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CA 2307586 C 2007/02/27

(11)(21) 2 307 586

(12) BREVET CANADIEN
CANADIAN PATENT

(13) C

(86) Date de dépôt PCT/PCT Filing Date: 1998/11/06
(87) Date publication PCT/PCT Publication Date: 1999/05/20
(45) Date de délivrance/Issue Date: 2007/02/27
(85) Entrée phase nationale/National Entry: 2000/05/01
(86) N° demande PCT/PCT Application No.: IB 1998/001775
(87) N° publication PCT/PCT Publication No.: 1999/024652
(30) Priorité/Priority: 1997/11/10 (US08/966,614)

(51) Cl.Int./Int.Cl. *D03D 3/02* (2006.01), *F16L 11/08* (2006.01), *F16L 58/16* (2006.01), *D03D 19/00* (2006.01)

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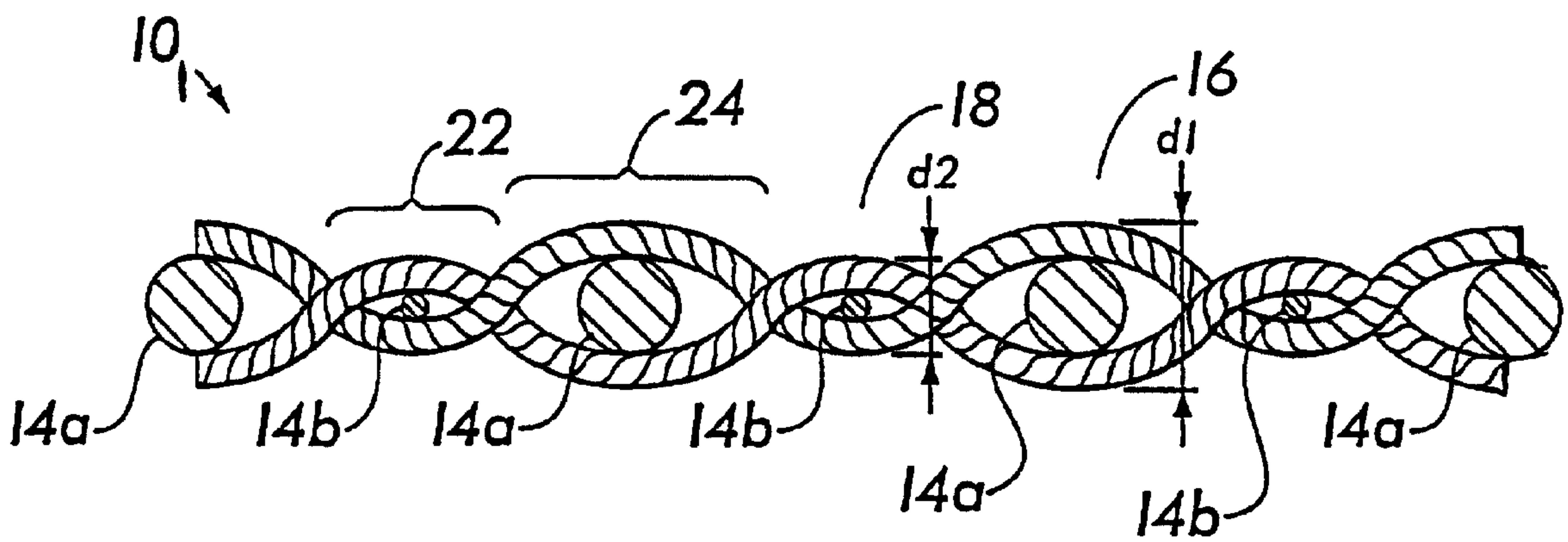
(54) Title: WOVEN FABRIC SLEEVE



(57) Abrégé/Abstract:
A woven fabric sleeve (16, Figure 1a) for protecting and covering elongated substrates is made up of circumferentially and longitudinally extending interlaced fill and warp members (14a, 14b and 12a, 12b) respectively. The fill members extend through the fabric to form circumferentially extending alternating bands of relative flexibility separating bands of inflexibility. The fill members may be comprised of monofilament or multifilament yarns of alternating large and small diameters and may include wire, especially resilient wire, heat settable materials, including polyester served wire and DREF yarns having resiliently settable cores. The fill members may be held in relation to one another utilizing Leno and mock Leno weaving. The fabric may be woven directly as a closed tubular sleeve or woven flat and folded into sleeve form.

PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : D03D 3/02	A1	(11) International Publication Number: WO 99/24652 (43) International Publication Date: 20 May 1999 (20.05.99)

(21) International Application Number: PCT/IB98/01775

(22) International Filing Date: 6 November 1998 (06.11.98)

(30) Priority Data:
08/966,614 10 November 1997 (10.11.97) US

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(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, HR, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published
With international search report.

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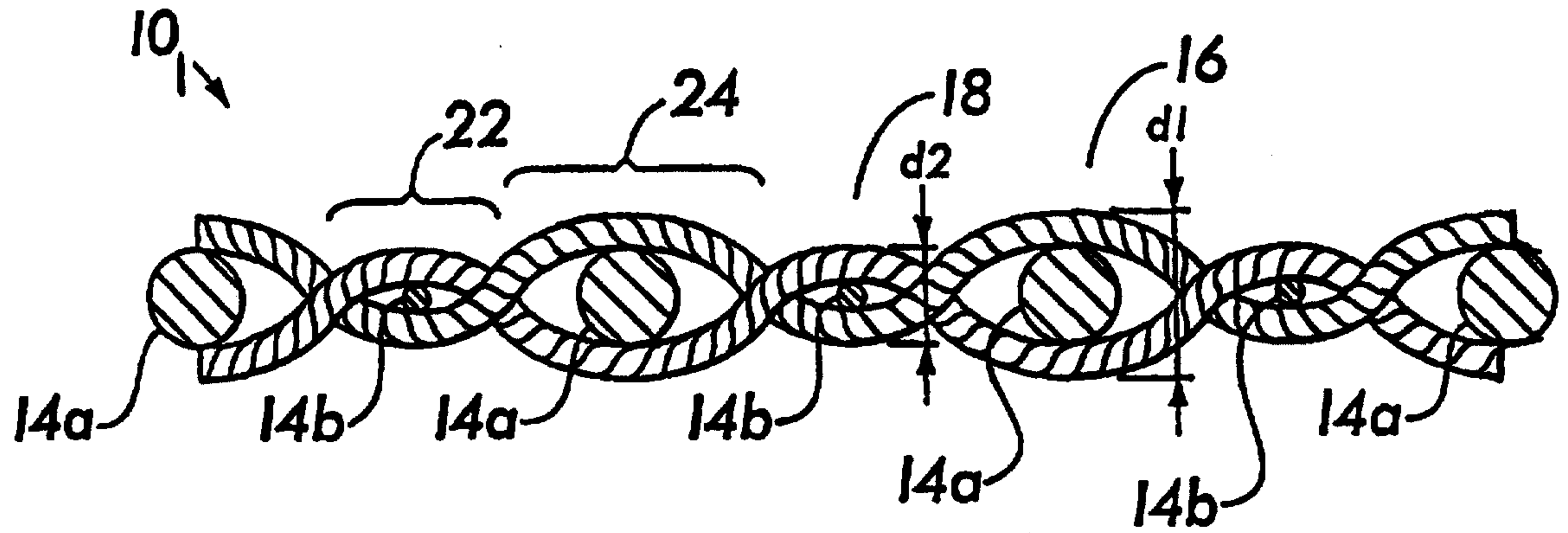


(57) Abstract

A woven fabric sleeve (16, Figure 1a) for protecting and covering elongated substrates is made up of circumferentially and longitudinally extending interlaced fill and warp members (14a, 14b and 12a, 12b) respectively. The fill members extend through the fabric to form circumferentially extending alternating bands of relative flexibility separating bands of inflexibility. The fill members may be comprised of monofilament or multifilament yarns of alternating large and small diameters and may include wire, especially resilient wire, heat settable materials, including polyester served wire and DREF yarns having resiliently settable cores. The fill members may be held in relation to one another utilizing Leno and mock Leno weaving. The fabric may be woven directly as a closed tubular sleeve or woven flat and folded into sleeve form.

Woven Fabric Sleeve

Field of the Invention

This invention relates to woven fabric sleeves for use in industrial applications as a protective or insulating covering for hoses, wires, piping and like objects and especially to flexible, conformable woven fabric sleeves.

Background of the Invention

Woven fabric sleeves are used extensively to provide a protective or insulating layer over a vast variety of items. For example, a sleeve of woven material is often fitted over branches of an electrical wiring harness to bundle the individual wires together and to protect the wires against abrasive wear which might otherwise damage the insulation or the conductors and lead to short circuits or broken circuits. Another common application is as an insulator of hot tubing, such as is found in automobile exhaust manifolds or power plant steam lines. Sleeves performing an insulating function are typically woven or braided from insulating yarns or filaments and often laminated with coatings, films or foils which increase their insulating capability, for example, by providing a reflective surface blocking infrared radiation. Woven fabrics are, of course, used extensively to protect items having shapes other than tubular as well.

Woven fabrics are economical to manufacture and see extensive use in the protective covering role because woven fabrics provide stable and robust membrane structures due to the orthogonal orientation of the warp and weft yarns comprising the fabric. However, the orthogonal orientation of a woven fabric also tends to detrimentally inhibit flexibility and conformability. When compared with braided fabrics, for example, the orthogonal fabric structure of woven fabrics is not as flexible or conformable. There is clearly a need to provide increased flexibility and conformability to woven fabrics, thereby combining woven fabrics' inherent characteristics of stability and robustness and ease of manufacture with increased flexibility and conformability comparable to braided fabrics.

Summary and Objects of the Invention

This invention provides woven fabric sleeving having increased flexibility and conformability as compared with traditional sleeving. Control of the relative flexibility of the sleeving, according to the invention, is provided by alternating circumferentially extending unidirectional zones of relative flexibility separating adjacent zones of inflexibility. The relatively flexible zones serve as pivot points about which the relatively inflexible zones pivot in a manner somewhat analogous to the ridges and valleys of corrugated or convolute tubing.

Woven fabrics are typically comprised of a multiplicity of first filamentary members arranged parallel to each other and interlaced with a plurality of second filamentary members oriented orthogonally (at 90°) to the first filamentary members. As used hereinafter, the terms filamentary members or members is used to mean wires, threads, yarn whether twisted or laid together, monofilaments and combinations of the above, including yarns formed by the DREF process. Where monofilaments are employed, relatively resilient engineered plastic materials are generally preferred, although resilient wire may sometimes serve as well. Particularly preferred monofilaments have a modulus of elasticity greater than 3250 MN/M^2 (50,000 psi) and preferably up to about 13000 MN/M^2 (200,000 psi). Exemplary monofilament materials include polyester, aramid polymers as sold under the trademark Kevlar nylon 6 and nylon 6/6.

In a simple plain 1/1 weave, warp filamentary members cross over and under the weft filamentary members in an alternating pattern, i.e., for a given warp crossing over a particular weft filamentary member, the adjacent warp filamentary member will cross under the particular fill filamentary member, thereby locking the fill filamentary member in place.

It is an object of the invention to provide a woven fabric sleeve having enhanced flexibility and conformability, as compared with conventional woven fabric sleeves. It is also an object of the invention to provide a woven fabric sleeve of which the relative stiffness of the woven fabrics is controlled.

According to the present invention a woven fabric sleeve for protecting and covering elongated substrates, comprises a woven fabric having orthogonally interlaced fill members and warp members arranged to extend circumferentially and longitudinally of the sleeve, and is characterised by said warp members or said fill members forming circumferentially extending alternating bands of relative flexibility separating bands of inflexibility.

Within the woven fabric, art fill members are also known as weft members and in this specification the terms "fill" and "weft" will be used interchangeably.

In one embodiment of the invention, enhanced flexibility of tubular sleeves of woven fabric is achieved by use of alternating fill filamentary members of small and large diameter, thereby creating relatively empty spaces at the locations of the small diameter filamentary members. These relatively empty spaces function as pivot points for the relatively large diameter filamentary members resulting in substantial increases in flexibility and conformability of the fabric in the sleeve. The filamentary member employed in the fill may be relatively rigid or non-rigid. Heat shrinkable monofilaments may be used in preselected zones in the fill as a means of creating a self-locating protective sleeve.

Although tubular sleeves according to this embodiment of the invention are preferably made on a circular weaving machine, conventional looms producing flat fabrics may be employed, and which flat fabrics may incorporate heat settable monofilaments or ductile wire. Where heat settable monofilaments are employed, the monofilaments are heat set on a mandrel to form a tubular sleeve. DREF* yarns consisting of polyester monofilaments as a core with spun staple polyester as an outer layer combine the property of being heat settable with the texture and friction of a multifilament. The flat fabric may conveniently be used in the production of laminated sleeves as by application of foils or films to one or both surfaces.

In another embodiment of the invention, pivot points in the product are provided by use of one size diameter fill yarn and an intermittent take-up system. A bellows effect is created by stacking picks at predetermined discrete locations lengthwise of the fabric. This embodiment has the capability of being tailored to meet particular curvatures. Use of the intermittent stacking system allows for incorporation of the bellows at predetermined locations. The warp yarns may be twisted glass fibre and the fill may be wire served with glass fibre. In an exemplary product, four picks were placed in the fabric before the take-up advanced, thus creating bundles of filaments spaced apart by single picks. The sleeve may be produced as a flat fabric having this structure and curled so that a tubular article having a side opening is formed.

In each of these embodiments, the alternating configuration of larger and smaller diameter weft members results in a fabric having alternating adjacent regions of greater and lesser relative flexibility. The regions between the large diameter filamentary members allow for relative pivotal movement of the regions having the large diameter filamentary members due

(* trade-mark)

to the tendency of the fabric to pivot more readily about the regions of lesser stiffness; that is, it becomes more flexible and conformable to irregular contours than typical fabric woven with uniform diameter weft filamentary members.

In yet another embodiment, the sleeve fabric has the warp members grouped in pairs, each warp member having a neighbour warp member. Fill, or weft, members are interlaced with the warp members, but in between each weft member, the warp member pairs are twisted around one another, in effect eliminating the alternate weft members and reducing the separation of the warp members almost to zero in between the weft members. This is known in the art as a Leno type weave. In this weave, regions of relatively greater stiffness are formed in the fabric along the weft members where the warp members cross and adjacent regions of relatively lesser stiffness are formed in the spaces in between the weft members where the warp member pairs are twisted together. The empty spaces between weft members function as pivot points resulting in a flexible fabric which readily conforms to complex contours. The relative effectiveness of the pivot points can be augmented or diminished by adjusting the size of the weft members. Weft member size can be set either by using single strands of a predetermined diameter or pairs of even bundles of strands built up to a desired effective diameter of weft member.

Still other embodiments of the invention involve the interlacing of filamentary members utilising so-called mock Leno weaving. The mock Leno weaving places the warp yarns in groups with intervening empty spaces which lock the weft yarns in place in spaced apart relationship, thereby providing a flexible fabric structure characteristic of Leno fabrics without twisting of the warp members.

Sleeving produced using fabric having increased flexibility and conformability is advantageously used for industrial purposes as for the covering of piping, wiring and other tubular shaped items. By using the teaching of the use of the invention, the relative stiffness of the sleeving can be controlled to produce a flexible fabric sleeves tailored to a particular curvature and the flexibility built in at predetermined regions where flexibility is required.

Giving the warp members a helical turn relative to the longitudinal axis of the sleeve has been found to reduce the stiffness of the sleeve because helically extending warp members are eccentrically loaded (not loaded along their center lines) in compression and tension when the sleeve is bent when conforming to a curve. The eccentric loading induces additional bending forces in the warp members not normally present in straight warp members with the result that the warp members yield more readily under compression or tension forces, thus making the sleeve even more conformable and flexible.

All of the embodiments described above, as well as other embodiments incorporating the principles of the invention, are particularly suited to laminating with other materials such as films, foils coatings and heat set wrappings. When laminated, sleeving according to the invention is found to be more flexible and conformable than conventional woven sleeves similarly laminated. This provides a great advantage for example with insulating sleeves laminated with metallic foils which reflect infrared radiation. The stiffening effect of the foil is compensated for by the increased flexibility of the woven fabric substrate, yielding a conforming sleeve with both superior insulating characteristics and enhanced flexibility not otherwise achieved with such laminated sleeves made of conventional woven fabrics. In another example, a woven fabric sleeve according to the invention laminated with a heat settable wrap is easily conformed to a curved shape, such as a pipe elbow bend, and then heat set into shape. The increased flexibility and conformability of the woven fabric yields a superior covering which adjusts easily to, and holds, complex shapes.

The warp and fill members may comprise filamentary members of virtually any fibre, yarn or filament in the various embodiments of the invention. For example, textured polyester multifilament yarns in the warp have been combined with materials such as monofilament polyesters or DREF yarns in the weft with good results. Glass fibre yarns may be used, as well as wires served with glass. Sleeves woven wholly or in part of multifilament yarns may be coated or impregnated with coatings as is well known in the art. For static electricity dissipation applications, conducting weft members made from stranded copper wire, for example, are used to avoid unwanted static charge build-up. Heat shrinkable members are especially useful as weft members in the production of heat shrink sleeving.

Whereas in the above-mentioned embodiments, the fill members have extended circumferentially and defined by their size, material and spacing the zones of flexibility, it is within the overall purview of the invention that a sleeve may be produced from fabric in which it is the warp members which extend in the circumferential direction and equally define the zones of flexibility.

These and other objects will become apparent from a consideration of the following drawings and detailed description of preferred embodiments of the invention.

Brief Description of the Drawings

Figure 1 shows a cross-sectional side view illustrating the fabric construction of a first embodiment of a woven fabric sleeve according to the invention,

Figure 1a is a perspective view of a sleeve having the fabric construction of Figure 1,

Figure 1b is a perspective view of another form of sleeve of the invention,

Figure 2 shows a cross-sectional side view illustrating the fabric construction of a second embodiment of a woven fabric sleeve according to the invention,

Figure 3 is a cross-sectional side view of a third embodiment illustrating a different fabric construction for carrying out the invention,

Figure 4 is a plan view of another fabric construction for a fourth sleeve embodiment formed according to the invention,

Figure 4a is a sectional view along line 4a-4a of Figure 4, and

Figure 5 is a plan view of another embodiment of the invention of similar construction to the embodiment of Figure 4.

Detailed Description of Preferred Embodiments

Referring to Figures 1 and 1a, Figure 1 is a schematic showing a cross-sectional side view of a portion of a fabric 10_1 of 1/1 plain weave construction formed into a sleeve according to one embodiment of the invention and shown in Figure 1a at 16. Neighbouring warp filamentary members 12a and 12b are interlaced with weft filamentary members 14a and 14b, the warp filamentary members 12a-12b passing alternately above and below the weft filamentary members 14a and 14b. As will be recognized, neighbouring warp member pairs such as 12a and 12b do not pass over and under the same weft members together, but alternate, 12a passing over a particular fill, or weft, member 14a while 12b passes under that particular weft member. This pattern is repeated throughout the fabric, thereby locking the weft members in place. Note that warp members 12a and 12b are representative of other warp members arrayed adjacent to each other in the plane of the drawing.

In one form of this construction, weft members 14a and 14b are of alternating large and small diameter. Although a variety of filamentary materials may be employed, one example of this embodiment was woven on a circular loom and incorporated 0.25mm (0.010") diameter polyester monofilaments in the warp and 0.686mm (0.027") diameter monofilaments alternating with 0.25mm (0.010") diameter monofilaments in the weft. The warp monofilaments were comprised of two ends.

Alternatively, in a second example 1250 denier texturised polyester multifilament yarn is used in the warp and employed large and small diameter polyester monofilaments of 0.686mm (0.027") and 0.25mm (0.010") diameter, respectively, in an alternating pattern forming a sleeve approximately 25.4mm (1") in diameter. Since these products were made on a circular loom, with the warp members extending substantially longitudinally of the resultant sleeve, but with a slight helical twist introduced in the warp direction. The resulting sleeves were very flexible and conformable. The small diameter monofilaments created circumferential zones of relative flexibility separating the relatively stiff, large diameter monofilaments. This construction allowed for curvature of the sleeves on relatively sharp radii without kinking. Glass fibre yarns may be substituted for polyester in the warp. Stainless steel wire may be substituted for the polyester monofilaments in whole or in part.

Sleeve 16 may have laminated to it a cover layer 18 formed, for example, from an adhesive bonded texturised reflective film.

A third example incorporating the weave shown in Figure 1 and woven on a circular loom used 1250 denier texturised polyester yarn in the warp and stranded copper wire of about 0.635mm (0.025") diameter in the fill alternating with 1250 denier polyester yarn. The copper wire is provided for the dissipation of static electricity. This sleeve was exceptionally flexible but lacked the circumferential stiffness provided by the first and second of the above examples.

Referring to Figure 1b, in a modification of the above similar sleeve woven on a conventional loom is made by weaving a flat fabric and then forming it into tubular shape that is resiliently set by the application of heat. In the example shown, polyester monofilaments as the fill were of about 2.54mm (0.10") in diameter and the flat fabric was wrapped on a mandrel and heated to set the resilient monofilaments. A side opening 20 allows for fitting the sleeve over elongated substrates, as shown at 22, and allows for breakouts.

Referring now to Figure 2, this shows another embodiment of a woven fabric 10_2 according to the invention where fill, or weft, filamentary members 26a are formed from a plurality of individual weft monofilaments 26 formed into a bundle. Bundled weft monofilaments 26a have a greater effective diameter than adjacent weft monofilaments 26b which preferably have a diameter equal to monofilaments 26. This fabric of Figure 2 was constructed with the use of an intermittent take-up by stacking picks at discrete locations extended circumferentially of the fabric. In the example making use of the structure shown in Figure 2, a glass fibre yarn was used in the warp, and relatively ductile wire served with glass was used in the fill. Four picks were placed in the fabric before the take-up advanced. A sleeve was made by weaving the fabric flat on a conventional loom, thereafter placing it on a mandrel where it was curled to form a sleeve similar to the sleeve of Figure 1b, the shape of the sleeve being retained by the curled wires.

It will be understood that the flexibility of the sleeve can be controlled by varying the number of picks per inch between stacked picks.

Figure 3 shows a third another embodiment of a woven fabric 10_3 according to the invention wherein fill, or weft, members 28 are spaced apart by twists formed in warps 12a and 12b. In this embodiment warp members 12a are each paired with an adjacent neighbour member 12b. Instead of being interlaced with weft members in an alternating pattern as in the previous embodiments, the warp member pairs 12a and 12b are twisted about each other as seen at 30, after passing over and under a weft member 28 utilizing a Leno harness which lifts and twists the warp yarns during every weft insertion. This is the characteristic of the so called Leno weave, where every other weft member is eliminated and replaced by a warp member twist 30. The twisting effect secures a filling weft yarn or pick in place and allows for less picks per inch to form a stable but flexible fabric. The empty spaces where the twists occur between the fill members create pivot points which allow the sleeve to readily contour over sharp curves.

Although other ways of establishing the fabric in a sleeve shape may be employed, such as by use of heat setting resiliently settable monofilaments used in the fill. A preferred method involves coating a sleeve material with a B-stage epoxy and allowing the epoxy to dry without curing and then forming the coated sleeve material with a sleeve shape and before heating to cure the epoxy. The sleeve maintains its shape even at high temperature on account of the thermosetting characteristic of the epoxy. In an example based upon the illustrated embodiment, the yarn employed was a Nomex DREF yarn, and the sleeve was made using the Leno weave. The fabric so formed was laminated with aluminum foil using a hot melt adhesive and was slit to width following lamination and then kiss coated with the epoxy.

A fourth embodiment of the invention is illustrated in Figures 4 and 4a. The sleeve fabric 10_4 incorporates a so-called mock Leno weave. The mock Leno weave forms the warp members into groups with empty spaces intervening, giving an open fabric structure without a twisting of warp members and giving increased flexibility. As seen from Figure 4, spaced groups of three warp members 40 comprise a relatively large diameter warp filamentary member 40, or equivalent bundle of smaller warp members, with pairs of relatively small diameter warp filamentary members 40_2, 40_3, the warp filamentary members woven with fill yarns 43. At each cross over, the fill yarns 43 are locked in place between the groups of three warp filamentary members, the middle warp filamentary member of each group passing in an alternating over-and-under pattern on the opposite side of each fill yarn to the outer warp filamentary members and locking the fill yarns in spaced apart relationship. Zones of relative flexibility are created by determining the separation of the fill yarns. The spaces between the fill members can be varied as required to provide the sleeve with the requisite flexibility and conformability. The fill members may be resiliently settable monofilaments set to cause the fabric to resiliently form a sleeve. The warp filamentary members may be monofilaments or any of the yarns mentioned herein.

A fifth embodiment of the invention comprises a sleeve having a fabric construction 10_3 shown in Figure 5. The fabric construction is similar to Figures 4 and 4a in that a mock Leno weave is employed. In fabric 10_3 the warp member 44 comprises a group of three filamentary members 44_1, 44_2 and 44_3 each formed of a texturised polyester multifilament yarn. The fill is a DREF yarn 46 comprised of a polyester monofilament over which staple polyester is spun. As illustrated in the Figure, the fill yarns 46 are placed in spaced apart groups of two, although a greater or smaller number may be employed. The fabric so constructed is formed into tubular shape on a mandrel and heat is applied to cause the core monofilaments of the DREF yarn to resiliently set. When so formed, the fill members may assume somewhat of a bias relatively to the warps. The resulting sleeve has excellent flexibility, is a relatively closed construction as compared with the fabric 10_4 of Figure 4 and is abrasion resistant. The fill yarns combine the heat setting properties of a monofilament with the texture and feel of a multifilament.

The flexibility of the fabric can be tailored by the introduction of zones of flexibility between relatively inflexible zones and sleeves formed with the zones extending circumferentially so that the sleeving flexes similarly to convolute or corrugated tubing.

The provision of filamentary weft members of large and small diameter in the examples of Figures 1 and 2 produces the pivot points which enable the sleeves to conform to complex shapes and severe curvatures. In Figure 3, this flexibility is accomplished by twisting the warp yarns to create empty spaces between the fill yarns creating pivot points which function similarly to the pivot points of Figures 1 and 2. In the construction of Figures 4 and 4a, open spaces which form pivot points are created between adjacent fill yarns by the use of groups of three warp yarns to lock the fill yarns in place. By virtue of the characteristics of increased flexibility and conformability woven fabric sleeves according to the invention are suitable for a wider variety of applications than heretofore possible with conventionally woven fabric sleeves.

What is claimed is:

1. A woven fabric sleeve for protecting and covering elongated substrates, said sleeve comprising a woven fabric having orthogonally interlaced fill members and warp members arranged to extend circumferentially and substantially longitudinally of the sleeve, and characterised in that said fill members form circumferentially extending alternating bands of relative flexibility separating bands of inflexibility.

2. A woven fabric sleeve according to claim 1 characterised in that said fill members comprise first fill members having a first diameter and second fill members having a second diameter smaller than the first, said second fill members being spaced between said first fill members.

3. A woven fabric sleeve according to claim 2 characterised in that said second fill members comprise stranded wire.

4. A woven fabric sleeve according to claim 2 or claim 3 characterised in that said first fill members are monofilaments.

5. A woven fabric sleeve according to claim 4 characterised in that said monofilaments comprising the first fill members are resilient.

6. A woven fabric sleeve according to any one of claims 2 to 5 characterised in that said first fill members have at least twice the diameter of said second fill members.

7. A woven fabric sleeve according to claim 2 or claim 3 characterised in that said first fill members comprise bundles of said second fill members.

8. A woven fabric sleeve according to any one of claims 1 to 7 characterised in that said warp members are arranged in groups, the warp members of each group being twisted at locations on each of selected fill members to lock said selected fill members in place, said locations being positioned within the bands having relatively greater flexibility.

9. A woven fabric sleeve according to claim 8 characterised in that said warp-members are arranged in pairs.

10. A woven fabric sleeve according to claim 1 characterised in that said warp members comprise groups of relatively flexible filamentary members, each group comprising a first warp filamentary member disposed between a pair of second warp filamentary members, said first warp filamentary member and said pair of second warp filamentary members being woven in interlocking relationship with at least one of said fill members in a mock Leno weave pattern.

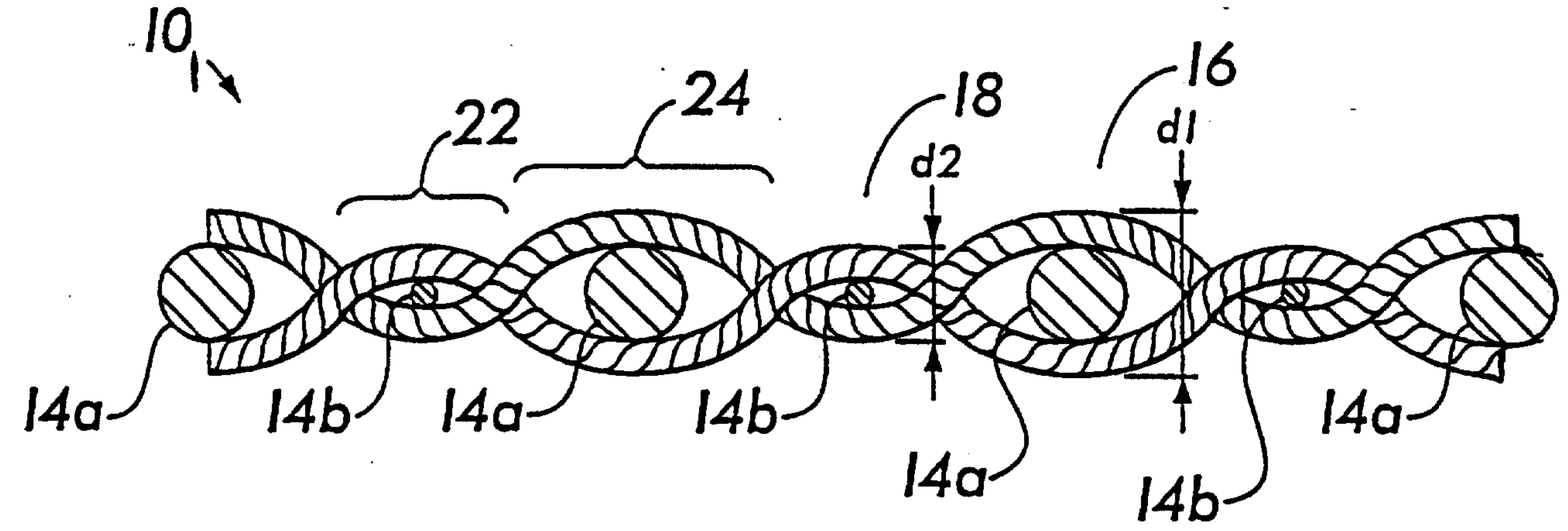
11. A woven fabric sleeve according to claim 10 characterised in that said first filamentary members of each group are of larger diameter than the second filamentary members of said group.

12. A woven fabric sleeve according to claim 11 characterised in that said warp members are monofilaments.

13. A woven fabric sleeve according to any one of claims 10 to 12 characterised in that said fill members comprise at least one yarn having a resiliently settable core resiliently set to maintain said sleeve in a substantially tubular configuration.

14. A woven fabric sleeve according to any one of claims 10 to 13 characterised in that said fill members are grouped in pairs.

FIG.1



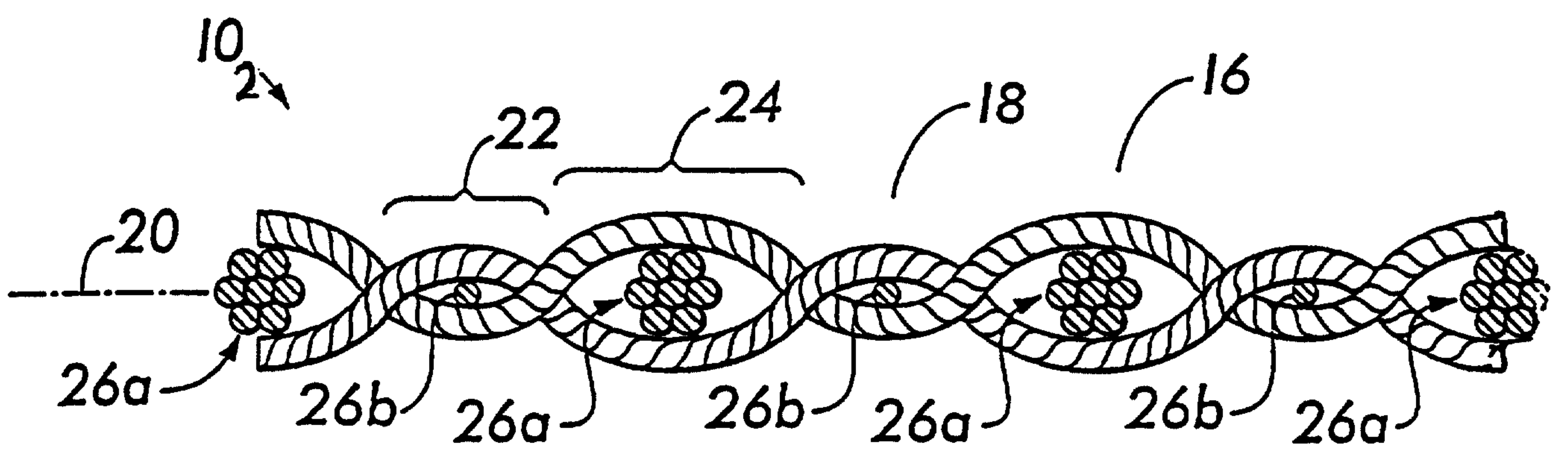


FIG.2

FIG.3

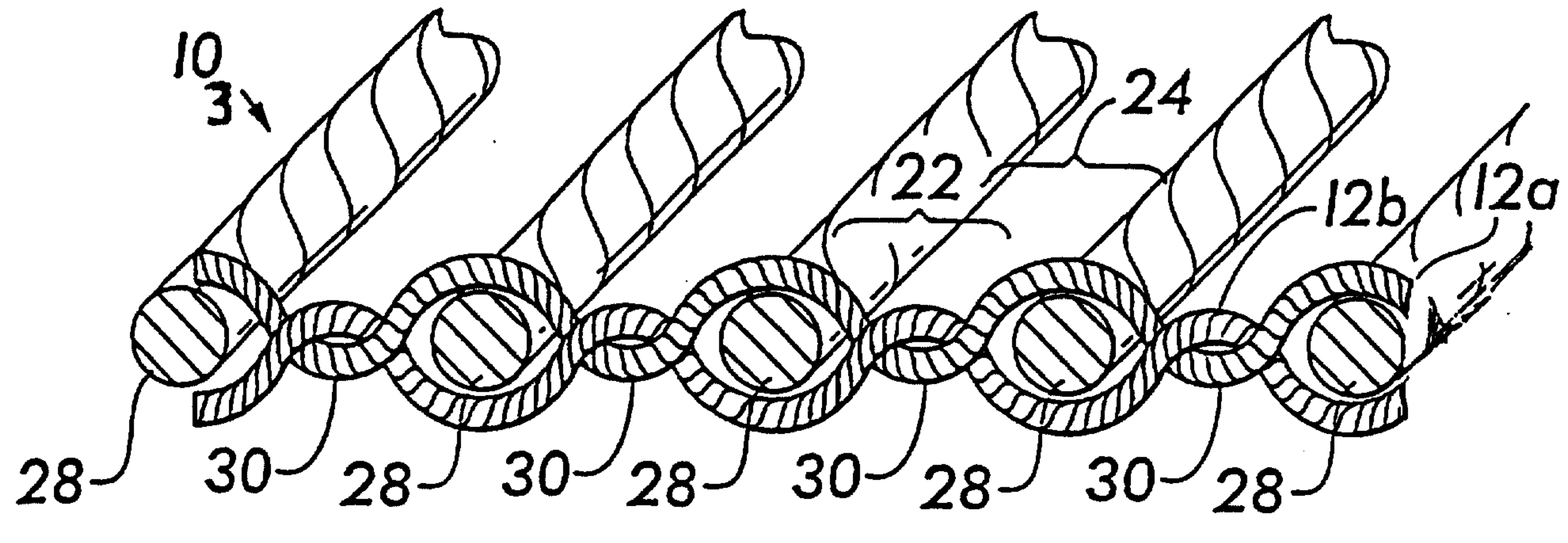
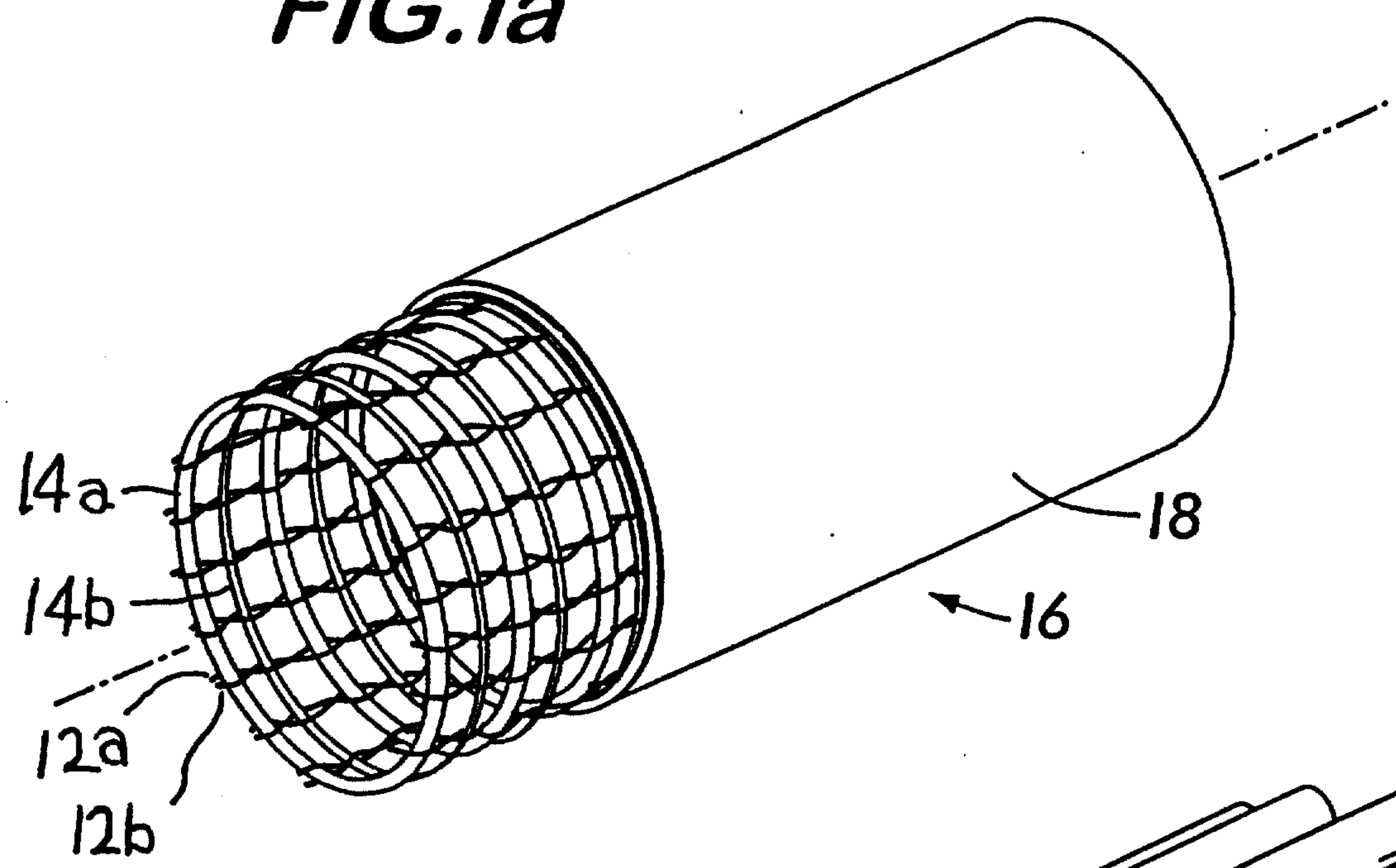


FIG. 1a



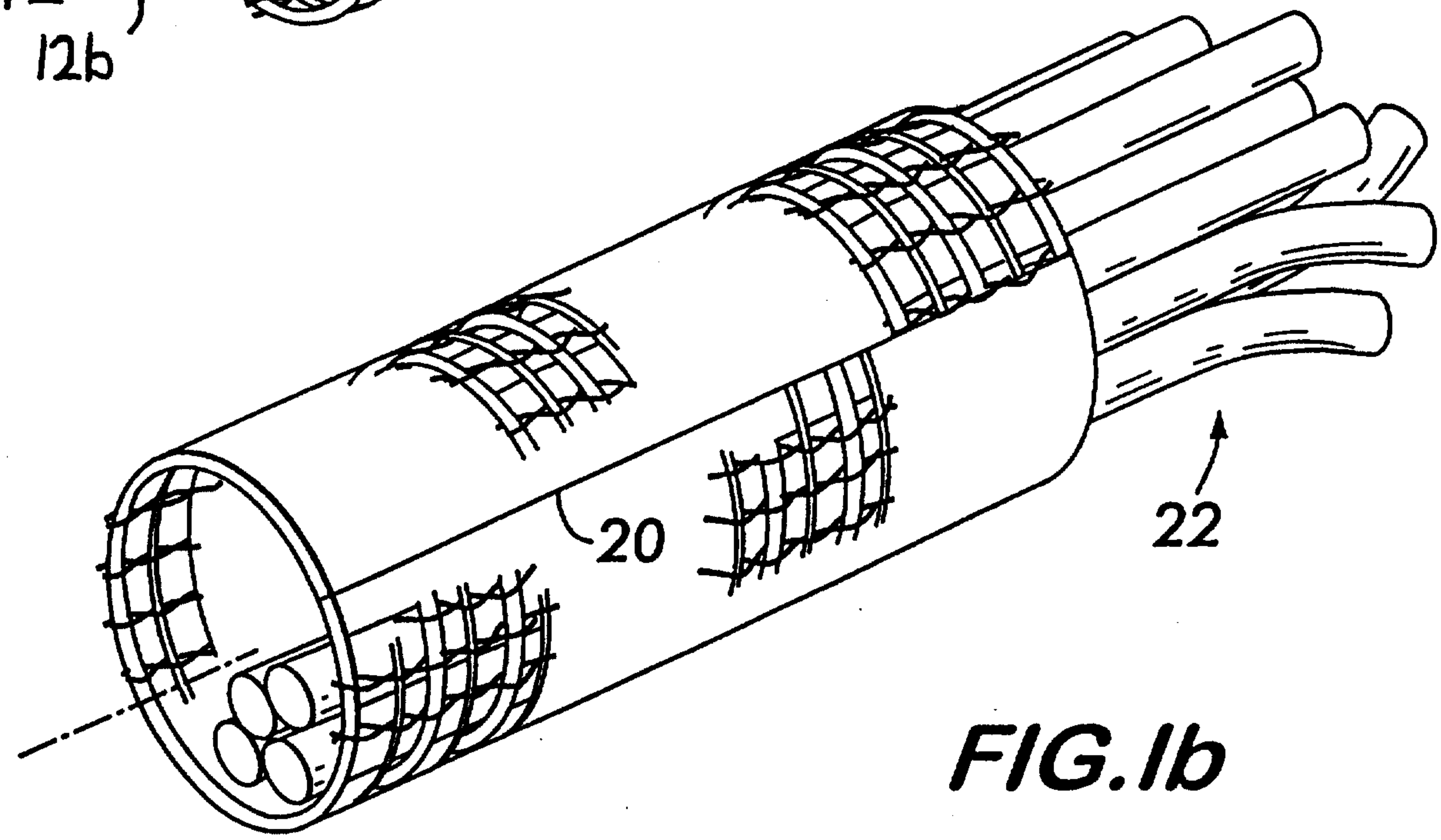
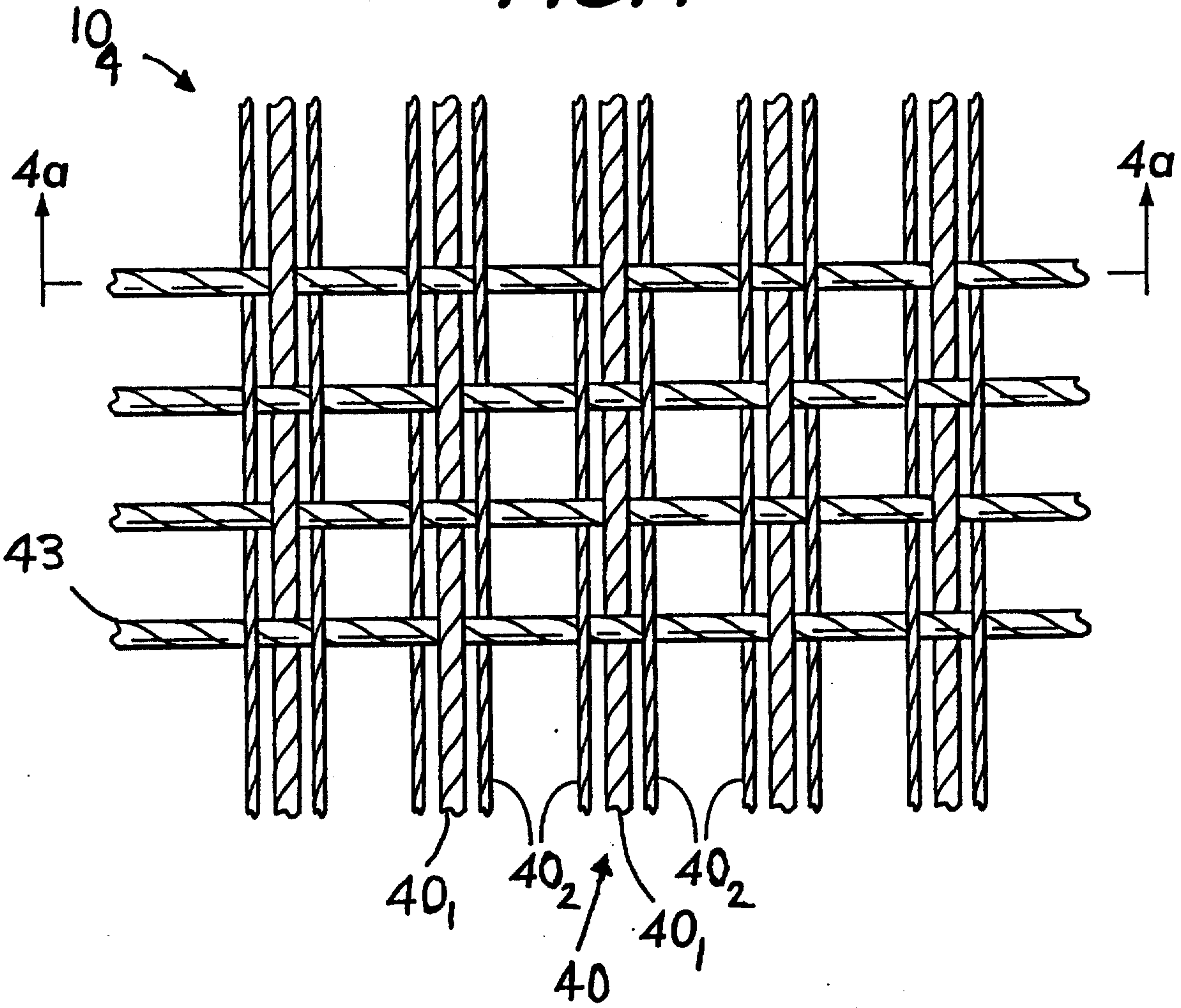


FIG. 1b

FIG.4



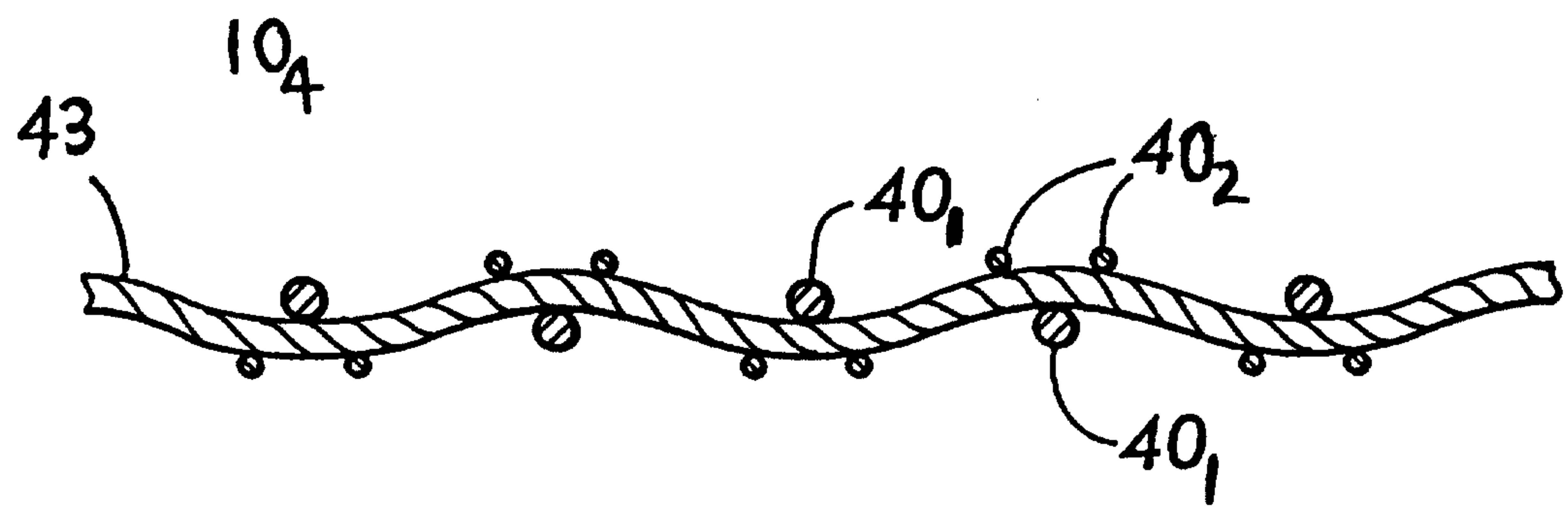
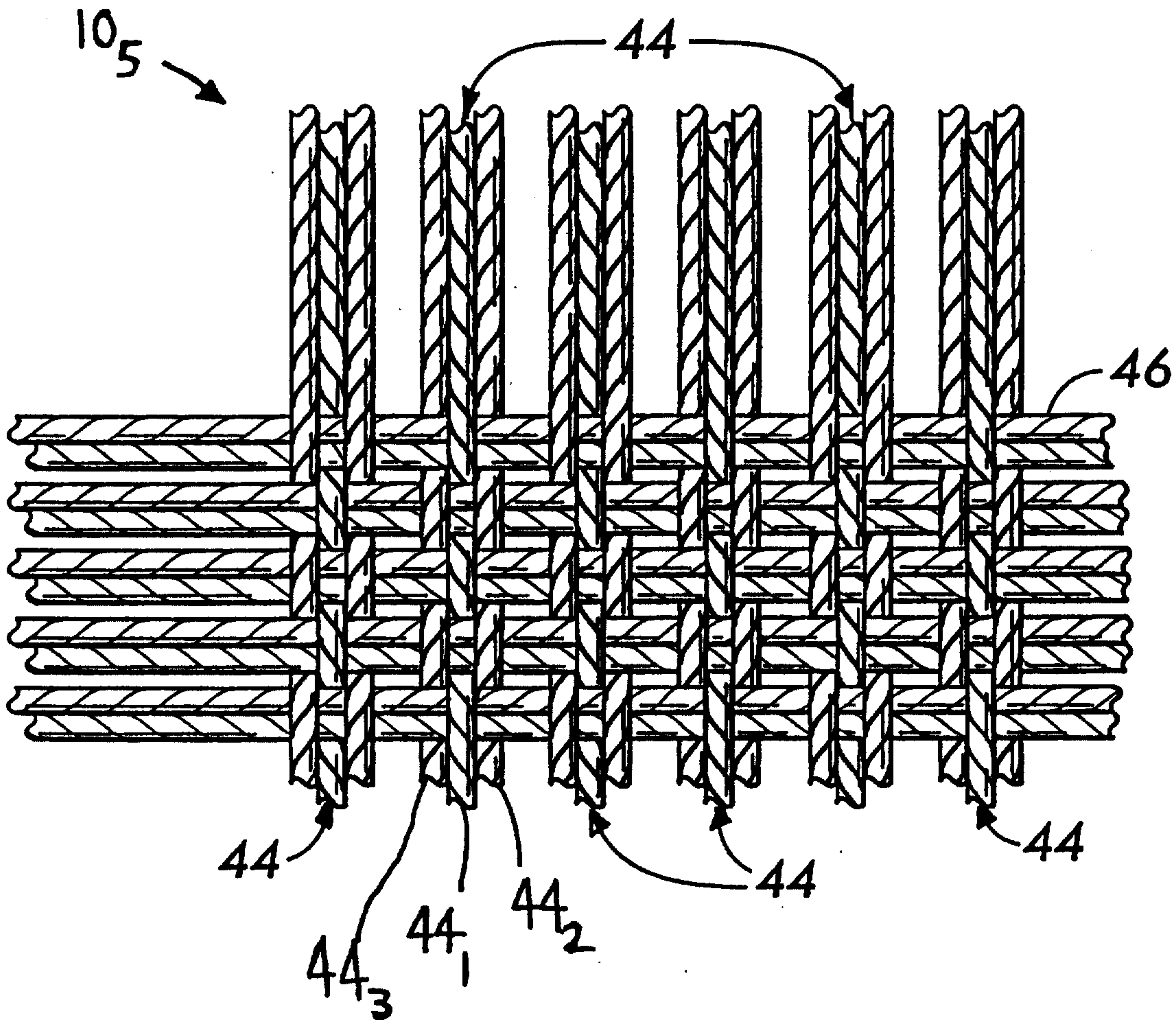
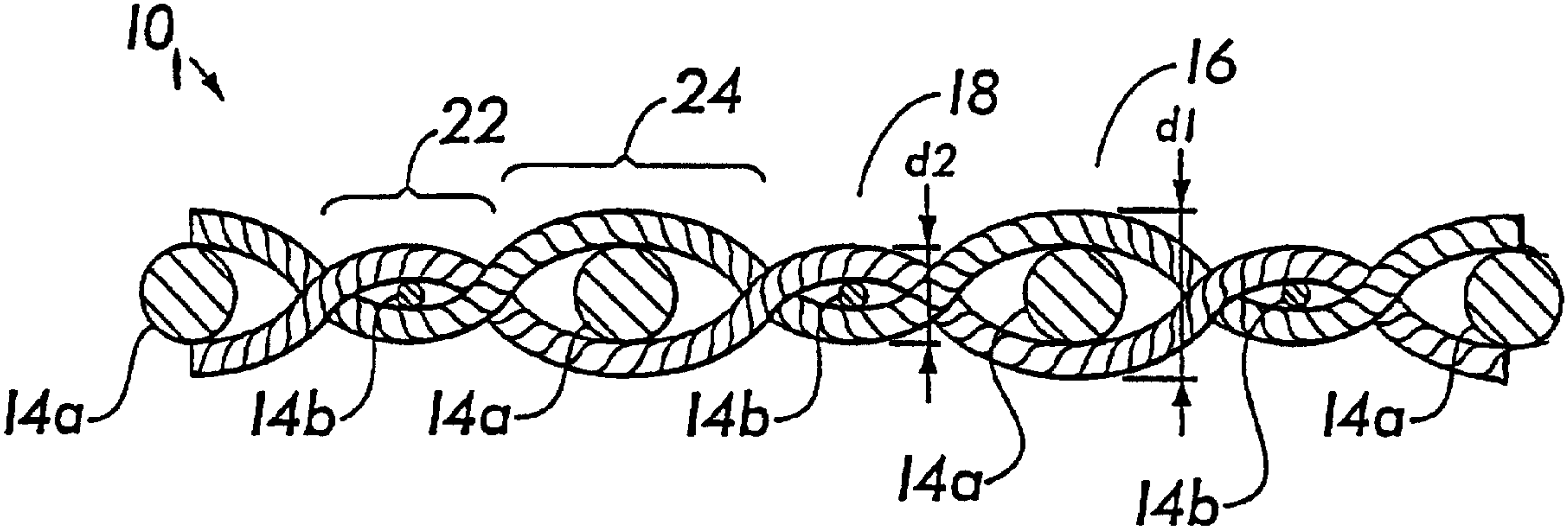


FIG.4a

FIG.5





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