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(54) SELF-CURLING SLEEVE

(76) Inventor: Angela L. Baer, Westminster, MD (US)

Correspondence Address:
Robert L. Steams
Dickinson Wright PLLC
38525 Woodward Avenue
Bloomfield Hills, MI 48304-5092

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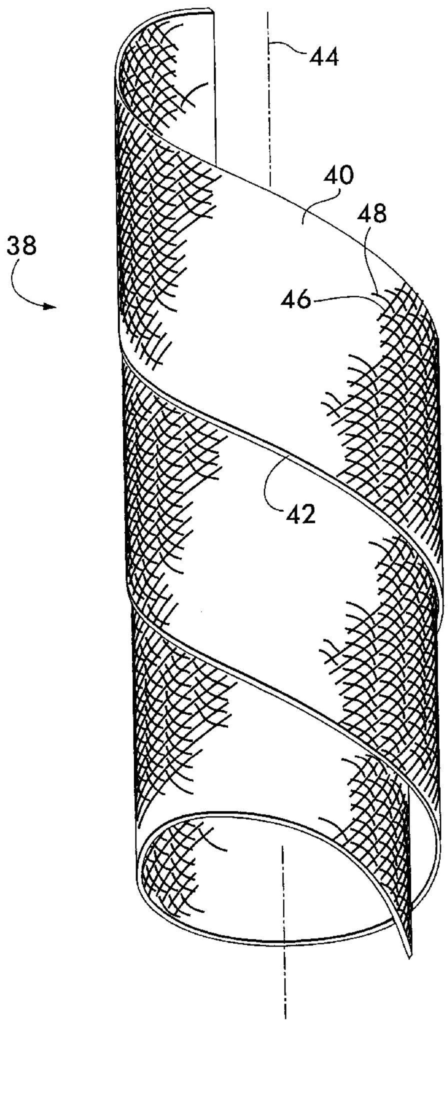
(57) **ABSTRACT**

A substrate including a plurality of monofilaments, or a combination of monofilaments and multi-filament yarns oriented in perpendicular directions, has a tendency to curl around a central space. When all monofilaments are used, the monofilaments along one direction may have a larger diameter than the monofilaments along the other direction. The monofilaments are woven such that the larger diameter monofilaments form floats predominantly on one side of the substrate. For the monofilament-multifilament combination the monofilaments form floats predominantly on one side of the substrate. The substrate curls about an axis parallel to the monofilaments forming the floats. The side having the floats faces outwardly away form the central space. Preferably, the monofilaments are orientated in the warp direction along the substrate. The filaments may be woven in a herringbone twill weave, a double cloth herringbone twill weave or a satin weave to provide the floats.



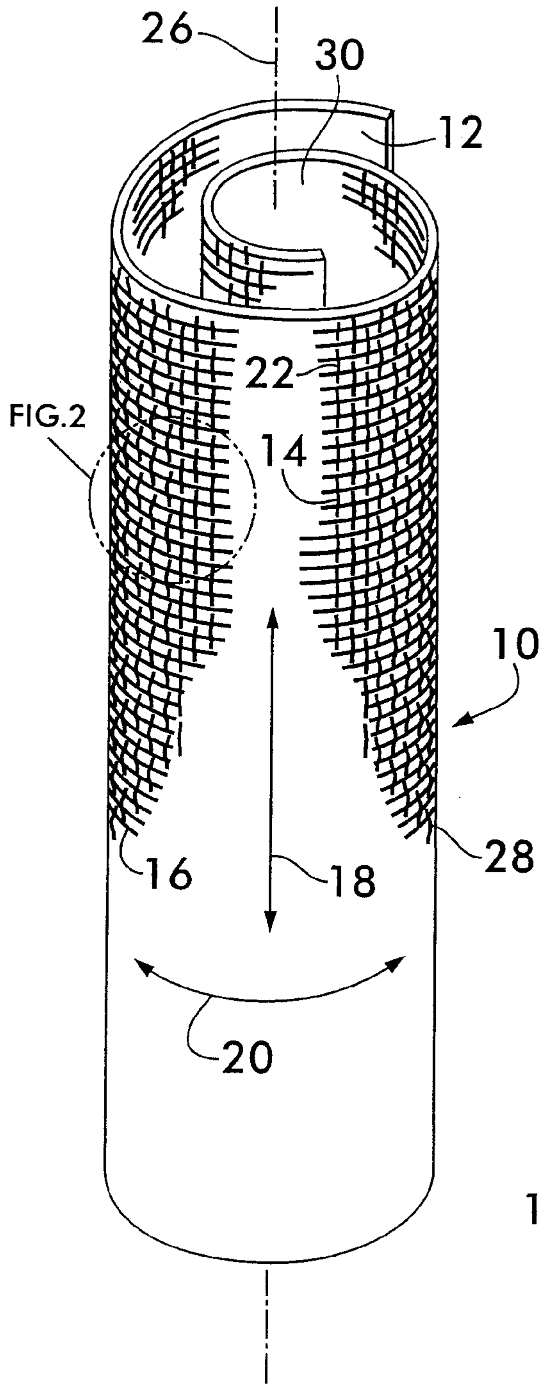
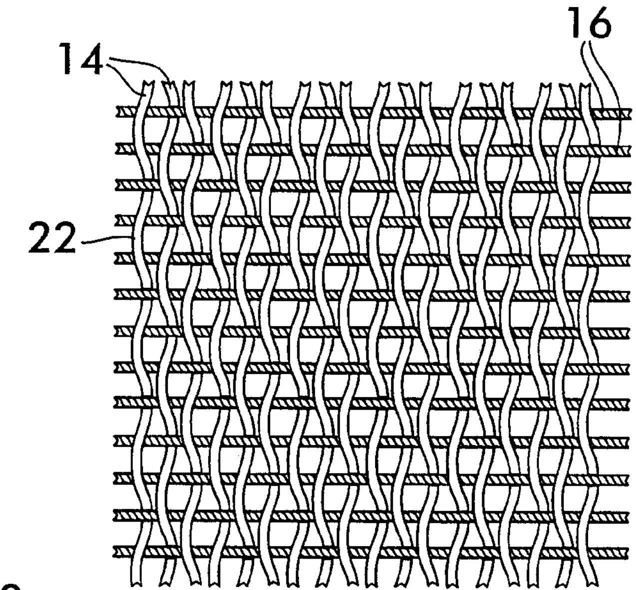


FIG. 1

FIG. 2



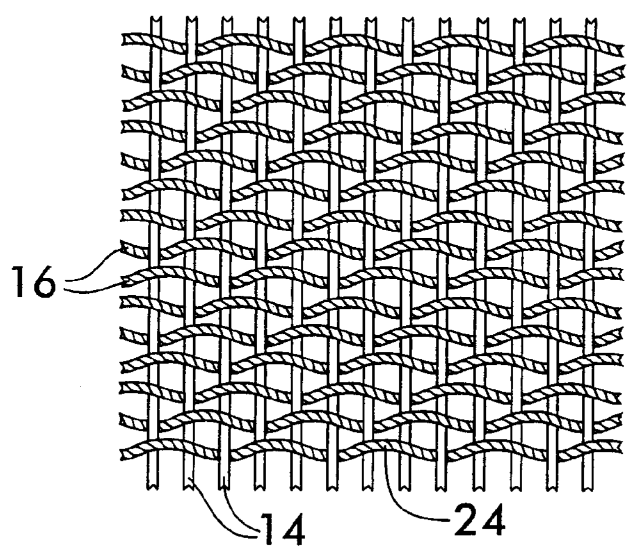
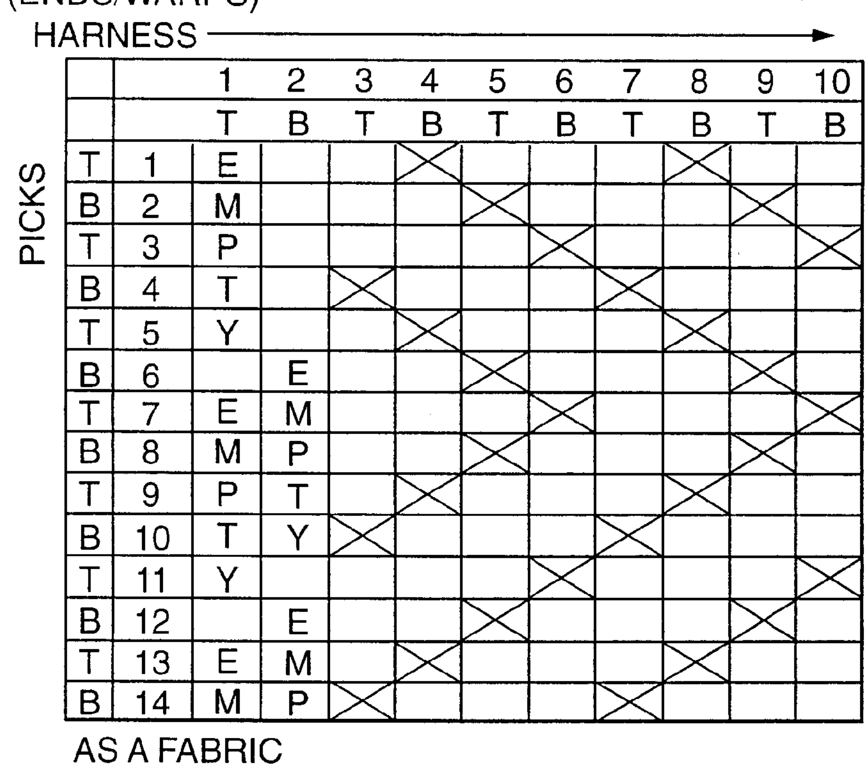


FIG. 3

FIG.4


(ENDS/WARPS)
HARNESS
PICKS
1 2 3 4 5 6 7 8 9 10
T B T B T B T B T B
T 1 E
B 2 M
T 3 P
B 4 T
T 5 Y
B 6 E
T 7 E M
B 8 M P
T 9 P T
B 10 T Y
T 11 Y
B 12 E
T 13 E M
B 14 M P
AS A FABRIC

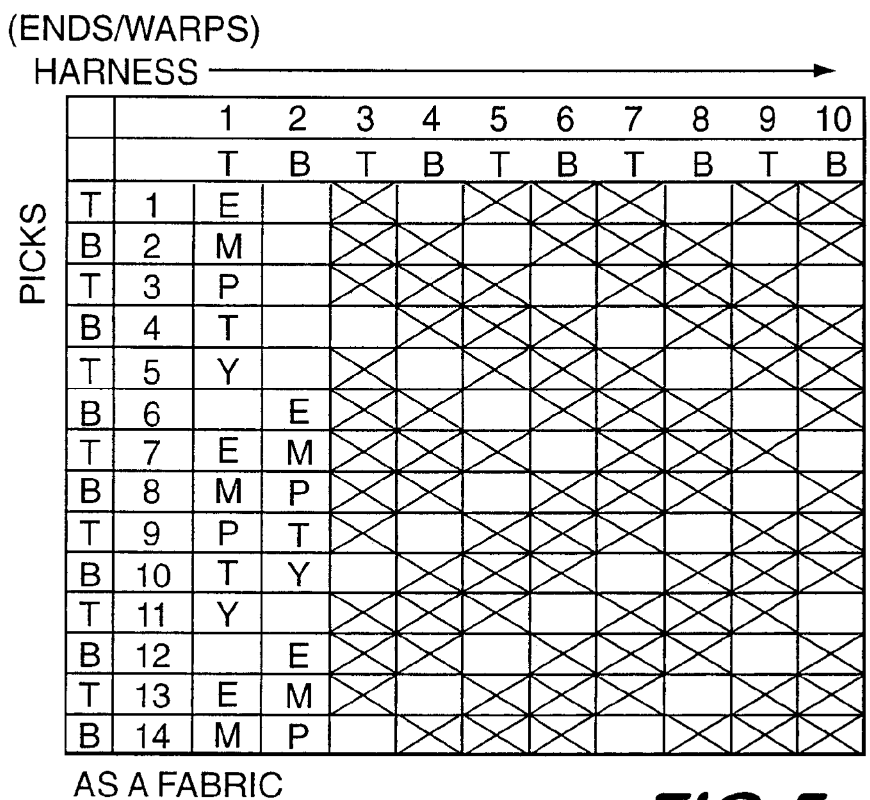

(ENDS/WARPS)
HARNESS
PICKS
1 2 3 4 5 6 7 8 9 10
T B T B T B T B T B
T 1 E
B 2 M
T 3 P
B 4 T
T 5 Y
B 6 E
T 7 E M
B 8 M P
T 9 P T
B 10 T Y
T 11 Y
B 12 E
T 13 E M
B 14 M P
AS A FABRIC

FIG.5

FIG. 6

(ENDS/WARPS)
HARNESS →

PICKS

		1	2	3	4	5	6	7	8	9	10
		T	B	T	B	T	B	T	B	T	B
T	1	E		X				X			
B	2	M			X				X		
T	3	P			X	X			X	X	
B	4	T					X				X
T	5	Y			X	X			X	X	
B	6		E		X				X		
T	7	E	M	X				X			
B	8	M	P		X				X		
T	9	P	T		X	X			X	X	
B	10	T	Y				X				X
T	11	Y			X	X			X	X	
B	12		E		X				X		
T	13	E	M	X				X			
B	14	M	P								

AS A FABRIC

(ENDS/WARPS)
HARNESS →

PICKS

		1	2	3	4	5	6	7	8	9	10
		T	B	T	B	T	B	T	B	T	B
T	1	E		X		X	X	X		X	X
B	2	M		X			X	X			X
T	3	P		X	X	X		X	X	X	
B	4	T			X	X	X		X	X	X
T	5	Y		X		X	X	X		X	X
B	6		E	X			X	X			X
T	7	E	M	X	X	X		X	X	X	
B	8	M	P	X			X	X			X
T	9	P	T	X		X	X	X		X	X
B	10	T	Y		X	X	X		X	X	X
T	11	Y		X	X	X		X	X	X	
B	12		E	X			X	X			X
T	13	E	M	X		X	X	X		X	X
B	14	M	P		X	X	X		X	X	X

AS A FABRIC

FIG. 7

FIG. 8

(ENDS/WARPS)
HARNESS →

PICKS

		1	2	3	4	5	6	7	8	9	10
		T	B	T	B	T	B	T	B	T	B
T	1	E			X					X	
B	2	M					X				
T	3	P		X					X		
B	4	T				X					X
T	5	Y						X			
B	6		E			X					X
T	7	E	M					X			
B	8	M	P		X					X	
T	9	P	T				X				
B	10	T	Y	X					X		
T	11	Y				X					X
B	12		E					X			
T	13	E	M			X					X
B	14	M	P					X			

AS A FABRIC 5-FLOAT FILLING FACED SATIN

FIG. 9

(ENDS/WARPS)
HARNESS →

PICKS ↓

		1	2	3	4	5	6	7	8	9	10
		T	B	T	B	T	B	T	B	T	B
T	1	E		X	X	X	X	X			
B	2	M			X			X		X	
T	3	P		X	X		X				
B	4	T			X		X	X	X	X	
T	5	Y			X	X	X				
B	6		E		X		X	X		X	X
T	7	E	M	X	X	X	X			X	
B	8	M	P				X	X		X	
T	9	P	T	X	X	X	X	X			
B	10	T	Y		X			X		X	
T	11	Y		X	X		X				
B	12		E		X		X	X	X	X	
T	13	E	M		X	X	X				
B	14	M	P		X		X	X		X	X
T	15	P	T	X	X		X				
B	16	T	Y		X		X	X	X	X	
T	17	Y		X	X	X	X	X			
B	18		E		X			X		X	
T	19	E	M	X	X	X	X			X	
B	20	M	P				X	X		X	
T	21	P	T		X	X	X				
B	22	T	Y		X		X	X		X	X
T	23	Y		X	X		X				
B	24		E		X		X	X	X	X	
T	25		M	X	X	X	X	X			
B	26		P		X			X		X	
T	27		T	X	X	X	X			X	
B	28		Y				X	X		X	

AS A DOUBLE CLOTH

FIG. 10

(ENDS/WARPS)
HARNESS →

PICKS

		1	2	3	4	5	6	7	8	9	10
		T	B	T	B	T	B	T	B	T	B
T	1	E		X	X		X		X		
B	2	M		X		X	X			X	
T	3	P			X	X	X				X
B	4	T		X	X	X		X			
T	5	Y		X	X		X		X		
B	6		E	X		X	X			X	
T	7	E	M		X	X	X				X
B	8	M	P	X		X	X			X	
T	9	P	T	X	X		X		X		
B	10	T	Y	X	X	X		X			
T	11	Y			X	X	X				X
B	12		E	X		X	X			X	
T	13	E	M	X	X		X		X		
B	14	M	P	X	X	X		X			

AS A FABRIC

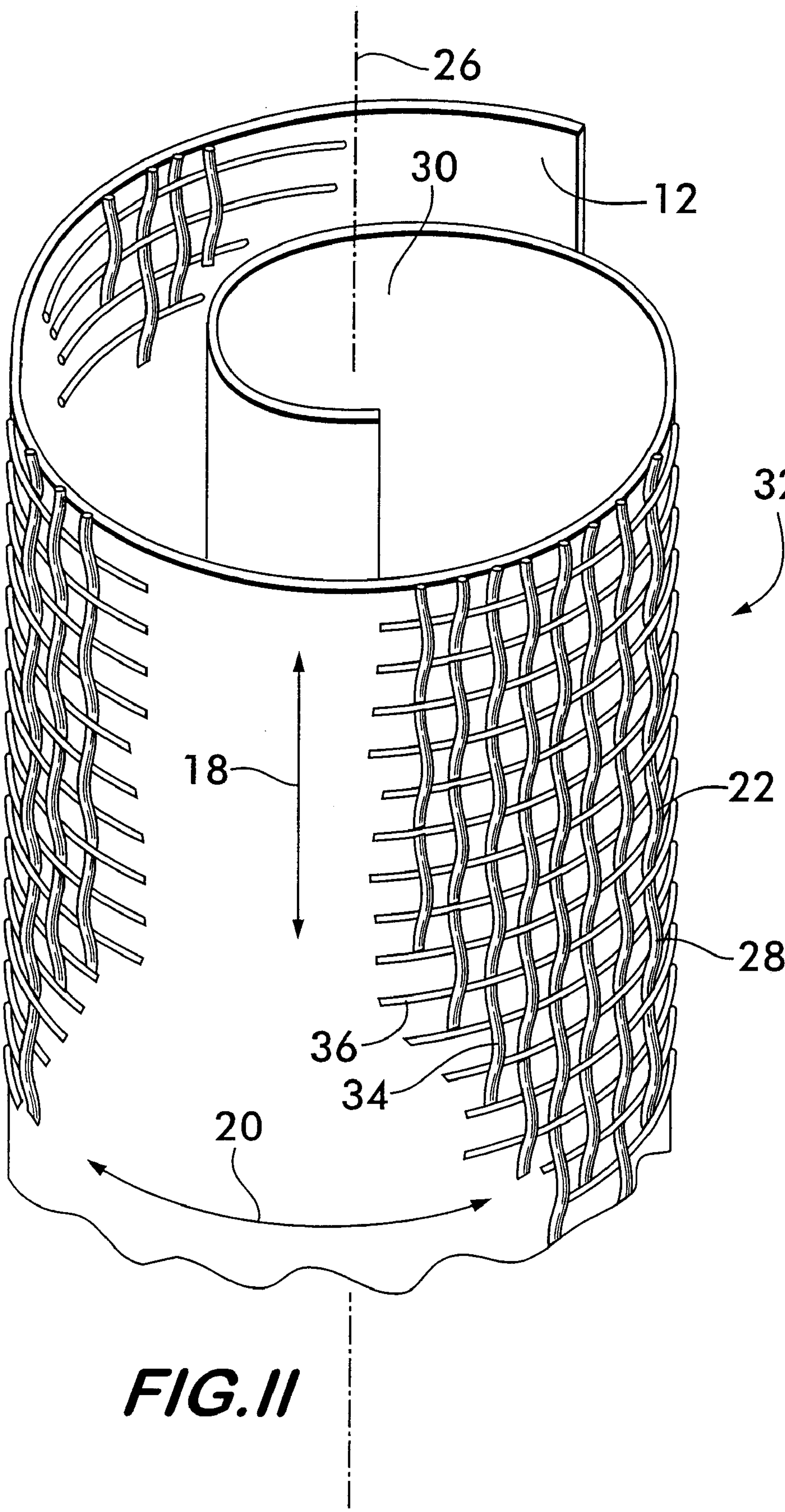


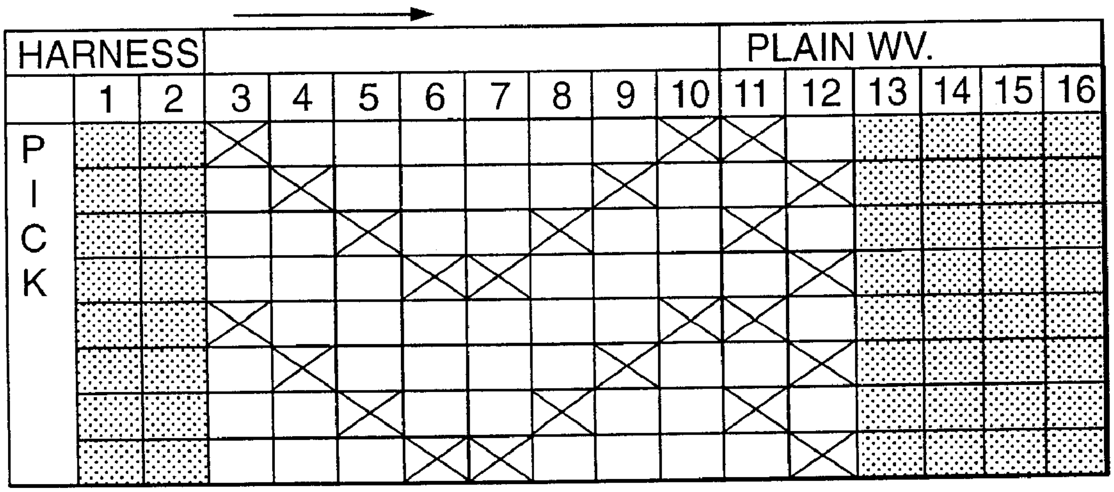
FIG.11

FIG. 12

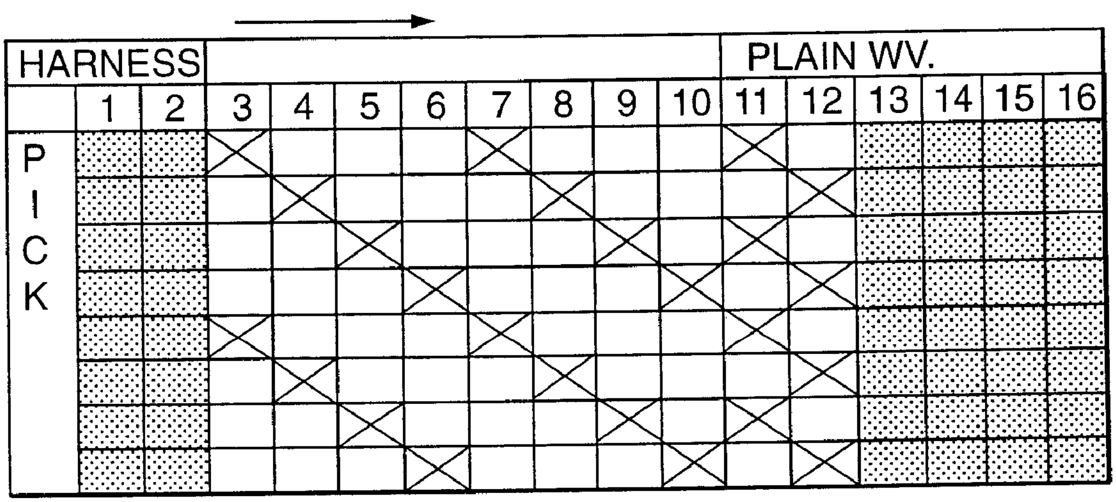
HARNESS											PLAIN WV.					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
P						X				X	X					
I					X				X			X				
C				X				X			X					
K			X				X					X				
						X				X	X					
					X				X			X				
				X				X			X					
			X				X					X				
P				X				X			X					
I					X				X			X				
C						X				X	X					
K			X				X					X				
				X				X			X					
					X				X			X				
						X				X	X					

LONGITUDINAL WRAP

FIG. 13



LONGITUDINAL WRAP (A.K.A. COIL WRAP)



HELICAL WRAP

FIG. 14

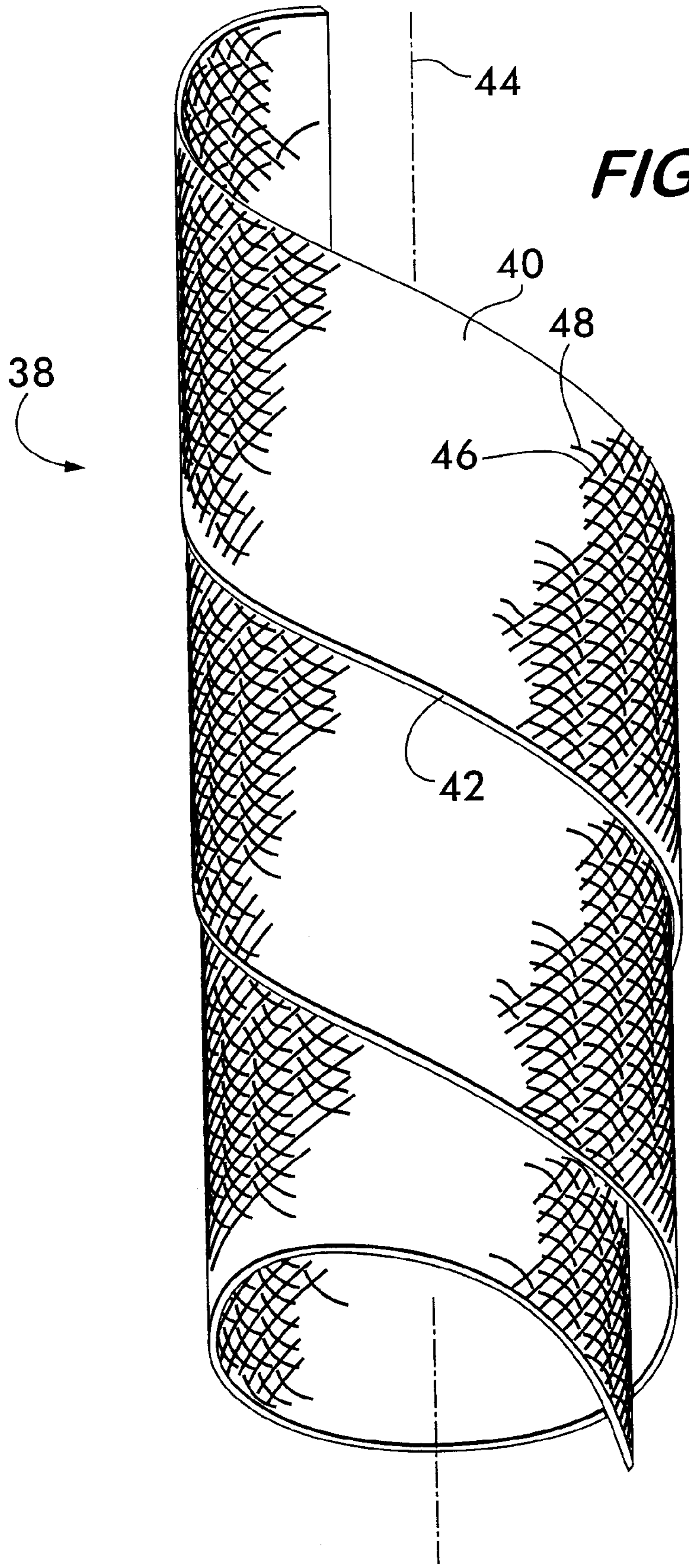


FIG. 15

SELF-CURLING SLEEVE

RELATED APPLICATIONS

[0001] This application is a divisional of priority application U.S. Patent Application Ser. No. 11/185,589, filed Jul. 20, 2005.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH

[0002] None

TECHNICAL FIELD

[0003] This invention concerns sleeves for receiving and protecting elongated items, such as wiring harnesses.

BACKGROUND OF THE INVENTION

[0004] Protective sleeving is used throughout the automotive, marine and aerospace industries to organize and protect elongated items, such as wiring harnesses and optical fiber cables. The sleeving surrounds the elongated items and protects them against cuts, abrasion, radiant heat, vibration induced wear and other harsh environmental threats. When positioned within protective sleeving, the wiring or cables are also held together in a neat bundle, allowing a multiplicity of different items to be handled like a sub-assembly, thus saving time and effort during integration of the items into a product.

[0005] Protective sleeving may be made by weaving filaments into a substrate and then resiliently biasing the substrate into a tubular form to define a central space for receiving the elongated items. Biasing may be effected by various means appropriate to the types of yarns used to make the substrate. Polymer filaments may be biased by heating them when the substrate is wrapped about a cylindrical mandrel, the filaments taking a permanent set conforming to the shape of the mandrel. Filaments can also be resiliently biased into a curved shape by chemical means as well as by cold working.

[0006] When substrates are biased into a tubular shape, monofilaments are typically oriented in the "hoop" or circumferential direction of the tube. Monofilaments provide excellent stiffness and strong resilient biasing that maintains the substrate in the tubular shape and tens to restore the substrate to this shape in the absence of distorting forces such as occur when the sleeve is manipulated to insert or remove an elongated item.

[0007] A significant disadvantage associated with sleeves that are biased into a tubular shape is that the biasing is effected by a separate step in the process of making the sleeve. The filaments comprising the sleeve may be biased by cold working before weaving or may be biased after weaving by heating the substrate when wrapped about a mandrel, but these actions constitute a separate step that adds to the cost and the time required to produce the sleeve. It would be advantageous to provide a sleeve formed from a substrate that is self-curling and needs no separate step to effect resilient biasing of the filaments into the tubular shape.

SUMMARY OF THE INVENTION

[0008] The invention concerns a self-curling sleeve for receiving and protecting elongated items. The sleeve comprises a substrate woven from a plurality of monofilaments or a combination of monofilaments and multi-filament yarns. When all monofilaments are used, the monofilaments along one direction may have a larger diameter tan the monofilaments along the other direction. For the combination embodiment, the monofilaments are oriented along a first direction and the multifilament yarns are oriented along a second direction substantially perpendicular to the first direction. The monofilaments are woven such that the larger diameter monofilaments form floats predominantly on one side of the substrate. For the monofilament-multifilament combination the monofilaments form floats predominantly on one side of the substrate. The substrate curls about an axis parallel to the monofilaments forming the floats to define and surround a central space. The side having the floats faces outwardly away from the central space. In a certain embodiment, the longitudinal floats face outwardly, and the horizontal floats face inwardly.

[0009] Relatively more rigid filaments are preferably located in the warp direction, and relatively less rigid filaments are preferably located in the weft direction. Preferably, the monofilament yarns are oriented in the warp direction along the substrate. For the combination of monofilaments and multifilaments, the monofilaments are preferably oriented in the warp direction.

[0010] The filaments may be woven in a herringbone twill weave, a double cloth herringbone twill weave or a satin weave to provide the floats.

[0011] These and other features and advantages of this invention will become more apparent to those skilled in the art from the detailed description of a preferred embodiment. The drawings that accompany the detailed description are described below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The present invention will now be described by way of example with reference to the following drawings in which:

[0013] FIG. **1** is a perspective view of a self-curling sleeve according to the invention;

[0014] FIG. **2** is a perspective view of a self-curling sleeve according to the invention;

[0015] FIG. **3** is a perspective view of a filling faced substrate;

[0016] FIGS. **4-10** are schematic diagrams describing weave patterns used for the self-curling sleeve according to the invention;

[0017] FIG. **11** is a perspective view of another embodiment of a self-curling sleeve;

[0018] FIGS. **12-14** are schematic diagrams describing weave patterns used for the self-curling sleeve according to the invention; and

[0019] FIG. **15** is a perspective view of another embodiment of the self-curling sleeve according to the invention, and corresponding to the weave pattern of FIG. **14**.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

[0020] FIG. **1** shows a self-curling sleeve **10** according to the invention. Sleeve **10** comprises a substrate **12** woven from a plurality of monofilaments **14** and multifilament yarns **16**. The monofilaments **14** are oriented in a first direction, shown by arrow **18**, and the multifilament yarns **16** are oriented in a second direction, substantially perpendicular to the first direction, and indicated by arrow **20**. Preferably, the monofilaments **14** are oriented in the warp direction of the substrate and the multifilament yarns are oriented in the weft direction and constitute the "fill yarns" or "picks" of the weave.

[0021] Preferred weave patterns for weaving the substrate **12** are those such as twills and satin weaves that form "floats" predominantly on one side of the substrate. As shown in FIG. **2**, a "float" **22** is formed when a filament or yarn, such as monofilament **14**, crosses over more than one filament or yarn oriented perpendicular to it, such as weft yarns **16**. The substrate is called "warp faced" when woven with a predominance of warp yarn floats on the surface of the substrate, as illustrated in FIG. **2**. A "filling faced" substrate, where filling yarn floats **24** predominate on the surface of the fabric is shown in FIG. **3**.

[0022] As shown in FIG. **1**, the substrate **12**, whether warp-faced or filling faced, when woven with monofilaments **14** in the warp direction and multifilament yarns **16** in the weft direction, exhibits a pronounced tendency to curl about an axis **26** substantially parallel to the monofilaments **14**. The direction of curl is away form the surface having the floats **22**, i.e., the substrate **12** naturally curls about axis **26** such that the floats **22** formed by the monofilaments **14** are on what becomes the outside surface **28** of the sleeve **10**. Upon curling, the substrate **12** takes on a tubular shape and defines a central space **30** for receiving the elongated items.

[0023] The reason for the curling of this exemplary substrate **12** is thought to arise from at least two factors. First, the relatively stiff members (e.g., monofilaments **14**) are oriented in the warp direction, while the more flexible and pliant members (e.g., multifilament yarns **16**) are oriented in the weft direction. Accordingly, it has been found that the sleeve is self-curling when the filamentary members in the warp direction have greater beam strength than those in the weft.

[0024] With reference to the embodiment of FIG. **1**, monofilaments in the warp direction stiffen the substrate **12** along he longitudinal axis **26**, provide rigidity to the sleeve **10** and resist bending. In contrast, the more flexible multifilament yarns **16**, oriented in the weft direction, are pliant and bend easily to allow the substrate **12** to curl about axis **26**, the bending axis for the multifilament weft yarns **16**. Multifilament yarns having deniers from about 200 to about 2000 are feasible.

[0025] The second factor causing substrate curling is related to the floats **22** which are thought to generate the forces that induce the substrate to curl. As noted above, the substrate **12** curls away form the surface **28** having floats **22**. The substrate **12** is unbalanced in the sense that one surface is different from the other in that on one surface floats **22** predominate. This surface imbalance causes internal stresses throughout the substrate which cumulatively manifest themselves in a curvature of the substrate about axis **26**.

[0026] It is further thought that the repeating chevron pattern that is apparent in herringbone twill weaves adds to the strength of the curl, because it is observed that substrates woven in warp and weft faced herringbone twill patterns show a greater tendency to curl than substrates formed from satin weaves. Although the satin weaves have floats, they do not display the chevron pattern associated with the herringbone twill and do not manifest the curling tendency to the same degree as the herringbone twill substrates.

[0027] FIGS. **4-10** illustrate various weave patterns that form substrates that curl when the warp members comprise monofilaments **14** and the weft members comprise multifilament yarns **16**. Because it is difficult to clearly illustrate the actual woven substrate, weave patterns are preferably schematically illustrated using a matrix. The matrix represents a repeating weave pattern. The columns of the matrix represent the warp members and the rows represent the fill or weft members. Each square of the matrix represents the member that appears on the upper surface of the fabric as woven on the loom. An "X" in a square represents a cross-over point at which the corresponding warp member crosses over a corresponding weft or filling member. The upper surface is not necessarily the outer surface of the sleeve **10**, as that will be determined by on which side the floats predominate.

[0028] FIGS. **4** and **5** represent simple herringbone twill patterns, FIG. **4** being filling faced and FIG. **5** being warp faced. Both of these weave patterns produce substrates having a relatively strong tendency to curl about the warp axis.

[0029] FIGS. **6** and **7** are more complex herring bone weaves in that they differ from FIG. **4** and **5** at columns **4** and **8** where there are four extra warp cross-overs on the surface for the filling faced pattern (FIG. **6**) or two extra weft cross-overs for the warp faced pattern (FIG. **7**) as well as a greater frequency of the repeated pattern. Substrate woven with this pattern tend to show weaker tendency to curl than the simple herringbone patterns of FIGS. **4** and **5**.

[0030] FIG. **8** shows a satin weave. Substrates woven from this pattern show a weaker tendency to curl than the complex herringbone pattern of FIGS. **6** and **7**. Note that the chevron pattern characteristic of the herringbone weave is largely absent from the satin weave shown in FIG. **8**.

[0031] Bar far, the strongest tendency to curl is manifest in substrates woven according to the herringbone double cloth pattern shown in FIG. **9**. Double cloth is a compound fabric in which a face cloth and a back cloth, each with its own warp and filling, are combined during weaving. Although the aforementioned chevron pattern is not readily visible in FIG. **9**, which shows the double cloth weave, when shown as fabric comprising the double cloth, as in FIG. **10**, the chevron pattern of the fabrics is clearly manifest.

[0032] Preferred materials for both the monofilaments and multifilament yarns include synthetic polymers such as polyester, polypropylene and aramids such as Kevlar and nylon. It is also feasible to use materials such as stainless steel, nitinol, elgiloy or other resilient metals having a high yield stress, preferably for the warp monofilaments.

[0033] Self-curling substrates according to the invention provide a sleeve that takes a tubular shape without the need for a separate biasing step. Such sleeves may be used to unsheathe elongated items and may rely on their inherent resilient biasing to contain the items within a central space, or closing means, such as tape, may be used as a wrap to further secure the sleeve. The sleeve may also be outfitted with other closure means, such as lacing, hook and loop fasteners, buttons, zippers and the like which allow easy application and removal of the sleeve to a substrate.

[0034] Another embodiment of a self-curling sleeve **32** according to the invention is shown in FIG. **11**. Self-curling sleeve **32** comprises a substrate **12** woven from monofilaments **34** that extend in the warp direction **18** and monofilaments **36** that extend in the weft direction **20**.

[0035] As described for the previous embodiment having both monofilaments and multifilament yarns, substrate **12** can be induced to curl about an axis **26** through the use of a twill or satin weave pattern that creates an imbalance between the surfaces of the substrate. Again, warp faced or filling faced substrates are advantageous.

[0036] The strength and degree of curl can be further augmented by appropriate choice of the monofilaments **34** and **36** comprising the substrate **12**. For example, to induce or augment the curl about axis **26** when it is oriented in the warp direction **18**, monofilaments **34**, oriented parallel to the warp direction **18**, are chosen that have a larger diameter than the monofilaments **36** oriented in the fill direction **20**. The larger diameter monofilaments **34** have a greater area moment of inertia than the smaller diameter monofilaments **36** and, for filaments having the same elastic modulus, have greater bending stiffness. The less stiff monofilaments **36** bend more easily and thus allow the substrate to curl around the axis **26** due to the imbalance engendered by the floats. Monofilaments having diameters between about 0.001 inches to about 0.020 inches provide practical filaments for forming self-curling sleeves according to the invention. Practical examples have been made which exhibit strong curling force. Some examples include a substrate comprising warp monofilaments made of polyphenylene sulfide (PPS) and having a diameter of about 0.010 inches woven with dual (side by side) PPS fill monofilaments having a diameter of about 0.008 inches. In another example, warp monofilaments of polyester having a diameter of about 0.010 inches were woven with polyester fill monofilaments having a diameter of about 0.006 inches.

[0037] It is also possible to augment or control the curling through varying the material of the monofilaments used it he warp direction as compared with that of the fill direction. Varying the material allows the designer to vary the modulus of elasticity of the monofilament. By using material having a higher or lower elastic modulus in monofilaments extending in one direction or the other, the curling tendency can be augmented or reduced, and fine tuning of the curl can be achieve in conjunction with the weave pattern and the relative diameter of the monofilaments. For example, to increase the curl about the warp axis, fill monofilaments having a relatively lower modulus would be used to make the fill monofilaments more flexible than the warp monofilaments. Similarly, if it were desired to weaken the curling tendency about the warp axis, fill monofilaments having a greater modulus would be used.

[0038] Many materials are feasible for use as monofilaments in self-curling sleeves according to the invention. The materials include poly(ethylene terephthalate) PET, a type of polyester), nylon 6 and nylon 6,6, silver coated nylon, olefins, aramids such as Nomex®, which is a registered trademark of E.I. du Pont de Nemours and Company of Wilmington, Del., and Kevlar®, which is a registered trademark of E. I. du Pont de Nemours and Company of Wilmington, Del., poly(ether ether ketone) (PEEK), modacrylic, glass fibers, carbon fibers, acrylic fibers, spandex, rayon, acetate, poly(lactic acid) PLA), poly (ethylene naphthalate) (PEN, a type of polyester), melamine (Basofil®, which is a registered trademark of BASF Aktiengesellschaft of Germany), fluorocarbons, as well as natural fibers such as cotton.

[0039] A further feature is the addition of heat to the sleeve. For certain materials the application of heat will induce further curling and also provide a thermosetting action that will hold the sleeve in its further curled configuration.

[0040] FIG. **12** shows a weave pattern matrix that schematically depicts a twill weave. The twill weave shown is characterized by the chevron pattern of the warp monofilament cross-over points being oriented in the fill direction. The cross-over points are indicated by the "X" at various intersection of warp and fill monofilaments. Note again, the columns represent the warp monofilaments and the rows represent the fill monofilaments. The chevron pattern is not continued to the edge of the substrate (columns **11** and **12**) where a basket weave is introduced to produce a clean edge.

[0041] FIG. **13** describes a twill weave wherein the chevron pattern is oriented along the warp direction.

[0042] FIG. **14** illustrates yet another practical curl inducing weave pattern wherein the warp monofilament cross over points, indicated by the "X" symbols running diagonally to both the warp and fill directions of the substrate. This pattern produces a self-curling sleeve embodiment **38** as sown in FIG. **15**, wherein the substrate **40** curls into a helix **42** around the longitudinal axis **44** of the sleeve. The monofilaments comprising the warp elements **46** and fill elements **48** of the sleeve are oriented at an angle to the axis **44**. It is further noted that the weave patterns illustrated in any of the diagrams in FIGS. **4-10** and **12-14** may be used with any combination of monofilament or monofilament-multifilament forming a substrate.

[0043] Although examples of woven substrates are provided, it is also recognized that self-curling sleeves can also be made through weft insertion of filaments during warp knitting, or also by warp knitting alone, to produce the imbalance necessary to induce the substrate to curl.

[0044] The foregoing invention has been described in accordance with the relevant legal standards, thus the description is exemplary rather than limiting in nature. Variations and modifications to the disclosed embodiment may become apparent to those skilled in the art and do come within the scope of the invention. Accordingly, the scope of legal protection afforded this invention can only be determined by studying the following claims.

We claim:

1. A self-curling sleeve for protecting elongate members received in a central space of said sleeve, said sleeve comprising:

a substrate fabricated of a plurality of interlocked yarns and having a pair of free edges extending along a length of said sleeve, said interlocked yarns including at least one monofilament exerting a bias force causing said substrate to self-curl about said central space.

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