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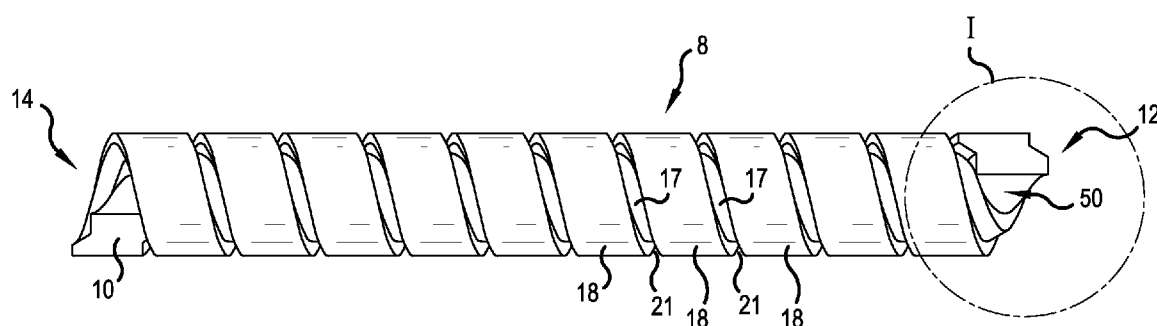


FIG. 1

(57) Abstract: A cable protector has a helical winding which adds rigidity to a cable inserted therein, while still exhibiting flexibility to navigate curves within a conduit. The helical winding allows a flaccid small cable to be pushed into a conduit and protects the cable from damage. The helical winding may include a first protrusion and second indentation extending along a first side of the helical winding at radially outer and inner portions, respectively, of the helical winding. The helical winding may also include a second protrusion and a first indentation extending along a second side of the helical winding at radially inner and outer portions, respectively, of the helical winding. The first and second protrusions face the first and second indentations of adjacent sections within the helical winding. A first gap is optionally formed between the second protrusion and first indentation. A second gap is formed between the first protrusion and first indentation.



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FLEXIBLE PUSHABLE CABLE WITH SELF-LOCKING
ANTI-BUCKLING STRUCTURAL ELEMENT

FIELD OF THE INVENTION

5 **[0001]** The present invention relates to a helical winding installed upon a cable to provide improved a push capability of the cable when installing the cable into a conduit. The helical winding protects the cable contained therein during a pushing operation, and provides a new pushing method to install the cable into the conduit.

BACKGROUND OF THE INVENTION

10 **[0002]** It is often desirable to install a cable into a conduit by a pushing operation. An end of the cable is inserted into a first end of a conduit and then the cable is fed into and pushed through the conduit until the inserted end of the cable exits at a second end of the conduit. Commonly one or more curved fittings, e.g., ninety degrees or forty-five degrees, are positioned
15 along the length of the conduit. If thin, flaccid cables, such as small fiber optic cables or small gauge electric cables, are fed through conduits, it is common that the cable push operation will fail. At one bend or another within the conduit, or as the cable abuts a pre-existing cable within the conduit, the cable will kink or loop back upon itself. Further in-feeding of cable results in overlapping and tangling of the cable, e.g., similar to a bird's nest, at the bend or obstacle within
20 the conduit. Therefore, it is desirable to reinforce the cable to improve its rigidity prior to a pushing operation.

25 **[0003]** Communication and power cables in various applications where movement occurs in exposed environmental areas and/or in rough conditions will often need reinforcement so that the cable is not damaged as it is repeatedly flexed and/or encounters obstacles. One class of reinforcement is commonly known as a chain protector. Chain protectors may be used on moving printer head cables, reciprocating textile shuttle cables, power cables for vehicles, etc. The reciprocating nature of the movement of the cable heightens the risk of a kink or deformation of the cable that would render the cable inoperable. The cable protectors in this class tend to resemble chain-linked or hinged conduit segments with air gaps between the
30 conduit segments. Examples of such protectors may be found in US Patent numbers 3,994,373;

4,111,236; 4,228,825; 4,702,281; 4,727,908; 5,178,247; 5,445,252; 5,860,274; and 7,426,824, the disclosures of which are hereby incorporated by reference in their entirety.

[0004] Such hinged conduit segments are limited in their range of bending to flexing about the hinges along a single axis. Therefore, such chain protectors may not be well suited to push a cable through a conduit, as the cable may encounter bends within the conduit which do not align with the axis of the hinges between the conduit segments. Also, the large openings between the conduit segments can catch on other pre-existing cables within the conduit and stop the progress of the chain-protected cable through the conduit during a pushing operation.

[0005] Additionally, another class of cable reinforcements is casings and sheaths for cables to increase their rigidity. This increased rigidity allows for better transfer of longitudinal forces along the cable, so that the cable and its reinforcement may be pushed through a conduit with enough force to overcome the friction of the cable rubbing along bends in the conduit. This class of cable reinforcements focuses on tight sheaths surrounding cables to increase rigidity. Patents in this class of cable protectors are illustrated in US Patent numbers 2,706,494; 3,015,969; 6,479,752; 7,705,241; 8,222,525 and 10,325,468, the disclosures of which are hereby incorporated by reference in their entirety.

[0006] In particular, US Patent 2,706,494 to Morse discloses a cable casing with multiple layers around an inner grouping of cables. The outer layers circumferentially surround the inner grouping of cables as a continuous sequence of rings that are radial and perpendicular to the longitudinal direction of the internal cables. The various cable casings, however, increase rigidity at the expense of flexibility, which limits the angle of bends in a conduit that the cable and casing can navigate. In other words, the flexibility is limited and often sacrificed to increase the rigidity for longitudinal strength. Further, many of these casings and sheaths are factory installed and often include an extruded outer jacket. The casings and sheaths may not be installed onto a cable and/or removed from a cable by a field technician.

SUMMARY OF THE INVENTION

[0007] It is an object of the present invention to address one or more of the disadvantages of the prior art. For example, the flat edge to edge mating of the rings, found in US Patent 2,706,494, results in immediate resistance to any bending in any direction. In addition, since all the longitudinal force is directed to these edges, the ring reinforcements are susceptible to giving

way and sliding radially unless secured by another tight layer, such as the outer jacket in US Patent 2,706,494. The outer jacket, however, only further decreases the flexibility of the cable and casing and adds costs. It is, therefore, an object of the invention to provide flexibility, but also strength to a cable when pushed.

5 **[0008]** Many of the solutions of the prior art are applied to the cable in a factory setting. It is a further object of the invention to provide a cable protector, which can be assembled onto the cable in the field. It is yet a further object of the invention to provide a cable protector which is optionally removable from the cable.

[0009] These and other objects are provided by a cable protector having a helical
10 winding comprising: a first protrusion extending along a first side of said helical winding at a radially outer portion of said helical winding; a second protrusion extending along a second side of said helical winding at a radially inner portion of said helical winding; a first indentation extending along said second side of said helical winding at said outer portion of said helical winding; and a second indentation extending along said first side of said helical winding at said
15 inner portion of said helical winding, wherein adjacent sections within said helical winding have said first protrusion facing said first indentation and also have said second protrusion facing said second indentation.

[0010] Moreover, these and other objects are provided by a cable and cable protector having a helical winding comprising: a first feature extending along a first side of said helical
20 winding; a second feature extending along a second side of said helical winding; an open core formed within said helical winding; and said cable positioned within said open core and extending from a first end of said helical winding to a second end of said helical winding, wherein adjacent sections within said helical winding have said first feature gapped from said second feature when in a stable uncompressed state, and said adjacent sections of said helical
25 winding have said first feature in abutment with said second feature when in a compressed state.

[0011] Further, these and other objects are provided by a method of installing a cable within a conduit, comprising: attaching the cable protector to the cable; and pushing the cable protector with the cable therein through the conduit, where the cable protector includes a helical
winding comprising: a first protrusion extending along a first side of said helical winding at a
30 radially outer portion of said helical winding; a second protrusion extending along a second side of said helical winding at a radially inner portion of said helical winding; a first indentation

extending along said second side of said helical winding at said outer portion of said helical winding; and a second indentation extending along said first side of said helical winding at said inner portion of said helical winding, wherein adjacent sections within said helical winding have said first protrusion facing said first indentation and also have said second protrusion facing said second indentation.

[0012] Further scope of applicability of the present invention will become apparent from the detailed description given hereinafter. However, it should be understood that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications will become apparent to those skilled in the art from this detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The present invention will become more fully understood from the detailed description given hereinbelow and the accompanying drawings, which are given by way of illustration only, and thus, are not limits of the present invention, and wherein:

[0014] FIG. 1 is a side view of a helical winding according to an embodiment of the present invention;

[0015] FIG. 1A is a close-up view of a first end of the helical winding of Fig. 1, as enclosed within a circle labeled I in Figs. 1 and 1A;

[0016] FIG. 2 is a left side perspective view of the helical winding of FIG. 1 with a cable contained therein;

[0017] FIG. 2A is a close-up view of a second end of the helical winding of FIG. 2, as enclosed within a circle labeled II in Figs. 2 and 2A;

[0018] FIG. 3 is a cross sectional view of the helical winding and cable taken along line III-III in Fig. 2 while placed inside of a conduit;

[0019] FIG. 3A is a cross sectional view similar to Fig. 3, but showing an alternative embodiment of the present invention;

[0020] FIG. 4 is a view of a profile the helical winding of Figs. 1-3;

[0021] FIG. 5 is a cross sectional view of the helical winding of Fig. 1 under lateral stress according to an implementation of the invention;

[0022] FIG. 6 is a side view of the helical winding of Fig. 1 under lateral stress according

to an implementation of the invention;

[0023] FIG. 7 is a left side perspective view of the helical winding of Fig. 2 inserted into a first end of a conduit with other cables; and

[0024] FIG. 8 is a flow chart of a method of installing of a cable within a conduit using a helical winding according to an implementation of the invention.

DETAILED DESCRIPTION OF THE DRAWINGS

[0025] The present invention now is described more fully hereinafter with reference to the accompanying drawings, in which embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art.

[0026] Like numbers refer to like elements throughout. In the figures, the thickness of certain lines, layers, components, elements or features may be exaggerated for clarity.

[0027] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the invention. Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. It will be further understood that terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the specification and relevant art and should not be interpreted in an idealized or overly formal sense unless expressly so defined herein. Well-known functions or constructions may not be described in detail for brevity and/or clarity.

[0028] As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items. As used herein, phrases such

as "between X and Y" and "between about X and Y" should be interpreted to include X and Y. As used herein, phrases such as "between about X and Y" mean "between about X and about Y." As used herein, phrases such as "from about X to Y" mean "from about X to about Y."

[0029] It will be understood that when an element is referred to as being "on", "attached" to, "connected" to, "coupled" with, "contacting", etc., another element, it can be directly on, attached to, connected to, coupled with or contacting the other element or intervening elements may also be present. In contrast, when an element is referred to as being, for example, "directly on", "directly attached" to, "directly connected" to, "directly coupled" with or "directly contacting" another element, there are no intervening elements present. It will also be appreciated by those of skill in the art that references to a structure or feature that is disposed "adjacent" another feature may have portions that overlap or underlie the adjacent feature.

[0030] Spatially relative terms, such as "under", "below", "lower", "over", "upper", "lateral", "left", "right" and the like, may be used herein for ease of description to describe one element or feature's relationship to another element(s) or feature(s) as illustrated in the figures.

It will be understood that the spatially relative terms are intended to encompass different orientations of the device in use or operation in addition to the orientation depicted in the figures. For example, if the device in the figures is inverted, elements described as "under" or "beneath" other elements or features would then be oriented "over" the other elements or features. The device may be otherwise oriented (rotated 90 degrees or at other orientations) and the descriptors of relative spatial relationships used herein interpreted accordingly.

[0031] Fig. 1 depicts a side view of a segment 8 of a helical winding 10. The segment 8 as depicted in Fig. 1 is in a static, stable, unstressed, uncompressed state. The segment 8 is unbent and without an inserted cable. A first cut is formed at a first end 12 of the segment 8, and a second cut is formed at a second end 14 of the segment 8. The segment 8 of the helical winding 10 may be formed of any desired length. The cut ends of the segment 8 illustrated in Fig. 1 are positioned so that the profile of the helical winding 10 is visible.

[0032] Fig. 1A is a close-up view of the first end 12 of the helical winding 10 of Fig. 1, as enclosed within a circle labeled I in Figs. 1 and 1A. A radially outer portion of the helical winding 10 forms an outer surface 18 of the segment 8. The radially outer portion includes a projection or first protrusion 11 facing toward the second end 14 of the segment 8 and a first indentation 13 facing toward the first end 12 of the segment 8. A radially inner portion of the

helical winding 10 includes a second protrusion 17 facing the first end 12 of the segment 8 and a second indentation 15 facing the second end 14 of the segment 8. The first protrusion 11 is adjacent to, and radially outward of, the second indentation 15, while the second protrusion 17 is adjacent to and radially inward of the first indentation 13. The first and second protrusions 11 and 17 and the first and second indentations 13 and 15 are formed continuously along the helical twists of the helical winding 10. Gaps 21 between the outer surfaces 18 of helical winding 10, as illustrated in Fig. 1, reveal the second protrusion 17 and block a view of an open core 50 within the helical winding 10.

[0033] As can be seen in the Fig. 1A, the transition between the radially outward, first indentation 13 and the radially inward, second protrusion 17 occurs along a first portion 19 of the helical winding 10. The first portion 19 is not parallel to the outer surface 18, but rather has an angle or slope, such that an end of the first portion 19 attached to the first indentation 13 is radially outward relative to an end of the first portion 19 attached to the second protrusion 17. The angle or slope of the first portion 19 more easily engages and guides the second protrusion 17 into the second indentation 15 of an adjacent portion of the helical winding 10, when the second end 14 of segment 8 is pushed toward the first end 12 of the segment 8, and the gaps 21 close along the length of the segment 8.

[0034] Likewise, the transition between the radially outward first protrusion 11 and the radially inward second indentation 15 occurs along a second portion 16 of the helical winding 10. The second portion 16 is not parallel to the outer surface 18, but rather has an angle or slope, such that an end of the second portion 16 attached to the first protrusion 11 is radially outward relative to an end of the second portion 16 attached to the second indentation 15. The angle or slope of the second portion 16 more easily engages and guides the first protrusion 11 into the first indentation 13 of an adjacent portion of the helical winding 10, when the second end 14 of segment 8 is pushed toward the first end 12 of the segment 8, and the gaps 21 close along the length of the segment 8. If the first and second portions 19 and 16 were parallel to the outer surface 18, rectangular profiles would exist and the guidance features for nesting of the first and second protrusions 11 and 17 into the first and second indentations 13 and 15, respectively, would not be as easily accomplished. Hence, a preferred embodiment of the present invention includes the angled or sloped first and second portions 19 and 16, as depicted in Figure 1A.

[0035] Fig. 2 is a left side perspective view of the segment 8 of the helical winding 10 of

Fig. 1, with a fiber optic cable 20 contained therein. As with Fig. 1, the gaps 21 in the segment 8 show the helical winding 10 in a stable, unstressed, uncompressed state. The outer surface 18 of the helical winding 10 of Fig. 2 may be slightly expanded in diameter due to the presence of the fiber optic cable 20 within open core 50 of the helical winding 10, which may cause a frictional engagement between the fiber optic cable 20 and the open core 50 of the helical winding 10. That is, the segment 8 of helical winding 10 in Fig. 2 may have a larger outer diameter (due to receiving the fiber optic cable 20) than the empty helical winding 10 of Fig. 1.

[0036] Fig. 2A is a close-up view of the second end 14 of the helical winding 10 of FIG. 2, as enclosed within a circle labeled II in Figs. 2 and 2A. A portion of the fiber optic cable 20 extends beyond the segment 8 of the helical winding 10 at the first and second ends 12 and 14. The fiber optic cable 20 includes an optical fiber 22 at its core. The fiber optic cable 20 may be gapped or spaced apart from an inner surface of the open core 50 of the helical winding 10. Alternatively, the helical winding 10 of the cable protector may be form fitting and have an open core 50 matching a diameter of the fiber optic cable 20. Alternatively, the fiber optical cable 20 may have the before described friction-fit within the open core 50 of the helical winding 10, which slightly expands the diameter of the helical winding 10.

[0037] The helical winding 10 will increase the rigidity of the fiber optic cable 20. The increased rigidity will improve the manual handling capabilities of the fiber optic cable 20 during a pushing operation to insert the fiber optic cable 20 into a conduit. For example, the helical winding 10 will reduce the likelihood of buckling, kinking, or deformations of the fiber optic cable 20 during a pushing operation. The helical winding 10 will reduce the flexibility of the cable 20 to a preferred range which is more advantageous for navigating conduits.

[0038] Structurally, when the helical winding 10 expands to accept the fiber optic cable 20, the helical winding 10 may locally slide longitudinally to a limited degree along the length of the fiber optical cable 20 or rotate locally around the fiber optic cable 20 to a limited degree despite any local frictional engagement between the fiber optic cable 20 and the helical winding 10. However, during the local sliding and rotating, the first and second protrusions 11 and 17 stay aligned with the first and second indentations 13 and 15, respectively. The ability to locally slide and rotate acts to protect the fiber optic cable 20 from damage as the helical winding 10 navigates through bends in a conduit. However, over the length of the segment 8 of the helical winding 10, a cumulative friction will exist between the fiber optic cable 20 and the helical

winding 10 which will keep the fiber optic cable 20 within the segment 8, i.e., the fiber optic cable 20 will not slide free of the segment 8 of the helical winding 10 as the helical winding 10 is pushed into a conduit.

[0039] A material, such as a polymer, may be extruded to form the helical winding 10.

5 For example, the extruded material may be formed of one of, or a mixture of, Acrylonitrile butadiene styrene (ABS), Polyethylene (PE), Liquid-crystal polymer (LCP), polyamide (PA), Polyamide-imide (PAI), Polybutylene terephthalate (PBT), Polycarbonate (PC), polyethylene terephthalate (PET), polypropylene (PP), polytetrafluoroethylene (PTFE) and/or polyvinyl chloride (PVC). Further, the extruded material may be reinforced with different quantities of
10 fibers, such as glass fibers, carbon fibers, or mineral fillers. The polymers of the helical winding 10 may be based on stronger and more rigid compounds, as compared to any buffering or jacketing material used on the fiber optic cable 20. The polymers of the helical winding 10 offer increased mechanical properties such as impact and crush resistance with retained low radius of bend performance. Such materials have a high stiffness and hardness, high modulus, with a very
15 low elongation at break. These stiffer compounds may impart an elastic or spring-like resilience to the helical coil 10, such that the helical winding 10 returns to a straight segment, as shown in Figs. 1 and 2, after bending or navigating a bend in conduit.

[0040] The helical winding 10 may be extruded as a core with the profile shown at the ends of the segment 8, as best seen in the close-up views of Figs. 1A and 2A. Depending on the
20 material, the width, height and/or thickness of the helical winding 10 may vary. For instance, if a metal or alloy, e.g., containing aluminum or steel, is used for the helical winding instead of a polymer, then a much thinner profile with a similar shape may provide the same resilience. That is, the first and second protrusions 11 and 17 and the first and second indentation 13 and 15 may be radially thinner, resulting in a thinner overall profile for the helical winding 10. In a preferred
25 embodiment however, the helical winding 10 is formed of an extruded polymer material, which is quickly wound (while still hot and/or pliable) on a cylindrical rod in a helical manner, as the cylindrical rod both rotates and linearly travels past a linear feed point, such as the extruder output. The hot and/or pliable helical winding 10 may then be cooled or cured on the rod and then may be removed from the rod as the helical winding 10 of Fig. 1 with the open core 50
30 (previously occupied by the cylindrical rod). Once cooled, the helical winding 10 will obtain a natural resilience, which will make the helical winding 10 tend to resume its shape shown in Fig.

1 after a deformation.

[0041] Fig. 3 is a cross sectional view of the helical winding 10 and cable 20 taken along line III-III in Fig. 2, while enclosed within a conduit 30. Fig. 3 illustrates how the windings of the helical winding 10 may wrap the cable 20. In particular, the windings of the helix may progress from the second end 14 to the first end 12 of the helical winding 10 at an angle A1. Of course, in practice the length of the helical winding 10 will correspond to the length of the cable 20 to be inserted into a conduit, e.g., tens to hundreds of feet of cable 20. The angle A1, as depicted in Figure 3, is measured between the longitudinal extension direction of the helical winding 10 (e.g., parallel to the extension direction of the open core 50 and cable 20) and the slant of the cross section of a section of the helical winding 10. Angle A1 may be in the range of 40 to 70 degrees, such as in the range of 45 to 65 degrees, or about 55 to 60 degrees.

[0042] As illustrated in Figure 3, a first gap x1 exists between the second protrusion 17 and the second indentation 15 of adjacent windings of the helical winding 10. Further, a second gap x2 exists between the first protrusion 11 and the first indentation 13 of adjacent windings of the helical winding 10. In Fig. 3, the first gap x1 and the second gap x2 may be substantially equal. If the first gap x1 and the second gap x2 are substantially equal, then when the first protrusion 11 and the first indentation 13 have engaged, the second protrusion 17 and the second indentation 15 also engage nearly simultaneously during a linear compression of the helical winding 10, e.g., pushing the second end 14 of the helical winding 10 toward the first end 12 of the helical winding 10.

[0043] During a linear push operation, the combined engagements of the first and second protrusions 11 and 17 within the first and second indentations 13 and 15 along the length of the helical winding 10 ensures that force is not concentrated on any particular section of the helical winding 10 that may deform, break, or damage the cable 20. The implementation where the first and second gaps x1 and x2 are equal or substantially equal may be preferable for cable installations in conduits with a tight fit (like Fig. 3) requiring more force to overcome the friction. The longitudinal force of a push on the second end 14 of the helical winding 10 closes the first and second gaps x1 and x2 and causes engagements to form between the first and second protrusions 11 and 17 and the first and second indentations 13 and 15, respectively. Thus, the friction between the outer surface 18 of the helical winding 10 and an inner surface of the conduit 30 may be overcome by the push, and the cable may be moved along within the conduit

along with the helical winding 10 within the conduit 30 (in the right to left direction in Fig. 3).

[0044] Another implementation of the helical winding 10 is illustrated in the cross sectional view of Fig. 3A. In this implementation, the first gap x1 between the second protrusion 17 and the second indentation 15 has the same dimension as depicted in the embodiment of Fig. 3. A third gap y1 is provided between the first protrusion 11 and the first indentation 13. In Fig. 3A, the third gap y1 is larger than the first gap x1. When the third gap y1 between the first protrusion 11 and the first indentation 13 is wider than the first gap x1, the helical winding 10 may be able to better navigate sharper curves in the conduit 30. This occurs because when the inner, first protrusions 11 and first indentations 13 are engaged to push the helical winding 10 further into the conduit 30, the third gap y1 is not closed, but remains partially open. This partial opening in the third gap y1 allows for more extensive pivoting about each radial inner abutment within the helical winding 10, such that the first protrusion 11 can pivot slightly into the remaining opening in the third gap y1 in tighter curves in the conduit 30. It would also be possible for the second protrusion 17 and the second indentation 15 of the helical winding 10 to remain in constant contact along the length of the helical winding 10, while the helical winding 10 was in a stable and uncompressed state, e.g., as depicted in Fig. 1, since the third gap y1 will provide a flexing ability to the helical winding 10. In certain implementations, the third gap y1 may be 5 to 30% larger than the first gap x1, such as 10 to 25% larger, for example 20% larger.

[0045] Fig. 4 illustrates an expanded view of an example profile of the helical winding 10 according to Figs. 1-3. An inner edge 31 of the profile forms a sidewall segment of the open core 50 of the helical winding 10. The inner edge 31 is opposite the outer surface 18 of the helical winding 10. First and second radial edges 32 and 33 extend from the outer surface 18 towards the open core 50. Third and fourth radial edges 34 and 35 extend from the inner edge 31 towards an outer surface 18. The first and second radial edges 32 and 33 may meet the outer surface 18 at ninety-degree angles. The third and fourth radial edges 34 and 35 may meet the inner edge 31 at ninety-degree angles. These ninety-degree corners may be rounded off.

[0046] The first portion 19 connects the second radial edge 33 to the third radial edge 34 to form the first indentation 13 and the second protrusion 17. Likewise, the second portion 16 connects the first radial edge 32 to the fourth radial edge 35 to form the first protrusion 11 and the second indentation 15. A second angle 42 is formed between the second radial edge 33 and the first portion 19. The second angle 42 is greater than 90 degrees, such as 91 to 150 degrees,

or 100 to 140 degrees, for example 120 degrees or 130 degrees. A third angle 43 is formed between the third radial edge 34 and the first portion 19. The third angle 32 is greater than 90 degrees, such as 91 to 150 degrees, or 100 to 140 degrees, for example 120 degrees or 130 degrees. In a preferred embodiment, the second angle 42 is equal to, or substantially equal to, the third angle 43.

[0047] A fourth angle 44 is formed between the first radial edge 32 and the second portion 16. A fifth angle 45 is formed between the fourth radial edge 35 and the second portion 16. In a preferred embodiment, the fourth and fifth angles 44 and 45 have the same measurements as the second and third angles 42 and 43, although such an equivalency is not necessary to the advantages of the present invention.

[0048] The second and third angles 42 and 43 define a slope for the first portion 19, as it transitions from the second protrusion 17 to the first indentation 13. The fourth and fifth angles 44 and 45 define a slope for the second portion 16, as it transitions from the first protrusion 11 to the second indentation 15. Although the slopes are shown as linear, the slopes may include a curvature. The slopes are advantageous for ensuring a smooth engagement of the second protrusion 17 within the second indentation 15, and the engagement of the first protrusion 11 within the first indentation 13. The first and second portions 19 and 16 engage with each other between adjacent winding/sections of the helical winding 10 forming a continuous abutment between the first and second portions 19 and 16, when the helical winding 10 is compressed longitudinally and a partial abutment when the helical winding 10 is laterally deformed. The helical winding 10 may flex and/or rotate about these abutments like a joint when navigating a bend in the conduit 30 or under a lateral stress, as will be described next.

[0049] Fig. 5 depicts a helical winding 10 in cross sectional view under lateral stress, while Fig. 6 depicts the outside view of the helical winding 10 under the same lateral stress. The helical winding 10 has the open core 50 that remains protected and continuous even under the high deformation illustrated. The helical winding 10 of Figs. 5 and 6 may, or may not, be under longitudinal or a compressive force, as well as the lateral force. If the helical winding 10 is under a longitudinal or compressive force, the force is being translated through the engaged first protrusions 11 and first indentations 13 on the inside of the curvature (left sides of Figs. 5 and 6). In particular, the gaps 21A on the inside of the curvature of the helical winding 10 may be engaged at least at the outer surface 18. The gaps 21B on the outside of the curvature (right side

of Figs. 5 and 6) are open wider than in the static, stable state of the helical winding 10, as depicted in Fig. 1. The bend depicted in Figs. 5 and 6 is illustrated at substantially 90 degrees, which is a common fitting angle for conduits. However, greater or lesser angles of flexure of the helical winding 10 are possible.

5 **[0050]** The tight fit between the helical winding 10 and the conduit 30 in Figs. 3 and 3A is purely exemplary. As illustrated in Fig. 7, the fit between the helical winding 10 and the conduit 70 may be loose such that one or more additional cables 71, 72 and 73 may be present within the conduit 70 during installation of the helical winding 10.

10 **[0051]** Fig. 8 depicts a process 800 for installing or inserting a cable 20 through a conduit 30 or 70. The process 800 may be performed in a factory so that the cable 20 is preloaded into the conduit 30 or 70 prior to the sale and delivery to the customer. Alternatively, the process 800 may be conducted in the field by a technician through an existing conduit 30, and/or alongside existing cables 71, 72, 73 in an existing conduit 70.

15 **[0052]** At step 801, the process 800 includes attaching the cable protector, e.g., helical winding 10, to a cable 20. Step 801 may include expanding the cable protector, e.g., helical winding 10. The helical winding 10 may have a loose fit, a matching form fit or a tight fit to the cable 20. The helical winding 10 may be expanded helically with an inserted rod, such as a screwdriver, ink pen, pencil, etc. The cable 20 is laid onto of the outside surface 18 of the helical winding 10. Optionally the cable 20 may be attached to the first end 12 of the helical winding 10. The rod is inserted into the open core 50 a slight distance and used to pull open the cut first end 12 of the helical winding 10, so as to lay the cut first end 12 over the cable 20. Then, the rod, while remaining in contact with the open core 50 is rotated along with the helical winding 10 about the cable 20, so as to progressively follow along the helical wraps and sequentially open each helical wrap so to progressively capture the adjacent cable 20 into the open core 50. In other words, the rod and helical winding 10 may be rotated helically about the cable 20 while also expanding a portion of the helical winding 10 to thereby wrap around the cable 20, capturing the cable 20 into the open core 50. Other attachment methods are also contemplated including lubricated insertion, shrink-fitting, and winding of the cable through the gaps in the helical winding 10 by rotating the cable 20 around the helical winding 10 while feeding the cable 20 into the continuous gap of the helical winding 10.

25 **[0053]** Step 803 of process 800 includes pushing the cable 20 within the helical winding

10 through the conduit 30 or 70. A longitudinal pushing force may be applied to the helical winding 10 manually at a second end of the conduit. It is preferred that the second end 14 of the helical winding 10 receives the pushing force because engagements between the first and second portions 19 and 16 of adjacent engaged sections of the helical winding 10 will tend to hold the
5 helical winding 10 together, so that one winding of the helical winding 10 does not pop over and ride along the outer surface 18 of the adjacent winding against which it is pressed. The pushing force may also be applied or supplemented by air pressure at the second end of the conduit and/or a vacuum introduced into the first end of the conduit. The outer surface 18 of the helical winding 10 may have a lubricant applied thereto, or embedded therein during fabrication, to
10 assist in the pushing operation. The helical winding 10 may be installed along a length of cable 20 greater than or equal to the length of the conduit 30 or 70, so that a section of helical winding 10 remains present at the second end of the conduit 30 or 70 during the entire pushing operation to allow for the manual pushing force. When the inserted end of the cable 20 exits the second end of the conduit 30 or 70, the process 800 may be completed, and the first and second ends of
15 the cable 20 located at the first and second ends of the conduit 30 or 70 may be terminated to connectors or further routed to other destinations, as desired.

[0054] Step 805 is an optional step. The process 800 may include detaching the cable protector, e.g., the helical winding 10, from the cable 20 (step 805). Once the initially-inserted end of the cable 20 exits the first end of the conduit 30 or 70, it is envisioned that the entire
20 length of the cable 20 contained within the helical winding 10 could be pulled through the conduit 30 or 70 along with the helical winding 10. As the cable 20 is continuous, a corresponding length of the cable 20 (not enclosed within any helical winding 10) would be automatically pulled from the second end to the first end of the conduit 30 or 70.

[0055] Since the helical winding 10 and its captured length of cable 20 within are fully
25 removed from the conduit at the first end of the conduit 30 or 70, the wrapping process of the helical winding 10 may be reversed to remove the helical winding 10 from the cable 20. That is, the rod may be inserted under the first or second end 12 or 14 of the helical winding 10 and lifted off the cable 20 by a rotation and progression of the rod and helical winding 10 relative to the cable 20. Once the entire helical winding 10 has been removed, the helical winding 10 may be
30 reused to feed another cable 20 through another conduit 30 or 70. Also, the conduit 30 or 70 has additional space available within it since the cable 20 occupies less space than the helical

winding 10.

[0056] If the additional length of cable 20 at the first end of the conduit 30 or 70 is not needed, it may be cut off. Optionally, the length of cable 20 outside the first end of the conduit 30 or 70 that was previously surrounded by the helical winding 10 may be pulled back through the conduit 30 or 70 by a pulling force from the second end of the conduit 30 or 70. In this optional step 805, the helical winding 10 acts as an insertion tool to enable the pushing of a flaccid, small cable 20 through a conduit 30 or 70. If step 805 is omitted, the helical winding 10 remains within the conduit 30 and 70. The helical winding 10 will act as a protective device for the small cable 20 to protect it from damage should other more rigid cables, such as cables 71, 72, or 73 be pushed or pulled through the conduit 70 after the cable 20 has been installed in the conduit 70.

[0057] The cable 20 has been described as a fiber optic cable, and may take the form of a 900um buffered optical fiber or a small diameter simplex cable, which may have added tensile structural elements, like aramid yarns. Of course, the invention would also be applicable to assist in the pushing of other types of fiber optic cables, which include one or more optical fibers, and could also be use in conjunction with other small, flaccid cables, like a cable containing one or more small gauge, e.g., 23-26 AWG, insulated electrical wires.

[0058] The foregoing embodiments are illustrative of the present invention, and are not to be construed as limiting thereof. Although exemplary embodiments of this invention have been described, those skilled in the art will readily appreciate that many modifications are possible in the exemplary implementations without materially departing from the novel teachings and advantages of this invention. Accordingly, all such modifications are intended to be included within the scope of this invention as defined in the claims. The invention is defined by the following claims, with equivalents of the claims to be included therein.

CLAIMS

1. A cable protector having a helical winding comprising:
a first protrusion extending along a first side of said helical winding at a radially outer portion of said helical winding;
5 a second protrusion extending along a second side of said helical winding at a radially inner portion of said helical winding;
a first indentation extending along said second side of said helical winding at said outer portion of said helical winding; and
a second indentation extending along said first side of said helical winding at said inner
10 portion of said helical winding,
wherein adjacent sections within said helical winding have said first protrusion facing said first indentation and also have said second protrusion facing said second indentation.
2. The cable protector according to claim 1, wherein, in an uncompressed state, a first
15 gap is formed between said second protrusion and said second indentation, and in a compressed state, said second protrusion engages said second indentation.
3. The cable protector according to claim 2, wherein, in an uncompressed state, a second
gap is formed between said first protrusion and said first indentation, and in a compressed state,
20 said first protrusion engages said first indentation.
4. The cable protector according to claim 3, wherein said first gap is offset longitudinally from said second gap.
- 25 5. The cable protector according to claim 3, wherein, in an uncompressed state, said second gap is larger than said first gap.
6. The cable protector according to claim 3, wherein, in an uncompressed state, said first protrusion covers said second gap to block a view of an open core within said helical winding.

7. The cable protector according to claim 3, wherein the compressed state is caused by a longitudinal force applied to said helical winding in a direction parallel to an open core of said helical winding, or is caused by a lateral force applied to said helical winding that causes said helical winding to bend away from a longitudinal direction.

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8. The cable protector according to claim 1, wherein, in an uncompressed state, a second gap is formed between said first protrusion and said first indentation, and in a compressed state, said first protrusion engages said first indentation, and, wherein, in an uncompressed state, no gap exists between said second protrusion and said second indentation.

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9. A cable and cable protector having a helical winding comprising:
a first feature extending along a first side of said helical winding;
a second feature extending along a second side of said helical winding;
an open core formed within said helical winding; and

15 said cable positioned within said open core and extending from a first end of said helical winding to a second end of said helical winding,

wherein adjacent sections within said helical winding have said first feature gapped from said second feature when in a stable uncompressed state, and said adjacent sections of said helical winding have said first feature in abutment with said second feature when in a

20

10. The cable and cable protector according to claim 9, wherein said cable is a fiber optic cable.

25 11. The cable and cable protector according to claim 9, wherein said first feature is a protrusion extending along said first side of said helical winding at a radially outer portion of said helical winding, and said second feature is an indentation extending along said second side of said helical winding at said radially outer portion of said helical winding.

12. The cable and cable protector according to claim 11, wherein, in an uncompressed state, a gap is formed between said first protrusion and said first indentation, and said first protrusion blocks a view of said open core and said cable within said open core.

5 13. The cable and cable protector according to claim 9, wherein said helical winding is formed of a flexible material that is deformable and resilient to expand to receive said cable such that said open core of said helical winding contacts said cable.

10 14. The cable and cable protector according to claim 13, wherein an inner portion of said open core engages said cable frictionally such that said cable is pushed via a frictional force along a longitudinal direction of the cable, as said helical winding is pushed along the longitudinal direction.

15 15. The cable and cable protector according to claim 9, wherein said helical winding has a helical twist angle relative to said open core containing said cable which is in the range of 40 to 70 degrees.

20 16. The cable and cable protector according to claim 9, wherein said first feature includes a first protrusion and a second indentation extending along said first side of said helical winding at a radially outer portion and a radially inner portion, respectively, of said helical winding, and said second feature includes a first indentation and a second protrusion extending along said second side of said helical winding at said radially outer portion and said radially inner portion, respectively, of said helical winding.

25 17. The cable and cable protector according to claim 16, wherein, in an uncompressed state, a first gap is formed between said second protrusion and said second indentation, and in a compressed state, said second protrusion engages said second indentation; and

30 wherein, in an uncompressed state, a second gap is formed between said first protrusion and said first indentation, and in a compressed state, said first protrusion engages said first indentation

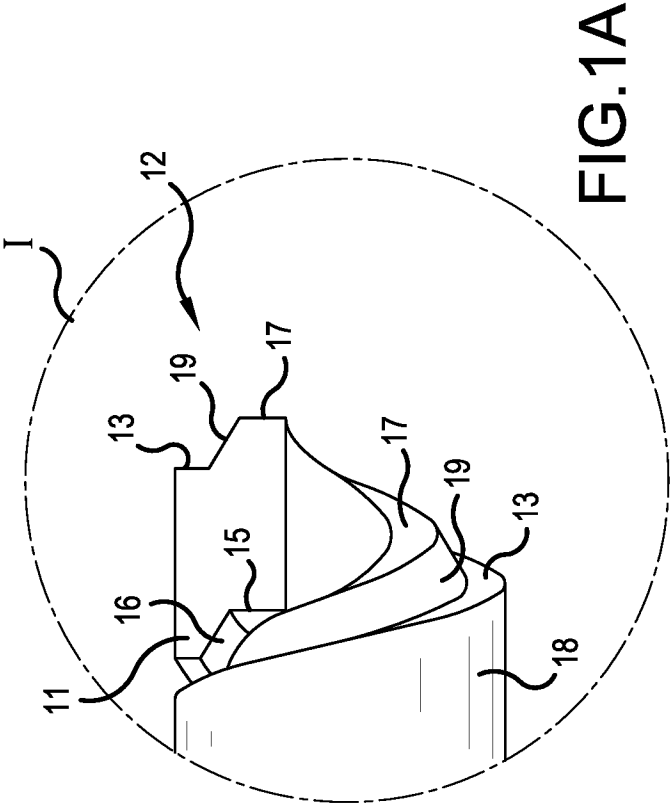
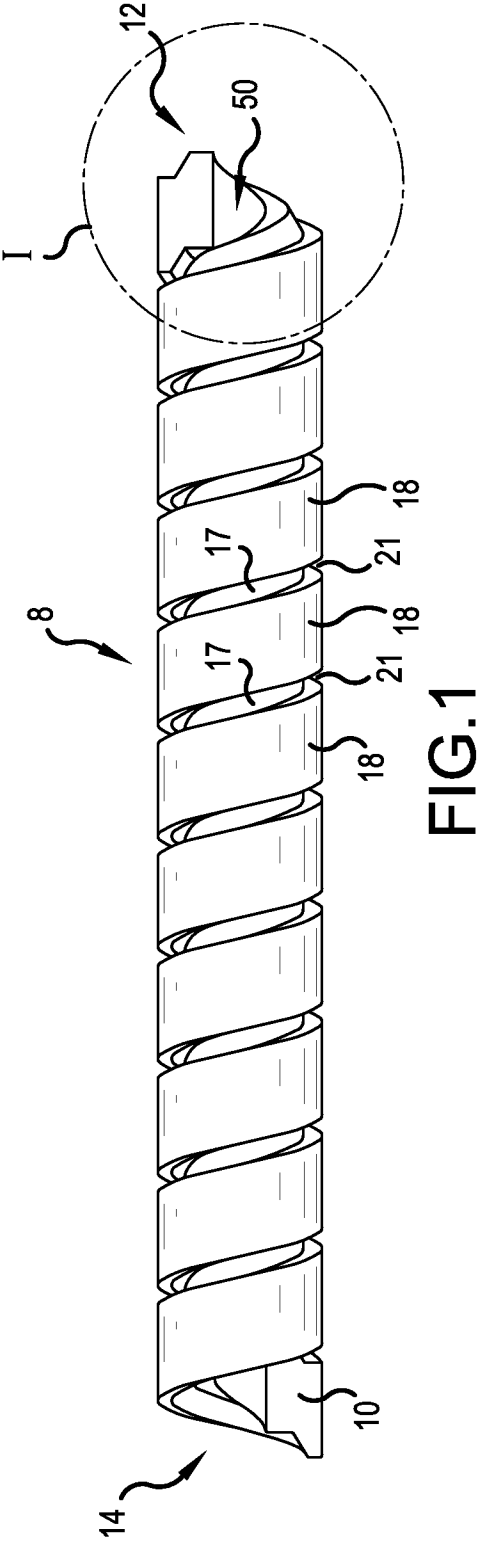
18. A method of installing a cable within a conduit, comprising:
attaching the cable protector according to claim 1 to the cable; and
pushing the cable protector with the cable therein through the conduit.

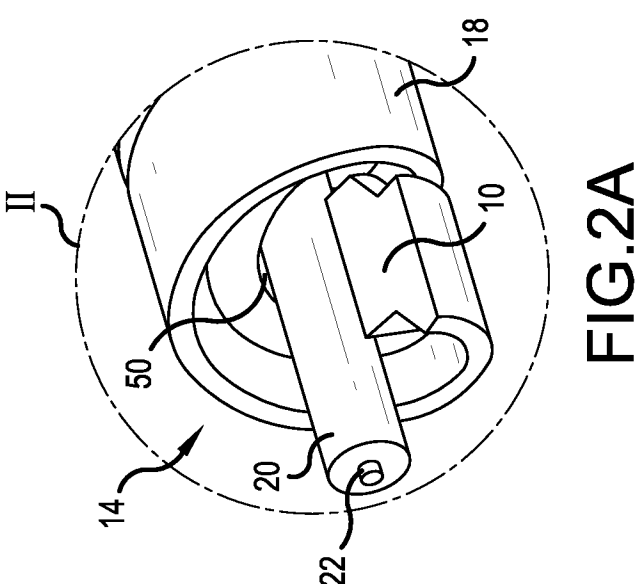
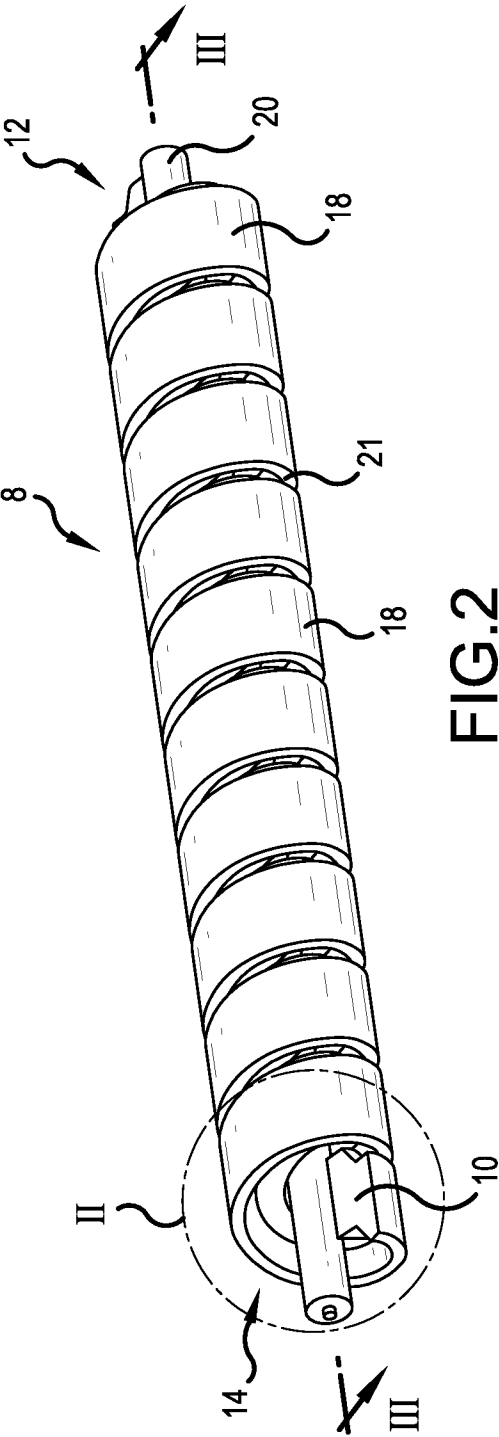
5 19. The method according to claim 18, wherein attaching the cable protector includes at least one of: expanding the cable protector to wind the cable protector onto the cable using a tool, lubricating at least one of the cable and the cable protector to insert the cable within the cable protector, or winding the cable into the cable protector through gaps along the length of the cable protector.

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20. The method according to claim 18, wherein the cable protector is attached along a length of the cable approximately equal to a length of the conduit, and further comprising:
pulling the cable protector and the cable within the cable protector completely through the conduit, and then detaching the cable protector from the cable.

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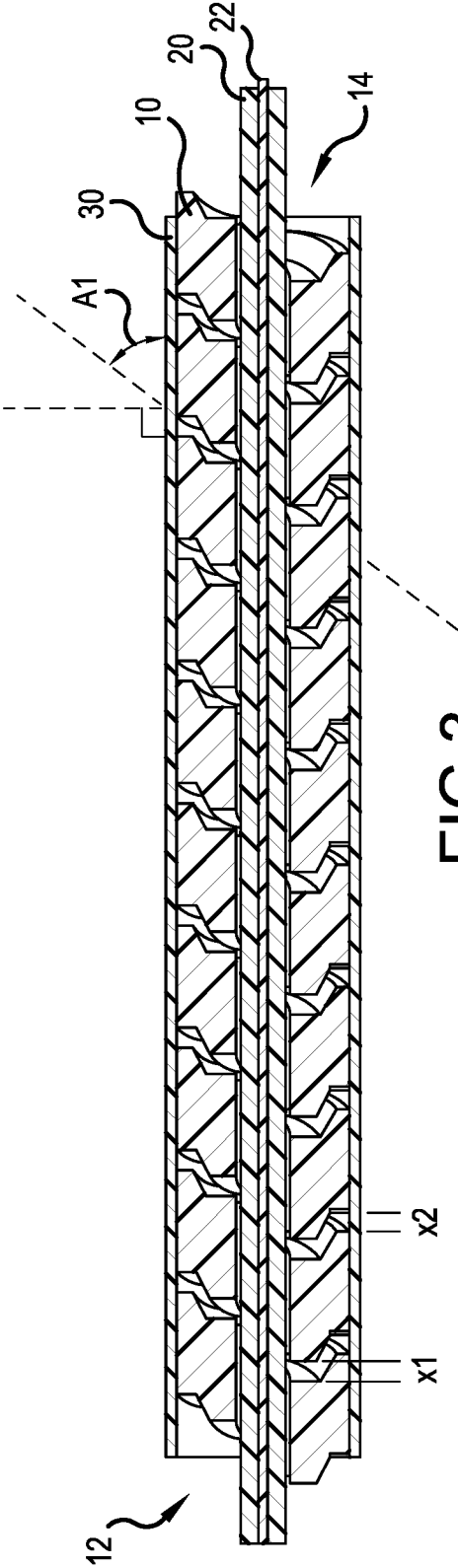


FIG.3

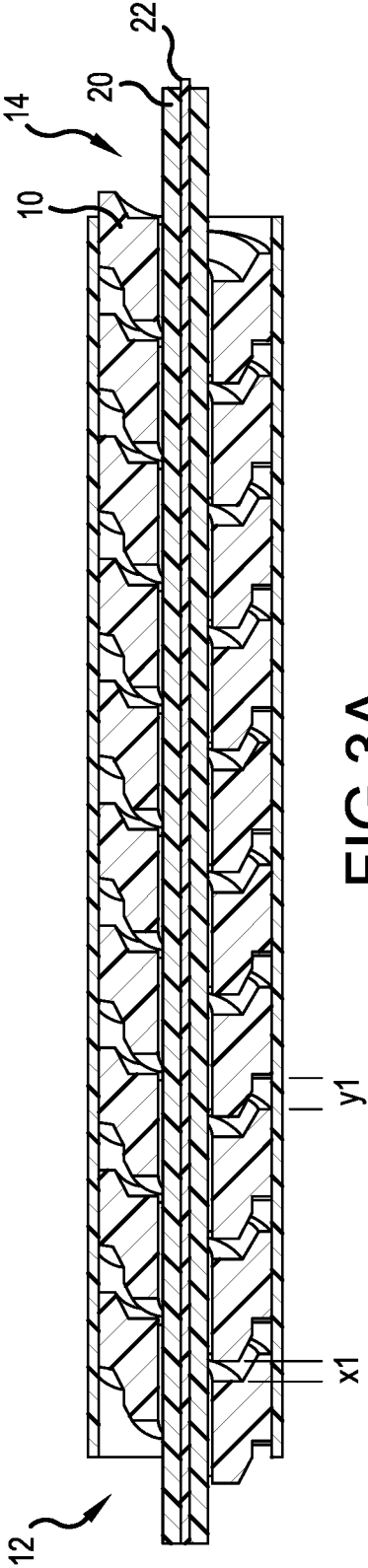


FIG.3A

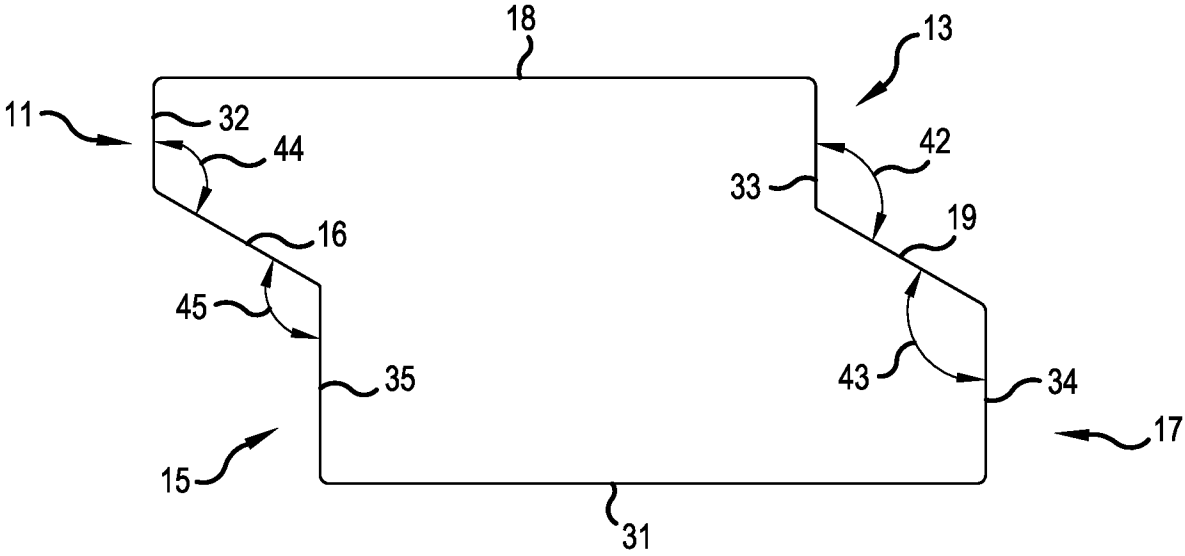


FIG.4

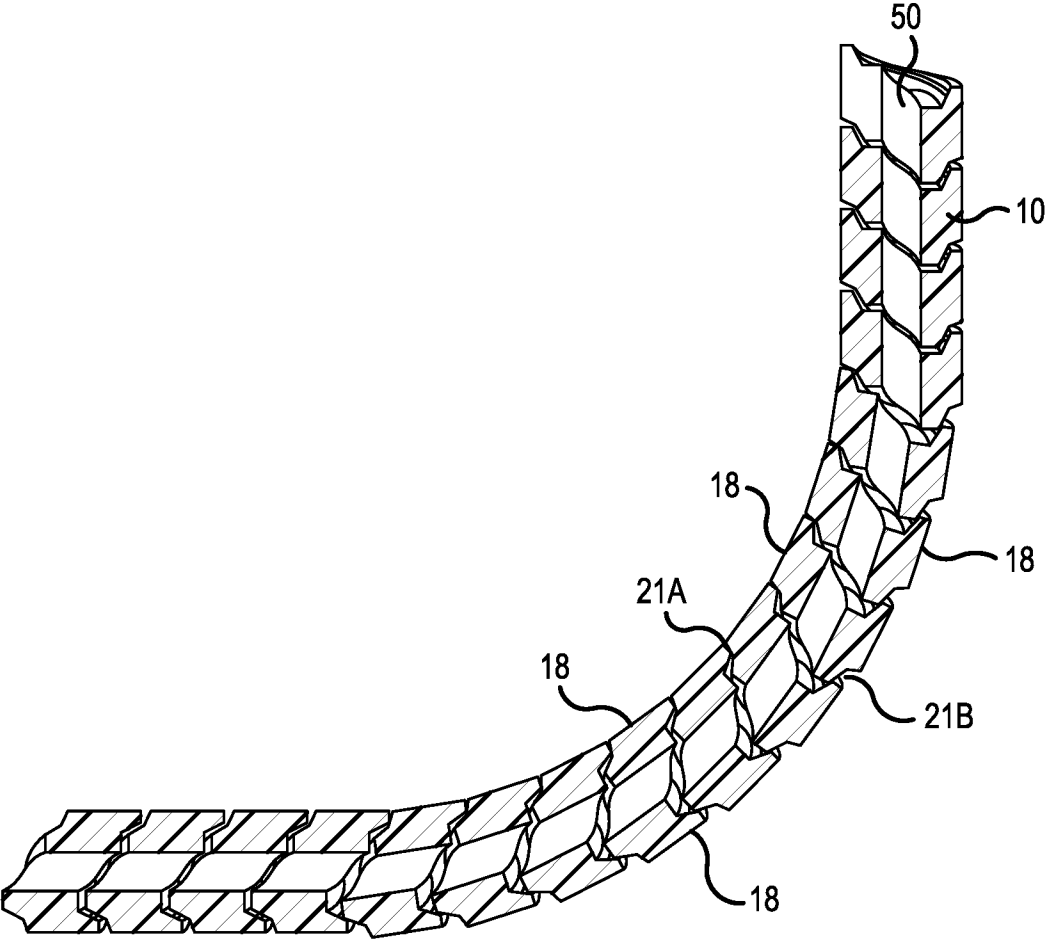


FIG.5

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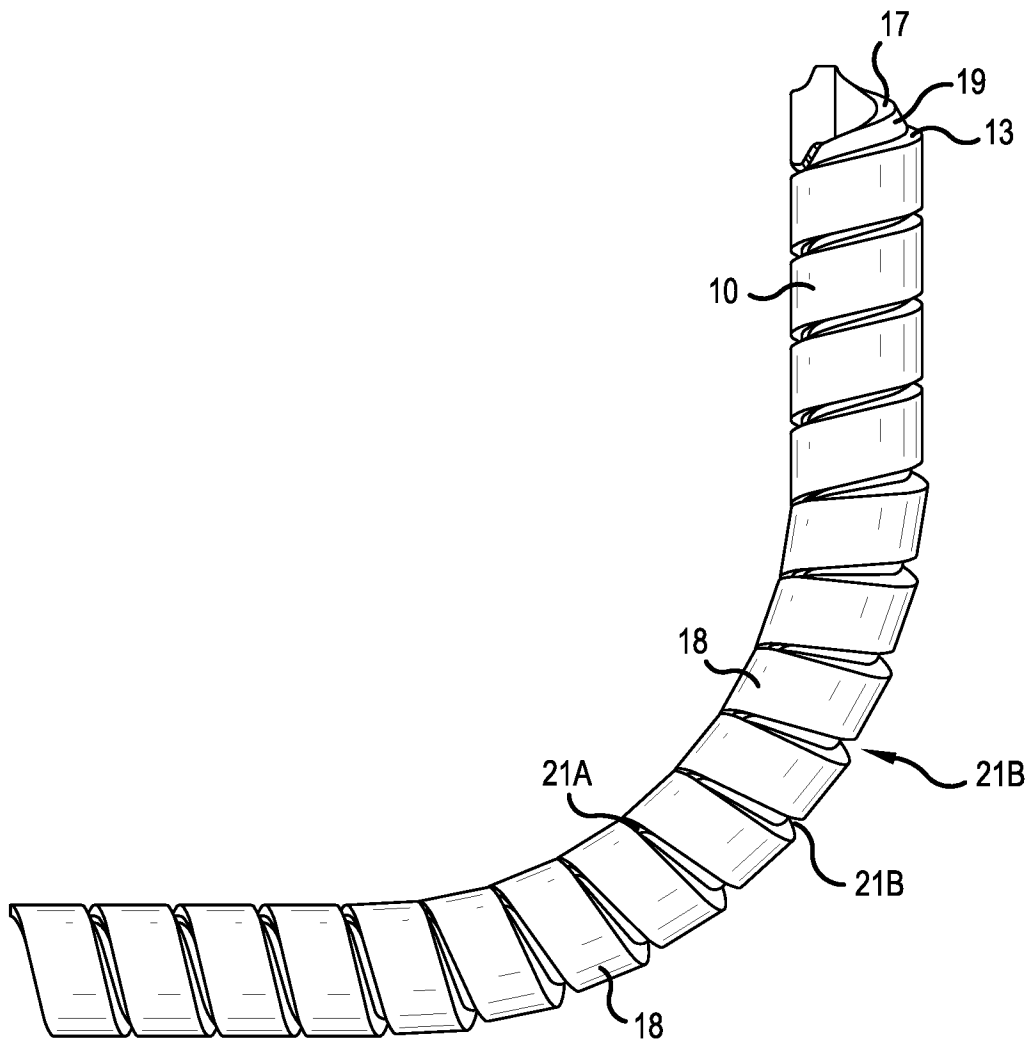


FIG.6

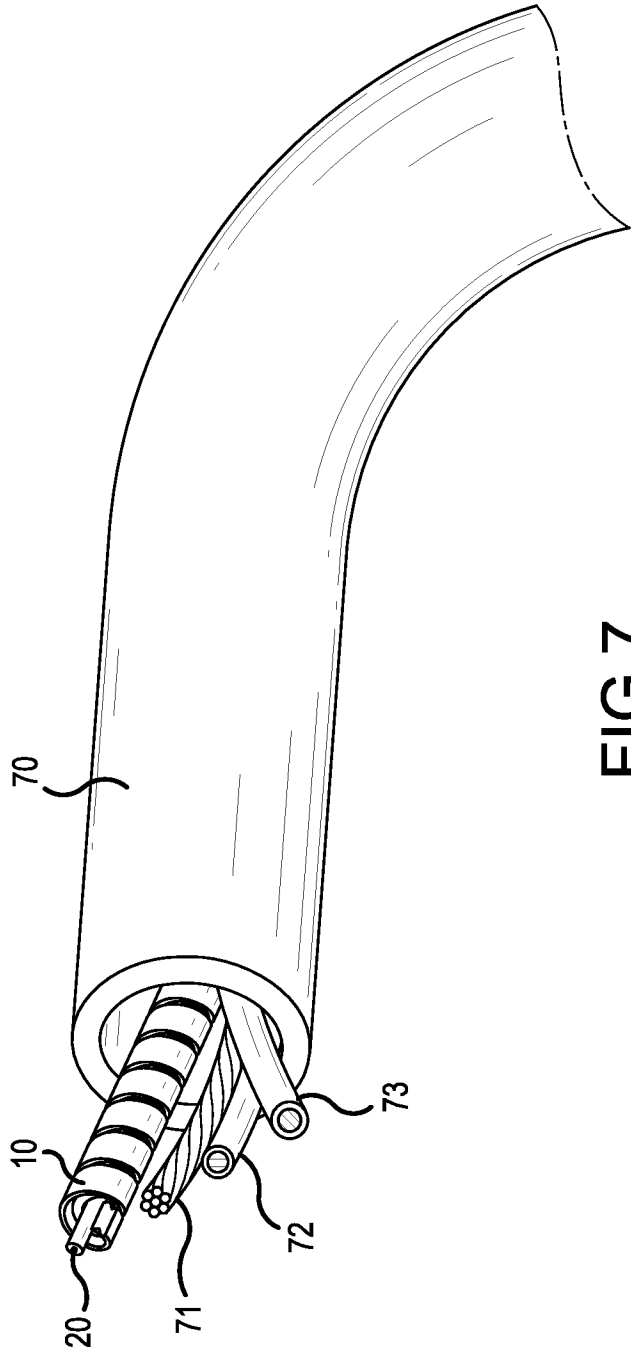


FIG. 7

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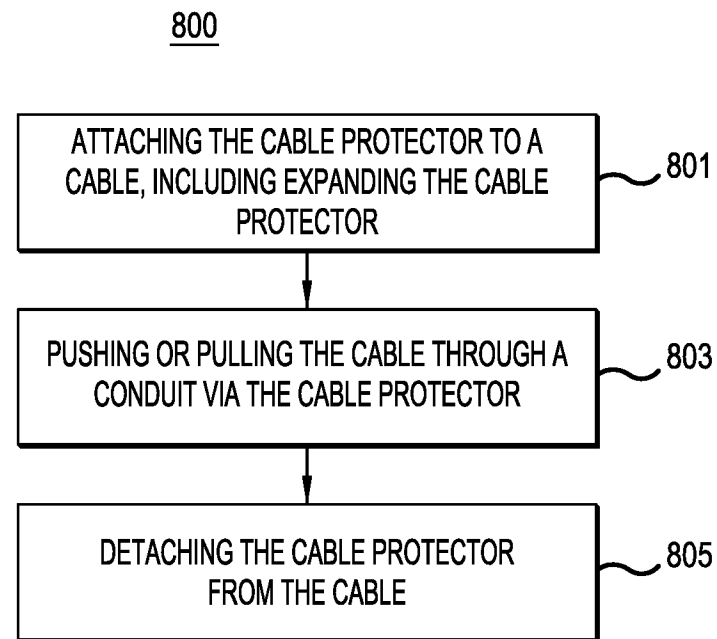


FIG.8

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2021/057199

A. CLASSIFICATION OF SUBJECT MATTER

INV. H02G1/08 H02G3/04 F16L3/12 H01B7/00 H01B7/18
F16L3/015 F16L11/16
ADD. F16C1/26 F16L1/028 F16L55/165 G02B6/44 G02B6/50

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H02G G02B F16L F16C H01B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Further documents are listed in the continuation of Box C.

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See patent family annex.

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Date of the actual completion of the international search

27 January 2022

Date of mailing of the international search report

07/02/2022

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Authorized officer

Braga, João

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2021/057199

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