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(54) FLEXIBLE PIPE HAVING PRESSURE ARMOUR LAYER AND COMPONENTS THEREOF

FLEXIBLES ROHR MIT EINER DRUCKARMIERUNGSSCHICHT UND KOMPONENTEN DAFÜR

TUYAU FLEXIBLE COMPRENANT UNE COUCHE ARMÉE ANTI-PRESSION ET COMPOSANTS DE CELUI-CI

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Description

[0001] The present invention relates to flexible pipes which may be used to convey fluids such as production fluids. In particular, but not exclusively, the present invention relates to flexible pipe body and a method for manufacturing flexible pipe body having a layer formed by interlocking adjacent windings of helically wound tape. The invention further relates to tapes for forming such a layer.

[0002] Traditionally flexible pipe is utilised to transport production fluids, such as oil and/or gas and/or water, from one location to another. Flexible pipe is particularly useful in connecting a sub-sea location to a further sub-sea location or a sea level location. Flexible pipe is generally formed as an assembly of a length of flexible pipe body and one or more end fittings. The pipe body is typically formed as a composite of tubular layers of material that form a fluid and pressure containing conduit. The pipe structure allows large deflections without causing bending stresses that impair the pipe's functionality over a desired lifetime. The pipe body is generally, but not necessarily, built up as a composite structure including metallic and polymer layers. Flexible pipe may be utilised as a flowline over land and/or at a sub-sea location. Flexible pipe may also be used as a jumper or riser.

[0003] In many prior known flexible pipes of this type a "pressure armour layer" is utilised to help reinforce an internal pressure sheath such as a fluid barrier or liner and prevent radial expansion and burst through due to differential pressure conditions acting across the pipe. The pressure armour layer is thus important for the pressure retainment capability of the flexible pipe. The pressure armour layer may also act as a principal reinforcement layer providing collapse resistance.

[0004] Typically the pressure armour layer which acts as a hoop strength layer is formed by helically winding one or more tapes about an underlying layer whereby adjacent tape windings interlock, with a claw or hook at one edge of a tape winding interlocking with a corresponding recess or valley region at an opposite edge in an adjacent winding.

[0005] Prior known pressure armour profiles are numerous and many have a Zeta or S-shape. One such example is illustrated in the European Patent Application having Publication Number EP 0929767. This discloses a flexible conduit formed with a helically wound band of metal to provide resistance to burst pressure. The band has a leading edge lip or hook and a trailing edge hook which engage and interlock when the band is helically wound. The cross section of the band has an asymmetrical Z-shape profile with a main body section intermediate the band end edges. However, it is noted that the handling of such winding through manufacturing may be difficult due to the asymmetry of the wire. Effectively the wire wishes to roll over on its side during manufacturing. Also the wire profile of the pressure armour layer constrains the wire's height to width ratio such that it is difficult to get a profile having a relatively large height. The constraint to the wire's height to width ratio limits the internal and/or external pressures which the pipe is able to withstand.

[0006] Patent document GB 1910 22,719A discloses an elongate composite tape according to the preamble of claim 1.

[0007] It is an aim of the present invention to at least partly mitigate the above-mentioned problems.

[0008] It is an aim of embodiments of the present invention to provide flexible pipe body including a pressure armour layer which is relatively simple to manufacture relative to prior known armour layers.

[0009] It is an aim of embodiments of the present invention to provide a pressure armour layer which can be included in flexible pipe body to improve burst resistance and collapse resistance and which is formed from one or more helically wound tapes having improved stability with respect to alternative prior known tape.

[0010] It is an aim of embodiments of the present invention to provide a pressure armour layer in which the cross section profile of tape wound in an interlocked fashion to provide the pressure armour layer, provides a layer thicker than layers formed via prior known techniques.

[0011] According to a first aspect of the present invention there is provided an elongate composite tape as described in claim 1.

[0012] According to a second aspect of the invention there is provided a method for manufacturing flexible pipe body as described in claim 20.

[0013] According to a third aspect of the invention there is provided a method for manufacturing flexible pipe body as described in claim 21.

[0014] Certain embodiments of the present invention can provide an increased overall thickness of the profile of the windings in a pressure armour layer in comparison to prior known techniques. This allows the pressure armour layer to be thicker relative to a conventional layer thus enabling the pipe to resist higher burst pressures and increased hydrostatic external pressure than is otherwise possible with prior known pressure armour layers.

[0015] Certain embodiments of the present invention provide a tape which lies stably onto a pipe which improves handling of the tape through pipe manufacturing processes and allows an increase in an overall thickness of the tape layer without greatly increasing the overall width of the tape.

[0016] Certain embodiments of the present invention also include features able to reduce local stresses from forming in the tape and during wrapping of the tape around an inner layer. These features include, but are not limited to, increased corner radii at specific locations.

[0017] Certain embodiments of the present invention separate the functions of prior known interlocking layers. These separated functions are performed by respective parts of a composite tape. One part of the composite tape is a substantially block-like winding having a relatively high height to width ratio. This part may be manufactured

from a particular type of material selected from a preferable range of materials to enhance pressure resisting performance. The other part of the composite tape performs an interlocking function. This may be provided either by a preformed tape having a convex and concave portion in which the windings of the first part of the composite tape are held together or alternatively may be formed during manufacture beginning with a flat strip which attains an interlocking shape as the pressure armour layer is generated during manufacturing. This second part of the composite tape can again be made from materials particularly well suited to the particular purpose of interlocking. This material can be the same or different from the material used for the first part of the composite tape.

[0018] A layer in the flexible pipe can be formed by winding a preformed composite tape or by simultaneously winding a tape and tape holder.

[0019] Embodiments of the present invention will now be described hereinafter, by way of example only, with reference to the accompanying drawings in which:

Figure 1 illustrates flexible pipe body;

Figure 2 illustrates a riser, flowline and jumper;

Figure 3 illustrates a perspective cross section of a pressure armour tape according to the invention; and

Figure 4 is a cross section of the pressure armour tape of Figure 3.

[0020] In the drawings like reference numerals refer to like parts.

[0021] Throughout this specification reference will be made to a flexible pipe. It will be understood that a flexible pipe is an assembly of a portion of pipe body and one or more end fittings in each of which an end of the pipe body is terminated. Figure 1 illustrates how a pipe body 100 is formed in accordance with an embodiment of the present invention from a composite of layered materials that form a pressure-containing conduit. Although a number of particular layers are illustrated in Figure 1, it is to be understood that the present invention is broadly applicable to composite pipe body structures including two or more layers. It is to be further noted that the layer thicknesses are shown for illustrative purposes only.

[0022] As illustrated in Figure 1, pipe body includes an innermost carcass layer 110 and a pressure sheath 120. The carcass 110 provides an interlocked metallic construction that can be used as the innermost layer to prevent, totally or partially, collapse of an internal pressure sheath 120 due to pipe decompression, external pressure, tensile armour pressure and mechanical crushing loads. It will be appreciated that embodiments of the present invention are applicable to 'smooth bore' as well as such 'rough bore' applications.

[0023] The internal pressure sheath 120 acts as a fluid retaining layer and typically comprises a polymer layer that ensures internal-fluid integrity. It is to be understood that this layer 120 may itself comprise a number of sublayers. It will be appreciated that when the optional carcass 110 layer is utilised the internal pressure sheath 120 is often referred to as a barrier layer. In operation without such a carcass 110 (so-called smooth-bore operation) the internal pressure sheath 120 may be referred to as a liner..

[0024] A pressure armour layer 130 is formed over the internal pressure sheath 120 and is a structural layer with a lay angle close to 90° that increases the resistance of the flexible pipe body 100 to internal and external pressure and mechanical crushing loads. The armour layer 130 also structurally supports the internal-pressure sheath 120 and typically consists of an interlocked metallic construction.

[0025] The flexible pipe body 100 may also include one or more layers of tape 140 and a first tensile armour layer 150 and second tensile armour layer 160. Each tensile armour layer 150, 160 is a structural layer with a lay angle typically between 20° and 55°. Each layer 150, 160 is used to sustain tensile loads and internal pressure. The tensile armour layers 150, 160 are counter-wound in pairs.

[0026] The flexible pipe body 100 also includes an outer sheath 170 which comprises a polymer layer used to protect the pipe body 100 against penetration of seawater and other external environments, corrosion, abrasion and mechanical damage. One or more layers 180 of insulation may also be included.

[0027] Each flexible pipe comprises at least one portion, sometimes referred to as a segment or section of pipe body 100 together with an end fitting located at at least one end of the flexible pipe body. An end fitting provides a mechanical device which forms the transition between the flexible pipe body and a connector. The different pipe layers as shown, for example, in Figure 1 are terminated in the end fitting in such a way as to transfer the load between the flexible pipe and the connector.

[0028] Figure 2 illustrates a riser assembly 200 suitable for transporting production fluid such as oil and/or gas and/or water from a sub-sea location 210 to a floating facility 220. For example, in Figure 2 the sub-sea location 210 is a connection to a sub-sea flow line 230. The flexible flow line comprises a flexible pipe, wholly or in part, resting on the sea floor or buried below the sea floor. The floating facility may be provided by a platform and/or buoy or, as illustrated in Figure 2, a ship. The riser 200 is provided as a flexible riser, that is to say a flexible pipe connecting the ship to the sea floor installation. Alternatively the flexible pipe can be used as a jumper 240.

[0029] Figure 3 illustrates a cross section of a tape 10 according to an embodiment of the present invention. Throughout this specification reference is made to a tape and it will be understood that such a term is to be broadly construed as encompassing an elongate structure having a preformed cross section or a desired cross section

generated during manufacturing of the flexible pipe body and which can be wound in a helical fashion around an underlying structure, primarily to provide reinforcement or pressure resistance to the structure.

[0030] Tape 10 of Figure 3 is a composite tape comprising an elongate tape element 12 and a tape element holder 14. In Figures 3 and 4 a continuous elongate composite tape is shown which is helically wound in a series of adjacent windings 10_1, 10_2 and 10_3. Thus first winding 10_1 includes tape element winding 12_1 and tape element holder winding 14_1, second winding 10_2 includes tape element winding 12_2 and tape element holder winding 14_2 and third winding 10_3 includes tape element winding 12_3 and tape element holder winding 14_3 and so on.

[0031] The tape element 12 comprises an elongate body which is most preferably a solid (monolithic) body and whose function is to provide the strength or reinforcement properties required of the composite tape element. That is, the tape element is configured to provide internal and/or external pressure resistance, and/or resistance to crushing loads. Tape element 12 thus functions as a so-called hoop strength layer. It can have a relatively high height to width ratio and can be made from a respective material having selected characteristics for providing good hoop strength. Alternatively the elongate body of the tape element can be a composite body formed from multiple elongate strands held in a matrix or loosely bound together.

[0032] The tape element holder 14 functions to retain the tape element 12 and to provide an interlocking effect between adjacent windings of the tape layer. The interlocking of the windings in the tape layer ensures that the pipe body can withstand bending forces. The interlocking is achieved by providing the tape element holder 14 with a hooked region 34 which is received in use in a hook receiving region 18 of an adjacent winding.

[0033] Tape element 12 is preferably invariant in shape along its length and is generally rectangular in cross section having a base surface 20, a top surface 22 opposed to the base surface and opposed first and second side walls 24, 26 extending between the base surface 20 and the top surface 22. The respective side walls 24, 26 include a recess 28, 30. A rebate 28 forming a recess is provided at the junction of base surface 20 with side wall 24 and a rebate 30 forming a further recess is provided at the junction of top surface 22 and side wall 26. The rebates are thus provided at opposite corners of the tape element 10. Each rebate 28, 30 may typically comprise approximately half of the dimension of the respective side wall 24, 26 as measured between base surface 20 and top surface 22. The rebate 30 on the second side wall includes a planar wall segment 30a. This planar wall segment 30a merges smoothly via curved surface portion 30b with top surface 22 and also merges with remainder of side wall 26 at a corner 26a via curved surface portion 30c. This provides an outwards step in the side wall. Similarly, the rebate 28 in the first side wall includes a planar wall segment 28a. This planar wall segment 28a merges smoothly via a curved surface portion 28b with the base surface 20 and also merges with remainder of side wall 24 at a corner 24a via curved surface portion 28c.

[0034] The tape element 12 may be made from a suitable metallic material such as hot or cold rolled steel, or a suitable composite material, depending, for example, on the intended service conditions. The tape element holder may be produced from a metallic material, polymeric material or composites, as appropriate to the particular intended use. The two parts of the composite tape may be formed from a common material or from different materials each selected to provide respective performance characteristics.

[0035] The tape element holder 14 comprises a first, generally concave, portion 32 configured to receive the elongate tape element 12 and a second, hooked, portion 34 configured to engage with and locate the tape element 12 in an adjacent winding. Thus, the interlocking of the adjacent windings of the tape 10 is achieved by engagement of the hooked portion 34 with the tape element 12 of an adjacent winding. In the example illustrated in Figures 3 and 4, hooked portion 34_3 of a later adjacent winding 10_3 engages tape element 12_2 or an earlier adjacent winding 10_2, hooked portion 34_2 of a relatively later winding 10_2 engages tape element 12_1 of a relatively earlier winding 10_1 and so on. Thus a winding of the tape element is held in a nested configuration by one region of the tape element holder whilst another, convex, region of the tape element holder hooks over or onto an adjacent winding of the tape element.

[0036] The first portion 32 of the tape element holder 14 comprises a base web 36 which is most preferably planar and which is arranged in confronting relation with the base surface 20 of the tape element 12. Preferably the upper surface 36a of base web 36 is maintained in contacting relation with the base surface 20 of the tape element. The tape element holder 14 further comprises opposed first and second side webs 38, 40 extending from opposed side margins of the base web 36. Side webs 38, 40 preferably extend substantially perpendicularly with respect to base web 36 and are substantially parallel to one another. The side webs 38, 40 merge smoothly into base web 36 via respective curved web portions 38a, 40a. The first and second side webs 38, 40 are arranged in confronting relation to the respective first and second side walls 24, 26 of the tape element 12, but are not necessarily in contacting relation therewith, as will be explained below. The side webs extend outwardly from the base web towards an imaginary centre line of the tape element holder.

[0037] The second portion 34 of the tape element holder 14 includes a cover web 42 extending from the second side web 40. The cover web 42 extends substantially perpendicularly with respect to the second side web 40 and merges smoothly into second side web 40 via a curved web portion 42a. Thus, cover web 42 is arranged substantially parallel to (but spaced apart from) base web 36. A third side web 44 extends from a distal (with respect

to second side web 40) side margin of the cover web 42. This third side web 44 extends substantially perpendicularly with respect to cover web 42 and merges smoothly into cover web 42 via a curved web portion 44a. Third side web 44 is thus substantially parallel to the second side web 40. Free end edges 38c, 44c of the respective first and third side webs 38, 44 are directed towards an imaginary lateral centre line "C" which bisects the second side web 40. The tape element holder 14 thus has approximately the shape of a stylised letter "S". The third side web 44 is configured to be disposed in use in confronting relation (but not necessarily contacting relation) with a distal side wall 26 of the tape element 12 of an earlier adjacent winding. That is, internal face 44 of third side wall 44 is juxtaposed in use with planar wall segment 30a of rebate 30 of the tape element 12 of the adjacent (earlier) winding.

[0038] In preferred constructions the dimension "A" of the tape element between base surface 20 and top surface 22 is configured to be substantially the same as the dimension "B" of the second side web 40 between upper surface 36a of base web 36 and under surface 42b of cover web 42. In this construction, subject to normal design and manufacturing tolerances, when, in use, base surface 20 of tape element 12 is in contact with the upper surface 36a of base web 36, top surface 22 of the earlier tape element 12 of the adjacent winding also is in contact with under surface 42b of cover web 42.

[0039] The tape element 12 and the tape element holder 14 are constructed to allow limited relative displacement of the tape element 12 and the tape element holder 14 in a direction nominally parallel to imaginary lateral centre line "C". Such displacement is provided to allow for bending of the pipe.

[0040] As particularly illustrated in Figure 4, the depth "d" and height "h" of the rebate 30 are sized fully to accommodate third side web 44 of the tape element holder 14 and similarly the depth and height of the rebate 28 are sized fully to accommodate the first side web 38. Taking as an example winding 14_3 of the tape element holder 14 in relation to winding 12_2 of tape element 12 and as shown in Figure 4, it can be seen that winding 14_3 of the tape element 14 is in its maximally extended configuration in which third side web 44_3 is in contacting relation with planar wall segment $30a_2$ of rebate 30_2. First side web 38_2 is spaced apart from second web 40_3 of the later adjacent winding and third side web 44_3 is spaced apart from second web 40_2 of the earlier adjacent winding. The compact configuration which may be adopted when the pipe is not in tension, or when the particular portion of the tape layer form the internal side of a pipe bend, is shown in Figure 4 in relation to windings 14_2 and 14_1 of the tape element holder 14. In this compact configuration, third side web 44_2 is in contacting relation with second web 40_1 of earlier adjacent winding 14_1 and second web 40_2 is in contacting relation with first side web 38_1 of earlier adjacent winding 14_1.

[0041] The composite tape according to certain embodiments of the present invention is wound helically around components of a pipe body to provide a helically wound tape layer. The helical winding may comprises one or more starts. By providing a composite tape having as a first part a tape element and as a second part a tape element holder, functions of the tape are separated between the respective components of the composite tape. Thus, the interlocking function is provided by the tape element holder and the strength imparting function is provided by the tape element. The properties of the tape element and the tape element holder can thus be optimised to their respective functions. For example, the tape element can be made from a material with substantial uni-axial properties which would prevent it functioning effectively for interlocking, but which are advantageous in maximising strength. Such materials include composites with a high degree of directional bias to fibre reinforcement.

[0042] Throughout the description and claims of this specification, the words "comprise" and "contain" and variations of the words, for example "comprising" and "comprises", means "including but not limited to", and is not intended to (and does not) exclude other moieties, additives, components, integers or steps.

[0043] Throughout the description and claims of this specification, the singular encompasses the plural unless the context otherwise requires. In particular, where the indefinite article is used, the specification is to be understood as contemplating plurality as well as singularity, unless the context requires otherwise.

[0044] Features, integers, characteristics, compounds, chemical moieties or groups described in conjunction with a particular aspect, embodiment or example of the invention are to be understood to be applicable to any other aspect, embodiment or example described herein unless incompatible therewith.

Claims

1. An elongate composite tape for forming at least one helically wound layer of interlocked windings in a flexible pipe body for transporting production fluid, the tape being configured to interlock adjacent windings in the layer of tape by nesting a hooked region of a winding into a hook-receiving region of an adjacent winding, wherein the composite tape comprises:

   an elongate tape element (12) and
   a tape element holder member (14) comprising a first portion (32) configured to retain a given winding of the elongate tape element (12) and a second, hooked portion (34) configured to engage an adjacent winding of the elongate tape element (12),
   wherein the tape element (12) comprises a body having a base surface (20), a top surface (22)

opposed to the base surface (20) and opposed first and second side walls (24, 26) extending between the base surface (20) and the top surface (22),
wherein the first portion (32) of the tape element holder member (14) comprises a base web (36) arranged in confronting relation with the base surface (20) of the tape element (12) and opposed first and second side webs (38, 40) extending from opposed side margins of the base web (36) and arranged in confronting relation to the respective first and second side walls (24, 26) of the tape element (12),
characterised in that the tape element (12) further includes a recess (28), and **in that** the first side wall (24) of the tape element (12) includes the said recess (28) which is sized and configured to receive the first side web (32) of the tape element holder member (14).

2. An elongate composite tape as claimed in claim 1 wherein the second portion (34) of the tape element holder member (14) is configured to extend wholly over the adjacent winding of the elongate tape element (12).

3. An elongate composite tape as claimed in claim 2 wherein the elongate tape element (12) is monolithic.

4. An elongate composite tape as claimed in claim 3 wherein the side webs (38, 40) of the tape element holder member (14) extend substantially perpendicularly with respect to the base web (36).

5. An elongate composite tape as claimed in claim 4 wherein the second portion (34) of the tape element holder member (14) includes a cover web (42) extending from the second side web (40) and a third side web (44) extending from a distal side margin of the cover web (42) and configured to be disposed in use in confronting relation with a distal side wall of the tape element (12) of an earlier adjacent winding.

6. An elongate composite tape as claimed in claim 5 wherein the third side web (44) is substantially parallel to the second side web (40).

7. An elongate composite tape as claimed in claim 5 or 6 wherein the cover web (42) is substantially parallel to the base web (36) of the tape element holder member (14).

8. An elongate composite tape as claimed in any of claims 5 to 7 wherein the second side wall (20) of the tape element (12) includes a further recess (30), sized and configured to receive, in use, the third side web (44) of the tape element holder member (14) of a later adjacent winding.

9. An elongate composite tape as claimed in claim 5 or 6 to 8 wherein the second side web (40) and the tape element (12) are so sized that when, in use, the base surface (20) of the tape element (12) of a given winding is in contacting relation with the inward surface (36a) of the base web (36), the top surface (22) of the tape element of an adjacent winding is in contacting relation with the inward surface (42b) of a cover web (42) of the adjacent winding.

10. An elongate composite tape as claimed in any of claims 6 to 9 wherein the dimension of the tape element (12) between the side walls (24, 26) is less that the corresponding dimension of the tape element holder member (14) between the first and second side webs (38, 40).

11. An elongate composite tape as claimed in any of claims 5 to 10 wherein the dimension of the tape element (12) of the adjacent winding is less than the corresponding dimension of the tape element holder member (14) between the second and third side webs (40, 44).

12. An elongate composite tape as claimed in any of claims 4 to 11 wherein the first side web (38) of the tape element holder member (14) extends for not more than about half the height of the tape element (12), measured between the base surface (20) and the top surface (22).

13. An elongate composite tape as claimed in claim 5 or any of claims 6 to 12 when dependent on claim 5 wherein the third side web (44) of the tape element holder member (14) extends for not more than about half the height of the tape element (12), measured between the base surface (20) and the top surface (22).

14. The elongate composite tape as claimed in claim 1, wherein:

a cross-section of said elongate tape element (12) is rotationally symmetric about an imaginary centre point.

15. The elongate tape composite as claimed in one of claims 1 or 8, wherein:

the recesses (28, 30) respectively comprise a region of the first side wall (24) between the base surface (20) and an outwardly stepped upper region of the first side wall (24) and/or a region of the second side wall (26) between the top surface (22) and an outwardly stepped lower region of the second side wall (26).

16. A flexible pipe body for transporting production fluids,

comprising: at least one helically wound layer of the elongate composite tape as claimed in any of claims 1 to 13, adjacent windings in the layer of tape being interlocked by a hooked region (34) of a winding nested in a hook-receiving region (18) of an adjacent winding.

17. A flexible pipe body as claimed in claim 16 further comprising an internal pressure sheath (120), wherein said at least one tape layer further comprises a pressure armour layer (130) over the internal pressure sheath (120).

18. A flexible pipe comprising the flexible pipe body as claimed in claim 16 or 17 and further comprising at least one end fitting.

19. A riser, flowline or jumper (200) comprising the flexible pipe as claimed in claim 18.

20. A method for manufacturing flexible pipe body, comprising the steps of:

helically winding a preformed composite tape over an underlying layer interlocking adjacent winding of the composite tape by nesting a hooked region of a tape holder element (14) of the composite tape in an adjacent winding of the composite tape, wherein the composite tape comprises an elongate tape element (12) and the tape holder element (14), the tape holder element (14) comprising a first portion (32) configured to retain a given winding of the elongate tape element (12) and a second hooked portion (34) configured to engage an adjacent winding of the elongate tape element (12), wherein the tape element (12) comprises a body having a base surface (20), a top surface (22) opposed to the base surface (20) and opposed first and second side walls (24, 26) extending between the base surface (20) and the top surface (22)
wherein the first portion (32) of the tape holder element (14) comprises a base web (36) arranged in confronting relation with the base surface (20) of the tape element (12) and opposed first and second side webs (38, 40) extending from opposed side margins of the base web (36) and arranged in confronting relation to the respective first and second side walls (24, 26) of the tape element (12),
and wherein the tape element (12) further includes a recess (28) which is sized and configured to receive the first side web (38) of the tape holder element (14), the first side wall (24) of the tape element (12) including the said recess (28).

21. A method for manufacturing flexible pipe body, comprising the steps of:

simultaneously helically winding a tape element (2) and a tape holder element (14) over an underlying layer interlocking adjacent windings by nesting a hooked region of the tape holder element in an adjacent winding, wherein the tape holder element (14) comprises a first portion (32) configured to retain a given winding of the tape element (12) and a second hooked portion (34) configured to engage an adjacent winding of the tape element (12), wherein the tape element (12) comprises a body having a base surface (20), a top surface (22) opposed to the base surface (20) and opposed first and second side walls (24, 26) extending between the base surface (20) and the top surface (22)
wherein the first portion (32) of the tape holder element (14) comprises a base web (36) arranged in confronting relation with the base surface (20) of the tape element (12) and opposed first and second side webs (38, 40) extending from opposed side margins of the base web (36) and arranged in confronting relation to the respective first and second side walls (24, 26) of the tape element (12), and wherein the tape element (12) includes a recess (28) which is sized and configured to receive the first side web (38) of the tape holder element (14), the first side wall (24) of the tape element (12) including the said recess (28).

22. The method as claimed in claim 20 or claim 21 wherein the hooked region of the tape holder element nests between a further recess (30) of a tape element (12) of the adjacent winding and a side web of the tape holder element (14) of the adjacent winding.

23. The method as claimed in any one of claims 20 or 21 when dependent upon 20 wherein the tape holder element (14) has a preformed, substantially S-shaped cross section.

24. The method as claimed in any one of claims 21 or 22 when dependent upon 21 further comprising the steps of:

generating a substantially S-shaped cross-section for the tape holder element (14) from a substantially flat cross section as the tape holder element (14) is wound.

Patentansprüche

1. Längliches Verbundband zum Bilden von wenigstens einer spiralförmig gewickelten Lage von miteinander verriegelten Wicklungen in einem flexiblen Rohrkörper zum Transportieren von Produktionsflu-

id, wobei das Band so konfiguriert ist, dass es benachbarte Wicklungen in der Bandlage durch Verschachteln einer Hakenregion einer Wicklung in einer Hakenaufnahmeregion einer benachbarten Wicklung miteinander verriegelt, wobei das Verbundband Folgendes umfasst:

ein längliches Bandelement (12), und
ein Bandelementhalteglied (14) mit einem ersten Abschnitt (32), der zum Halten einer gegebenen Wicklung des länglichen Bandelements (12) konfiguriert ist, und einem zweiten Abschnitt, dem Hakenabschnitt (34), der zum Eingreifen in eine benachbarte Wicklung des länglichen Bandelements (12) konfiguriert ist,
wobei das Bandelement (12) einen Körper mit einer Bodenseite (20), einer der Bodenseite (20) gegenüberliegenden Deckenseite (22) und gegenüberliegenden ersten und zweiten Seitenwänden (24, 26) umfasst, die zwischen der Bodenseite (20) und der Deckenseite (22) verlaufen,
wobei der erste Abschnitt (32) des Bandelementhalteglieds (14) eine in einer konfrontierenden Beziehung mit der Bodenseite (20) des Bandelements (12) angeordnete Basisbahn (36) und gegenüberliegende erste und zweite Seitenbahnen (38, 40) umfasst, die sich von gegenüberliegenden Seitenrändern der Basisbahn (36) erstrecken und in konfrontierender Beziehung zur jeweiligen ersten und zweiten Seitenwand (24, 26) des Bandelementes (72) angeordnet sind,
dadurch gekennzeichnet, dass das Bandelement (12) ferner eine Aussparung (28) aufweist, und dadurch, dass die erste Seitenwand (24) des Bandelements (12) die genannte Aussparung (28) aufweist, die so bemessen und konfiguriert ist, dass sie die erste Seitenbahn (32) des Bandelementhalteglieds (14) aufnimmt.

2. Längliches Verbundband nach Anspruch 1, wobei der zweite Abschnitt (34) des Bandelementhalteglieds (14) so konfiguriert ist, dass er ganz über die benachbarte Wicklung des länglichen Bandelements (12) verläuft.

3. Längliches Verbundband nach Anspruch 2, wobei das längliche Bandelement (12) monolithisch ist.

4. Längliches Verbundband nach Anspruch 3, wobei die Seitenbahnen (38, 40) des Bandelementhalteglieds (14) im Wesentlichen lotrecht mit Bezug auf die Basisbahn (36) verläuft.

5. Längliches Verbundband nach Anspruch 4, wobei der zweite Abschnitt (34) des Bandelementhalteglieds (14) eine sich von der zweiten Seitenbahn (40) erstreckende Abdeckbahn (42) und eine dritte Seitenbahn (44) aufweist, die sich von einem distalen Seitenrand der Abdeckbahn (42) erstreckt und so konfiguriert ist, dass sie in konfrontierender Beziehung mit einer distalen Seitenwand des Bandelements (12) einer früheren benachbarten Wicklung angeordnet ist.

6. Längliches Verbundband nach Anspruch 5, wobei die dritte Seitenbahn (44) im Wesentlichen parallel zur zweiten Seitenbahn (40) ist.

7. Längliches Verbundband nach Anspruch 5 oder 6, wobei die Abdeckbahn (42) im Wesentlichen parallel zur Basisbahn (36) des Bandelementhalteglieds (14) ist.

8. Längliches Verbundband nach einem der Ansprüche 5 bis 7, wobei die zweite Seitenwand (26) des Bandelements (12) eine weitere Aussparung (3) aufweist, die so bemessen und konfiguriert ist, dass sie beim Gebrauch die dritte Seitenbahn (44) des Bandelementhalteglieds (14) einer späteren benachbarten Wicklung aufnimmt.

9. Längliches Verbundband nach Anspruch 5 oder 6 bis 8, wobei die zweite Seitenbahn (40) und das Bandelement (12) so bemessen sind, dass beim Gebrauch die Bodenseite (20) des Bandelements (12) einer gegebenen Wicklung in Kontaktbeziehung mit der Innenfläche (36a) der Basisbahn (36) ist, die Deckenseite (22) des Bandelements (12) einer benachbarten Wicklung in Kontaktbeziehung mit der Innenfläche (42b) einer Abdeckbahn (42) der benachbarten Wicklung ist.

10. Längliches Verbundband nach einem der Ansprüche 6 bis 9, wobei die Abmessung des Bandelements (12) zwischen den Seitenwänden (24, 26) geringer ist als die entsprechende Abmessung des Bandelementhalteglieds (14) zwischen der ersten und der zweiten Seitenbahn (38, 40).

11. Längliches Verbundband nach einem der Ansprüche 5 bis 10, wobei die Abmessung des Bandelements (12) der benachbarten Wicklung geringer ist als die entsprechende Abmessung des Bandelementhalteglieds (14) zwischen der zweiten und dritten Seitenbahn (40, 44).

12. Längliches Verbundband nach einem der Ansprüche 4 bis 11, wobei sich die erste Seitenbahn (38) des Bandelementhalteglieds (14) über nicht mehr als etwa die Hälfte der Höhe des Bandelements (12) erstreckt, gemessen zwischen der Bodenseite (20) und der Deckenseite (22).

13. Längliches Verbundband nach Anspruch 5 oder ei-

nem der Ansprüche 6 bis 12 in Abhängigkeit von Anspruch 5, wobei sich die dritte Seitenbahn (44) des Bandelementhalteglieds (14) über nicht mehr als etwa die Hälfte des Bandelements (12) erstreckt, gemessen zwischen der Bodenseite (20) und der Deckenseite (22).

14. Längliches Verbundband nach Anspruch 1, wobei ein Querschnitt des genannten länglichen Bandelements (12) rotationssymmetrisch um einen imaginären Mittelpunkt ist.

15. Längliches Verbundband nach Anspruch 1 oder 8, wobei die Aussparungen (28, 30) jeweils eine Region der ersten Seitenwand (24) zwischen der Bodenseite (20) und einer nach außen gestuften oberen Region der ersten Seitenwand (24) und/oder eine Region der zweiten Seitenwand (26) zwischen der Deckenseite (22) und einer nach außen gestuften unteren Region der zweiten Seitenwand (26) aufweist.

16. Flexibler Rohrkörper zum Transportieren von Produktions fluiden, der Folgendes umfasst: wenigstens eine spiralförmig gewickelte Lage des länglichen Verbundbands nach einem der Ansprüche 1 bis 13, wobei benachbarte Wicklungen in der Bandlage durch eine Hakenregion (34) einer Wicklung miteinander verriegelt sind, die in einer Hakenaufnahmeregion (18) einer benachbarten Wicklung verschachtelt sind.

17. Flexibler Rohrkörper nach Anspruch 16, der ferner einen inneren Druckmantel (120) aufweist, wobei die genannte wenigstens eine Bandlage ferner eine Druckarmierungslage (130) über dem inneren Druckmantel (120) aufweist.

18. Flexibles Rohr, das den flexiblen Rohrkörper nach Anspruch 16 oder 17 umfasst und ferner wenigstens ein Endanschlussstück umfasst.

19. Steigleitung, Durchflussleitung oder Überbrückungsleitung (Jumper) (200), die das flexible Rohr nach Anspruch 18 umfasst.

20. Verfahren zur Herstellung eines flexiblen Rohrkörpers, das die folgenden Schritte beinhaltet:

spiralförmiges Wickeln eines vorgeformten Verbundbands über eine darunter liegende Lage, die eine benachbarte Wicklung des Verbundbandes durch Verschachteln einer Hakenregion eines Bandhalteelementes (14) des Verbundbandes mit einer benachbarten Wicklung des Verbundbandes verriegelt, wobei das Verbundband ein längliches Bandelement (12) und das Bandhalteelement (14) umfasst, wobei das Bandhalteelement (14) einen ersten Abschnitt (32) aufweist, der zum Festhalten einer gegebenen Wicklung des länglichen Bandelements (12) konfiguriert ist, und einen zweiten Hakenabschnitt (34), der zum Eingreifen in eine benachbarte Wicklung des länglichen Banelements (12) konfiguriert ist, wobei das Bandelement (12) einen Körper mit einer Bodenseite (20), einer der Bodenseite (20) gegenüberliegenden Deckenseite (22) und gegenüberliegenden ersten und zweiten Seitenwänden (24, 26) umfasst, die zwischen der Bodenseite (20) und der Deckenseite (22) verlaufen,
wobei der erste Abschnitt (32) des Bandhalteelements (14) eine Basisbahn (36) umfasst, die in einer konfrontierenden Beziehung mit der Bodenseite (20) des Bandelements (12) und gegenüberliegenden ersten und zweiten Seitenbahnen (38, 40) angeordnet ist, die sich von gegenüberliegenden Seitenrändern der Basisbahn (36) erstrecken, und in konfrontierender Beziehung zu der jeweiligen ersten und zweiten Seitenwand (24, 26) des Bandelements (12) angeordnet sind,
wobei das Bandelement (12) ferner eine Aussparung (28) aufweist, die so bemessen und konfiguriert ist, dass sie die erste Seitenbahn (38) des Bandhalteelements (14) aufnimmt, wobei die erste Seitenwand (24) des Bandelements (12) die genannte Aussparung (28) aufweist.

21. Verfahren zur Herstellung eines flexiblen Rohrkörpers, das die folgenden Schritte beinhaltet:

gleichzeitiges spiralförmiges Wickeln eines Bandelementes (2) und eines Bandhalteelementes (14) über eine zu Grunde liegende Lage, die benachbarte Wicklungen durch Verschachteln einer Hakenregion des Bandhalteelementes in einer benachbarten Wicklung verriegelt, wobei das Bandhalteelement (14) einen ersten Abschnitt (32) aufweist, der so konfiguriert ist, dass er eine gegebene Wicklung des Bandelements (12) festhält, und einen zweiten Hakenabschnitt (34), der zum Eingreifen in eine benachbarte Wicklung des Bandelementes (2) konfiguriert ist,
wobei das Bandelement (12) einen Körper mit einer Bodenseite (20), einer der Bodenseite (20) gegenüberliegenden Deckenseite (22) und gegenüberliegenden ersten und zweiten Seitenwänden (24, 26) umfasst, die zwischen der Bodenseite (20) und der Deckenseite (22) verlaufen,
wobei der erste Abschnitt (32) des Bandhalteelementes (14) eine Basisbahn (36) umfasst, die in konfrontierender Beziehung mit der Boden-

seite (20) des Bandelements (12) und gegenüberliegenden ersten und zweiten Seitenbahnen (38, 40) angeordnet ist, die sich von gegenüberliegenden Seitenrändern der Basisbahn (36) erstrecken und in konfrontierender Beziehung zu den jeweiligen ersten und zweiten Seitenwänden (24, 26) des Bandelementes (12) angeordnet sind,
und wobei das Bandelement (12) eine Aussparung (28) aufweist, die so bemessen und konfiguriert ist, dass sie die erste Seitenbahn (33) des Bandhalteelementes (14) aufnimmt, wobei die erste Seitenwand (24) des Bandelementes (12) die genannte Aussparung (28) aufweist.

22. Verfahren nach Anspruch 20 oder Anspruch 21, wobei die Hakenregion des Bandhalteelements zwischen einer weiteren Aussparung (30) eines Bandelements (12) der benachbarten Wicklung und einer Seitenbahn des Bandhalteelements (14) der benachbarten Wicklung verschachtelt ist.

23. Verfahren nach Anspruch 20 oder 21 in Abhängigkeit von Anspruch 20, wobei das Bandhalteelement (14) einen vorgeformten, im Wesentlichen S-förmigen Querschnitt hat.

24. Verfahren nach Anspruch 21 oder 22 in Abhängigkeit von Anspruch 21, das ferner den Schritt des Erzeugens eines im Wesentlichen S-förmigen Querschnitts für das Bandhalteelement (14) von einem im Wesentlichen flachen Querschnitt beinhaltet, während das Bandhalteelement (14) gewickelt wird.

Revendications

1. Ruban composite allongé pour former au moins une couche, enroulée de façon hélicoïdale, d'enroulements imbriqués dans un corps de tuyau souple afin d'assurer l'acheminement de fluides de production, le ruban étant configuré pour imbriquer des enroulements adjacents dans la couche en ruban grâce à l'emboîtement d'une région à crochets d'un enroulement dans une région réceptrice de crochets d'un enroulement adjacent, cas dans lequel le ruban composite comprend :

un élément ruban allongé (12) et
un organe de retenue de l'élément ruban (14) comportant une première portion (32) laquelle est configurée pour retenir un enroulement spécifique de l'élément ruban allongé (12), et une seconde portion à crochets (34) configurée pour se solidariser avec un enroulement adjacent de l'élément ruban allongé (12),
cas dans lequel l'élément ruban (12) comporte un corps possédant une surface de base (20), une surface supérieure (22) opposée à la surface de base (20) et opposée à des première et deuxième parois latérales (24, 26) s'étendant entre la surface de base (20) et la surface supérieure (22),
cas dans lequel la première portion (32) de l'organe de retenue de l'élément ruban (14) comporte une nappe de base (36) laquelle est agencée en relation de vis-à-vis avec la surface de base (20) de l'élément ruban (12) et opposée à des première et deuxième nappes latérales (38, 40) lesquelles s'étendent à partir de marges latérales opposées de la nappe de base (36) et agencées en relation de vis-à-vis par rapport aux première et deuxième parois latérales respectives (24, 26) de l'élément ruban (12),
caractérisé en ce que l'élément ruban (12) comporte en outre un évidement (28), et **en ce que** la première paroi latérale (24) de l'élément ruban (12) inclut ledit évidement (28) qui est dimensionné et configuré pour recevoir la première nappe latérale (32) de l'organe de retenue de l'élément ruban (14).

2. Ruban composite allongé selon la revendication 1, la seconde portion (34) de l'organe de retenue de l'élément ruban (14) étant configurée pour s'étendre entièrement au-dessus de l'enroulement adjacent de l'élément ruban allongé (12).

3. Ruban composite allongé selon la revendication 2, l'élément ruban allongé (12) étant monolithique.

4. Ruban composite allongé selon la revendication 3, les nappes latérales (38, 40) de l'organe de retenue de l'élément ruban (14) s'étendant sensiblement dans un plan perpendiculaire par rapport à la nappe de base (36).

5. Ruban composite allongé selon la revendication 4, la seconde portion (34) de l'organe de retenue de l'élément ruban (14) incluant une nappe de recouvrement (42) laquelle s'étend depuis la deuxième nappe latérale (40) et une troisième nappe latérale (44) laquelle s'étend depuis une marge latérale distale de la nappe de recouvrement (42), et configurée de façon à être disposée, lors de l'utilisation, en relation de vis-à-vis avec une paroi latérale distale de l'élément ruban (12) d'un enroulement adjacent antérieur.

6. Ruban composite allongé selon la revendication 5, la troisième nappe latérale (44) étant sensiblement parallèle à la deuxième nappe latérale (40).

7. Ruban composite allongé selon la revendication 5 ou 6, la nappe de recouvrement (42) étant sensiblement parallèle à la nappe de base (36) de l'organe

de retenue de l'élément ruban (14).

8. Ruban composite allongé selon l'une quelconque des revendications 5 à 7, la deuxième paroi latérale (20) de l'élément ruban (12) incluant un évidement supplémentaire (30) lequel est dimensionné et configuré pour recevoir, lors de l'utilisation, la troisième nappe latérale (44) de l'organe de retenue de l'élément ruban (14) d'un enroulement adjacent ultérieur.

9. Ruban composite allongé selon la revendication 5 ou 6 à 8, la deuxième nappe latérale (40) et l'élément ruban (12) étant dimensionnés de telle sorte que, lors de l'utilisation, la surface de base (20) de l'élément ruban (12) d'un enroulement spécifique se trouve en relation de contact avec la surface dirigée vers l'intérieur (36a) de la nappe de base (36), alors que la surface supérieure (22) de l'élément ruban (12) d'un enroulement adjacent est en relation de contact avec la surface dirigée vers l'intérieur (42b) d'une nappe de recouvrement (42) de l'enroulement adjacent.

10. Ruban composite allongé selon l'une quelconque des revendications 6 à 9, la dimension de l'élément ruban (12) entre les parois latérales (24, 26) étant inférieure à la dimension correspondante de l'organe de retenue de l'élément ruban (14) entre les première et deuxième nappes latérales (38, 40).

11. Ruban composite allongé selon l'une quelconque des revendications 5 à 10, la dimension de l'élément ruban (12) de l'enroulement adjacent étant inférieure à la dimension correspondante de l'organe de retenue de l'élément ruban (14) entre les deuxième et troisième nappes latérales (40, 44).

12. Ruban composite allongé selon l'une quelconque des revendications 4 à 11, la première nappe latérale (38) de l'organe de retenue de l'élément ruban (14) s'étendant sur une distance ne dépassant pas la moitié environ de la hauteur de l'élément ruban (12), telle qu'elle est mesurée entre la surface de base (20) et la surface supérieure (22).

13. Ruban composite allongé selon la revendication 5 ou l'une quelconque des revendications 6 à 12, quand elle est subordonnée à la revendication 5, la troisième nappe latérale (44) de l'organe de retenue de l'élément ruban (14) s'étendant sur une distance ne dépassant pas la moitié environ de la hauteur de l'élément ruban (12), telle qu'elle est mesurée entre la surface de base (20) et la surface supérieure (22).

14. Ruban composite allongé selon la revendication 1 :

une coupe transversale dudit élément ruban allongé (12) étant symétrique sur le plan de la rotation autour d'un point central imaginaire.

15. Ruban composite allongé selon l'une quelconque des revendications 1 ou 8 :

les évidements (28, 30) comportant respectivement une région de la première paroi latérale (24), entre la surface de base (20) et une région supérieure à gradins dirigée vers l'extérieur de la première paroi latérale (24) et/ou une région de la deuxième paroi latérale (26) entre la surface supérieure (22) et une région inférieure à gradins dirigée vers l'extérieur de la deuxième paroi latérale (26).

16. Corps de tuyau souple pour assurer l'acheminement de fluides de production comprenant : au moins une couche, enroulée de façon hélicoïdale, du ruban composite allongé selon l'une quelconque des revendications 1 à 13, des enroulements adjacents dans la couche en ruban étant imbriqués par une région à crochets (34) d'un enroulement emboîté dans une région réceptrice de crochets (18) d'un enroulement adjacent.

17. Corps de tuyau souple selon la revendication 16, comprenant en outre une gaine anti-pression intérieure (120), cas dans lequel ladite au moins une couche en ruban comporte en outre une couche armée anti-pression (130) située au-dessus de la gaine anti-pression intérieure (120).

18. Tuyau souple comportant le corps de tuyau souple, selon la revendication 16 ou 17, et comportant en outre au moins un raccord d'extrémité.

19. Colonne montante, conduite d'écoulement ou tuyau de pontage (200) comprenant le tuyau souple selon la revendication 18.

20. Procédé de fabrication d'un corps de tuyau souple, comprenant les étapes consistant à :

enrouler de façon hélicoïdale un ruban composite préformé au-dessus d'une couche sous-jacente imbriquant un enroulement adjacent sur le ruban composite grâce à l'emboîtement d'une région à crochets d'un élément de retenue de ruban (14) du ruban composite dans un enroulement adjacent du ruban composite, cas dans lequel le ruban composite comporte un élément ruban allongé (12) et l'élément de retenue de ruban (14), l'élément de retenue de ruban (14) comportant une première portion (32) laquelle est configurée pour retenir un enroulement spécifique de l'élément ruban allongé (12), et une seconde portion à crochets (34) configurée pour se solidariser avec un enroulement adjacent de

l'élément ruban allongé (12), cas dans lequel l'élément ruban (12) comporte un corps possédant une surface de base (20), une surface supérieure (22) opposée à la surface de base (20) et opposée à des première et deuxième parois latérales (24, 26) s'étendant entre la surface de base (20) et la surface supérieure (22),
cas dans lequel la première portion (32) de l'élément de retenue de ruban (14) comporte une nappe de base (36) laquelle est agencée en relation de vis-à-vis avec la surface de base (20) de l'élément ruban (12) et opposée à des première et deuxième nappes latérales (38, 40) lesquelles s'étendent à partir de marges latérales opposées de la nappe de base (36) et agencées en relation de vis-à-vis par rapport aux première et deuxième parois latérales respectives (24, 26) de l'élément ruban (12), et cas dans lequel l'élément ruban (12) comporte en outre un évidement (28) qui est dimensionné et configuré pour recevoir la première nappe latérale (38) de l'élément de retenue de ruban (14), alors que la première paroi latérale (24) de l'élément ruban (12) inclut ledit évidement (28).

21. Procédé de fabrication d'un corps de tuyau souple, comprenant les étapes consistant à :

simultanément enrouler de façon hélicoïdale un élément ruban (2) et un élément de retenue de ruban (14) au-dessus d'une couche sous-jacente imbriquant des enroulements adjacents grâce à l'emboîtement d'une région à crochets de l'élément de retenue de ruban dans un enroulement adjacent, cas dans lequel l'élément de retenue de ruban (14) comporte une première portion (32) laquelle est configurée pour retenir un enroulement spécifique de l'élément ruban (12), et une seconde portion à crochets (34) configurée pour se solidariser avec un enroulement adjacent de l'élément ruban (12), cas dans lequel l'élément ruban (12) comporte un corps possédant une surface de base (20), une surface supérieure (22) opposée à la surface de base (20) et opposée à des première et deuxième parois latérales (24, 26) s'étendant entre la surface de base (20) et la surface supérieure (22),
cas dans lequel la première portion (32) de l'élément de retenue de ruban (14) comporte une nappe de base (36) laquelle est agencée en relation de vis-à-vis avec la surface de base (20) de l'élément ruban (12) et opposée à des première et deuxième nappes latérales (38, 40) lesquelles s'étendent à partir de marges latérales opposées de la nappe de base (36) et agencées en relation de vis-à-vis par rapport aux première et deuxième parois latérales respectives (24, 26) de l'élément ruban (12), et cas dans lequel l'élément ruban (12) comporte un évidement (28) qui est dimensionné et configuré pour recevoir la première nappe latérale (38) de l'élément de retenue de ruban (14), alors que la première paroi latérale (24) de l'élément ruban (12) inclut ledit évidement (28).

22. Procédé selon la revendication 20 ou la revendication 21, la région à crochets de l'élément de retenue de ruban étant emboîtée entre un évidement supplémentaire (30) d'un élément ruban (12) de l'enroulement adjacent et une nappe latérale de l'élément de retenue de ruban (14) de l'enroulement adjacent.

23. Procédé selon l'une quelconque des revendications 20 ou 21, lorsqu'elle est subordonnée à la revendication 20, l'élément de retenue de ruban (14) présentant une coupe transversale préformée sensiblement en forme de S.

24. Procédé selon l'une quelconque des revendications 21 ou 22, lorsqu'elle est subordonnée à la revendication 21, comprenant en outre l'étape consistant à :

générer une coupe transversale sensiblement en forme de S pour l'élément de retenue de ruban (14) à partir d'une coupe transversale sensiblement plate au fur et à mesure que l'élément de retenue de ruban (14) est enroulé.

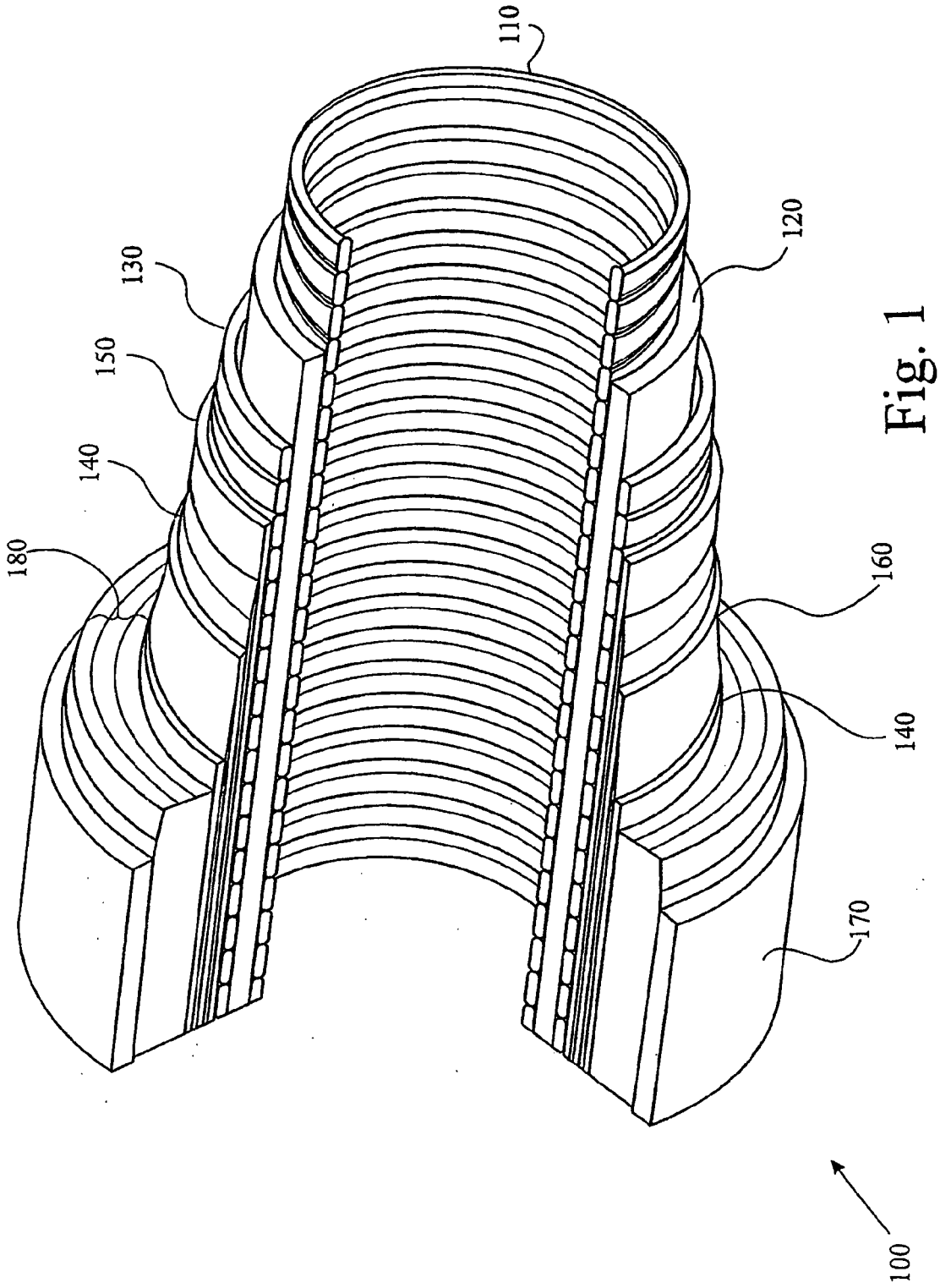


Fig. 1

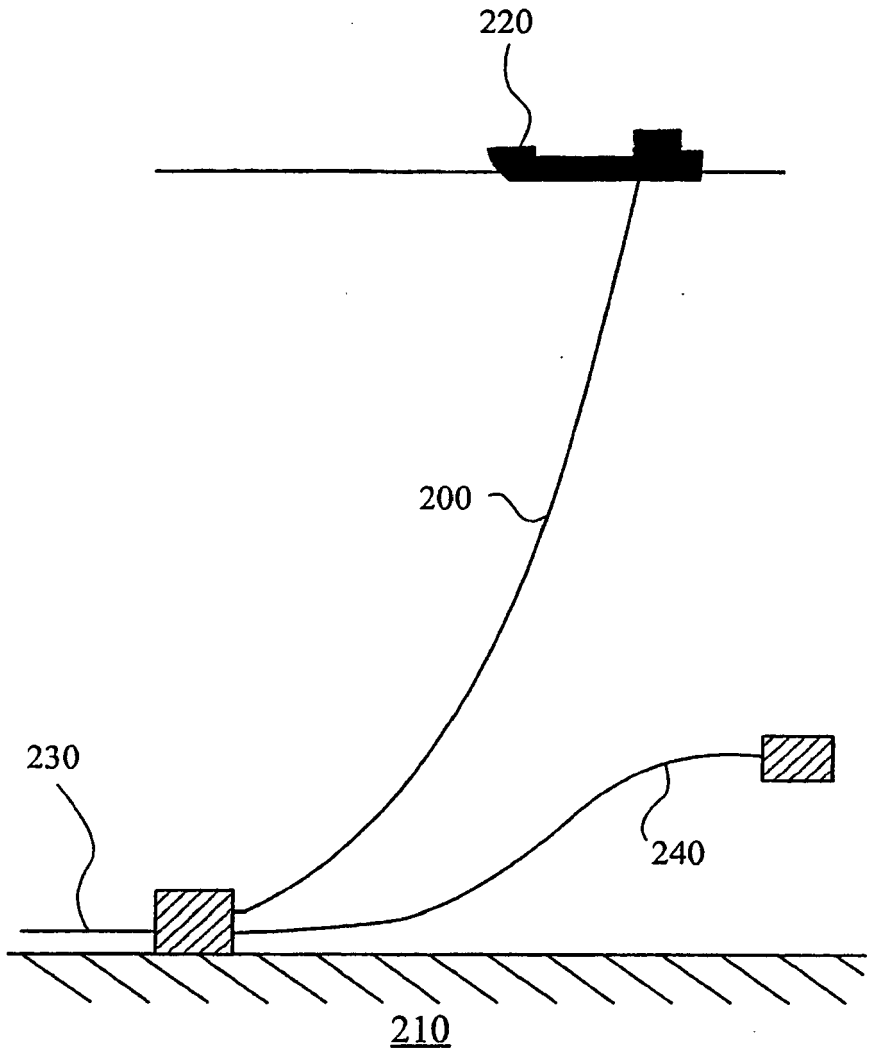


Fig. 2

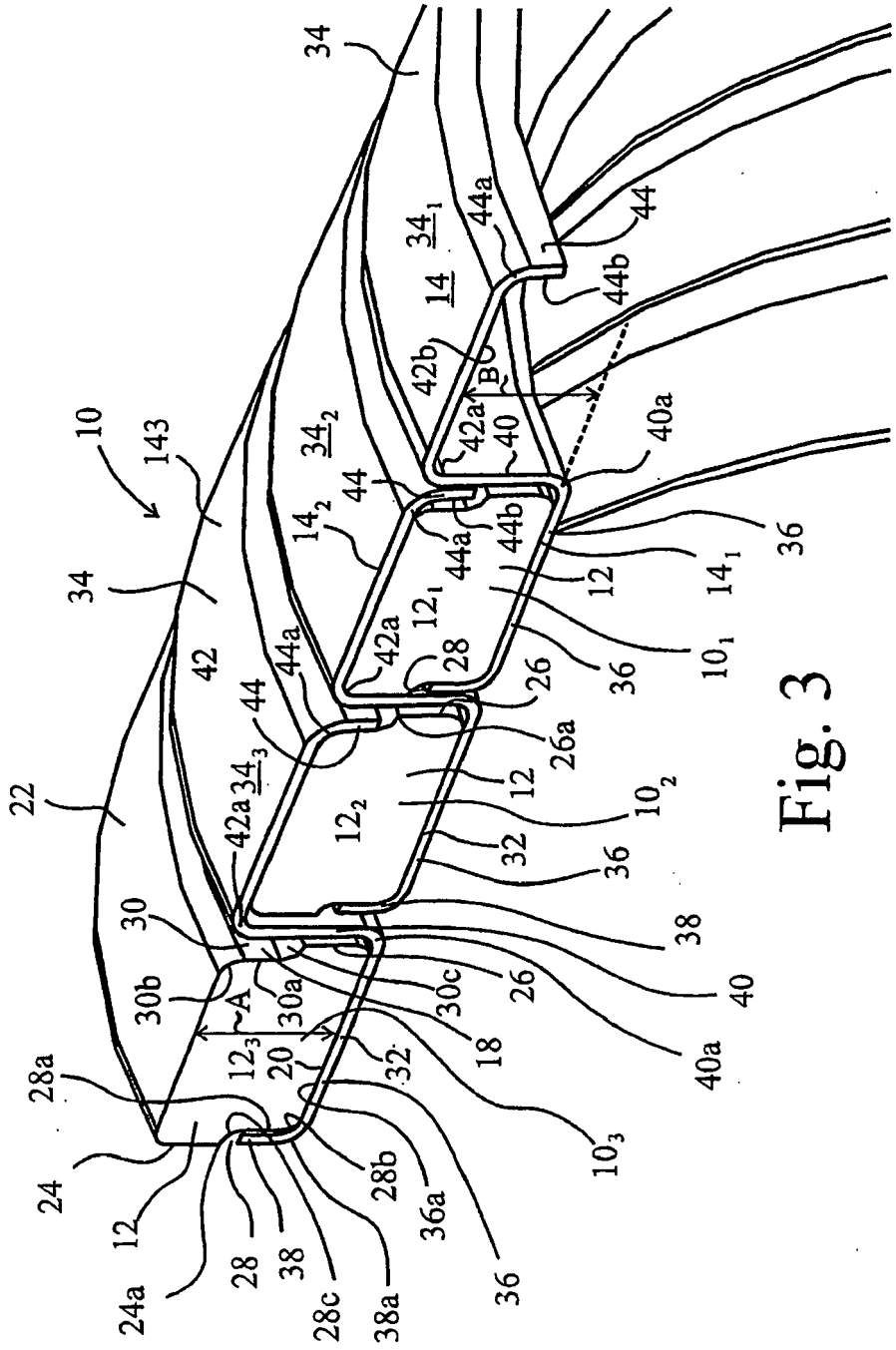

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44a
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26a
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10_2
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10_1

Fig. 3

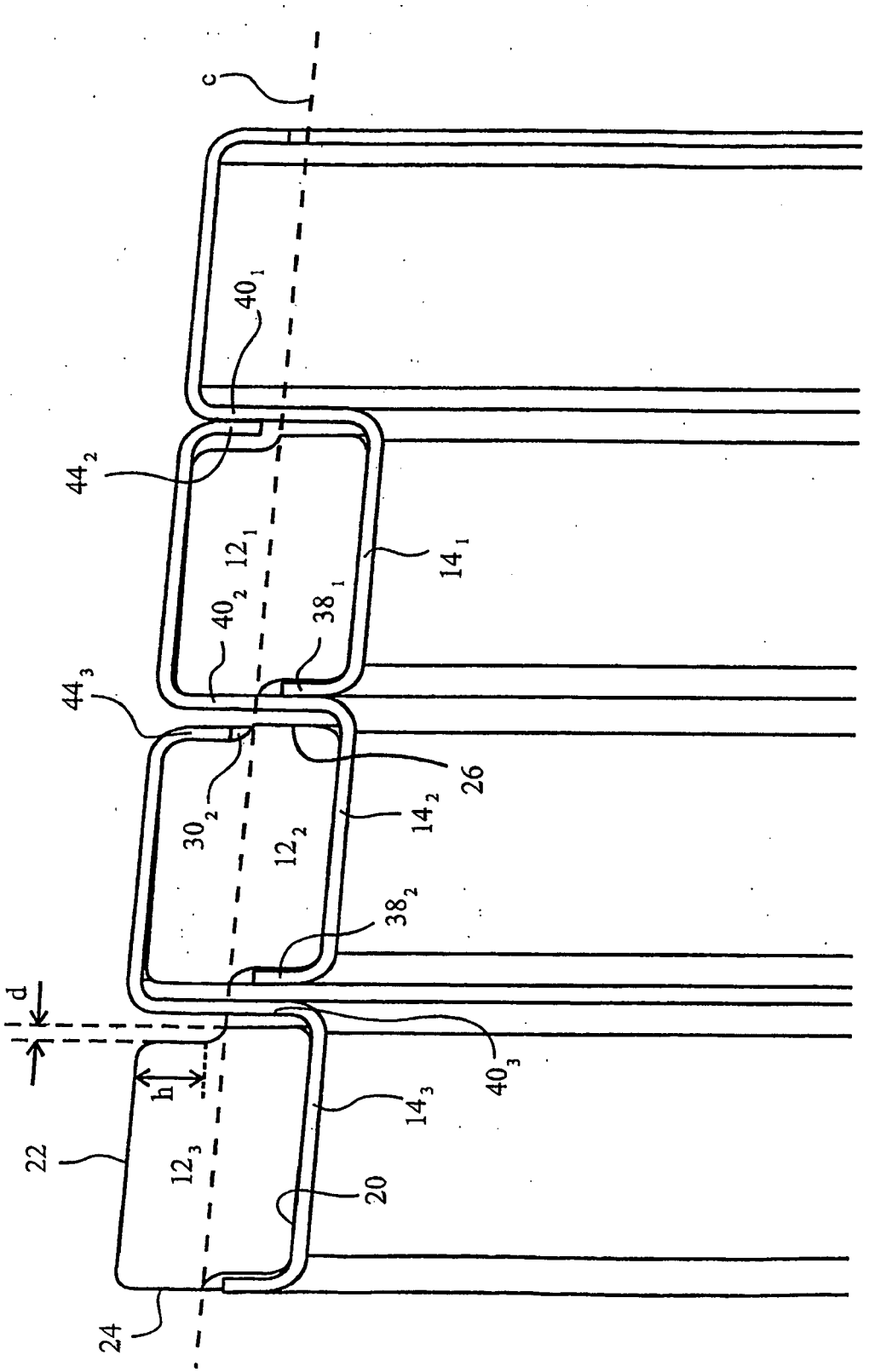

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14_1
44_3
26
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12_2
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38_2
d
h
40_3
14_3
22
12_3
20
24

Fig. 4

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- EP 0929767 A **[0005]**
- GB 191022719 A **[0006]**