteenth course is the same as at the first course.

[0057] As best seen in FIG. 6A, the knit pattern represents a loop yarn 160' (threaded in the loop guide bar GB1) defining a first loop stitch 164' and a second loop stitch 164'a separated from a bond stitch 162', 166', 168' by a different needle distance ND_1, ND_2, ND_3, ND_4. For example, the loop guide bar GB1 (threaded with the loop yarn 160') forms a first loop stitch 164' at needle distance of four (4) in a weft direction and a second loop stitch 164'a at needle distance of two (2) in a weft direction. More particularly, the loop guide bar GB1 (threaded with the loop yarn 160') may form a first loop stitch 164' on a first free knitting needle 155' at a first needle distance ND_1 of four (4) from a first bond stitch 162' and a second needle distance ND_2 of four (4) from a second bond stitch 166', and a second loop stitch 164'a on a second free knitting needle 155'a at a third needle distance ND_3 of two (2) from the second bond stitch 166' and a fourth needle distance ND_4 of two (2) from a third bond stitch 168'. The first loop stitch 164' producing a larger loop extending from the ground structure of the knit than the second loop stitch 164'a.

[0058] In some embodiments, the loop guide bar GB1, first ground guide bar GB2, and second ground guide bar GB3 are single threaded one full, two empty, according to the following knitting pattern (as represented in FIG. 6B) according to the standard ISO 11676 (publication year 2014):

Loop Guide Bar GB1: 2-3/7-6/3-2/0-1/2-3/7-6/3-2/0-1/2-3/7-6/3-2/0-1//
Ground Guide Bar GB2: 3-2/3-4/1-0/3-4/3-2/5-6/3-2/3-4/1-0/3-4/3-2/5-6//
Ground Guide Bar GB3: 3-4/3-2/5-6/3-2/3-4/1-0/3-4/3-2/5-6/3-2/3-4/1-0//.

[0059] A sixth aspect of the present disclosure is depicted in Figs. 7A-7B which illustrate a sixth knitting pattern suitable for forming a prosthetic knit and/or looped prosthetic knit as described herein. The warp direction Wa, the weft direction We, the loop yarns 260 (threaded in the loop guide bar GB1), the first ground yarns 270 (threaded in the first ground guide bar GB2), and the second ground yarns 280 (threaded in the second ground guide bar GB3) are represented. FIG. 7B depicts the knitting pattern of each of the three guide-bars (and/or yarns) collectively.

[0060] The knitting pattern of the first ground yarns 270 (threaded in the first ground guide bar GB2) and the second ground yarns 280 (threaded in the second ground guide bar GB3) are the same as depicted in FIG. 5A. The knitting pattern of the loop yarn 260 (threaded in the loop guide bar GB1) is different, as well as the knit pattern repetition.

[0061] As shown in FIG. 7A, the knitting pattern repetition unit for the loop guide-bar GB**1** may include a displacement of the loop yarns 260 over ten (10) needles per course along twelve (12) courses. The overall pattern repetition size of the knit being twelve (12) courses. The evolution of the yarns at the thirteenth course is the same as at the first course.

[0062] As best seen in FIG. 7A, the knit pattern represents a loop yarn 260 (threaded in the loop guide bar GB1) defining a first loop stitch 264, a second loop stitch 254, a third loop stitch 244, and a fourth loop stitch 234, each separate by one or more bond stitches 262, 266, 268, 292, 296, 298, 300 by a different needle distance $ND_{1\text{-}8}$. For example, the loop guide bar GB1 (threaded with the loop yarn 260) forms a first loop stitch 264 at a first and second needle distance ND_1, ND_2 of four (4) in opposite weft directions, a second loop stitch 254 at a third and fourth needle distance ND_3, ND_4 of two (2) in opposite weft directions, a third loop stitch 244 at fifth and sixth needle distance ND_5, ND_6 of five (5) in opposite weft directions, a fourth loop stitch 234 at seventh needle distance ND_7 of five (5) in a first weft direction and at an eighth needle distance ND_8 of four (4) in a second opposite weft direction.

[0063] More particularly, in some embodiments, as shown in FIGS. 7A-7B, the loop guide bar GB1 (threaded with the

loop yarn 260) may form:

- a first loop stitch 264 on a first free knitting needle 255 at a first needle distance ND_1 of four (4) from a first bond stitch 262 and a second needle distance ND_2 of four (4) from a second bond stitch 266, the first and second needle distances ND_1, ND_2 being in opposite weft directions of each other;
- a second loop stitch 254 on a second free knitting needle 253 at a third needle distance ND_3 of two (2) from the second bond stitch 266 and a fourth needle distance ND_4 of two (2) from a third bond stitch 268, the third and fourth needle distances ND_3, ND_4 being in opposite weft directions of each other;
- a third loop stitch 244 on a third free knitting needle 257 at a fifth needle distance ND_5 of five (5) from a fifth bond stitch 292 and a sixth needle distance ND_6 of five (5) from a sixth bond stitch 296, the fifth and sixth needle distances ND_5, ND_6 being in opposite weft directions of each other; and/or
- a fourth loop stitch 234 on a fourth free knitting needle 259 at a seventh needle distance ND_7 of five (5) from a seventh bond stitch 298 in a first weft direction and an eighth needle distance ND_8 of four (4) from an eight bond stitch 300 in a second opposite weft direction.

[0064] As further represented in FIGS. 7A-7B, in some embodiments, at least one of the first or third loop stitches 264, 244, respectively, may produce a larger loop extending from the ground structure of the knit than the second loop stitch 254, the fourth loop stitch 234, or both. The size of each of the loop being determined by the needle distance ND as described herein. Since the knitting pattern of FIGS. 7A-7B provides different loops placed with different alternating needle distances ND in an unordered and/or nonsymmetrical fashion, the knitting patterns of FIGS. 7A-7B may produce a prosthetic knit with two or more different loop heights/sizes, with a staggered and/or nonsymmetrical placement of said loops.

[0065] Although the loop stitches represented in each of FIGS. 2A-6B are represented as open loop stitches, in some embodiments, as represented in FIGS. 7A-7B, at least one loop stitch 244 of the prosthetic knit may be a closed loop stitch 244. herein. The use of an open or closed loop stitch can be decided by the movement of the guide bar and/or in an effort to try and evenly distribute tension along the loop stitch and/or loop yarn. A left to right movement of the guide bar may distribute tension to the loop yarn/stitch differently than a right to left movement of the guide bar. This difference may be due to the shape of the eyelet guiding the loop yarn/stitch along the guide bar which may produce varying amounts of friction on the yarn/stitch, which may produce different size/shape loops. The use of an open stitch or closed loop stitch can be adjusted to the loop guide bar movement to distribute the tension more evenly.

[0066] As further represented in FIGS. 7A-7B, in some embodiments, the loop guide bar GB1 (threaded with the loop yarn 260) may further form at least one loop anchor stitch 297 between a pair of bond stitches 296, 298. A loop anchor stitch 297 forms a part of the ground structure of the knit by interacting with one of the ground stitches and/or yarns but without leading directly to a loop stitch. A loop anchor stitch 297 is not formed on a free needle and therefore does not form any part of the loop extending from the ground structure. The loop anchor stitch 297 is a closed loop anchor stitch 297.

[0067] In some embodiments, the loop guide bar GB1, first ground guide bar GB2, and second ground guide bar GB3 are single threaded one full, two empty, according to the following knitting pattern (as represented in FIG. 7B) according to the standard ISO 11676 (publication year 2014):

Loop Guide Bar GB1: 2-3/7-6/3-2/1-0/2-3/5-4/9-10/5-4/7-8/5-6/0-1/4-5//

Ground Guide Bar GB2: 3-2/3-4/1-0/3-4/3-2/5-6/3-2/3-4/1-0/3-4/3-2/5-6//

Ground Guide Bar GB3: 3-4/3-2/5-6/3-2/3-4/1-0/3-4/3-2/5-6/3-2/3-4/1-0//.

lb. <u>thermosetting the looped prosthetic knit</u>

[0068] Once the looped prosthetic knit is formed as described herein generally and/or specifically as provided in any of the six aspects described hereinabove, the looped prosthetic knit may be subjected to a thermosetting step which stabilizes a length and width of the knit. The thermosetting may be performed using any conventional manner.

[0069] In some embodiments, the step of thermosetting may include exposing and/or heating the looped prosthetic knit to a thermoset temperature ranging from about 50°C to about 300°C. In some embodiments, the step of thermosetting may include exposing and/or heating the looped prosthetic knit to a thermoset temperature ranging from about 125°C to about 275°C. In some embodiments, the step of thermosetting may include exposing and/or heating the looped prosthetic knit to a thermoset temperature ranging from about 135°C to about 250°C. In some embodiments, the step of thermosetting may include exposing and/or heating the looped prosthetic knit to a thermoset temperature ranging from about 145°C to about 200°C. Any suitable heating system may be utilized, such as an oven, dryer, hot-air blower, and the like.

[0070] The exposure and/or heating of the looped prosthetic knits may occur over a period of time ranging from about 1

second to about 10 minutes. In some embodiments, the exposure and/or heating of the looped prosthetic knits may occur over a period of time ranging from about 5 seconds to about 5 minutes. In some embodiments, the exposure and/or heating of the looped prosthetic knits may occur over a period of time ranging from about 15 seconds to about 3 minutes.

Ic. transforming one or more of the loops to form grip members

[0071] Following thermosetting, the looped prosthetic knit may be subjected to a phase transformation of grip members by cutting and/or melting of one or more of the loops extending from the ground structure into two separate grip members protruding from the ground structure. Any conventional method of cutting and/or melting may be used, including but not limited to, blades, lasers, ultrasonics, heated cylinders, and the like.

[0072] As shown in FIG. 8, in some embodiments, the process of cutting and/or melting of the loop(s) 1014 of the looped prosthetic knit 1010a may include passing the looped prosthetic knit 1010a over a heated cylinder 1013 containing an electrical heating resistor. The knit 1010a can be pressed flat on the cylinder 1013 by two pairs of rollers, upstream 1015a, 1015b and downstream 1016a, 1016b, respectively, which are vertically displaceable for controlling the pressing force. This vertical displaceability may be helpful in looped knits which include loops of varying loop heights and/or shapes. (See FIGS.9E-9F).

[0073] This control as well as that of the temperature of the resistor placed in the cylinder 1013 and of the speed of movement of the knit sheet 1010a across the cylinder 1013 make it possible to melt the head 1014a of each of the loops 1014 so that each loop 1014 separates to form a pair of grip members and/or spiked naps 1017, 1018. Each grip member and/or spiked nap 1017, 1018 is attached to the knit 1010a, and particularly the ground structure 1009 of the knit 1010a, by one of the two bond stitches 1019, 1020 positioned on the same weft side of the loop 1014 (and/or loop stitch). Formation of the loops 1014 into grip members 1017, 1018 transitions the looped prosthetic knit 1010a to a self-gripping prosthetic knit 1010b including the same ground structure 1009.

[0074] Each grip member 1017, 1018 thus has a substantially rectilinear body protruding perpendicularly with respect to the generally planar ground structure 1010 and, at the free end of this body, a head 1017a, 1018a, respectively, of greater width than that of this body. This head 1017a, 1018a may have a generally spheroidal shape or a mushroom shape.

II. Prosthetic Knits

[0075] Each of the knitting patterns of FIGS. 2A-7B described hereinabove are configured to produce looped prosthetic knits as schematically represented in FIGS. 9A-9F and/or self-gripping prosthetic knits as schematically represented in FIGS. 10A-10F. At least some of the ground yarns 70, 80, 170, 180 and loop yarns 60, 60', 60", 160, 160', 260, as provided herein are represented to exemplify some of the various stitches, as well as loop heights and/or shapes described herein in the prosthetic knit. However, for clarity purposes not all yarns and/or stitches are represented.

[0076] Each of FIGS. 9A-9C depict a looped prosthetic knit 100a-100f including a ground structure 105a-105f of the knit 100a-100f, respectively, formed from an arrangement of yarns including first ground yarns 70, 170, or 270 and second ground yarns 80, 180, or 280 stitched together and defining at least a first face 107a-107f and a second opposite face 109a-109f. One or more loop yarns 64, 64', 64", 164, or 264, interact with the ground yarns to form loops 65, 65', 65", 165, 265, 265', 265", or 265‴ extending a distance or height, as controlled by the needle distance ND described herein, from at least the first face 107a-107f.

[0077] FIGS. 9A-9C illustrate a loop stitch 64, 64', 64" forming a loop 65, 65', 65", having a loop height H_1, H_2, H_3, from a face 107a,107b, 107c of the ground structure 105a, 105b,105c increases as the needle distance ND is increased, e.g., from 1 to 2 to 4 in the knitting patterns of FIGS. 2A-4B. FIGS. 9A-9C also illustrate that when a loop stitch 64, 64', 64" maintains an equal (i.e., symmetrical) needle distance ND between each of the bond stitches 62, 62', 62", 66, 66', 66" (that bond the loop stitch 64, 64', 64" to the ground structure 105a-c), as represented in FIGS. 2A-4B, the resulting loops 65, 65', 65" in the looped knit 100a-c produced may depict a constant loop height H_1, H_2, H_3 and/or shape profile across the entire face 107a-c.

[0078] FIGS. 9D-9F depict some additional non-limiting examples of looped prosthetic knits 100d, 100e, 100f, including loops 165, 165', 165a', 235, 245, 255, 265 of varying height and/or shape that may be considered. For example, FIG. 9D illustrates that when a loop stitch 164 maintains an unequal (i.e., asymmetrical) needle distance ND between each of the pair of bond stitches 162, 166 positioned on the same weft-side of the loop stitch 164 (and/or that bind the loop stitch 164 to the ground structure 105d), as represented in the knitting pattern of FIGS. 5A-5B, the resulting loops 165 in the knit 100d produced may depict an asymmetrical shape profile wherein the loop 165 appears to favor or lean towards one warp side more than the other, as opposed to the symmetrical sinusoidal loops 65, 65', 65" of FIGS. 9A-9C.

[0079] FIG. 9E depicts a knit 100e including two different symmetrical loops 165', 165'a of alternating loop heights H_4, H_5, wherein the needle distance ND for each of the alternating loop stitches 164', 164'a remain constant. FIG. 9F depicts a knit 100f including both symmetrical loops 265', 265", 265‴, and asymmetrical loops 265⁗ of various loop heights H_6, H_7, H_8, H_9, wherein the needle distances ND for each of the loop stitches 264, 254, 244, 234 may or may not be constant.

These differences in loop height and/or shape may be used to form grip members of varying grip member heights after thermosetting and/or cutting of the loops as provided in more detail hereinbelow.

[0080] Each of FIGS. 10A-10F depict a self-gripping prosthetic knit 101a-101f formed after the cutting and/or melting of the loops on the looped prosthetic knits 100a-100f of FIGS. 9A-9F, respectively. The self-gripping prosthetic knits 101a-101f include a plurality of grip members and/or spiked naps 67, 69, 67', 69', 67", 69", 167, 169, 167', 169', 267, 269, 267', 269', protruding a grip member height h_{1-11} from a face 107a-f of the ground structure 105a-105f of the knit 101a-101f.

[0081] As shown in FIGS. 10A-10C, each bond stitch 62, 62', 62", 66, 66', 66" may bind a pair of grip members 67, 67', 67", 69, 6', 69" extending therefrom. In some embodiments, the grip member height h_1-h_3 may be constant across the entire face of the knit 101a-101c. As further exemplified in FIGS. 9A-9C and 10A-10C, in some embodiments, as the loop height H_1, H_2, H_3 increases ($H_1<H_2<H_3$) on the looped prosthetic knit 100a-100c, the resulting grip member height h_{1-3} may also increase ($h_1<h_2<h_3$).

[0082] FIG. 10D depicts a self-gripping prosthetic knit 101d derived from the looped prosthetic knit 100d of FIG. 9D. As depicted in FIG. 10D, an asymmetrical loop 165 may produce a prosthetic knit including a pair of grip members 167, 169 of different grip member heights h_4, h_5 bound to a common bond stitch 166'.

[0083] FIG. 10F depicts a self-gripping prosthetic knit 101f derived from the looped prosthetic knit 100f of FIG. 9F. As depicted in FIG. 10F, in some embodiments, a self-gripping prosthetic knit 101f may include grip members 267, 269, 267', 269"of multiple different grip member heights h_{8-11} (e.g., $h_{11}>h_{10}> h_8>h_9$) and/or some bond stitches 262, 266 may include a pair of grip members 267, 269 extending therefrom and some bond stitches 292, 298 may include only one grip member 267', 269' extending therefrom.

[0084] The looped knits and/or self-gripping knits described herein are made from various yarns. The yarns described herein may be monofilaments or multi-filaments yarns. The yarns may be made of any sterilizable biocompatible material including bioabsorbable polymeric materials, non-bioabsorbable polymeric materials, or both.

[0085] Some non-limiting examples of suitable bioabsorbable yarn materials include polymers derived and/or prepared from lactone monomers such as lactide (including L-lactide, D-lactide, etc.), glycolide, trimethylene carbonate, tetramethylene carbonate, dioxanones, dioxepanones, caprolactone, valerolactone, or any combinations thereof; biopolymers derived from proteins such as collagen (I, II and III), elastin, fibrin, fibrinogen, silk, and/or albumin; polysaccharides such as hyaluronic acid (HA), dextran, alginate, chitin, chitosan, and/or cellulose; and/or catgut.

[0086] Some non-limiting examples of suitable non-bioabsorbable yarn materials include polyolefins such as polyethylene (including ultra-high molecular weight polyethylene) and polypropylene including atactic, isotactic, syndiotactic, and blends thereof; polyethylene glycols; polyethylene oxides; ultra-high molecular weight polyethylene; copolymers of polyethylene and polypropylene; polyisobutylene and ethylene-alpha olefin copolymers; fluorinated polyolefins such as fluoroethylenes, fluoropropylenes, fluoroPEGSs, and polytetrafluoroethylene; polyamides such as nylon, Nylon 6, Nylon 6,6, Nylon 6,10, Nylon 11, Nylon 12; polyesters such as polyethylene terephthalate, polyethylene naphthalate, polytrimethylene terephthalate, and polybutylene terephthalate; polyethers; polybutester; polytetramethylene ether glycol; 1,4-butanediol; and/or polyurethanes.

[0087] The yarns described herein may be formed using any technique within the purview of those skilled in the art, such as, for example, extrusion, molding, casting and/or spinning. Where the yarn is made of multifilament yarn, the filaments may be combined using any known technique such as, for example, braiding and/or weaving.

[0088] In some embodiments, both the ground yarns and the loop yarns are monofilament yarns. In some embodiments, at least one, if not both, of the ground yarns and the loop yarns are multifilament yarns.

[0089] In some embodiments, both the ground yarns and the loop yarns are made of bioabsorbable materials. In some embodiments, at least one, if not both, of the ground yarns and the loop yarns are non-bioabsorbable material.

[0090] In some embodiments, the loop yarns and the ground yarns may be made of different materials. For example, the loop yarns may be made of one or more bioabsorbable materials (e.g., polylactide, polyglycolide, polycaprolactone, polytrimethylene carbonate, and the like) and the ground yarns may be made of a one or more non-bioabsorbable materials (e.g., polypropylene, polyethylene terephthalate, and the like). In another example, the loops may be made of a biocompatible material (e.g., PLA) having a first elasticity, i.e., elastic modulus, and the ground yarns may be made of a biocompatible material (e.g., polypropylene, polyethylene terephthalate) having a second elasticity, wherein the first elasticity is lower than the second elasticity.

[0091] The ability of the knitting methods described herein to vary and/or control the initial height and/or shape of the loops can be used to compensate for any shrinkage of the loop (and/or loop yarn) that may occur during thermosetting and/or cutting of the loop. For example, as shown in FIGS. 11A-11B, in some embodiments, the looped prosthetic knit 1100a may include loops 1165 configured to transition from an initial height IH to a second height SH after thermosetting of the looped knit 1100a, and particularly the thermosetting of the ground structure 1105, to form a thermoset looped prosthetic knit 1100b including loops 1100b shrunk to the second height SH.

[0092] The looped prosthetic knit 1100a of FIG. 11A includes a ground structure 1105 including an arrangement of ground yarns 1170, 1180 made of a first biocompatible material and loops 1165 including loop yarns 1160 made of a second biocompatible material which is different than the first biocompatible material of the ground yarns. The loop yarns 1160

and/or loop 1165 define an initial loop height IH and/or shape (as defined by the needle distance(s) ND as described herein) prior to thermosetting.

[0093] As shown in FIG. 11B, in some embodiments, after the looped prosthetic knit 1100a is thermoset at a thermoset temperature optimal for the biocompatible material of the ground yarns 1170, 1180, the loop yarns 1160 may shrink to a second loop height SH and/or shape, while the ground yarns 1170, 1180 will be thermoset in the same general size/configuration in the thermoset looped knit 1100b.

[0094] In some embodiments, the prosthetic knit (and/or ground structure) may be thermoset at a thermoset temperature optimal for the biocompatible material of the ground yarns, which is a different (i.e., higher/lower) temperature than a potential thermoset temperature optimal for the biocompatible material of the loop yarns. For example, the prosthetic knit (and/or ground structure) may be thermoset at a thermoset temperature ranging between 125-300°C, which may be optimal for heat-setting the biocompatible material of the ground yarns, while a potential thermoset temperature optimal for thermosetting the biocompatible material of the loop yarns ranges between 50-120°C.

[0095] As shown in FIG. 11C, the resulting grip members 1167 will be smaller in grip member height bh than the initial loop height IH prior to thermosetting in the self-gripping knit 1100c. In some embodiments, the height and/or shape of the loops and/or grip members may be controlled by a needle distance of the knitting pattern and a difference in thermosetting temperatures (or difference in elasticity) between the materials used to form the ground yarns and loop yarns.

[0096] In embodiments, the prosthetic knits described herein may have a tensile breaking strength in the warp direction of at least about 240 N, particularly about 250 N. In embodiments, the knits described herein may have a tensile breaking strength in the weft direction of at least about 190 N, particularly of about 225 N. In embodiments, the knits described herein may have an elongation percentage @50N in a warp direction of at least about 50%, particularly 55%. In embodiments, the knits described herein may have an elongation percentage @50N in a weft direction of at least about 52%, particularly 56%. In embodiments, the knits described herein may have an elongation percentage @break in a warp direction of at least about 90%, particularly 95%. In embodiments, the knits described herein may have an elongation percentage @break in a weft direction of at least about 100%, particularly 109%. In embodiments, the knits described herein may have a tear strength in the warp direction of at least about 30 N, preferably of about 33 N. In embodiments, the knits described herein may have a tear strength in the weft direction of at least about 28 N, preferably of about 30 N. In embodiments, the knits described herein may have a suture pull out strength in the warp direction of at least about 35 N, preferably of about 40 N. In embodiments, the knits described herein may have a suture pull out strength in the weft direction of at least about 35 N, preferably of about 39 N. In embodiments, the knits described herein may have a tensile strength of at least about 53 N/cm, preferably of about 56 N/cm.

[0097] It will be understood that various modifications may be made to the embodiments of the presently disclosed composite implants. Therefore, the above description should not be construed as limiting, but merely as exemplifications of embodiments. Those skilled in the art will envision other modifications within the scope and spirit of the present disclosure.

EXAMPLES

Example 1

[0098] Knit A, of the prior art, was formed on a knitting machine according to the knitting pattern of FIG. 1. The first and second ground guide bars (i.e., front guide bar(s)) of the knitting machine were threaded with ground yarns made of polypropylene monofilaments and the third ground bar (i.e., rear guide bar) was threaded with loop yarns made of polylactic acid (PLA).

Example 2

[0099] Knits B-G, of the present application, were formed on a knitting machine according to the knitting patterns of FIGS. 2A-7B, respectively.

[0100] For Knits B-G, the first guide bar (i.e., front guide bar) of the knitting machine was threaded with loop yarns made of polylactic acid (PLA) and the second and third guide bars (i.e., rear guide bar(s)) were threaded with ground yarns made of polypropylene monofilaments.

[0101] Knit A and Knits B-G were thermoset and the loops cut and/or melt in the same manner.

Example 3

[0102] Knit A and Knit E were subjected to various tests, the results of which are shown in Table 1 below.

Table 1:

Test		**Knit E**		**Knit A**	
Pore size (mm)		**Width**	**Height**	**Width Height**	
		1,7 ± 0,1	1,6 ± 0,1	1,6 ± 0,1	0.8 ± 0,0
Surface density (g/m^2)		80 ± 1		75 ± 0	
Ball burst	**Force max (N)**	308 ± 17		262 ± 10	
	Deflection (mm)	23,0 ± 0,3		17,5 ± 0,3	
	Tensile strength (N /cm)	56 ± 3		53 ± 1	
Direction		**Warp**	**Weft**	**Warp**	**Weft**
Uniaxial tensile **test***	**Breaking strength (N)**	250 ± 11	225 ± 36	201 ± 6	233 ± 16
	Elongation @50N (%)	55 ± 3	56 ± 4	15 ± 0	14 ± 0
	Elongation @break (%)	95 ± 4	109 ± 10	54 ± 2	59 ± 5
Tear strength (N)**		33 ± 2	29 ± 1	21 ± 1	20 ± 3
Suture pull-out strength (N)		40 ± 6	39 ± 4	36 ± 1	31 ± 2

Claims

1. A method of producing a prosthetic knit comprising,
knitting a loop yarn, a first ground yarn, and a second ground yarn on at least three guide bars to form a looped knit, the at least three guide bars including a first ground guide bar and a second ground guide bar for forming a ground structure of the prosthetic knit, and a loop guide bar for forming one or more loops extending from the ground structure of the prosthetic knit, the first ground guide bar including the first ground yarn, the second ground guide bar including the second ground yarn, and the loop guide bar including the loop yarn, wherein the loop yarn forms a loop stitch between a first bond stitch and a second bond stitch, the first and second bond stitch formed on a same side in a weft direction of the loop stitch.

2. The method of claim 1 further comprising thermosetting the prosthetic knit and transforming the loops to grip members by pressing the prosthetic knit flat across a cylinder maintained at a temperature which results in melting of a head of the loop into a plurality of grip members.

3. The method of claim 1, wherein the first and second ground guide bars are rear guide bars of a knitting machine and the loop guide bar is a front guide bar of the knitting machine.

4. The method of claim 1, wherein the loop stitch is within a needle distance of one of the first bond stitch, the second bond stitch, or both.

5. The method of claim 1, wherein the loop stitch is within a needle distance of two of the first bond stitch, the second bond stitch, or both.

6. The method of claim 1, wherein the loop stitch is within a needle distance of four of the first bond stitch, the second bond stitch, or both.

7. The method of claim 1, wherein the loop yarn is a bioabsorbable yarn and at least one of the first ground yarn or the second ground yarn is a non-bioabsorbable yarn.

8. The method of claim 1, wherein the loop yarn is made of a first biocompatible material having a first elasticity and at least one of the first or second ground yarns is made of a second biocompatible material having a second elasticity, wherein the first elasticity is lower than the second elasticity.

9. The method of claim 1, wherein the loop guide bar follows one of the following knitting patterns:

0-1/2-1/0-1/2-1 /0-1/2-1//,
0-1/3-2/0-1/3-2/0-1/3-2//,
0-1/5-6/0-1/5-6/0-1/5-6//, or
1-2/7-6/3-2/6-5/0-1/4-5//.

10. The method of claim 9, wherein the first and second ground guide bars follow the following knitting patterns:

First Ground Guide Bar: 3-2/3-4/1-0/3-4/3-2/5-6//
Second Ground Guide Bar: 3-4/3-2/5-6/3-2/3-4/1-0//.

11. The method of claim 1, wherein the loop guide bar, the first ground guide bar and the second ground guide bar follow the following knitting patterns:

Loop Guide Bar: 2-3/7-6/3-2/0-1/2-3/7-6/3-2/0-1/2-3/7-6/3-2/0-1//
First Ground Guide Bar: 3-2/3-4/1-0/3-4/3-2/5-6/3-2/3-4/1-0/3-4/3-2/5-6//
Second Ground Guide Bar: 3-4/3-2/5-6/3-2/3-4/1-0/3-4/3-2/5-6/3-2/3-4/1-0//,
or
Loop Guide Bar: 2-3/7-6/3-2/1-0/2-3/5-4/9-10/5-4/7-8/5-6/0-1/4-5//
First Ground Guide Bar: 3-2/3-4/1-0/3-4/3-2/5-6/3-2/3-4/1-0/3-4/3-2/5-6//
Second Ground Guide Bar: 3-4/3-2/5-6/3-2/3-4/1-0/3-4/3-2/5-6/3-2/3-4/1-0//.

12. A prosthetic knit comprising,

a ground structure of the prosthetic knit including an arrangement of yarns including a first ground yarn and a second ground yarn, the ground structure defining a first face and an opposite second face, and
at least one loop extending from the first face of the ground structure, the loop including a loop yarn extending between a first bond stitch with the ground structure and a second bond stitch within the ground structure with a loop stitch positioned therebetween, wherein the first and second bond stitches are positioned on the same side in a weft direction of the loop.

13. The prosthetic knit of claim 12, wherein the loop stitch is within a needle distance of one of the first bond stitch, the second bond stitch, or both.

14. The prosthetic knit of claim 12, wherein the loop stitch is within a needle distance of two of the first bond stitch, the second bond stitch, or both.

15. The prosthetic knit of claim 12, wherein the loop stitch is within a needle distance of four of the first bond stitch, the second bond stitch, or both.

16. The prosthetic knit of claim 12, wherein the loop yarn is knitted following one of the following knitting patterns:

0-1/2-1/0-1/2-1 /0-1/2-1//,
0-1/3-2/0-1/3-2/0-1/3-2//,
0-1/5-6/0-1/5-6/0-1/5-6//, or
1-2/7-6/3-2/6-5/0-1/4-5//.

17. The prosthetic knit of claim 16, wherein the first and second ground yarns are knitted following the knitting pattern:

First Ground Guide Bar: 3-2/3-4/1-0/3-4/3-2/5-6//
Second Ground Guide Bar: 3-4/3-2/5-6/3-2/3-4/1-0//.

18. The prosthetic knit of claim 12, wherein the loop guide bar and the first and second ground guide bars follow the following knitting patterns

Loop Guide Bar: 2-3/7-6/3-2/0-1/2-3/7-6/3-2/0-1/2-3/7-6/3-2/0-1//
First Ground Guide Bar: 3-2/3-4/1-0/3-4/3-2/5-6/3-2/3-4/1-0/3-4/3-2/5-6//

Second Ground Guide Bar: 3-4/3-2/5-6/3-2/3-4/1-0/3-4/3-2/5-6/3-2/3-4/1-0//,
or
Loop Guide Bar: 2-3/7-6/3-2/1-0/2-3/5-4/9-10/5-4/7-8/5-6/0-1/4-5//
First Ground Guide Bar: 3-2/3-4/1-0/3-4/3-2/5-6/3-2/3-4/1-0/3-4/3-2/5-6//
Second Ground Guide Bar: 3-4/3-2/5-6/3-2/3-4/1-0/3-4/3-2/5-6/3-2/3-4/1-0//

19. A self-gripping prosthetic knit comprising,

a ground structure of the prosthetic knit including an arrangement of yarns including a first ground yarn and a second ground yarn, the ground structure defining a first face and an opposite second face, and
at least one pair of grip members derived from a common loop stitch of a loop yarn, the grip members extending from the first face of the ground structure, a first grip member of the pair secured to the ground structure by a first bond stitch, a second grip member of the pair secured to the ground structure by a second bond stitch, wherein the first and second bond stitches are positioned on the same side in a weft direction of the pair of grip members.

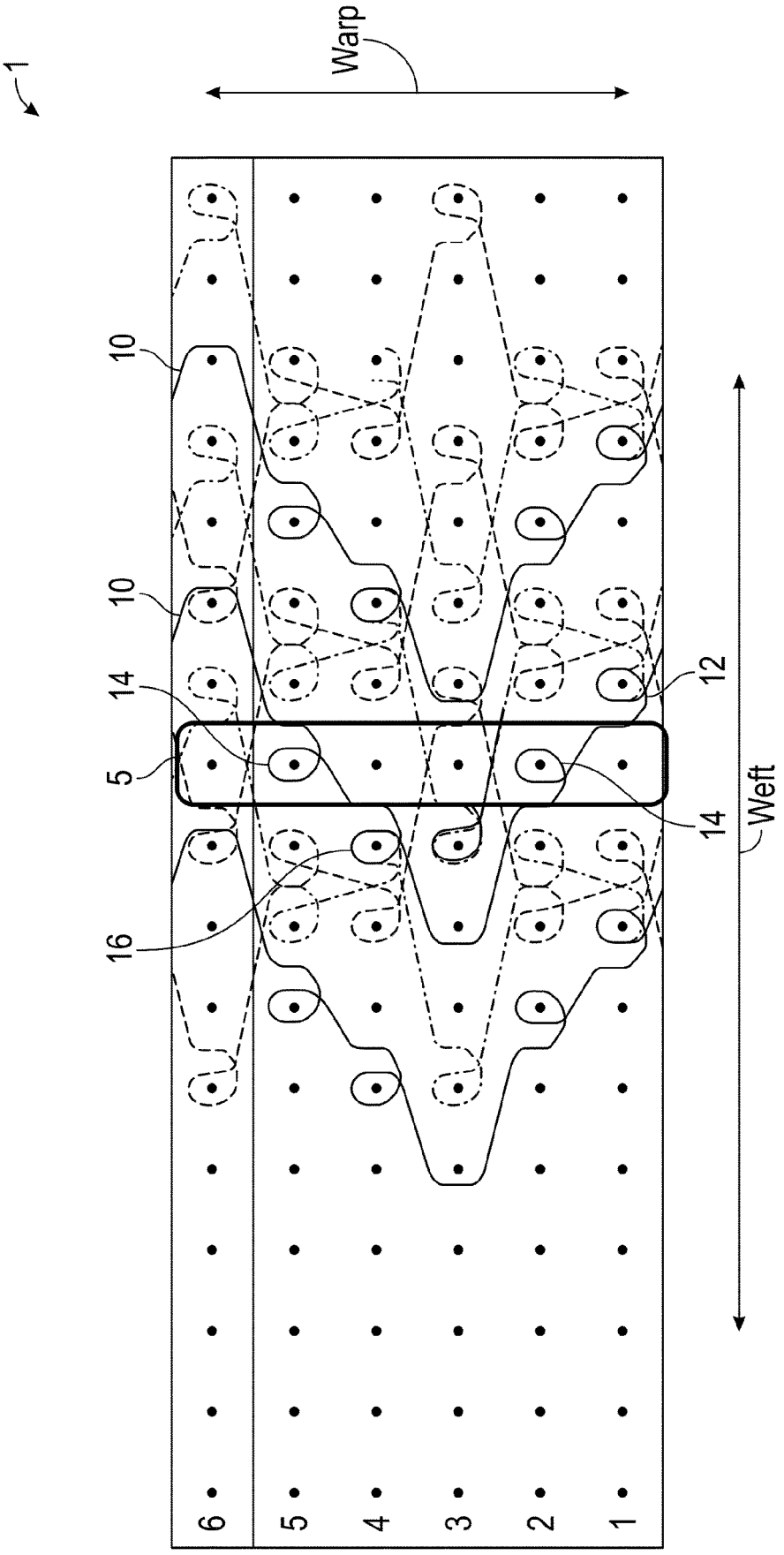
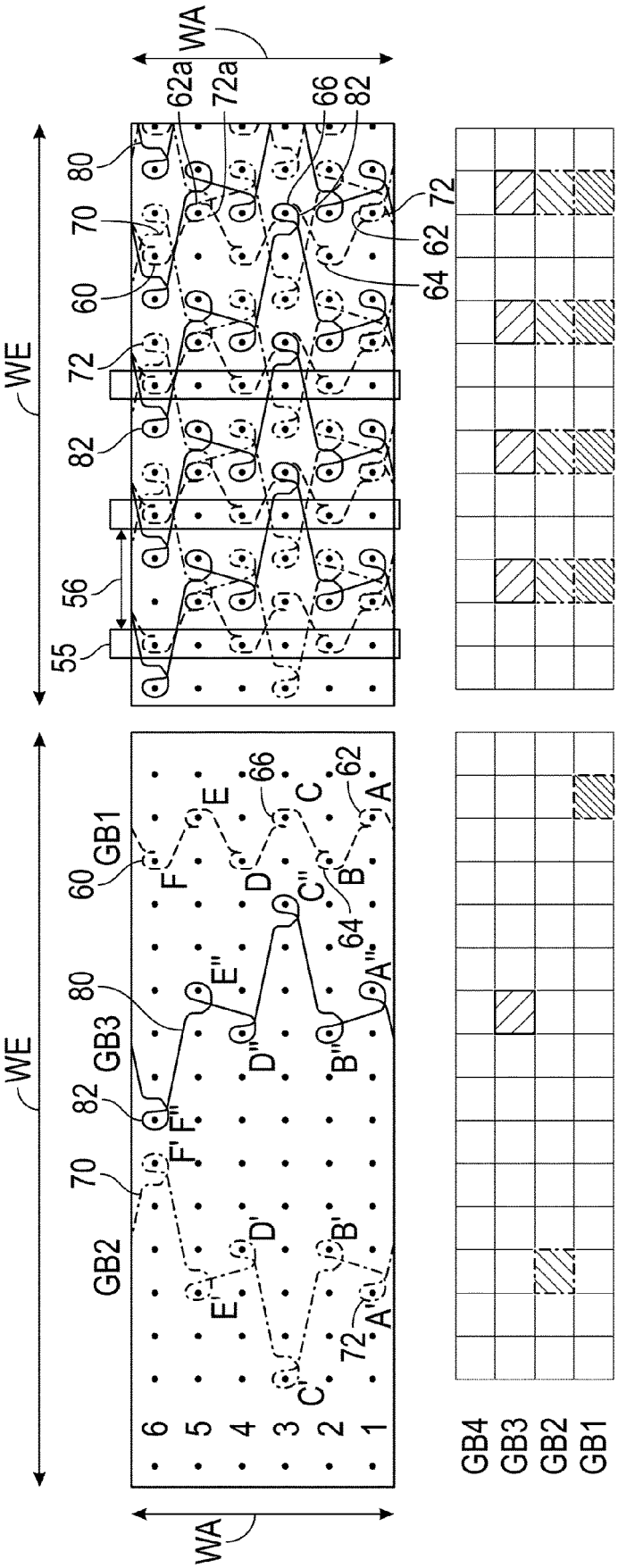


FIG. 1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GB4
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3
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1
GB2
GB3
GB1
A'
B'
C'
D'
E'
F'
A''
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D''
E''
F''
A
B
C
D
E
F

FIG. 2B

FIG. 2A

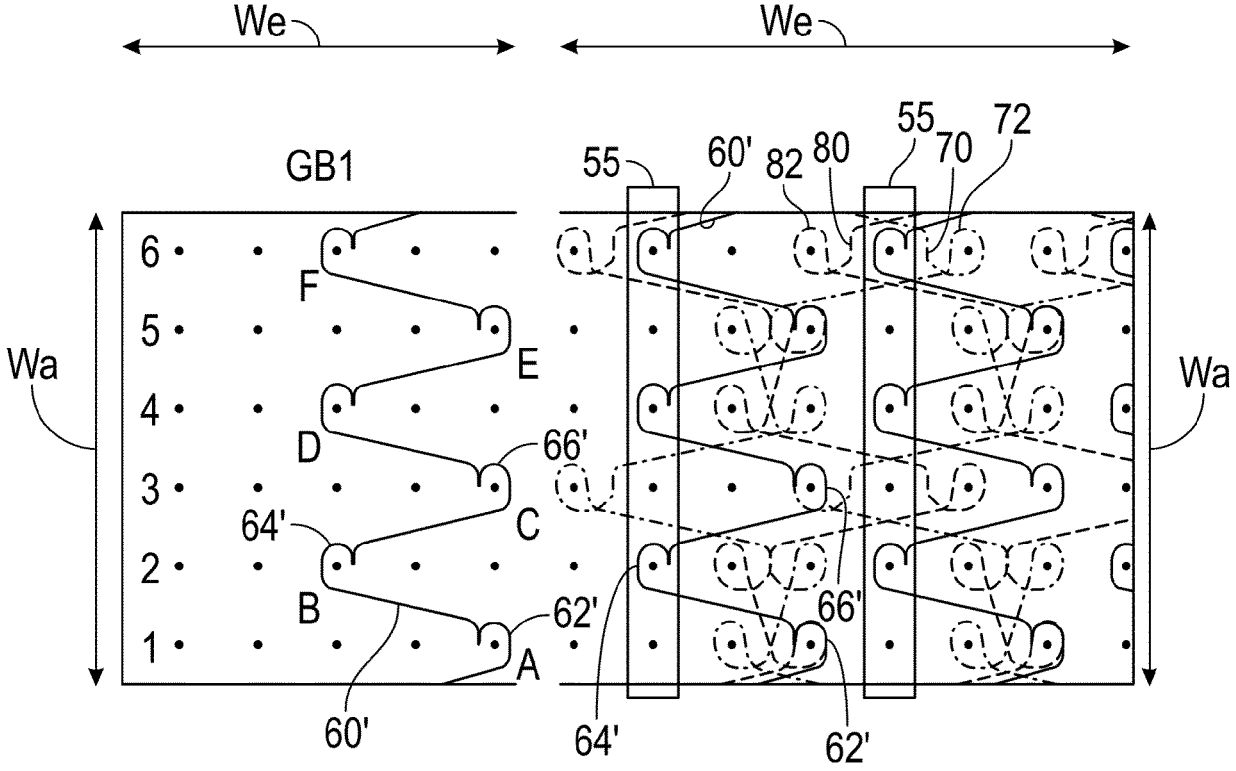


FIG. 3A

FIG. 3B

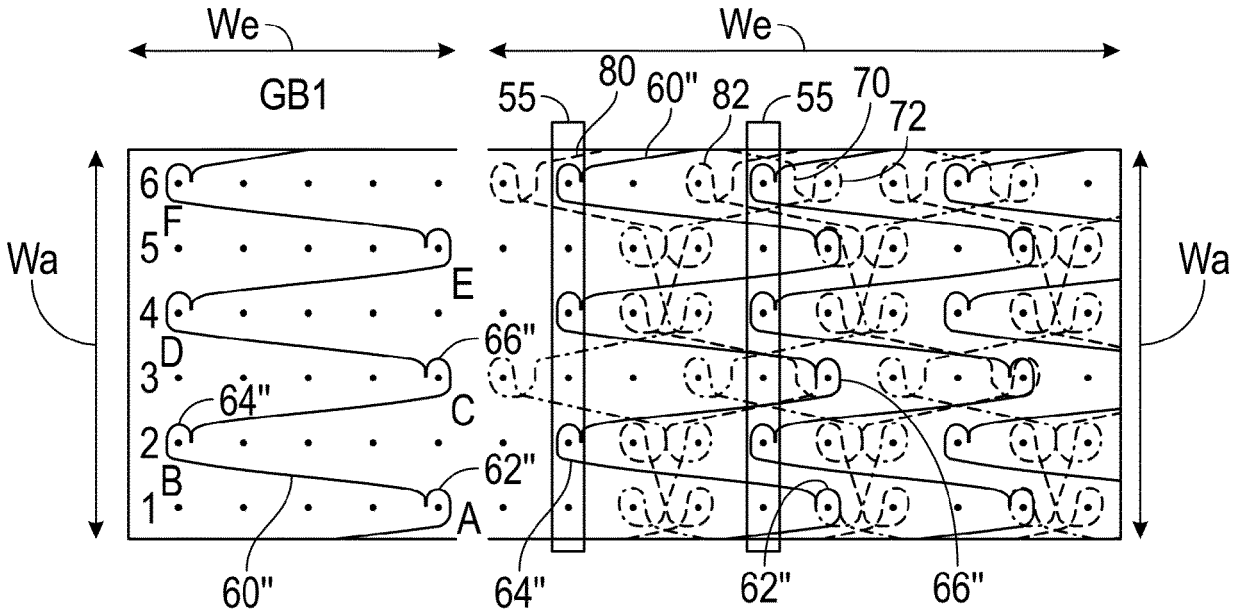
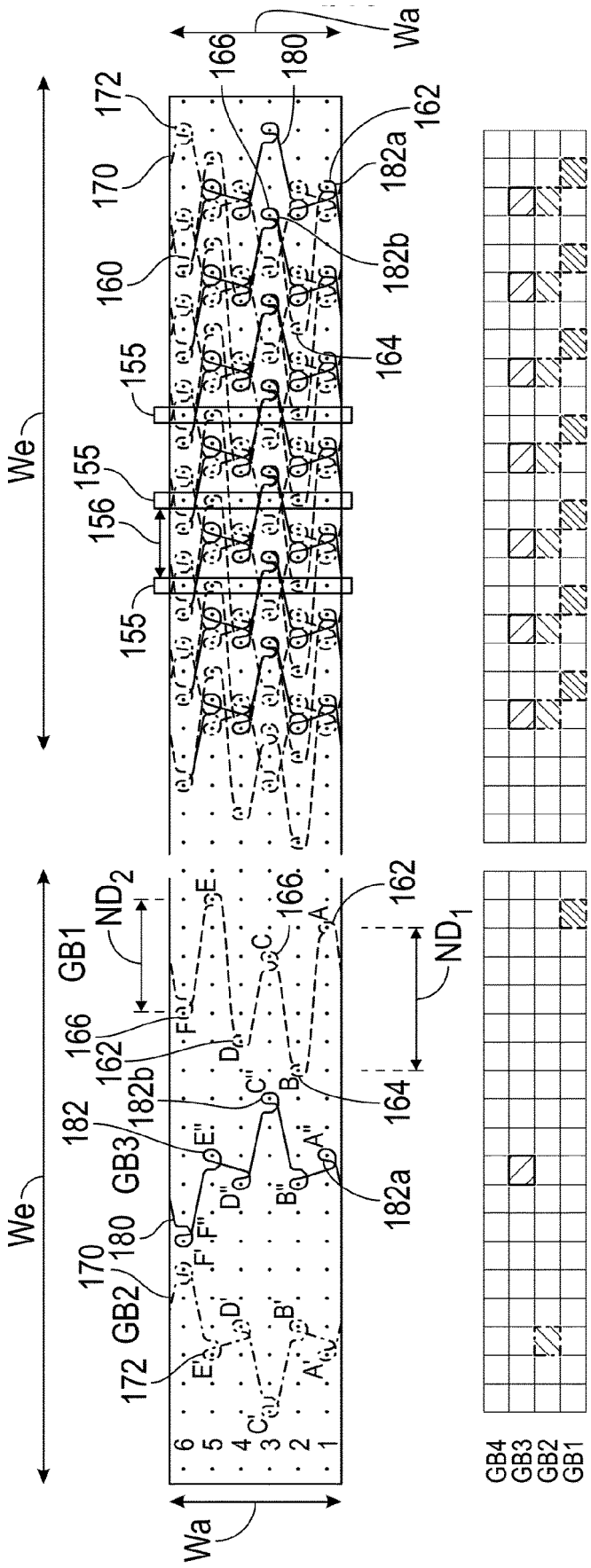


FIG. 4A

FIG. 4B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182b
A
B
C
D
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F
A'
B'
C'
D'
E'
F'
A"
B"
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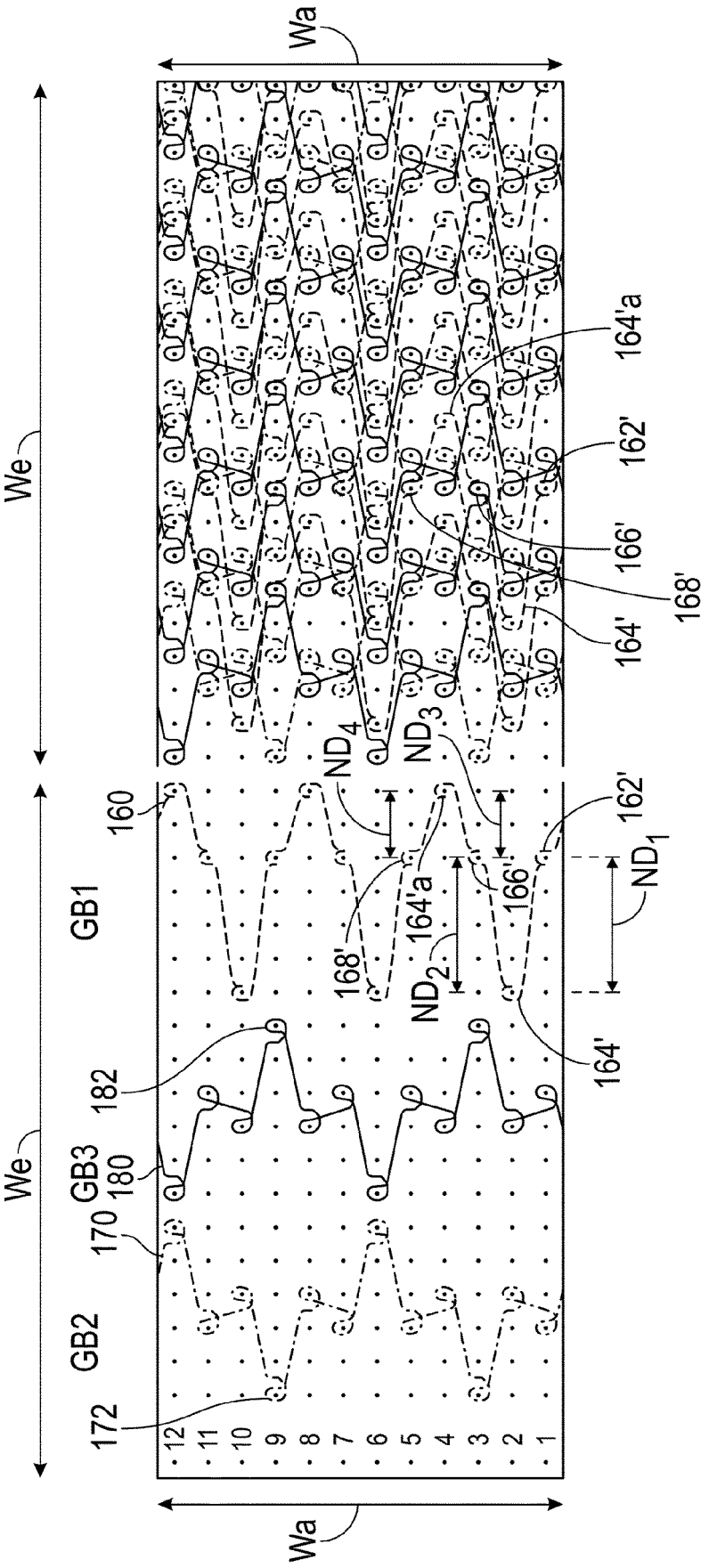
GB1

FIG. 5A

FIG. 5B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ND3
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164'a
166'
162'
164'
164'a
162'
166'
168'
164'
Wa
We

FIG. 6A

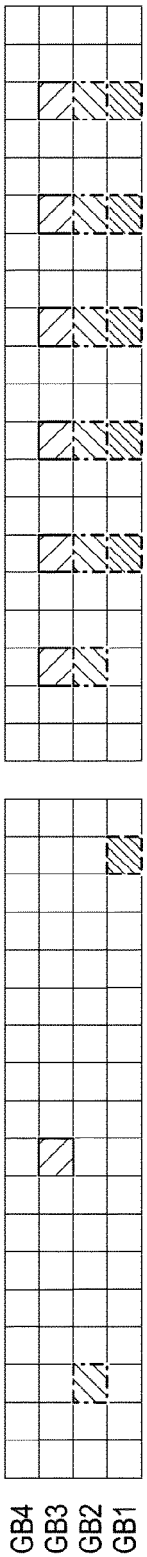
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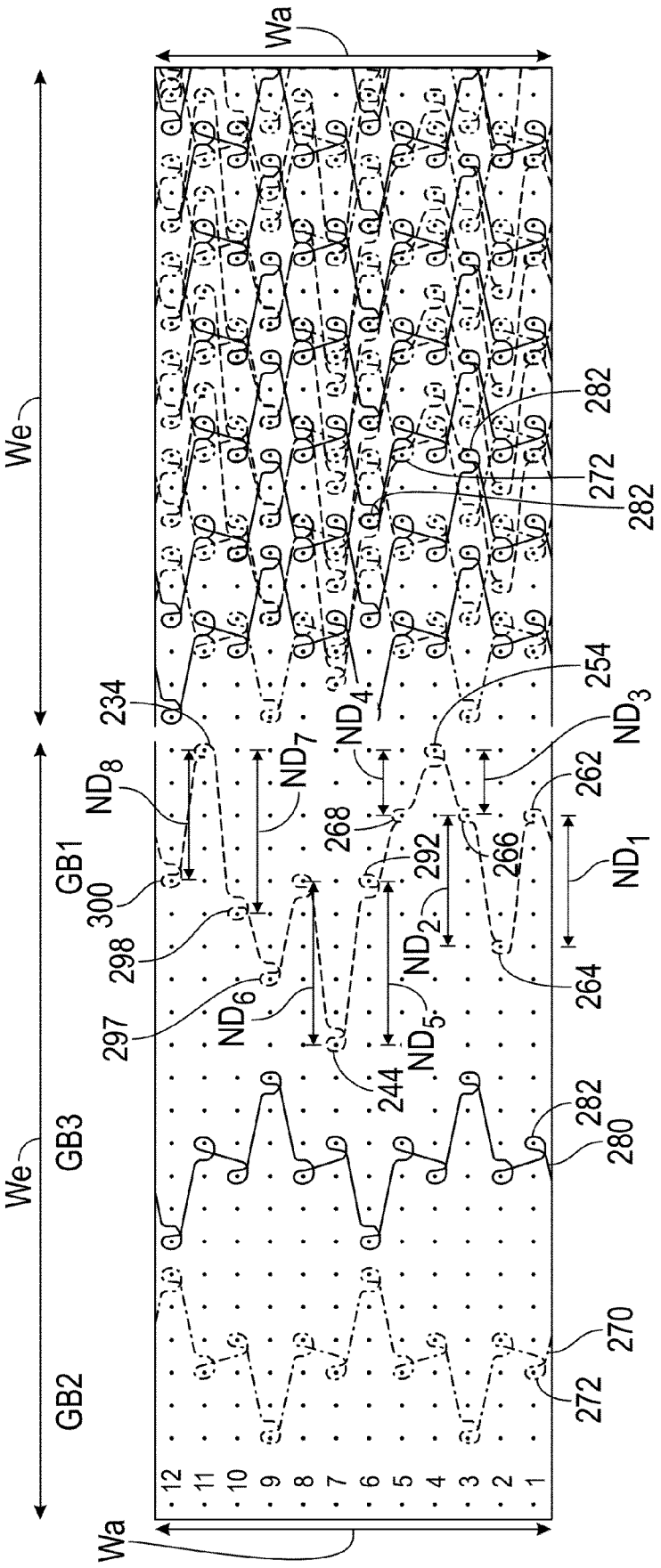
FIG. 6B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We
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ND8
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ND3
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266
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297
ND6
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8
7
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5
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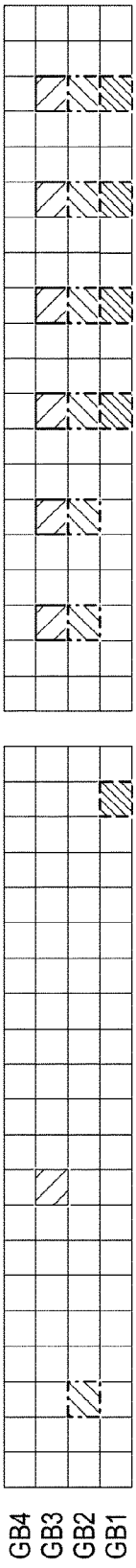
3
2
1

FIG. 7A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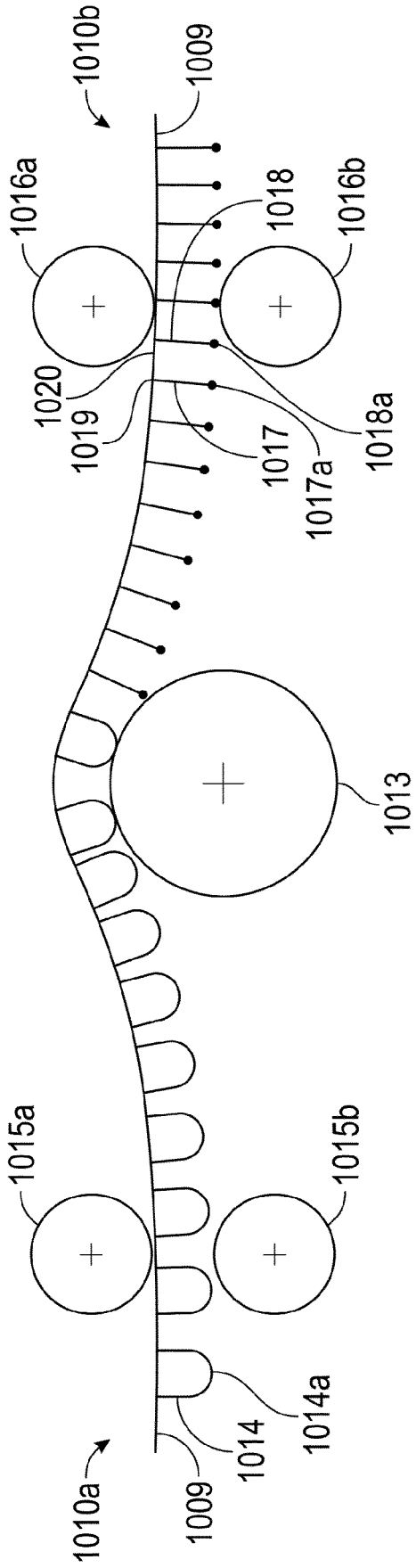
GB3
GB2
GB1

FIG. 7B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1018
1016b
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1018a
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1015b
1014a
1014
1009
1010a

FIG. 8

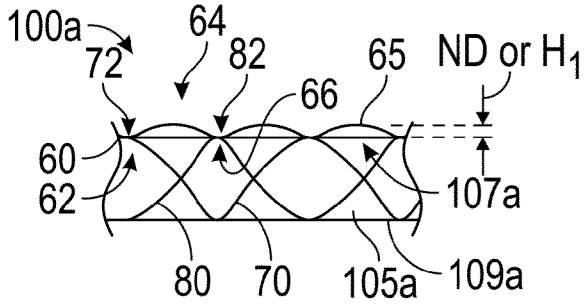

FIG. 9A

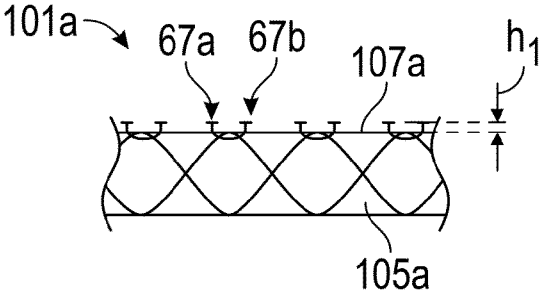

FIG. 10A

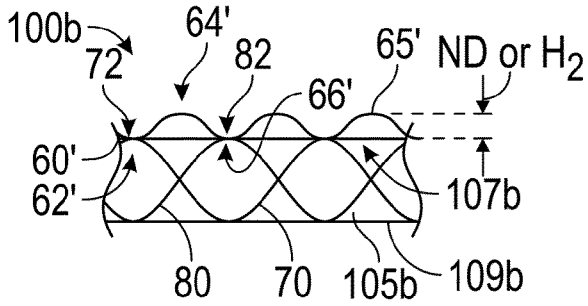

FIG. 9B

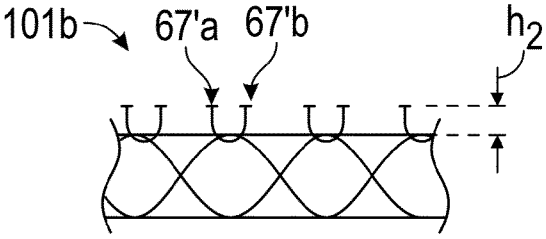

FIG. 10B

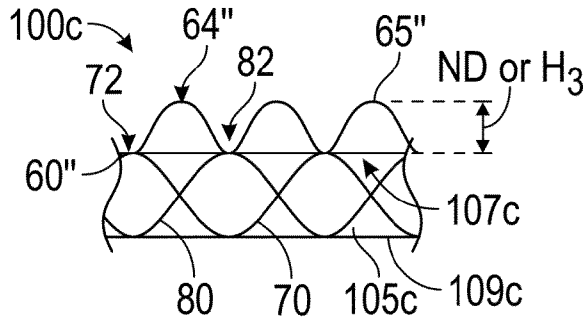

FIG. 9C

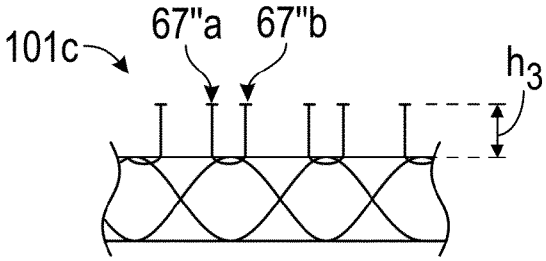

FIG. 10C

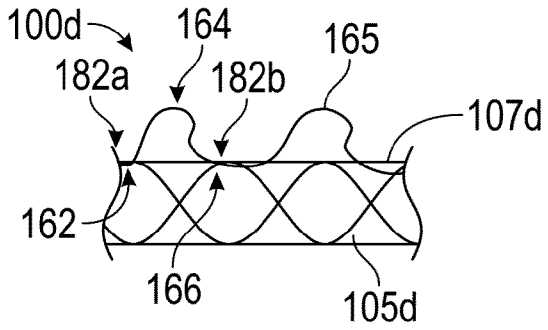

FIG. 9D

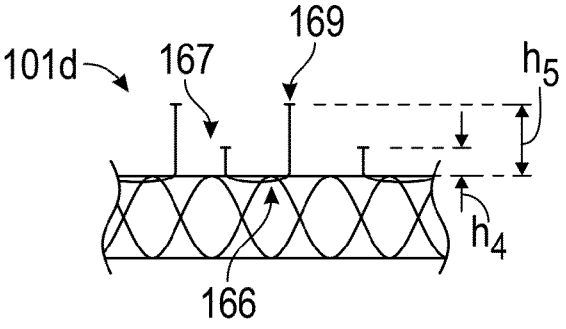

FIG. 10D

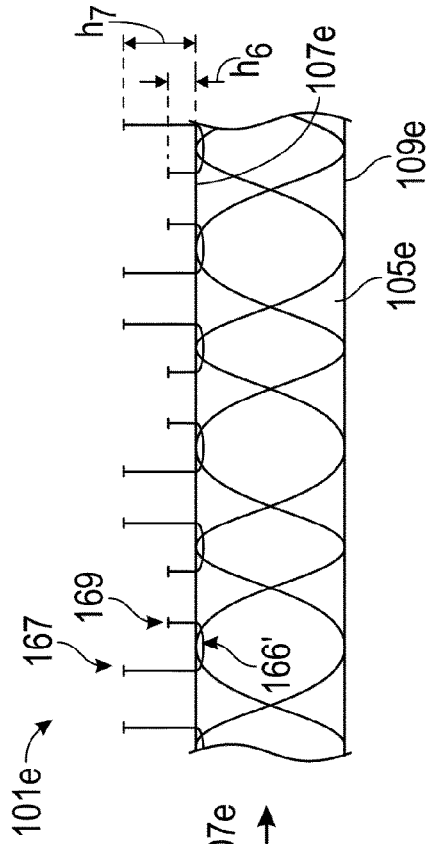

FIG. 9E

FIG. 10E

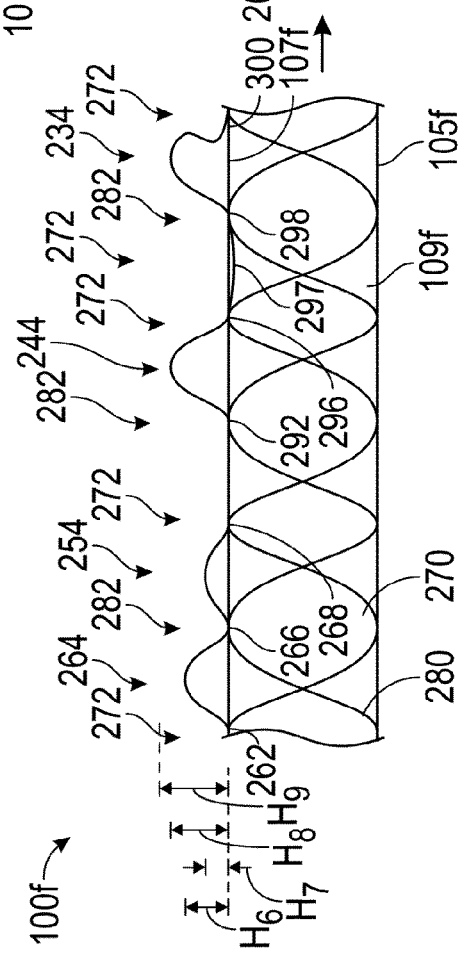

FIG. 9F

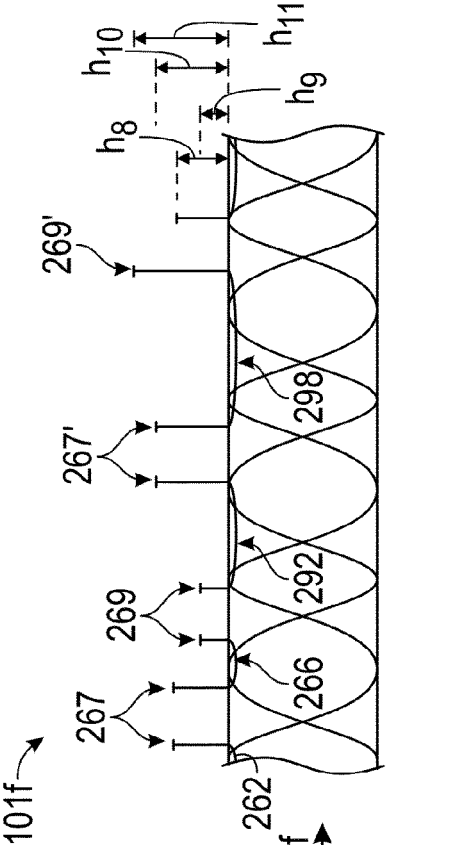

FIG. 10F

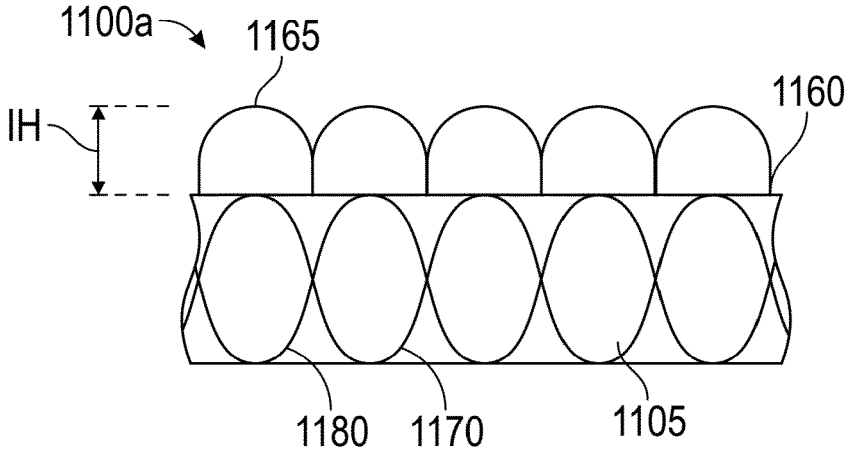

FIG. 11A

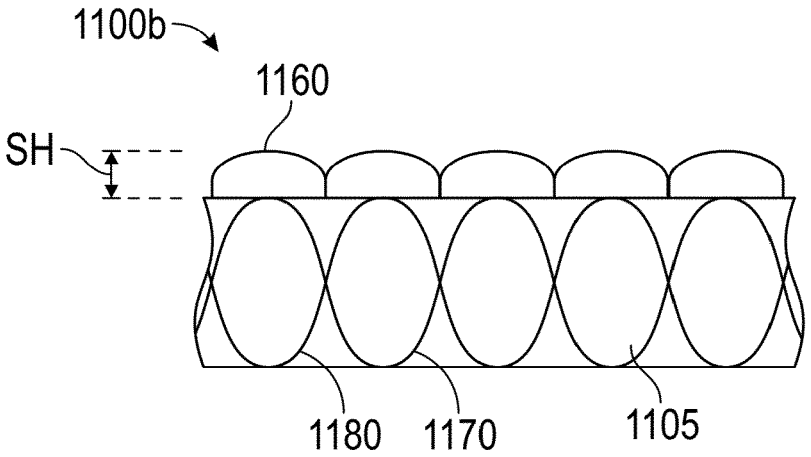

FIG. 11B

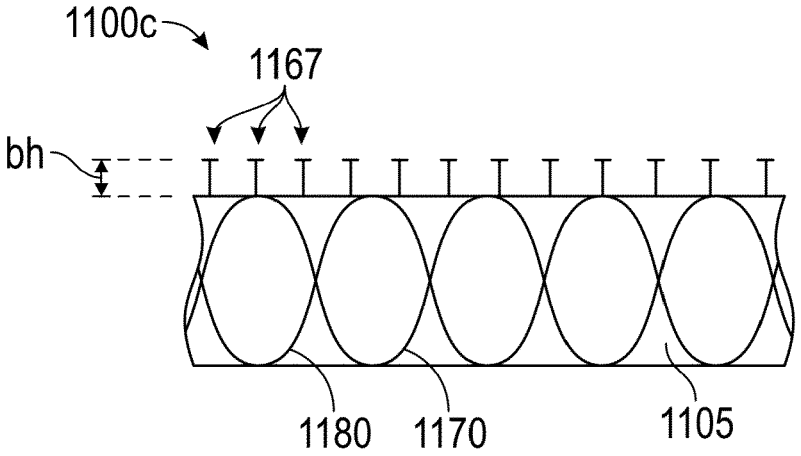

FIG. 11C

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EUROPEAN SEARCH REPORT

Application Number
EP 23 30 6318

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 Y A	EP 3 628 763 A1 (SOFRADIM PRODUCTION [FR]) 1 April 2020 (2020-04-01) * paragraphs [0046], [0047], [0072], [0089]; claims 1,4,5; figures 3,4 *	1-6,10, 12-15, 17,19 7 8,9,11, 16,18	INV. D04B21/04 D04B21/12
X	PL 221 018 B1 (POLITECHNIKA LÓDZKA [PL]) 29 February 2016 (2016-02-29) * paragraphs [0011], [0017]; figures 1-3 *	1,8-10, 12,16,17	
X Y	EP 1 350 879 A1 (GFD FABRICS INC [US]) 8 October 2003 (2003-10-08) * page 3, table; figures 1, 2 a-e *	1,10,12, 17 7	

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	4 January 2024	Messai, Sonia

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04-01-2024

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82